# Cambridgeshire and Peterborough Combined Authority Transport Model

## Model Specification Report

Cambridgeshire and Peterborough Combined Authority

October 2022

# Notice

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## Client signoff

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# 1. Introduction

## 1.1. Background

The Cambridgeshire and Peterborough Combined Authority (CPCA) has a long-term strategy to improve transport in their area; and have recently consulted on an updated Local Transport and Connectivity Plan which sets out their vision and a framework to deliver a modern integrated transport system for the residents and businesses in Cambridgeshire and Peterborough.

According to the 2021 Census, the usual resident population for Cambridgeshire and Peterborough was 894,300 with the two main cities growing faster than other districts over the past ten years. The aspiration is to make future growth more sustainable and to improve the transport system to provide travellers with choice, making it easier to access opportunities across the region using alternatives to the car. This is a significant challenge as the region is diverse including the cities of Peterborough and Cambridge, many towns of varying size and rural areas focused on agriculture with a high reliance on car for travel between communities.

To successfully meet its vision and goals, CPCA is looking to deliver an integrated transport network which includes the following[1]:

- Integrated and seamless interchanges between modes
- Accessible travel and spatial planning
- High-quality and effective digital connectivity through the region
- Investment in high quality public realm
- Safe and attractive walking and cycling infrastructure
- Efficient highway network that accommodates the needs of all users
- Accessible, affordable, reliable, and frequent public transport and
- Innovative new transport modes.

The CPCA recognises the importance of having an up to date and robust evidence base and tools to allow them to stress test future transport plans which support economic growth aspirations, while balancing environmental concerns across Cambridgeshire and Peterborough.

Two transport models currently provide coverage of most of the CPCA area:

- Cambridge Sub Regional model represents travel to / from and within four districts of Cambridgeshire
- Peterborough transport model (PTM) provides detailed representation of highway travel for Peterborough.

To achieve the aims of a “good growth” and balanced assessment across the wider region, CPCA have approved the development of a new regional transport model to assess transport projects across the whole of Cambridgeshire and Peterborough area using one tool.

The new model will replace the existing Cambridge Sub Regional Model (CSRM), which is limited to four districts of Cambridgeshire, with a detailed model which covers the whole of the Cambridgeshire and Peterborough Combined Authority area. It will allow the costs and benefits of proposed transport schemes, and the transport impacts of new housing developments, to be fairly assessed for the whole area.

## 1.2. Client group

A Combined Authority working group has been set up to oversee the model development. This working group includes representatives from Cambridgeshire County Council, Peterborough City Council, and the Greater Cambridge Partnership.

## 1.3. Model suppliers

Atkins and WSP will collaborate and act as joint suppliers of the new transport model on the Cambridgeshire and Peterborough Joint Professional Services Framework. The management and governance of the supplier team, including our approach to quality assurance is provided in the Model Delivery Plan.

[1] Source: Draft Local Connectivity and Transport Plan: https://yourltcp.co.uk/wp-content/uploads/2022/05/Draft-Regional-Section.pdf

## 1.4. Model Name

The model is proposed to be formally named as CaPCAM, the **C**ambridge **a**nd **P**eterborough **C**ombined **A**uthority **M**odel. To avoid confusion, references to the regional model throughout this specification report refer to the new model.

# 2. Model requirements and functionality

## 2.1. Objectives

### 2.1.1. Background to the proposed model

Strategic transport modelling is central to developing the evidence base for spatial strategies, major scheme business cases, other transport improvements and policy changes. However, the current modelling / data approach across the region has been developed over a number of years, with different models and approaches and it has been some time since the last significant update of the strategic transport models within the region. This is now the right time to develop a new, consistent, evidence-based modelling tool for Cambridgeshire and Peterborough, with improved functionality which meets the objectives and requirements detailed in this chapter.

### 2.1.2. Model uses

The model is intended to be used to:

- Support local spatial and regional strategy development;
- Inform **local plans** and land-use policies/strategies;
- Allow testing of a wide range of **highway schemes** and input into more detailed operational studies;
- Provide inputs into **public transport** modal assessment studies, including rail projects and bus-based corridor studies;
- Support **business case** development and submission, including **major scheme bids** to central government;
- Highway Control and Planning – support on larger strategic growth sites;
- Support transport policy considerations;
- Provide **walk** and **cycle** modal share metrics to inform health and sustainability assessments;
- Test **Park and Ride** interventions and consider the importance of central area parking constraint and charges; and
- Provide outputs to other studies on **indirect transport issues** (e.g. carbon generation, operational assessments).

## 2.2. Model functionality

In order to meet these user requirements, the functionality of the model needs to include:

- Highway and public transport assignment models, and a variable demand model for personal travel with a robust **modal choice** decision process;
- Ability to reflect regional priorities around sustainable transport modes including**: guided bus, bus, rail**
- Ability to model the influence of both **walking and cycling**, both for access to other modes, and for entire trips;
- Ability to produce inputs into other **mode** assessments including rail projects and bus-based public transport corridors.
- representation of existing and future **Park and Ride** and replicate **parking costs and constraints** in strategic regions
- Representation of **active travel** (walking and cycling) including off road facilities and attractiveness of dedicated cycle facilities impacting users' perception of mode.
- Representation of **parking capacity** in addition to charges to better reflect constraints on car use.
- Road freight (**goods vehicles**) will be included in the highway assignment model to reflect the road space they use and their impact on congestion.

The model functionality aims to address all the study requirements but with the expected limitations of a model of this scale and nature.

### 2.2.1. Model structure

- CapCAM will be a full transport model for variable demand modelling (VDM) and both highway and public transport (PT) assignment that will be developed based on the latest government guidance (TAG) and values.
- The CaPCAM model will be based on primary (i.e. mobile network data (MND), counts, journey time data, etc) and secondary data (i.e. NTS, Census 2011 / 2021, mid-year population estimates, NTEM, NRTF, etc) collected during the same period(s) to ensure commonality between traffic flows and distributions between local and regional study areas.
- Local highway assignment models for testing small schemes could then be developed as required from the parent models by cordoning.
- It will be ensured that there is a connection between any existing local highway assignment models (costs and routing) and the new regional model demand model. This could be achieved by ensuring zone and network correspondence between the two models, and user class compatibility.
- If a finer zoning system is required in any local models the ability to disaggregate the regional model zone system to e.g. the PTM4 zone system would also be required. This would enable the PTM4 matrices to be used as a source of prior matrix demand data for the base year model if required.
- Full documentation of the regional model build to ensure uncertainties around assumptions are accounted for within local model builds and adequately reported within local transport studies or business cases.

### 2.2.2. Model standards and measures of success

Traditionally, transport models tend to measure success primarily on technical quality criteria as defined by the DfT Transport Analysis Guidance (TAG). Whilst we are proposing to maintain this technical quality, additional measures are also proposed:

1. **DfT TAG technical "Quality" criteria.**
    a. A wide range of quality tests defined in TAG for all the models will be utilised as standard.
    b. An extra "near" criteria based on the approach with National Highways Regional Traffic Models (RTMs). A similar approach of Red/Amber/Green system of validation can be developed and applied.
2. **Proportionality, pragmatism and cost**
    a. Building a transport model is time consuming and expensive. We recognise that CPCA seek to use budgets as efficiently as possible, and where possible, limit spending unless it delivers high value;
    b. Where there are decisions which might require a choice between high quality & cost vs medium quality & cost, we will not automatically advocate the higher quality option. We will seek to explain to CPCA the relative benefits of each approach and aim to recommend the option which is most efficient and provides the most value for money.
    c. By focusing on supporting strategic transport and planning requirements, time and cost is not wasted in building unnecessary functional capability which would add to appraisal times, file size and other complications. Rather the model would provide the platform for additional bespoke capability that could be rapidly added to applications of the whole, or part of the model, for business case evidence for all potential schemes throughout CPCA.
3. **Appraisal time**
    a. To reduce costs, we will seek to reduce the time the model needs to "run".
    b. The "run-speed" of a model is not just how quickly the model "runs" or even its time to implement (although these are important considerations) the "model run" must include the time for a modeller to produce clear, transparent outputs through which they are able to interpret, appraise and assess if the outputs are plausible;
    c. Hence the success of this metric is to seek to reduce the whole "appraisal time" (i.e., the model set-up and implementation, the model run, and interpretations and appraisal of the outputs).
4. **Ease of use, accessibility and transparency**
    a. It is proposed that all model inputs and outputs will be easily accessible (on a web browser), fast, intelligible and map-based.
    b. This will help all users (including the modelling delivery team, independent reviewers, CPCA and stakeholders) to understand and influence the implications of any decisions.

We will seek to suitably "balance" all of these measures, i.e., we will neither seek to develop a technically excellent model which is expensive, slow to provide outputs and cannot be understood by key stakeholders nor develop a model which is quick and easy to use but is based on low levels of evidence.

# 3. Existing models and data

## 3.1. Models

### 3.1.1. Introduction

This section provides a brief overview of the range of existing modelling tools available to the stakeholders to answer these questions:

- What can existing models provide (data) that can be taken forward for the new model?
- Which features from existing models should be retained and any aspects to be dropped (more problematic than the value they add)?
- Where do the existing models fall short for foreseeable applications - gaps in existing model to be addressed by new model.
- How will / should the new model replace, complement and, if appropriate, interface with the existing model and implications for consistency.

The existing models considered in this section are as follows:

- Cambridge Sub Regional Model (CSRM2 F-series)
- Peterborough Transportation Model (PTM3)
- Wisbech Area Transport Model (SATURN and Vissim)
- March Area Transport Study Models (SATURN and Vissim)
- Ely Traffic Model – (SATURN)
- Regional Traffic Models (SATURN, National Highways)
- Cambridge CUBE PT assignment model; and
- Various microsimulation and local junction models within the Cambridgeshire and Peterborough area (Cambridge, Huntingdon and St Ives)

The section concludes by considering the questions posed above and highlights aspects to be addressed by CaPCAM.

### 3.1.2. Cambridge sub regional model (CSRM2 F-series)

The CSRM2 F-series model represents the demand for personal travel to, from and within the Cambridge sub region, defined as the four districts of Cambridge City, South Cambridgeshire, East Cambridgeshire and Huntingdonshire. CSRM2 comprises a variable demand model (VDM) integrated with assignment models for highway, public transport, walk and cycle modes.

The model has 313 zones for the four districts representing the internal model area and a further 161 external model zones. The zones are defined from the Middle layer Super Output Areas with some subdivisions relating to specific sites, eg separating major employment areas and to provide detail in the urban centres and some aggregation in rural areas.

The demand model is implemented for an average weekday and considers choices of mode, time period and destination. Travel demand is highly segmented to reflect travellers' education / working status, household income, size and car availability, as well as the trip purpose.

Highway matrices were developed for a 2015 base year from mobile phone data, 2011 Census data and synthetic matrices (from the VDM) for 12 user classes (8 purpose and income combinations, 4 goods vehicles to reflect restrictions in Huntingdon). The highway assignment model is implemented for the peak hours of 0800-0900 in the morning and 1700-1800 evening and an average hour (from 1000-1600) during the day.

The other assignment models operate for the morning, interpeak and evening periods of 0700-1000, 1000-1600 and 1600-1900 respectively and in each case the demand (trips) estimated by VDM is assigned.

Land use and trip end spreadsheet models are used to forecast personal travel demand based on land use activity (dwellings containing population, commercial development containing jobs). Trip rates for total travel derived from the National Travel Survey (NTS) akin to those used in DfT's NTEM dataset are applied to the forecast population to estimate future travel demand. Growth for goods vehicles and external (through) trips is derived from DfT's Road Traffic Forecasts.

The VDM estimates travel by mode in each time period. The base year highway matrices are updated by applying growth from the VDM (incremental approach). Matrices of light and heavy goods vehicle trips, and through trips are added to the car trips from the demand model.

The modelling system runs iteratively until demand estimates are in equilibrium with the levels highway congestion forecast.

CSRM F-series included a detailed representation of Park and Ride with car access to the city bus-based park and ride sites and the Cambridge Busway guided bus. Car access to rail is also explicitly modelled. The representation of cycling has been enhanced for the F-series, with varying perception of cycle facilities (on / off road) and modelling the ability to drive to Park and Ride sites then walk or cycle to the destination (Park and Active).

The model does not include any representation of public transport crowding (discomfort / delays to passengers due to standing / lack of capacity on the services). Parking costs are included, but no impacts of limited parking capacity on travellers' choices.

### 3.1.3. Peterborough Transportation Model (PTM3)

The current PTM3 model represents highway travel in the Peterborough Unitary Authority, with its detailed modelled area (simulation network) covering the City Council boundary bounded by the A1 in the west, Bourne and Yaxley to the north and south respectively, and to Guyhirn in the east. The model has 250 internal and 63 external zones. The zoning is based on Census Output Areas with additional zones to represent city car parks.

PTM3 is a three-stage model with trip generation and distribution for new developments carried out using spreadsheet models, and highway assignment in SATURN. An update to create PTM4 is being planned and will run in parallel with the new regional model development.

Highway matrices were developed for a 2019 base year from mobile phone data and synthetic matrices (from NTEM based trip ends and a gravity model) for 5 user classes (commute, business, other, LGV and HGV). The highway assignment model is implemented for the peak hours of 08:00-09:00, 14:00-15:00 and 17:00-18:00. Detailed networks represent the connectivity across the study area with signal timings provided by Peterborough City Council and checked against observed average timings. Level crossings are also included either as traffic signals based on observed barrier timings in the modelled hours, or link based time penalties.

Forecasts have been generated for the future years of 2026, 2031 and 2036. The trip generation spreadsheet model is used to forecast additional highway demand generated by developments in the modelled area. Trip rates derived from TRICS, count data and local studies are applied to land use units (dwellings, square metres of commercial floorspace). Background growth for car travel associated with existing land use activities, is determined from NTEM v7.2 applying alternative planning assumptions, and making allowance for changes in income and vehicle operating costs through time. Growth for HGVs and for through trips (external to external) is taken from the DfT's Road Traffic Forecasts.

### 3.1.4. Wisbech Area Transport Model

The Wisbech Area Transport model is a highway model that was updated for the Wisbech Area Transport Study in 2016/17 and has a base year of 2015. The model is implemented using the SATURN software and has a study area of Fenland district in Cambridgeshire and Kings Lynn and West Norfolk in Norfolk. Zones are defined from Output Areas with 34 zones representing Wisbech and its surrounds, and 61 external zones.

Highway matrices were developed for the 2015 base year from 2016 mobile phone data supplemented by earlier 2008 RSI data and information from SERTM. Matrices for HGV trips were derived from DfT's Base Year Freight Matrices (BYFM) for 2006 uplifted to 2015. The assignment model operates with 5 user classes (commute, business, other, LGV and HGV) and is implemented for the peak hours of 0800-0900 and 1700-1800, and an average interpeak hour (1000-1600).

Forecast highway matrices are developed using the same concepts as set out for PTM3. Growth in zones with developments is estimated using an Uncertainty Log with trip rates derived from TRICS data and distribution patterns taken from the existing zones. For zones without development, background growth is derived from NTEM forecasts with income and fuel adjustment factors applied. The final stage is constraining overall growth to NTEM levels.

Results from the strategic highway model were fed into a microsimulation model in Vissim for use in the Wisbech Access Study.

### 3.1.5. March Area Transport Study (MATS) Model

This strategic highway model was developed for the March Area Transport Study (MATS) to assess the impact of new developments on future traffic growth, and evaluate the impact and benefit of a number of proposed highway improvement schemes.

The MATS model is implemented in SATURN with two spreadsheet models to provide trip generation / land use and trip distribution modelling for developments, similar to the implementation of the current Peterborough transport model (PTM3). Outputs from the model are used with the DfT's Transport User Benefit Appraisal (TUBA) software for the cost-benefit analysis of highway schemes.

The study area focuses on the town of March and with network representation of connectivity to Wisbech in the North, Chatteris in the South and Whittlesey in the West. To the East the detailed modelling covers the area towards the A1101. The detailed modelling is focused on the town centre and the A141 to the west. Zoning in MATS is based on the Lower layer Super Output Areas (LSOAs) with some sub divisions to represent car parks in the town centre, and comprises 38 internal and 8 external zones.

The base year is 2018 with the highway demand matrices developed from automatic number plate recognition (ANPR) and car park surveys, allocated to journey purposes (commuting, business and other) using National Travel Survey, 2011 Census and the car park survey data. Three separate hours are modelled for an average weekday 08:00-09:00, 14:00-15:00 and 17:00-18:00. Signal timings were provided by Cambridgeshire County Council and checked against observations to provide best representation of dynamic signals under prevailing conditions. Four level crossings are included in the model and represented using traffic signals taking into account the time the barriers were closed during the one hour periods modelled.

Forecasts were generated for the years of 2026 and 2031. An uncertainty log was used to identify development sites to include, and trip rates derived from TRICS applied to the planned developments using the spreadsheet models. Background traffic growth is derived from DfT's NTEM and Road Traffic forecasts.

### 3.1.6. Ely Traffic Model

The Ely Traffic Model (ETM) is a highway assignment model developed originally for the AM and PM peak hours, using SATURN software with a 2009 base year. The model was built to allow tests to be conducted for the East Cambridgeshire District Council LDF proposals for Ely. The network covers the built-up area of Ely City and the local hinterland network enclosing Ely as far south as the A1123 from Soham to Stretham. Forecast years were established for 2017 and 2031. The forecasts were controlled to TEMPRO 6.2 levels of household and employment growth, although there was evidence that the employment growth in Ely anticipated by the local district council may be significantly higher than the reported TEMPRO 6.2 level.

The ETM was updated in 2021 using the 2031 Do Something network as it included the Southern Bypass which is now open and the 2017 matrix, with a Present Year Validation to 2019 data. A limited amount of manual matrix estimation was required and the inclusion of signals to represent level crossings, and an hgv ban added at the north end of Queen Adelaide Way where there is a height restriction. Calibration of link speeds and speed flow curves resulted in a good fit to 2019 count data, and further checks were carried out against routing and journey times for OD pairs against data derived from Google Maps.

### 3.1.7. Regional Traffic Models

National Highways have a suite of five regional traffic models (RTMs) covering the whole of England. The original development of the models in 2015 was to enable National Highways to progress schemes identified in the Road Investment Strategy (RIS). As the models were designed to provide the base for multiple highway schemes the geographical coverage is broad, with no one centre of focus. The suite of models were developed for a 2015 base year to a common design, with a consistent set of standards and utilised common datasets. The RTMs are currently being updated to a 2019 base year.

Cambridge and Peterborough are both within the area covered by the South East Regional Traffic model (SERTM), though Peterborough is fairly close to the edge. Peterborough is also in the area covered by the Midlands RTM, though Cambridge lies just outside.

The RTMs comprise a highway assignment model implemented in SATURN, and a variable demand model using DfT's DIADEM (Dynamic Integrated Assignment and Demand Modelling) software.

The primary data source for the development of the base year trip matrices was mobile phone data processed into the Trip Information System dataset, supplemented with information from Trafficmaster and DfT's Base Year Freight Matrices. Rail trip matrices are also developed for the base year to enable demand changes to / from rail when forecasting. Highway networks were developed from Ordnance Surveys ITN (Integrated Transport Network) again supplemented with traffic signal data and information from existing traffic models.

The assignment models operate for average hours in each of three time periods (morning, interpeak and evening peak) for an average weekday. Five user classes are defined for car commute, business and other trips and for light and heavy goods vehicles.

Forecast demand is developed using NTEM data for car growth and DfT's Road Traffic Forecasts for LGV and HGV trips. Specific development sites are not considered in these large-scale strategic models.

### 3.1.8. Cambridge CUBE PT assignment model

The Cambridge CUBE public transport assignment model is derived from the CSRM2 D-series public transport assignment model with some refinements related to specific GCP corridor schemes. The 2015 base year public transport matrices have been taken from CSRM2 base year and modified to improve the validation for the schemes being considered. The public transport network and service representation was taken largely from CSRM2, with improvements to zone connectors, non-transit legs utilising CUBE functionality.

The CUBE PT model does not include any specific forecasting functionality, with demand changes taken from CSRM2 forecasts and applied in CUBE.

CSRM2 has been updated to the F-series since this model was implemented. Many of the enhancements made for the CUBE PT model relating to zoning, highway detail for bus stops and routing, have been incorporated into the CSRM2 F-series networks.

### 3.1.9. Microsimulation and local junction models

For more detailed operational assessment relating to scheme proposals and design, micro simulation models are often used for smaller areas than the models outlined above. Junction specific models are also created for key locations. The main micro simulation modelling packaged used are Paramics, Aimsun and PTV Vissim. Several micro-simulation models exist for areas within Cambridgeshire and Peterborough including:

- Paramics based models for Cambridge, St Ives, A14 Huntingdon
- Aimsun – within Peterborough
- Vissim – Wisbech, March and corridors in Peterborough

Many of the micro simulation models were developed from the more strategic SATURN highway models, and thus provide similar network detail, though they could provide supplementary junction information where it is still up to date.

Detailed junction models are developed to provide operational assessments and look at specific details of scheme design. The focus of these models is very different to the proposed strategic model, however if sufficiently up to date, they could provide detailed junction geometry and signal phasing and timings. The transfer of such information already coded for the purposes of transport modelling will be considered should this be more efficient than collating the data from alternative sources.

### 3.1.10. What can existing models provide?

The models described above provide a large collection of information which could be utilised when developing the new model. However much of the data underlying the models is now quite dated, and hence the appropriateness of this data in terms of coverage and age will need to be considered. In particular, demand data from traffic surveys is pre Covid and hence its usefulness will be limited.

CSRM2, PTM3, MATS and the Wisbech area transport model provide coverage for most, if not all, of the study area being considered and could potentially provide highway network information for the new model.

The local microsimulation and junction models will be considered as a source for junction coding and signal timing, depending on the age of the data and whether junction changes mean the data is no longer valid.

In addition, these models could provide the basis for model zoning.

Recent data collated for forecast scenarios is also directly relevant. Uncertainty logs (where they exist) should be pooled, and form the basis for development and infrastructure logs for the wider area.

Public transport network data could be taken from CSRM, however contemporary PT modelling software (such as PTV Visum and CUBE Voyager) has functionality to process timetable information and hence this approach will be more efficient.

More importantly where existing models are expected to continue in use due to their more detailed, local coverage, consistency in definitions should be considered carefully to facilitate the sharing of data or transfer of information between modelling tools in the future.

For consistency, definitions should be the same or compatible wherever possible with simple one to one, many to one aggregations.

- Same highway assignment hours (including definition of average weekday)
- user classes – same or simple aggregations
- definition of modes – “car”, van and HGV – same or simple aggregations
- same price base
- zoning – nested across models
- Classification of road types

Network coding rules will be required for the new regional model, and these might be taken from an existing model, particularly where consistency is desirable between models in the longer term.

### 3.1.11. Shortcomings in existing models and functionality to adopt

Table 3 sets out some of the functionality in the existing models that has been identified as desirable for including in CaPCAM to provide the range of tools required for the likely scenario applications.

**Table 3-1 - Functionality options**

| Existing Model | Desirable | Debatable (sufficient value added?) |
|---|---|---|
| CSRM | P&R modelling<br>Cycle modelling<br>LU / trip end growth based on local uncertainty logs or constrained to NTEM<br>Representation of area licence for Cambridge City | Income segmentation - should be useful – but limited application to date<br>Treatment of bus v guided bus (HQPT) – was useful – but more important now to differentiate off road dedicated track versus on road running<br>Macro time of day choice – limited use to date, important for time period specific charging.<br>Assigning walk (cycle is desirable). |
| PTM, MATS | Clarity of trip generation for future developments | Representation of individual car parks – too much detail for strategic model though data potentially useful. |
| SERTM | Goods vehicle demand<br>Strategic road network | |

The existing models provide a wide range of functionality across the CPCA area, particularly for highway modelling. The main shortcomings identified with the existing models are:

- Area of coverage and consistency across tools
- Demand data underpinning models are now quite dated (eg 2011 Census) and require updating to remain valid
- Multi modal modelling limited to Cambridge sub region only
- Limited / time consuming graphical outputs for presentation
- Bespoke and complex approach to represent Park and Ride
- Transparency of planning inputs
- Modelling constraints imposed on car travel by restricted parking capacity
- Changes in traveller behaviour due to emerging technology and post Covid

The proposed approach to developing CaPCAM seeks to address these shortcomings.

### 3.1.12. Interaction between CaPCAM and existing models

The outline specification of CaPCAM has highlighted some areas of consistency in terms of geographical building blocks for zone definitions, time periods and segmentation (user classes) across the existing models. Some of the definitions are slightly different (eg for the inter peak highway assignment hour). The definitions will be finalised for CaPCAM based on analysis of data and in discussion with the existing model owners to maximise consistency in definition across the existing models which are expected to be used in future applications. The most relevant model is PTM where the proposed update provides the opportunity to align definitions with CaPCAM.

Having maximised consistency in definitions, some of the potential benefits of sharing information between modelling and assessment tools are as follows:

- Single maintained Uncertainty log for all developments across the CPCA area to maximise consistency in forecast growth assumptions for alternative scenarios;
- Derivation of modal (expected to be primarily highway) growth factors from CaPCAM for application in existing models in a variety of ways: as background growth, for longer distance movements not captured in the local model or to create a reference scenario;
- Single maintained Uncertainty log for potential transport schemes across the CPCA area;
- Sharing of scheme coding for potential highway schemes across relevant models – with adjustments required for appropriate level of detail in each application;
- Ability to develop new detailed assessment tools from CaPCAM, eg by cordoning the highway model, extracting a subset of the demand matrices for a local micro simulation, cycling or public transport and adding additional detail for local applications.

It must however be noted that each model or assessment tool will be focused on meeting specific objectives, with more local models intended to provide more detail than the strategic CaPCAM. While inconsistency can be minimised and information can be shared between the various tools, this does not ensure consistency in forecasts outputs. The most appropriate tool should be used for the relevant application and the validity of the tool confirmed at the outset.

## 3.2. Data

### 3.2.1. Introduction

This section briefly outlines existing data sources we are aware of, and in many cases have previously used for models and studies within the CPCA area. The datasets fall into two main groups:

- National datasets providing information for the CPCA area which are published or can be made available for applications such as transport modelling.
- Locally collected data collected regularly (e.g. annually) or as a one-off for a specific purpose.

The data requirements for the model development are covered in Chapter 8 of this report, covering both data which exists (as summarised here) and datasets which would need to be collected.

The following sections provide a brief summary of the existing data relating to the different components of the proposed model and stages of development.

### 3.2.2. Planning data and demand model

Planning statistics are published by the Local authorities on levels of development and growth in their area. Many of the development assumptions are already collated for the CSRM and PTM models. The existing data would need confirming with the relevant local authorities, with data expected to be available for 2022.

Statistics are published at least annually, by the Office for National Statistics, and freely available relating to population, households and employment at a district level and in some cases for more spatially disaggregate areas. Again data for 2022 is or will be available for use in the base year model development. Data is also collated by various government departments on housing developments (Live tables) and school places (School Census)

Commercial datasets such as the Ordnance Survey AddressBase relate postcodes to geographic locations and enable more spatial detail to be incorporated into models. This dataset, and some others, are freely available to public authorities. Where such data is required, we will request access to the data via the relevant client authority.

The Census of Population carried out every ten years provides a wealth of spatially detailed information on the population and households living in each area. Data from the 2021 Census is now being published, with more information due out by Spring 2023. The 2021 Census will provide an excellent dataset from which to derive 2023 segmented population data, with more aggregate growth statistics being applied.

Trip rates are required to determine the amount of travel made people living, working, shopping etc in the study area. Trip rates can be obtained from two sources:

- travel diaries recording every trip made by a set of individuals for a defined period (usually a day or a week).
- Counts at specific facilities (eg retail parks, science parks, specific development areas).

The National Travel Survey is an excellent source of information on travel behaviour and available for all recent years. The survey is however a very small sample of people, sampled across England and hence cannot be reliably applied for spatially detailed areas. It does however provide robust information on trends and can be used to provide statistics at a more aggregate spatial level (while ensuring sample sizes are sufficient). A limited amount of data is published and freely available. A licence can be obtained to access more detailed NTS data for specific purposes, such as transport modelling.

The TRICS database is a widely used system for trip generation analysis particularly in relation to Transport Assessments. The database provides access to a wide range of traffic and multi-modal transport surveys for different development types.

Changes in behaviour have also been monitored by ONS, with a variety of datasets collected from lifestyle surveys such as the Living Costs and Food survey, and Opinions and Lifestyle survey. hese data are not specific to the study area, but can provide useful insights for the demand model on the factors influencing the ability / desire to work from home.

### 3.2.3. Base year trip matrix and distributional data

The Census of Population also records information on the usual workplaces and methods (mode) of travel to work for employed people, and has historically been widely used in transport modelling. This data is unlikely to be reliable for 2021 due to restrictions on movement imposed due to the Covid-19 pandemic at the time the Census was completed. Data from 2011 is available, but now very dated so of limited use meaning existing data on commuting patterns across the CPCA area is limited and will need to be addressed.

Public transport ticketing information can provide information on volumes and patterns of movement on public transport. Ticketing data from Stagecoach has been used for analysis of bus travel patterns for CSRM. Similar data is likely to be available from other bus operators, though restrictions are usually imposed to ensure the commercial sensitivity of patronage data is respected.

Annual rail ticketing data is available via LENNON which holds the vast majority of national rail tickets purchased in Great Britain. The MOIRA model makes extensive use LENNON to predict the number of people who travel on each service. MOIRA is the rail industry standard source of information on rail patronage and can provide information on station to station movements (based on ticket sales). There are limitations with the data particularly in major conurbations covered by travel cards which the stations used are not defined. Times of travel are not determined for some tickets, and it is not clear how accurately the MOIRA information reflects variations across the year and throughout the day at local stations.

Mobile phone or other mobile device data, collectively known as mobile network data (MND) can also be used to obtain information on patterns of movement. Mobile phone datasets have been used for CSRM, PTM and the Wisbech transport models. This data ranges from 2015 to 2019 and is sourced from different providers.

Various companies collate and sell information on vehicle movements through fleet tracking systems using GPS devices in a sample of vehicles. These include INRIX, Teletrac Navman and TomTom. The sample sizes for the data vary and the bias of the sample is not known. These datasets are often used to provide data for vans or heavy goods vehicles.

### 3.2.4. Network data

Many sources of geo-coded network data for alternative modes are widely available. Opensource datasets such as OpenStreetMap are available and provide some of the information required. Commercial datasets provide more attributes for the networks which can be valuable for transport modelling. OS Mastermap and HERE maps are examples of networks where additional detail can be purchased.

As outlined in Section 3.1, the existing models provide good coverage of the proposed CaPCAM study area and already contain detailed network information appropriate for modelling.

Signal timing information could be taken from existing models, but the age the data means it should be verified or updated with current information from the local authorities.

### 3.2.5. Highway model

The highway model development requires information on the volumes of traffic using the network, observed speeds of travel and journey time routes to calibrate and validate the model. Count data is used to help scale and shape the matrices of demand with additional (independent) data then used to validate the resulting traffic flows across sets of links.

Ideally the data will be collected close to the date being used to validate the model. Adjustments can be made to the data to account for monthly variations due to seasonality, though the aim to represent travel for an average weekday during (school and university) term time.

National Highways continuously monitor traffic flows and speeds on the strategic road network and this data is available via WebTRIS. There are approximately 1,400 permanent traffic sensors on the strategic road network within Cambridgeshire and Peterborough. This dataset is expected to be key data source for the strategic road network, managed by National Highways.

The Department for Transport also collect data from 300 automatic traffic counters and approximately 8,000 manual classified traffic counts across the country each year. There are many sites in Cambridgeshire and Peterborough. Data is collected between 7am and 7pm between March and October excluding public and school holidays. Major roads are surveyed regularly with the interval between counts being 1, 2, 4 or 8 years depending on the traffic level. A sample of minor roads are counted each year. Traffic estimates are derived for all years based on the data collected.

Cambridgeshire County Council have a series of permanent sensors to provide count data and the annual traffic monitoring surveys (7am-7pm). The surveys include:

- Annual town monitoring sites in March, Wisbech, Chatteris, Whittlesey, Ely, Huntingdon, Ramsey, St Ives, and St Neots.
- Annual Cambridge radial sites on routes to / from Cambridge City.
- Annual Cambridge river screenline sites.

The annual town monitoring sites and Cambridge radial are one-day surveys in October / November counting pedestrians, cyclists and motorised vehicles by type at half hourly intervals. The same information is collected for the Cambridge river screenline during two-day counts carried out in April / May each year. Information on the surveys is geocoded with GIS layers of information on the counts available.

In addition to these regular counts, adhoc surveys are undertaken for individual projects with data potentially available to CCC. The relevance and availability of any such data will be investigated when defining the new data collection programme in collaboration with CCC.

To update the PTM model to a 2019 base year (PTM3), Peterborough resurveyed many of the earlier 2015 traffic count sites in September / October 2019 to provide link and turning count data. Weekly ATC counts were carried out for the links, with one day video surveys for classified turning counts. A further programme of traffic surveys is being planned for the update to PTM4 and should be available for CaPCAM.

As well as this more traditional data, both Cambridgeshire and Peterborough have a number of permanent Vivacity sensors counting pedestrians, cycles and motorised vehicles in 5-minute, 15-minute, hourly and daily intervals, with more sites proposed. Both authorities have been analysing data and comparing results with more traditional data forms to better understand the robustness and reliability of the data. We will engage with the relevant users of the data at Cambridgeshire and Peterborough to explore the extent this data can be reliably used to supplement traditional count data for model calibration and validation.

Journey time information is now typically derived from vehicle tracking devices and available from a number of providers as noted in Section 3.2.3 for GPS based distributional data. Historic journey time information has also been collated for the existing models, though this is now too dated to be relied on for CaPCAM. CCC have access to Trafficmaster journey time / speeds data pre-2021 and CTrack/Inrix data from 2021 onwards.

### 3.2.6. Public transport model

The Bus Open Data Service (BODS) is a portal providing access to bus timetable, vehicle location and fares data (Bus Open Data Service (dft.gov.uk)). Vehicle location information can be use to calculate speeds of travel and journey times. The data is in GTFS format (which can be now read by leading public transport modelling software packages). Rail timetable information can be obtained from the Associate of Train Operating Companies in the equivalent GTFS format.

The national public transport access nodes (**NaPTAN**) is a national dataset of all public transport 'stops' in England, Scotland and Wales.

These publicly available datasets are now national standards and widely used for transport modelling applications.

## 3.2.7. Park and ride

Passenger journeys using the Cambridge Park and Ride sites were counted annually as part of the CCC Rolling Count programme until the Covid-19 pandemic. From the induction loops on the entry and exit of each city P&R site it has historically been possible to obtain vehicle entry and exit counts for each site. Differences in data collection and the ability for travellers to park at the site and not use the bus, or walk or cycle to the site to access the bus services has made these two datasets difficult to combine.

Additional surveys carried out in November 2018 provided supplementary information on cycle parking, those arriving and leaving the site by active mode and interview surveys providing information on the ultimate orign and destination of the park and ride trips. This data is now dated, with major developments occurring in close proximity to some of the P&R sites making it less reliable for continued use.

## 3.2.8. Car parking

Daily car park usage data by length of stay is available from Cambridge City Council for the public multi-storey and surface access car parks in Cambridge. The multi-story car parks provide daily data by length of stay, while the surface access car parks provide monthly totals.

The availability of similar data for other districts, particularly Peterborough, will be investigated.

Information is also available from the internet for Cambridgeshire and Peterborough on the number of spaces at each car park and their usage charges.

## 3.2.9. Active modes

CCC carry out annual one-day surveys each April / May counting pedestrians and cyclising at half-hourly intervals between 7am and 7pm on a set of Cycle routes.

Additional data collection is being planned as part of the Greenways count programme.

To calibrate the varying perception of different types of cycle faclilities for CSRM F-series enhancements data on cycling was obtained from Strava. This data is a relatively small sample of data from “members” who tend to be focused on fitness / exercise. How well this data represents the range of cyclists across the study area is not known.

No existing data has been identified beyond the Cambridge area.

## 3.2.10. Summary of existing data sources

Table 3-2 provides a brief summary of the existing data sources identified and discussed in the previous sections.

**Table 3-2 - Existing data sources**

| Associated model component | Identified existing datasets |
|---|---|
| Planning data and travel demand | Census of Population: 2021 and 2011<br>Local authority records of developments<br>Government collated tabulations on dwellings, school places<br>ONS statistics – mid year population estimates, Business register and employment survey<br>AddressBase: geocoding of residential and commercial addresses<br>Trip rates: National Travel Survey (NTS) and TRICS database<br>Behavioural / lifestyle surveys: Living costs and food survey |
| Trip matrices / patterns | Census travel to work: 2011 (old), 2021 (unreliable due to Covid-19)<br>Electronic ticketing data from bus operators<br>LENNON / MOIRA station-to-station rail data<br>Mobile phone data used for CSRM/PTM and Wisbech – old |
| Network data | Existing models<br>Open source: OpenStreetMap<br>Commercial data: OS Mastermap, HERE maps |

| Associated model component | Identified existing datasets |
|---|---|
| Highway model | CCC annual traffic monitoring<br>2019 data collection for PTM3<br>Data from Vivacity sensors for Cambridgeshire and Peterborough<br>National Highways WebTRIS data<br>DfT traffic counts |
| PT model | Bus Open Data System: timetables, fares, location (speeds / journey times)<br>Rail timetables and fares (ATOC) |
| Park and Ride | Historic CCC rolling count programme P&R passenger counts<br>P&R site vehicle entry / exit counts<br>Interview surveys (November 2018) |
| Car parking | Cambridge City Council – multi-storey and surface car park usage records<br>Car park capacities and charges from websites |
| Active modes | CCC annual cycle route monitoring surveys<br>Strava data obtained for CSRM2 F-series |

# 4. Model scope

## 4.1. Model overview

The proposed CaPCAM model will incorporate four main elements as follows:

- A trip generation model to estimate the demand for personal travel from land use activities;
- A variable demand model (VDM) to consider the choice of mode, macro time period and destination faced by travellers;
- A highway assignment model (HAM) with a representation of the road network; and
- A public transport assignment model (PTAM) representing bus and rail public transport services, and the ability to walk and cycle.

Multi-modal trips, for example park and ride (P&R) will be explicitly modelled, with the car and public transport legs of the journeys included in the relevant assignment model. The demand model would be implemented for an average weekday with assignment models for specific times of the day.

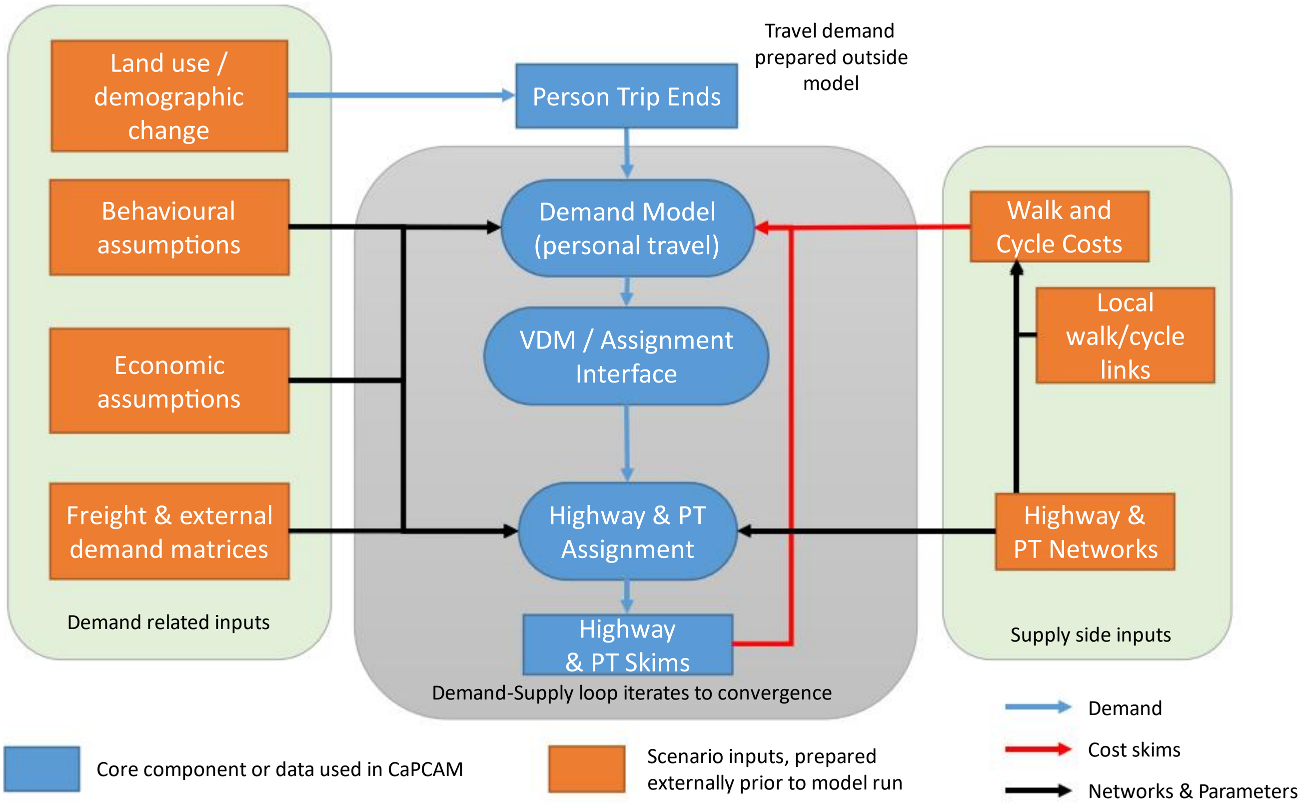
The attractiveness of car is heavily influenced by the availability and cost of parking which will be reflected in the model. The CaPCAM model will also be able to represent alternative road pricing policies such as the Making Connections package of measures currently under consideration by the Greater Cambridge Partnership.

The initial implementation of CaPCAM will not include real time modelling or be an activity-based model. The proposed design and implementation is intended to facilitate (not create obstacles to) additional functionality being added at a later stage if it becomes appropriate for the model applications.

### 4.1.1. Model structure

The design and structure of the model is intended to remain as close as practical to a conventional TAG design for a four-stage transport demand and assignment model. A simple summary of the structure proposed is shown in Figure 4-1.

**Figure 4-1 - Overview of core model components and structure**



There would be no difference between the structure used for 'Base' and 'Forecasting' model runs, with model forecasts or scenarios being created simply by altering the appropriate demand or supply-side inputs.

The basic structure and principles of the model can be summarised as follows:

- **Person trip ends:** In the Base Year model, trip productions and attractions by zone will be calculated, separated by trip purpose and person type. These trip ends are used as the basis for any model scenario tests, with changes input either as scalar growth or additive changes. These trip ends, and all the demand modelling, is carried out for a 24-hour weekday;
- **Demand model (VDM):** A logit based variable demand model (VDM) will be used to determine personal choices of travel mode and destination. These choices are informed by the generalised cost for each possible journey, calculated based on journey time, distance and money costs (red arrows);
- **VDM/assignment interface**: The "synthetic" personal travel information calculated by the VDM is converted into public transport passenger trips and highway vehicle trips by time period, and used to apply changes to the Base Year assignment matrices for each mode;
- **Freight and external matrices:** The highway assignment matrices include matrices of road freight (goods vehicles) trips in the Base Year. Similarly those trips which pass through the study area without stopping (eg on the A1, A14, A47 etc) are included as "external matrices". Forecast growth or other changes in freight and external trips would be determined externally and applied within runs of the model;
- **Assignment models (HAM and PTAM):** Network assignment is carried out for highway and PT to determine routing and links flows, and to extract highway costs (distance, time and any toll charges) and PT costs (fares, journey times, wait times and interchange) for O-D zone pairs by time period;
- **Active mode costs**: Walk and cycle costs are estimated from travel distances extracted from the public transport network, which includes highway pavements and additional links where walk or cycle only links are known to exist. A fixed speed of walking and cycling is assumed.
- **Behaviour assumptions and economic assumptions**: These can be altered during scenario tests to determine the impact e.g. of changes in fuel costs or values of time; and
- **Model iteration:** For scenario testing the model includes a supply-demand loop which allows for iteration of VDM choices and highway congestion levels.

Additional features not shown in figure:

- **Highway / PT interaction:** The highway assignment network includes pre-loads of scheduled public transport services (bus and coach) based on the timetabled services, and on-road bus times responding to road congestion;
- **Parking Capacity Function (PCF):** parking penalties will be applied for "parking districts" in urban areas and park and ride sites where parking capacity is known to be limited. This will act to limit personal car trip destinations, and will not operate as a hard-constraint but as a deterrent function limiting growth in parking. The penalty will be calculated alongside the highway costs after each iteration and included in the generalised time for car mode).

Key components and features of the model are discussed in the following sections. The model system will be designed such that, to the greatest extent possible, information is coded only once and is available to all components which either directly or indirectly make use of it. For example, economic assumptions determining vehicle operating costs available to VDM and assignment models, and network information used by the HAM and PTAM.

Note that it will be possible to use the HAM, PTAM and VDM components independently from each other, for example to carry out fixed-demand assessments of infrastructure and service options.

### 4.1.2. Travel demand linkages

The travel demand in the model will at the highest level be derived via trip rates from the land use and economic activity assumptions, and act as an input to the demand model. The VDM and assignment models operate with different forms of demand: the VDM having what is termed a 'synthetic 24-hour person matrix of productions and attractions', and the assignment models requiring separate matrices of trips by time period on an origin-destination basis, which in the HAM are measured in vehicle trips not persons. To link these, the VDM / assignment model interface will comprise several data transformations carried out as part of a model run. These include:

- Transforming the 24-hour production-attraction person trips output by the VDM into matrices of origin–destination personal trips for the time periods represented in the assignment models;
- Conversion of VDM person car trips to vehicle trips via occupancy factors;

- Mapping of the VDM travel demand segments into assignment user classes;
- A ‘pivot’ process to adjust the base year assignment matrices based on forecast changes in personal trips from the VDM;
- Freight and external-external movements, calculated outside the main model, will be added to the pivoted vehicle matrices before assignment.

## 4.2. Geographical coverage

The geographic scope of the model is to focus on the two authorities making up the CPCA area (Cambridgeshire and Peterborough), and will cover all travel movements within, to and from the area shown in in Figure 4-2.

**Figure 4-2 - Model coverage**


Two factors require further consideration: the extent of the model coverage, and the spatial detail or granularity within each area. Note that the exact coverage and level of detail will be agreed early in model development in collaboration with CPCA through creation of a network topography in GIS.

The approach proposed is outlined in Table 4 with the definitions to be finalised early during model development. Analysis of the Census travel to work homes and workplaces and the patterns of travel in the proposed mobile network data will be carried out prior to finalising the definition of the different areas of coverage and associated levels of detail in the network and zoning.

**Table 4-1 – Geographical areas of coverage**

| | Area type | Areas Covered | HAM | PTAM | Demand Model |
|---|---|---|---|---|---|
| **Fully Modelled Area (FMA)** | **Area of Detailed Modelling (AODM)** | Cambridge, South Cambridgeshire, Peterborough, A14/A1/A10 corridors (including Ely, Huntingdon, St | Coded with junction delay represented where significant. Network to include most roads (e.g. all motorways, trunk roads, primary, secondary roads) Tertiary and unclassified roads | PT network representing all rail and bus services routing through the areas. | **Internal Area:** Full trip representation across all modes. |

| | Area type | Areas Covered | HAM | PTAM | Demand Model |
|---|---|---|---|---|---|
| | | Ives, March and Wisbech). | included where strategic routing occurs or where required for zone loading). Note, in rural areas, detail will be necessarily focussed on strategic (e.g. inter-urban and other important route) corridors. | Walk and cycle network to include primary, secondary, tertiary and unclassified roads which provide walk access from zones to wider network, as well as major walk/cycle only link such as off-road cycle routes. | |
| | **Rest of Internal Area** | Rest of Cambridgeshire plus Royston, Haverhill, Newmarket and Mildenhall | Motorway, trunk road, primary and secondary roads. Some tertiary roads where required for zone loading.<br>Primarily speed flow curves on links but with key junctions coded in detail. | | |
| **External Area** | **Immediate External Area** | Extending into Bedfordshire, Norfolk, Essex and Lincolnshire, precise detail to be agreed during network development. | Major routes (motorways and A roads) sufficient to join external zones into model.<br>Link representation only with fixed speeds. | Rail services which pass through the CPCA region coded in full within region and simplified on external parts. | Representation of trips to/from the internal area, including mode choice |
| | **Wider External Area** | Rest of GB | Skeletal network of key motorways sufficient to link zones defined at the County or Regional level. Link representation only with fixed speeds. | Public transport trips passing through internal area included | |

The terminology typically adopted varies for the different model components (demand and assignment), though a high level of consistency is required between the components for the modelling system as a whole.

For the demand model, coverage is split between trips produced (i.e. made by residents / employees) in internal and external areas, defined as follows:

- **Internal area:** All trip ends for person trips are included, and all travel choices within scope are determined in the model. This means that for each trip production in the internal area, the mode and distribution choice apply fully.
- **External area:** For these areas, only trips with production or attraction end in the internal area are considered in the demand model. This means that the model considers only a proportion of the trip productions and attractions in the external area, and moreover this proportion is determined as an input to the model.

These definitions have some implications for the application of the model and are therefore worth considering carefully. Key considerations are:

- While movements between external areas (external-external) will be included as exogenous assumptions in assignment matrices, and hence may re-route, they will not be variable within the demand model even where these cross the study area and are potentially influenced by travel conditions within the model. Growth in external-external highway movements will need to be input to the model for each assignment mode and segment.
- Internal to external movements, such as out-commuting to work and for shopping and leisure, will be subject to mode and destination choice in an identical manner to internal trips. As commuting is doubly-constrained (in line with guidance), the number of out-commuting trips to each external zone will need to be specified as an input to the model for each scenario;

* Conversely, for external-internal movements, the trip productions in each external zone will be input to the model, which corresponds (for example) to determining the number of workers in each external zone whose jobs are in the internal area and similarly how many people travel in to shop. The demand model will determine the travel mode and destination choice within the model area.

## 4.3. Zoning

It is important to consider the levels of spatial detail or granularity required within the model. A very large number of model zones will increase model running times and make the model unwieldy, whereas a lack of detail can limit the ability to represent walking and cycling, reflect where people board bus services, join the main road network and make the model less responsive to policy tests.

Table 4 shows the number of zones representing the internal area of the existing transport models. In comparison the Cambridgeshire and Peterborough area comprises approximately 2,500 Output areas which aggregate to 98 MSOAs as shown in Table 4.

**Table 4-2 - Comparison of zones**

| Model / ONS | CSRM2-F | PTM3 | WATS | MATS |
|---|---|---|---|---|
| Number of "internal" zones | 304 | 250 | 38 | 34 |

**Table 4-3 – MSOAs, LSOAs and Output Areas (OAs) in each local authority**

| Local Authority | MSOA | LSOA | OA |
|---|---|---|---|
| Peterborough | 22 | 112 | 604 |
| Cambridge | 13 | 69 | 372 |
| South Cambridgeshire | 20 | 96 | 473 |
| Huntingdonshire | 22 | 105 | 537 |
| East Cambridgeshire | 10 | 50 | 265 |
| Fenland | 11 | 55 | 290 |
| **Cambridgeshire & Peterborough** | **98** | **487** | **2,541** |

A reasonable number of zones for a highway model of this type is in the range 500 to 800 including both internal and external areas. It may however be appropriate to better represent access to PT stops to use more detailed zoning for the PT assignment. For simplicity of operation, the zoning used in the demand and assignment models would be identical, so any additional zoning required for PT would ideally be included throughout the model. The levels of detail will be confirmed early in model development based on experimentation with model run times.

For demand modelling purposes, the basic units used for zoning should be taken from Census geography and administrative boundaries, and nest within these at all times. By preference this would mean model zones are grouped from output areas (OAs), lower super output areas (LSOAs), middle super output areas (MSOAs) and Local Authority Districts (LADs), and should nest within this hierarchy. It appears from the numbers of zones in Table 4 that a basic building block of LSOAs would be appropriate, with some aggregation and splitting to provide appropriate detail for the policy areas of interest.

Urban zoning will be determined by the granularity of the highway and PT networks, and the locations of bus stops and routing options to be considered. The existing CSRM and PTM3 model zoning will be used as a guide, but zone structure will be developed bottom-up from Census geography and bus stop catchment areas. The zone system will be reviewed with the client prior to adoption.

## 4.4. Model years

The model will be prepared with a base year of 2023, which means that all model inputs will be developed based on this year, including calibration of the highway and PT assignment models. The decision to use 2023 is based on the possibility of collecting data representative of the 'post-Covid' period.

As specified by TAG, the model will represent a neutral period during 2023, nominally a typical working weekday outside the school holidays. The precise time period will be determined following data collection and during base matrix building, guided by availability and quality of data.

It will be possible to implement CaPCAM for any forecast year after the 2023 base year, and potentially create historic years as a back-casting exercise. For the initial model development, we propose implementing three forecast years to demonstrate the operation of the model and provide a set of outputs. The proposed forecast years are 2041 (end of Local Plan period) and 2031, with an interim year of 2036. These years will then be consistent with PTM (which currently uses 2031 and 2036).

## 4.5. Time periods

The base year model will represent a 24-hour average weekday in a neutral period in 2023. The VDM will consider choices at the average weekday level. The HAM and PTAM will each be divided into AM, interpeak (IP) and PM models, representing the average conditions during those time periods, based on differences in travel demand, road congestion and service schedules.

Table 4 illustrates the out and return time period combinations which will be considered in the model. The VDM will produce 24-hour P/A which for home-based trips implicitly include all trips which travel out and back in a single 24-hour period. Hence any combination of trip travelling from home in the morning pre-peak period (midnight until the start of the AM period) and returning during a later period is included. This would include trips entirely within the pre-peak or post-peak.

The assignment models will include only trip legs in the defined AM, IP or PM periods, which will include return legs in those periods for journeys starting in the pre-peak, and outward legs of journeys ending in the post-peak.

The AM, IP and PM periods for highway and PT assignments will be considered and defined during the matrix build and data collation. The main choice will be whether the AM and PM peaks are represented as single peak hours (e.g. 8-9am and 5-6pm), or as full periods (e.g. 7-10am and 4-7pm). This will be dependent on the proposed linkages with existing models and their definitions, the profile of demand across the peaks, the variation in journey times, and for PT the variation in service schedules. Time period conversion factors will then be derived to allow the 24-hour VDM production/attraction trips to be split into the required assignment time periods. Both exercises will make use of NTS data and directly observed data sources including mobile network data, traffic counts and ridership numbers for PT where available.

**Table 4-4 – Out and return time periods in VDM and assignment models (home-**based trips)

| | | Return time period (same day) | | | | |
|---|---|---|---|---|---|---|
| | | Ante-peak | AM | IP | PM | Post-peak |
| Outward Period | Ante-peak | | | | | |
| | AM | | | | | |
| | IP | | | | | |
| | PM | | | | | |
| | Post-peak | | | | | |

| Key |
|---|
| VDM and Assignment |
| VDM only |

## 4.6. Modes

Following designs previously adopted successfully, and in consideration of DfT guidance, the model would represent a full range of private, public and active travel modes. A ‘main mode’ choice would divide trips first between private car, public transport, walk and cycle trips. These four main modes represent very different trip lengths and characteristics and separating them initially improves the next step of destination choice.

The model would also include sub-mode choice covering bus, rail, bus park & ride and rail park & ride. The intention is to represent the improved quality of guided bus services through the coding associated with dedicated (off-road) infrastructure, rather than a separate mode (as is currently the case in CSRM). Taxi travel may be included separately but is not currently considered a core requirement and would by default be assumed to be part of the car mode.

The main mode and sub-mode choice are determined explicitly within the VDM, determining a 'dominant mode' for each O-D trip as input to the assignment models. Within the assignment model the journey may be split into journey legs with interchanges modelled and access legs using appropriate access/egress modes. For example, a rail trip may include access/egress legs by walk, cycle and bus. The bus and rail modes will allow interchange between services, with appropriate interchange penalties to address the inconvenience of this.

**Table 4-5 – Main modes and constituent modes by stage for access / egress**

| Demand Model | | Assignment models | | | |
|---|---|---|---|---|---|
| **Main mode** | **Sub-mode** | **Dominant mode** | **Access/Egress modes** | | |
| Car | Car | Car | | | |
| | Bus P&R | Car | Bus | Cycle* | Walk* |
| PT | Bus | Bus | Walk | Cycle* | |
| | Rail | Rail | Bus | Walk | Cycle |
| | Rail P&R/car access | Rail | Car | Bus* | Walk* |
| Walk | Walk | Walk | | | |
| Cycle | Cycle | Cycle | | | |

* Park & Ride modes will allow egress to the final destinations by walk, cycle and bus as appropriate. Cycling should be an access mode to specific bus stops with designated cycle parking, though normally not an egress mode.

The model will aim to consider the most common set of mode choices for journeys, in a manner which is applicable to the travel trends and policy choices faced by CPCA. However, there are some travel combinations explicitly excluded or only implicitly included. These include:

- Return journeys where the outward and return legs use radically different modes, e.g. walk or bus in the morning, and then train home;
- Lift sharing will be represented via a car occupancy factor only, a fixed input by travel purpose derived from TAG databook or local data;
- Kiss & Ride will be considered as part of Park & Ride, with the onward journey by the driver not explicitly considered.

The Base Year model will not include any 'new modes' such as e-scooters, autonomous vehicles or mobility as a service. However, it is anticipated that these can be added as a future enhancement should the need arise and suitable definitions of the travel modes and their characteristics become available.

# 5. Software choice

As part of the considerations for creating a new CPCA model, WSP/Atkins have evaluated the currently available software in order to make recommendations on the most appropriate model platform. This will ensure efficiency and value for money, taking policy objectives into consideration. WSP/Atkins have considerable experience in a range of different strategic transport modelling software packages and are therefore well placed to provide guidance on the software to utilise.

The review needs to take into consideration a wide range of facets and characteristics of modelling software. Aside from specific client needs the criteria include:

- Software design and ease of use;
- Technical complexity of modelling solutions;
- Interface with data and downstream needs;
- Reporting capabilities;
- User knowledge base;
- Training and support and
- Software costs

Taking account of these elements of software utility ensures that the client's interests are considered in respect of the overall suitability of the software chosen. More specifically the evaluation considers the approaches that need to be adopted for the model update and determine whether a combination of two or more software products for different components of the model is the best option or whether a single, integrated platform is a better approach.

## 5.1. Evaluation framework

### 5.1.1. Evaluation criteria

The main criteria listed below have been considered as key in the choice of software platform for the development and application of models in previous projects.

They allow the evaluation to focus on ranking each technical aspect of the packages in order of capability an approach that makes clear distinctions about the best package in each area:

- Technical capabilities;
- Functionality/flexibility; and
- Management and housekeeping

Each of these main factors consists of several detailed factors, as summarised in Table 5.

These criteria are used to evaluate software by looking at the strengths and weakness against each criterion in a framework in Section 5.3. This provides a comprehensive assessment for key software used in the UK transport modelling market.

In Section 5.3 we will make our recommendation based on the collective strengths of the software for specific use in the creation of CaPCAM.

**Table 5-1 – Main and sub-criteria of software evaluation**

| Main criteria | Sub-criteria |
|---|---|
| Technical Capabilities | Highway network modelling (highway path builders, junction modelling, urban applications, strategic application, etc)<br>Public transport modelling (public transport path builders, public transport fares, crowded assignment, etc)<br>Demand modelling<br>Mode and sub-mode choice models<br>Trip distribution<br>Activity chain modelling<br>Park and Ride (and other mixed mode trips) |
| Functionality / Flexibility | Matrix estimation<br>Matrix manipulation<br>Network calculation<br>Function definitions<br>Exports and Sub areas<br>Integrated platform (highway and public transport networks and matrices)<br>Integration with other packages (highway models involving junction modelling, micro-simulation, traffic analysis, and scheme evaluation packages) |
| Management and Housekeeping | Ease of use of the software<br>Scenario management<br>Application of individual model components<br>Data management and interface<br>Technical Support<br>GIS and visualisation linkage |

### 5.1.2. Software under consideration

As part of the initial review of options we have considered several leading software packages. These have been selected based on reputation and popularity within the UK market, based on the extent of skills available within the industry to develop and maintain such models.

The software platforms considered are

- PTV Visum;
- CUBE; and
- SATURN;

Based on the functionality of specific software suites it is recognised that a combination approach may be required and the analysis reflects this reality. SATURN is linked to highway assignment specifically.

Several software packages have been excluded, based on specific circumstances:

- MEPLAN. Used previously for CSRM but no longer under development / being supported
- EMME. Reduced use in the UK and with the vendor (INRO) now taken over by the CUBE software vendor (Bentley);
- Transcad. Primarily a US based package with strength in GIS capabilities but minimal application and skills in UK or Europe; and
- Omnitrans. Dutch package with limited use in UK.

Other bespoke software such as that available from Immense solutions or similar open-source software such as MATSim have not been evaluated as there is limited experience and evidence of outcomes in submitting plausible transport models to national UK government agencies.

## 5.2. Software evaluation

### 5.2.1. Technical evaluation

Table 5 sets out the perceived market leader(s) against each detailed evaluation criteria, together with further comments on relative capabilities of the software packages.

**Table 5-2 – Relative capabilities of software packages**

| Feature | Comments | Perceived leader(s) |
|---|---|---|
| **Technical Capabilities** | | |
| Highway Network Modelling | SATURN and PTV Visum are major tools for modelling of highway traffic and assignment capabilities in urban areas. They are able to model junctions of all types and take into account opposed flows and blocking back of traffic.<br>SATURN provides tried and tested functionality as de-facto industry standard. Its junction modelling is still regarded as the best in congested urban area modelling.<br>Visum and CUBE Voyager include built-in junction capabilities that can represent UK junction control methods to calculate delays that can be incorporated into the assignment run.<br>Visum 2023 includes assignment with ICA (Intersection Capacity Analysis), which includes blocking-back.<br>All packages are capable of multi-class multi-routing highway assignment based on users' equilibrium principle, and stochastic assignments.<br>All packages are capable of representing road pricing, SATURN has more advanced treatment of area licencing impacts on route choice. | SATURN |
| Public Transport Modelling | Visum and CUBE Voyager provide similar capabilities for building of paths, modelling of fares and crowding effects.<br>Visum can undertake multi-path PT assignment using headway or time-table based scheduling.<br>Visum has a social distancing module in response to COVID-19<br>CUBE Voyager has the ability to model a wide range of fare systems. | Visum / CUBE |
| Demand Modelling | CUBE Voyager and Visum both provide demand modelling capabilities. Both provide powerful and flexible set of tools for matrix manipulation to build demand models that suit local conditions.<br>CUBE Voyager has an easier to see model structure since the Scenario Manager provides a graphical user interface such that applications & loops can be viewed on screen. In comparison, Visum demand model relationships are less visible to users.<br>Visum provides a more extensive library of built-it functions for choice modelling, whereas users specify the functions to apply requiring more scripting ability or the transfer of functionality from one application to another. | CUBE / Visum |

| Feature | Comments | Perceived leader(s) |
|---|---|---|
| Mode Choice | CUBE Voyager and Visum provide mode (and sub-mode) choice modelling capabilities. Visum and CUBE Voyager are similar in their ability and provide powerful and flexible matrix manipulation tools which can be used to develop a wide range of alternative model forms.<br>Visum includes a built-in module to create logit functions. | Visum |
| Trip Distribution | CUBE Voyager and Visum both provide trip distribution capabilities. Visum has a number of built in trip distribution functions that can be selected by user. CUBE Voyager is not limited to specific functions but requires bespoke scripting.<br>Both packages can handle both singly and doubly constrained distribution. | Visum |
| Activity Chain Modelling | Visum Activity chain modelling possible. This is an increasingly tried and tested aspect of the software.<br>CUBE Voyager provides similar capabilities with scripting options. | Visum |
| Park and Ride | CUBE Voyager and PTV Visum provide facilities to model both bus and rail-based Park and Ride.<br>Visum and Cube Voyager can reflect both legs of Park and Ride trips within the PT assignment. | Visum / CUBE |
| **Functionality / Flexibility** | | |
| Matrix Estimation | CUBE Voyager, Visum and SATURN all provide facilities for highway matrix estimation, based on the maximum likelihood technique.<br>Both Visum and CUBE Voyager also provide procedures for estimating PT matrices. The CUBE Voyager PT matrix estimation process is considered superior as it is fully integrated in the public transport assignment process. | Visum / CUBE |
| Matrix Manipulation | All packages have facilities which enable effective matrix manipulation.<br>Visum and CUBE Voyager are all considered as market leaders in flexibility. | Visum / CUBE |
| Network Calculation | Visum and CUBE Voyager have facilities that enable network calculations.<br>CUBE Voyager has recently improved its functionality with enhanced geodatabase capabilities. The interfaces, however, are slower than the simpler .net approach and require an experienced user and powerful hardware to produce information.<br>Visum has a number of easy to use network calculation processes that are fully integrated with the GIS interface enabling easy disaggregation of zones, filters and redefining of link shapes.<br>SATURN only provides facilities for highway network calculation but can be linked with Voyager for extra functionality | Visum |
| Function Definitions | Visum and CUBE Voyager provide similar levels of sophistication for highway and public transport assignment | Visum |

| Feature | Comments | Perceived leader(s) |
|---|---|---|
| | function definitions. Visum includes a number of built-in functions that can be selected for highway assignments. | |
| Exports and Sub Areas | Visum is considered as the market leader due to built-in functions provided. In addition, Visum is fully interactive with the micro-simulation software Vissim.<br>This is followed by CUBE Voyager, which also provides facility for path analysis. CUBE Voyager can also be linked to CUBE Avenue for micro simulation modelling. | Visum |
| Integrated Platform Highway/PT/Matrices | CUBE Voyager and Visum are equal in flexibility due to their respective fully integrated highway and PT networks, and close connections between networks and matrices. | Visum / CUBE |
| Integration with Other Packages | Visum is fully integrated with the micro-simulation model Vissim and can produce data for analysis by Synchro as an add-on feature.<br>This is followed by CUBE Voyager due to its linkages to CUBE Avenue for micro-simulation and interface with Synchro. | Visum / CUBE |
| Modelling Transport Policies / Options | All packages, i.e. CUBE Voyager/SATURN and Visum, are considered as market leaders due to their respective levels of flexibility. With facilities providing matrix manipulation and network calculation capabilities to model various relevant options and policies. | Visum / CUBE / SATURN |
| **Management / Housekeeping** | | |
| Ease of Use | Visum and CUBE Voyager provide user-friendly, easy to use modern graphic interfaces, although this can cause issues with automating running.<br>SATURN can be menu driven or batch processed and provides excellent help functions.<br>CUBE Voyager provides structured modules (or building blocks) with pre-defined parameters and input/output files to be specified by the users. A similar structure has been adopted in Visum | Visum |
| Scenario Management | CUBE Voyager provides user-friendly scenario management facilities.<br>Visum adopts a different approach to scenario management with assignment procedures, networks and matrices loaded into separate version files. This provides a flexible approach. However, version files can be very large and slow to work with on large models. | CUBE |
| Data Management | Typically, CUBE Voyager modelling files are stored within Windows directories as defined by the model developer.<br>Visum contains data in version files, and allows exporting, importing and merging data into / from Microsoft Access and Excel databases. | CUBE |
| Technical Support | Visum, SATURN and CUBE Voyager are all covered under their respective technical support and maintenance agreements.<br>Training courses are provided by the developers of the three packages. | CUBE / SATURN / Visum |

| Feature | Comments | Perceived leader(s) |
|---|---|---|
| GIS Linkages & Visualisations | CUBE Voyager and Visum provide GIS linkages.<br>CUBE Voyager has a fully integrated geodatabase in which network and zonal based data can be stored, extracted and displayed. This enables the creation of scenario networks from master networks and the integrated display of link, zone, and node information on any specified GIS background.<br>Visum is also fully integrated with GIS and has many menus that facilitate the use of GIS databases.<br>SATURN can be increasingly easily linked to GIS applications but has no built-in functionality | Visum |

It is clear that no single software is a clear winner however PTV Visum has a number of strongly positive features, as does CUBE - to a more limited extent. Whilst SATURN has been considered to provide an edge in terms of highway model representation, it is required to be combined with other software to ensure multi-modal and variable demand model assessments can be undertaken. It appears that Visum and CUBE are also investing more heavily in development to future-proof the software. For example, Visum already has an agent-based model (ABM) should this be required at any point.

## 5.3. Proposed software choice

WSP/Atkins recommend the adoption of PTV Visum for all elements of the new CPCA model.

The conversion tools within Visum would still enable the existing CSRM and PTM SATURN models to be used as the basis of the new CPCA highway model, and help to ensure compatibility with PTM.

# 6. Assignment models

## 6.1. Highway

### 6.1.1. Networks

#### 6.1.1.1. Source for coding

It is envisaged that the existing CSRM and PTM3 SATURN networks will be utilised as the starting point for CaPCAM and converted to Visum software. The remaining coding will be undertaken using the other more local models (MATS, Wisbech, Ely) where appropriate and supplemented by online mapping and satellite imagery, with site visits if required.

#### 6.1.1.2. Coding rules

A network coding manual will be developed (drawing on coding manuals for the identified existing models and the RTM coding manual) to ensure consistency in approach and coding of the highway assignment model component. The coding manual will set out guidance on the use of saturation flows at junctions for different junction types, speed flow curves (or volume-delay functions (VDFs) in Visum), protocol for gap acceptance and other general coding principles. The coding manual will make use of best practice from recent model applications to ensure that lessons learnt are applied back into model development.

Following completion of an initial highway network, independent manual coding and consistency checks will be completed throughout and initial uncongested journey time validation will take place against prescribed journey time routes through the fully modelled area. Initial assignment of prior matrices will be used to review any anomalous routing, and discrepancies between modelled and observed journey times. Necessary adjustments will be made to coding as appropriate.

#### 6.1.1.3. Volume-delay functions / fixed speeds

In the fully modelled area, volume-delay functions (VDFs) will be used within the model for car and LGV based user classes where link delays are distinct and significantly in excess of junction delays. These will align with relationships provided in TAG Unit M3.1.

Cruise speeds should not necessarily directly relate to the speed limit on a given road. The speed limit will normally constitute a maximum for the coded cruise speed, but observed speeds may justify use of a different cruise speed, and this may on occasions be above the speed limit. The choice of the cruise speed is therefore open to a certain amount of interpretation and may need to be revisited during the course of model validation (e.g. high proportion of traffic using inappropriate local routes rather than primary / secondary roads) based on observed travel time information. Cruise speeds within urban areas may be refined to remove unrealistic routing and rat-running (routing on inappropriate routes e.g with traffic calming where higher standard alternative is available).

Speeds in the external area will be taken from INRIX data to represent fixed speeds. The times will take account of both link travel time and junction delay. This approach is compatible with TAG Unit M3.1, 2.9.8, which states that: "Cruise speeds should not be based on speed limits but should reflect mean speeds on a link."

In order to represent the restricted maximum speed for HGVs on the highway network it is necessary to reduce the maximum (free flow) speed available to HGVs in the assignment model.

#### 6.1.1.4. Junction modelling: Flow/delay relationships, signal timings, saturation flows

Each junction included in the FMA will require several parameters:

- Geometries
- Legs, lanes, and lane turns
- Junction control type (two-way stop, two-way yield, signalised, roundabout, uncontrolled)
- Turn types (Right turn; Straight ahead; Left turn; U-turn)
- Signal times, stages and phases
- Method of impedance at junctions.

All junctions within the AODM will be modelled in detail. Every junction in this area will use 'Node Impedance Calculation (ICA)' as the Method of Impedance at nodes. This is the PTV recommended method to be adopted on strategic models. ICA (Intersection Capacity Analysis) provides a model suitable for long term horizon planning with the added value that it can be used for operational planning. ICA will be used for calculating junction capacities and delays based on junction geometry and layout input into the model, and does not require the saturation flows to be input explicitly.

For junctions outside the AODM the less complex 'Turns Volume Delay Function (VDF)' Method of Impedance will be used. This requires entering saturation flow, free flow time (t0) and turn type (e.g. left turn, right turn, straight ahead). The saturation flows will be derived from the existing CSRM and PTM3 SATURN networks.

#### 6.1.1.5. Signal timings

Timings at all signal-controlled junctions will be coded based on signal timing data where available. However, experience suggests that average data are typically not held by local authorities and it is therefore envisaged that average green times will need to be calculated from the signal plans and timing sheets provided, using the maximum and minimum green times as upper bounds. Timing data from the existing SATURN models will be imported where available. If no signal data is provided or available from existing models, signal timings will be estimated (note that refinement may be required during calibration and validation, and the effort required at this stage will need to be assessed once all available signal data has been collated).

Level crossings will be treated as signalised junctions drawing on the approaches adopted in the CSRM2 and PTM3 models.

#### 6.1.1.6. Centroid connectors

Centroid connectors are how demand (trips) from a zone loads onto the network. The location and coding of these locations can have a significant influence on the performance of the base year network against observed counts and journey times. The centroid zone connectors in the updated CaPCAM will be reviewed and refined to realistically represent the way in which traffic joins the road network. In the AODM, where the zoning system is fine, specific access roads from residential and commercial areas will be used as a basis for connecting zones to the network via centroid connectors.  Zones in the External Area, which have a large geographical coverage and significant demand associated with them, will need to be connected to major routes to enter the network.

Connectors to access the modelled road network should include distance and time attributes, particularly for long connector links for example in external areas, to ensure the full journey costs are calculated for car travel in comparison with other modes.

#### 6.1.1.7. Car parks / parking

The treatment of car parks and parking charges will be handled primarily by the VDM and an additional sub-module as set out in Section 7.5. The highway assignment model may include specific car parks as zones, particularly for P&R sites, though these would be best represented in the network with appropriate connectivity for trips to reach their ultimate destination on foot.

#### 6.1.1.8. Restrictions (HGV bans, height / weight)

Part of the data collection exercise will be to ascertain the location of all HGV bans and/or weight and height restrictions around the network. Information will be sourced from existing models and confirmed. These will then be coded into the model network where applicable.

#### 6.1.1.9. Checking

It is essential to ensure that the highway assignment model networks are robust and correct prior to undertaking any adjustment of the trip matrices (matrix estimation) to account for any deficiencies in the comparison of observed and modelled traffic volumes. Failure to ensure that the highway networks are appropriate could result in adjustments to the underlying demand data that are otherwise the result of deficiencies or misrepresentations of the highway networks.

Network calibration checks will be carried out across a range of different topographic features. There is an inbuilt procedure within Visum which undertakes checks on all elements of the network coding within the model and highlights any coding errors. Coding warnings that will have also resulted in change of software from SATURN to Visum will need to be reviewed. From the highway network perspective, the software will check:

- Isolated nodes, ensuring that all nodes in the model are connected to links;
- Ensuring that the network does not permit a turn on the highway network for which either the preceding or exiting link is not allowed (e.g. a car movement into a bus lane);

- Ensuring that appropriate priorities (major / minor road definitions) are given to each link where multiple turns exist on the approach to a node;
- Disconnected zones, to check all zones in the model are connected to the highway network via centroid connectors allowing trips access/egress for assignment;
- Dead-end roads, ensuring that there are no locations where trips can access but not leave (either through onward link connections or U-turns);
- Link capacity, to check that there are no permitted links with a capacity of zero allocated;
- Appropriateness of coding for junction representation, checking all signalised junctions have been appropriately assigned saturation flows and signal timings; and
- Network consistency checks, allowing for all OD pairs to be checked to ensure the networks is connected between all zones for all user classes (e.g. car, LGV, HGV).

Further manual checks through the use of Google and OS maps, site visits and aerial photograph will be completed on:

- Link lengths: Link lengths should match those derived from GIS software. The conversion to Visum from SATURN will import link lengths from the existing CSRM and PTM3 models, and these will be checked against the direct-distance of the link created in Visum. The link distances should be greater than or equal to the direct-distance, and any excessive deviations (e.g. greater than 10%) will be checked and verified;
- Link characteristics: Checks will be undertaken to ensure that one-way links are appropriately represented (including HGV bans) and to make sure that, where traffic count data exist, the capacity of the link exceeds or – at a minimum – is equal to the observed data;
- Speeds;
- Length and position of flares;
- Junction coding;
- Location of public transport routes;
- Access points.

Prior to matrix estimation being undertaken, checks will be undertaken on the network structure, coding and route choice to ensure that they represent an appropriate starting point and that adjustments to the trip matrices would not be made to account for errors in the network.

The validation of the out-turn trip matrices, following estimation will be reviewed using the TAG screenline acceptability guidelines for the detailed study areas and key routes in the wider area.

### 6.1.2. User classes

The choice of user classes for assignment in the HAM is dictated by three main factors:

i. maintaining compatibility between CaPCAM and PTM3,
ii. the availability of data on values of time and vehicle operating costs, and
iii. the model assignment time. Given that the HAM requires the greatest computational 'load' within the overall model run process, it is advantageous to keep run times to a minimum. HAM run time will increase approximately linearly with the number of user classes chosen.

The TAG databook provides values of time as follows:

- Car Employer's Business
- Car Commuting
- Car Other (includes education)
- LGV work
- LGV non-work
- OGV 1
- OGV 2

These user classes will be taken as the starting definitions. CSRM2 also differentiates education trips, and further segments the non-business car trips by income band to better represent responses to pricing scenarios. An income segmentation (or similar) will be included should run times permit. Consideration will also be given to the merits of differentiating user classes for different driver characteristics (e.g. those with specific permits). User classes could be further differentiated by vehicle types (e.g. electric / low emission vehicles) however, there are significant run time overheads of introducing this level of detail, so it is unlikely to add sufficient value to be worthwhile in the base year, but worth considering the ease of introduction for specific scenario tests.

### 6.1.3. Generalised cost formulation

In the case of highway trips, the principal components of generalised costs are values of time (VoT), vehicle operating cost (VOC), and to a limited extent, tolls.  VoTs and VOCs will be derived from the version of the TAG databook current when the model implementation commences (forthcoming version 1.19 is expected to become definitive in November 2022). Tolls will be based on the average charge for each vehicle class (where required).

The balance of the generalised costs for HGVs is heavily weighted towards distance, which can lead to shorter local routes being favoured over motorway and trunk routes. TAG unit M3-1 §7.2.4 suggests that adjustments may be considered such as the use of HGV specific maximum link speeds and the inclusion of HGV specific penalties. Furthermore, TAG unit M3-1 §2.8.8 notes that it is possible to apply an owner/operator factor of 2.0 to HGV VoTs to take account of the influence of owners on the routing of these vehicles. This may ensure more appropriate routing via motorways and trunk roads, as the ratio between VoTs and VOCs will be reduced.

Whilst it is not envisaged that this facility will be used at the start of the model development process, it may be necessary to introduce this factor if there are consistent issues in ensuring appropriate HGV routing via the motorways and trunk road network. During the model development process, we will also undertake checks to identify the percentage of HGVs on key routes. Checks will ensure that HGV percentages are not materially in excess of observed values (where available) or are too low. Percentages will be reported as part of the Highway Validation.

### 6.1.4. Assignment methodology

CaPCAM will use ‘assignment with ICA’ the latest assignment algorithm developed by PTV. It uses blocking back and volume-delay functions by lane and turn. These are permanently recalibrated taking into account lane geometry and interdependencies between the individual turns via a node. Within the ‘assignment with ICA’ procedure, the ‘Equilibrium’ assignment algorithm will be selected as the sub-assignment procedure, which distributes the demand according to Wardrop’s first principle.

#### 6.1.4.1. Convergence.

The advice on model convergence is set out in TAG Unit M3.1 (Table 4) and is reproduced below in Table 6-1.

**Table 6-1 - Summary of Convergence Criteria**

| Convergence Measures | Type | Base Model Acceptable Values |
|---|---|---|
| Delta & %GAP | Proximity | Less than 0.1% or at least stable with convergence fully documented and all other criteria met |
| Percentage of links with flow change (P1) < 1% | Stability | Four consecutive iterations greater than 98% |

Source: TAG Unit M 3.1 Table 4

Convergence will be reported against the thresholds given in Table 6-1, with model run times also monitored and reported separately for each modelled period.

## 6.2. Public transport

The methodologies proposed follow the guidance outlined in TAG unit M1-2 ‘Data sources and surveys’ and unit M3-2 ‘Public Transport assignment modelling’.

Key features of the PTAM will include:

The PT model will be developed using Visum software.

- The PT model will represent bus and rail services in the model including guided bus.
- We anticipate that the sub-mode choice for PT will be determined within the demand model to allow for potential inclusion of exogenous factors such as journey quality etc. in trip choices, this is especially relevant when modelling new modes.  The PTAM will therefore assign Bus and Rail demand separately.
- The model will not include a dynamic representation of the effects of PT crowding (see Section 6.2.5.2) as this would have a significant impact on model run times, and could limit use of public transport in forecast scenarios to the assumed timetable provision.

- The PTAM will be developed for three time periods representing AM, IP and PM periods. Following review of service data specific time periods will be defined that represent the varying levels of service across these periods. It is likely that average hours over the morning and evening peaks will be modelled to capture infrequent services that fall outside formal peak hour but provide key accessibility to/from locations.
- The operation of public transport during the off peak will be examined to determine the best inputs for an off-peak model from other modelled periods.

## 6.2.1. Networks

### 6.2.1.1. Structure

The PT network will be fully integrated with the highway network to allow multimodal assignment and data will be easily transferred between the two assignments (highway travel times to the PTAM and numbers of buses operating on each link to the HAM).

The CaPCAM PT network will include all rail services running within and through the FMA and all the main local bus services in Cambridgeshire and Peterborough as well as a number of inter-town routes. The information on the bus and rail routes and service frequencies used for the development of the base year network will be obtained from databases from published timetables. The bus cruise times will be linked to car journey times. The bus and rail services in Visum will have no restriction on capacity and therefore the model will not show instances of overcrowding. All the zones outside of the study area will be connected by centroid connectors to at least one railway station.

The off-road links in the walk and cycle network will include major off-road cycle routes and local walkways that provide accessibility to PT stops.

A rail network will be developed to enable all services operating to, from and within the study area to be represented. A skeleton external network will be used to represent services to major centres outside the study area and represent journeys to external zones. The rail network will use the walk and bus network for access between stations and ultimate trip origins and destinations.

## 6.2.2. User classes

The PTAM will differentiate bus, rail and park and ride, and assign a maximum of the following user classes:

- Bus - Commute
- Bus - Education
- Bus - Other
- Bus - Employers Business
- Rail - Commute
- Rail - Education
- Rail - Other
- Rail - Employers Business
- P&R - Commute
- P&R - Education
- P&R - Other
- P&R - Employers Business
- Walk
- Cycle

Assignment classes will not differentiate car availability. Likewise, PT assignment classes will not be disaggregated by fare type (full / concession) as there are limited price differentials between services within each mode (bus and rail) suggesting no significant difference in route choice between full and concessionary fare passengers. Differences in attractiveness of PT modes between full and concessionary fare passengers will be captured in the demand model.

The public transport legs of rail P&R will be added into rail matrices with origin or destination as appropriate set to rail station zone. The public transport legs of bus P&R will be included in separate ‘P&R’ user classes with origin or destination set as appropriate to the bus P&R site zone. These matrices will be assigned with access to bus and rail services so as to represent users accessing rail services via bus P&R.

Walk and cycle assignment user classes will include all trip purposes as there is no difference in route choice for users with different values of time.

### 6.2.3. Stops and services

The PT network will include all bus services operating within the FMA and all train services running within or through the area. Services will be taken from the timetables in place in Spring 2023.

The information on bus stop and rail station locations and bus and rail routes and service frequencies will be imported directly in General Transit Feed Specification (GTFS) format using Visum's in-built GTFS importer. Bus services outside the FMA that do not provide any connectivity to the study area will not be included in the model.

The routes imported from GTFS will be checked against published bus and rail route information; modelling software typically selects the shortest route between stops which can be different to the route actually taken. Exact routing between stops defines the travel time, so once the stopping patterns of routes have been established on the network it is necessary to manually check and edit where necessary the routing between stops.

Long distance coach services (including National Express and Megabus) within the FMA will be coded into the PTAM. The routes and timetables will be sourced from the National Coach Services Database (NCSD), which contains scheduled timetable data for coach and strategic bus services across Great Britain. A similar process will be undertaken to the bus and rail timetables where services outside the FMA area will be deleted.

Fare systems and charging rates will be obtained from internet reviews of tariffs offered by the bus and rail operators and where available coded for each service. Visum allows the use of a range of fare systems including distance based, cordons and flat fares. Operator data will be obtained to undertake an analysis of concessionary fares available and used so that fares charged represent typical average fares paid for each journey purpose.

### 6.2.4. Generalised cost formulation

Within Visum, movements are assigned to different public transport services routes on the basis of the relative attractiveness (defined by the generalised cost) of the possible options. The generalised cost is dependent on various aspects of the journey including access and egress time, waiting time, in-vehicle travel time, interchanges and fares. These elements are combined into a generalised cost expressed in minutes which takes the form

$$GenCost = (w_{walk} * t_{walk}) + (w_{wait} * t_{wait}) + t_{ivt} + (fare/VoT) + (w_{interchange} * interchange)$$

Where

- $t_{walk}$, $t_{wait}$ and $t_{ivt}$ are the time spent walking, waiting and in-vehicle respectively
- $w_{walk}$, $w_{wait}$ and $w_{interchange}$ are weights applied to walking and waiting time and to interchanging
- interchange is the number of changes of vehicle required for the journey
- VoT is the value of time for each user segment (from TAG databook)

Values for the weighting parameters would be set during the model calibration guided by typical parameters given in TAG unit M3.2.

### 6.2.5. Assignment

#### 6.2.5.1. Method

PTV Visum allows two PT assignment approaches; timetable-based assignment which defines services based on individual route run timetable; and headway-based assignment which uses common stop to stop travel times for services within a time period and defined average interval between services. Both methods have strengths and weaknesses.

A timetable-based assignment approach has the following key benefits:

- Timetables provide a direct link to on-the-ground services and as such represent actual levels of service
- The model can be relatively simply updated to include revised real-world timetables which are readily available in required file formats for current / historic years

Whereas, a headway-based assignment approach (that defines service run time and frequency rather than specific timetable departures) has the benefits that runs are typically faster (according to PTV tests), and new services in test scenarios are simpler to code as detailed timetable is not required. However, defining base year timetables requires simplification of often varying service run times and frequencies across a time period.

In the latest version of Visum (2023) it is possible to incorporate a hybrid PT assignment method (i.e. timetabled and headway-based). This will provide advantages in that the base year services can be modelled with the exact timetable information and forecast services, where exact timetables are not yet known, can be modelled using headway-based assignment.Since the HAM and PTAM will be integrated in one model, the link run times will be fed between highway and PT assignments meaning no manual transfer of this data is required.

#### 6.2.5.2. Crowding

Crowding typically has differing effects on supply level of service across PT modes. For bus services higher passenger demand leading to excessive crowding usually results in additional service provision by operators as their operational model is often flexible enough to accommodate this although there may be parts of the network in the CPCA area where bus capacity and the need to balance high demand peak periods with quieter inter/off peak periods has resulted in bus crowding. Whereas for rail, service patterns and frequencies are determined centrally with very limited flexibility to change and as such some rail services in the region suffer from high levels of crowding in the base year. This is typically on AM and PM peak commuter services into Cambridge in particular.

Whilst a crowding model could, to some extent, represent the unattractiveness of congested bus and rail services the method typically significantly increases both run time of the PT assignment (which now needs to iterate to convergence) and the whole demand model where the PTAM must be run in each loop of the demand model. Bus and rail crowding will therefore not be included in the model.

## 6.3. Other modes

Walk and cycle will be assigned to a detailed network representation of the road and path network available to walk and cycle modes.

The varying perception of the safety / attractiveness of alternative cycling facilities will be included in the assignment model based on the “Propensity to Cycle” tool, similar to the approach applied in CSRM. It is likely that this special treatment of cycle is only relevant for Cambridge City, though wider application can be considered if sufficient data is available on existing cycle facilities (on road cycle lanes, dedicated off-road facilities).

## 6.4. Base year demand

### 6.4.1. Base year matrix development by mode for assignment

The time period assignment and demand model matrices will be aligned to the HAM, PTAM and VDM time periods.

The demand matrices will be developed to represent the following travel journey purposes:

- Home Based Work (from home) – HBWout
- Home Based Work (to home) - HBWto
- Home Based Education (from home) – HBEDout
- Home Based Education (to home) – HBEDto
- Home Based Employers Business (from home) – HBEBout
- Home Based Employers Business (to home) - HBEBto
- Home Based Other (from home) – HBOout
- Home Based Other (to home) - HBOto
- Non-Home Based Employers Business – NHBEB
- Non-Home Based Other – NHBO

For consistency throughout the model suite, it is expected that the travel demand matrices for motorised modes (highway, public transport) will be developed to represent the same time periods and trip purposes.

Freight demand (LGV goods and HGV traffic) will only be produced for highway travel, with freight by other modes not represent in the model.

The travel demand matrices will be developed as production-attraction (PA) trips for home-based purposes, and as origin-destination (OD) trips for non-home-based purposes and road freight. As part of the matrix development, "from-home" factors will be developed that allow home-based matrices to be converted to origin-destination level for assignment. Trip purposes will also be combined for assignment to give following assignment classes:

In the PTAM (public transport assignment model)

- Active modes
  - Cycle
  - Walk
- Bus
  - Bus Commute – HBWout + HBWto
  - Bus Education – HBEDout + HBEDto
  - Bus Other – HBOout + HBOto + NHBO +
  - Bus Employers Business – HBEBout + HBEBto + NHBEB
- Rail
  - Rail Commute – HBWout + HBWto
  - Rail Education – HBEDout + HBEDto
  - Rail Other – HBOout + HBOto + NHBO +
  - Rail Employers Business – HBEBout + HBEBto + NHBEB
- Bus based Park and Ride
  - P&R Commute – Element of 'Bus Commute' matrix using existing bus P&R sites
  - P&R Education – Element of 'Bus Education' matrix using existing bus P&R sites
  - P&R Other – Element of 'Bus Other' matrix using existing bus P&R sites
  - P&R Employers Business – Element of 'Bus Employers Business' matrix using existing bus P&R sites

In HAM (highway assignment model):

- Car
  - Commute – HBWout + HBWto + HBEDout + HBEDto
  - Other – HBOout + HBOto + NHBO
  - Employers Business – HBEBout + HBEBto + NHBEB
- Vans (freight, business and personal travel)
- HGV

### 6.4.2. Approach and data requirements for prior matrix development

The highway and public transport assignment models require trip matrices that represent demand patterns across the CPCA region in a neutral model period. Assignment models will represent origin destination trips disaggregated by time of day, mode / vehicle type and trip purpose. The variable demand model requires demand in Production Attraction format.

The list below summarises the intended initial approach to developing demand matrices. This approach is based on previous experience of developing regional model demand matrices from MND data and the known strengths and weaknesses of the available data sources. It is, however, expected that the detail of the approach will be refined based on the outcomes of the initial and ongoing verification exercises.

c. Development of base year land use and associated trip end estimates by purpose and mode as required for the VDM.
d. Verification of Mobile Network data (MND) – identify strengths and weaknesses that need addressing;
e. Bias correction (as necessary);
f. Development of Public Transport trip matrices;
g. Extraction of Public Transport trips from MND to leave highway trips;
h. Development of freight trip matrices;
i. Extraction of observed LGV and HGV trips from MND to leave car trips;
j. Development of synthetic car demand matrices by purpose;
k. Infilling of missing short distance car trips in MND – using synthetic demand;

l. Disaggregation of car trips by trip purpose – using synthetic demand.
m. Conversion to assignment model zone system OD matrices and demand model zone system PA Matrices - Matrices will retain the disaggregation of 'to-home' and' from-home' trips indicated in the MND data allowing creation of consistent PA matrices for demand modelling and OD matrices for assignment.
n. Iterative repetition of verification; including, comparison against synthetic trip end estimates, NTS trip length distributions and purpose splits, to identify required adjustments to assumptions in earlier stages.

### 6.4.3. Public transport demand

Subject to our review of the suitability of MND processing of rail demand during the initial verification, we expect that for public transport the primary source of data will be ticket sales data in the form of LENNON ticket sales data for rail travel and Electronic Ticket Machine (ETM) data from the bus operators within the study area. As with the development of the highway travel demand matrices, these data will be supplemented with information from other data sources such as the National Travel Survey and spatially aggregate base year trip-end estimates.

LENNON rail ticket sales data are in principle a complete representation of annual rail demand, including information on the start and end stations of each ticket and the ticket type in question. Using assumptions on the number of trips generated by each ticket type (including season ticket / travel cards) annual station to station passenger demand can be estimated. Industry standard trip rates per ticket type are included in the LENNON "sales journey" data set which will be used as a basis for rail passenger OD demand. Similarly, ETM data from bus operators will be interpreted to provide information on the stop-to-stop movements for bus travel.

The ticketing data provide insight on the part of journeys between rail stations and bus stops. The access and egress stages of the complete zone to zone journey will be synthesised based on zonal planning data and access distance, using relationships estimated from the VDM, NTS or local public transport survey data (if available).

Depending on the number of bus operators within the study area who provide ETM data there may be services for which ETM data is not available. In this situation the travel demand for unobserved services will be synthesised based on information available from the comparable observed bus services in the study area, eg assuming similar bus occupancy rates.

Both sets of ticket data will lack some of the attributes required for the model, namely trip purpose, and the linkage of outbound and return home trips. The rail ticket data is also annual and will lack information on the time of day in which each journey was made. NTS and older local public transport interview survey data, will be reviewed to determine the approach to be adopted. This will include consideration of the scale and nature of any multi stage journeys where data records separate journey stages. .

Bus and rail matrices will be disaggregated by fare (adult / concession) using ETM data (if available) and/or zone demographic data.

The public transport matrices will provide assignment demand for base year PT model, and be used (by subtracting from MND data) to isolate Highway MND trips.

P&R demand will be split so that the car leg to/from the P&R site/station are included in highway assignment matrices and the PT leg is included in bus and rail matrices as appropriate for the P&R site location.

### 6.4.4. Freight Demand

Van trip patterns will be based on INRIX (formally TrafficMaster) OD data at a sector to sector level then distributed to zone level using trip end estimates. Van trip end estimates will be based on detailed zonal land use data and indicative trip rates by land use. Resultant matrices will be scaled to match broad corridor screenline counts for vans.

HGV MND data will be requested. This data will be verified against independent data sources such as DfT continuous survey of road goods transport (CSRGT) data and trip end estimates based on land use data and indicative trip rates for different land uses. HGV matrices will also be obtained from National Highways SERTM model and compared against the MND data. Dependent upon the findings from this analysis HGV demand will be based on most appropriate data source at different levels of aggregation. Methods may include:

- Use of MND HGV trip patterns if and where they are consistent with CSRGT data at an aggregate level and land use at a disaggregate level.
- Use of SERTM HGV trip patterns if data suggests these are more appropriate than MND data.

- Direct disaggregation of (CSRGT) data based on trip end estimates - CSRGT provides NUTS3[2] level estimates. In the CPCA region there are two NUTS3 regions (Cambridgeshire and Peterborough) meaning data is highly aggregate; but, does provide an indication of broad total HGV trip volumes in the region. HGV trips would need to be distributed to zone level using trip end estimates derived from zonal planning data and indicative HGV trip rates based on TRICS. The trip end estimates will therefore have a link back directly to zone land use and the variations in typical HGV trip rates for different types of land use. The resultant matrices will be assigned and scaled to match broad corridor screenline HGV counts

### 6.4.5. Use of Synthetic Data

A known limitation of MND is the representation of shorter distance trips, and other data sources will be required to estimate shorter distance movements, it is standard practice to use synthesised demand for this purpose. A synthetic highway travel demand matrix will be developed based on estimates of base year trip-ends and observed trip-length distributions.

These synthetic matrices will be used in several ways as part of the processing of MND, namely the infilling of shorter distance trips, the detailed allocation of MND trips to model zones, and the estimation of travel purpose.

The development of the synthetic trip matrices will be undertaken through a staged approach, using traditional methods of matrix building and following approaches recommended in TAG unit M2.2. The process will be run separately for each trip purpose, time period and direction (to/from home).

The primary tasks are likely to include:

- Adoption of trip end estimates developed from land use data by purpose and mode as part of demand model development;
- Development of OD cost matrix based on skim of link free flow times; and
- Application of preliminary demand model outputs, possibly supplemented with gravity models to distribute the trip-end data in accordance with observed (NTS) trip-cost distributions.

### 6.4.6. Active Modes

As with the highway and public transport travel demand matrices, it is intended that the travel demand matrices for active modes (walking and cycling) will be developed.

Active mode trips are generally short and dispersed in nature. MND datasets can include active travel trips as a disaggregated group; however, given the shorter typical trip distances by walk or cycle, the issue of under representation of short distance trips is likely to be pronounced. Active travel trips will therefore be derived synthetically

This matrix synthesis will be undertaken separately for walking and cycling demand reflecting the different trip-length profiles for these two sub-modes, using base year estimates of trip-ends and observed trip-length profiles derived from NTS data. Walking and cycling level of service will be based on distance skims taken from the walk and cycle networks developed in the public transport model, with travel time estimated through application of average speed assumptions.

### 6.4.7. Data Merging Process

Reflecting on the outcome of the verification exercise, a decision will be made on the suitability of the spatial resolution where the mobile phone OD data should be used. Once reasonable confidence is gained on the suitability of the MND data, supported by the verification against independent evidence, a process will be developed to segment the matrices of person trips by time period and trip purposes.

Findings from verification tests, and potential methods to address biases will be presented and discussed. The methods adopted, and pre/post verification test analysis providing evidence base for adopting methods will be described in the model validation report.

The sections below broadly set out principles of the disaggregation approach based on previous experience from several recent applications.

#### 6.4.7.1. Disaggregation by Mode

The first step is to sub-divide the person trip matrices into constituent modes. The MND data specification states that the core requirement of MND mode definition is for trips to be classified as road, rail, or walk/cycle.

[2] NUTS3 regions typically correspond to counties, unitary authorities, or districts in England (some grouped).

The 'road' MND data should only include motorised road trips (i.e. car, bus, coach, motorcycle, LGV, and HGV). Prior experience has; however, indicated that often some rail trips are misallocated as road trips and may therefore be included in the data set. In the Cambridge area in particular, where road routes are particularly congested cycle trips could also be misallocated as road trips.

Subject to outcome of review of mode splits in the MND data set if it is necessary to address uncertainty in identification of rail trips, we will primarily make use of the 'all modes' MND data. We will then extract the observed rail matrices to give a revised 'fast mode road trip' data set.

Once we have a revised 'fast mode road trip' dataset, bus/coach trips will need to be separated from other trips. We will use the bus demand matrices prepared from ETM data to remove bus demand from the mobile data.

#### 6.4.7.2. Segmentation

MND road trips will need to be segmented into the following user classes:

- Car Employers' Business;
- Car Commuting;
- Car Education
- Car Other;
- LGV,
- HGV.

If income segmentation is included, as mentioned in section 6.1.2, the MND would need further disaggregation accordingly. In principle, there are two key requirements of the segmentation method:

- The segmentation should ensure that purpose split at each origin / destination reflects the diversity in the land-use, trip rates, and planning data (this is at trip end level); and
- The segmented matrices should reflect the differences in trip length distribution by vehicle type and journey purpose, as supported by independent observed data (this is at trip distribution level).

To meet both these criteria, segmentation factors are needed that not only reflect purpose splits at trip-ends, but also vary by distance for each OD pair to reflect different trip length distributions by trip purpose. The segmentation method will therefore use matrices (synthetic and observed), created separately for each vehicle type / trip purpose that reflects variations in purpose/vehicle type splits across ODs:

- Van and HGV matrices will be based on observed data sets (DfT CSRGT & INRIX data); and
- Synthetic car purpose matrices will be developed using the VDM, so that they reflect observed trip length profiles (from NTS) and zonal trip-ends (based on a trip end model capturing local planning data: population and employment).

This will ensure purpose split factors are different for each OD pair depending on their trip-ends and distance. Segmentation factors will then be calculated for each OD for each vehicle type/trip purpose combination. These factors will be used to split the all-vehicle MND data into vehicle type/trip purpose matrices.

This method will retain the total zone to zone demand from the mobile data whilst ensuring the trip end distribution and trip length distribution are representative within each vehicle type and trip purpose segment.

## 6.5. Calibration and validation

### 6.5.1. Highway Assignment Model

#### 6.5.1.1. Traffic Acceptability Guidelines

Assignments will be created following the latest TAG guidance. The acceptability guidelines outlined in TAG Unit M3.1 are shown in Table 6-1 and Table 6-2.

The observed flow and screenline flow criteria in the Table relate to total link flows, i.e., all vehicles, and should not be used when comparing partial link flows, e.g., heavy goods vehicles.

**Table 6-1 – Link Flow and Turning Movement Validation Criterion and Acceptability Guidelines**

| Criteria | | Acceptability Guideline |
|---|---|---|
| 1 | individual flows within 100 veh/h of counts for flows less than 700 veh/h | > 85% of cases |

| | | |
|---|---|---|
| | Individual flows within 15% of counts for flows from 700 to 2,700 veh/h | > 85% of cases |
| | Individual flows within 400 veh/h of counts for flows more than 2,700 veh/h | > 85% of cases |
| 2 | GEH <5 for individual flows | > 85% of cases |

**Table 6-2 – Journey Time Validation Criterion and Acceptability Guidelines**

| Criteria | Acceptability Guideline |
|---|---|
| Modelled times along routes should be within 15% of observed times (or 1 minute if higher than 15%) | > 85% of routes |

#### 6.5.1.2. Highway Model Calibration and Validation

As part of the generation of a new 2023 base year highway model, it should be ensured a consistent level of flow and journey time calibration and validation is achieved across the CPCA area. However, given the large-scale area this covers it would provide time consuming and carries an increased cost if a high level of local calibration and validation is sought to be achieved across the whole area.

Discussions will be held with CPCA along with the definition of the detailed model area mentioned previously to agree specific study areas to be focused on as part of the highway model calibration and validation, ensuring these locations receive a greater and more proportionate level of focus to achieve a high level of calibration and validation.

A key objective of the updated highway model should be to ensure a close level of fit is achieved in terms of turning movements at key junctions, particular major strategic interchanges which interface with the SRN.

Current expectation is that there would be a maximum of 50 journey time routes and 25 screenlines/cordons.

The highway model calibration and validation stage will be divided into four processes:

- Network
- Route Choice
- Trip Matrix
- Assignment.

A series of basic pre-calibration checks will be undertaken prior this stage, which includes checking and rectifying network debugging errors and checking of key junctions and intersections to ensure they connect correctly to the network and that all destinations are reachable.

Network calibration and validation will be undertaken by assigning an initial estimate of the prior matrix onto the network. The calibration process will include ensuring the speeds and flows on network links and delays at junctions are as anticipated from observations.

Further checks such as flow to capacity ratio and network routing inspection, including the difference between routes taken by HGV and other vehicles, will also be undertaken.

Comparison of observed and modelled journey times on time/distance graphs will be included as part of the network validation process.

The plausibility of the modelled routes will be part of the route choice calibration and validation process. Modelled routes between selected origin and destinations on important centres of population and employment or key junctions will be examined. As observations of routes are not usually available, the checks will be based on web-based route planning tools, local knowledge and judgement. HGV routes will be investigated to ensure longer and faster routes such motorways and trunk roads appear more attractive.

The prior trip matrices will be validated by comparing total modelled flows and counts and assessed against TAG validation criteria by vehicle type and time period for screenlines and cordons as follows:

- Screenlines and cordons generated from MND data
- Screenlines and cordons earmarked for matrix estimation

- Screenlines held back for independent validation.

From the analysis it will indicate whether there is a requirement of matrix estimation (ME) although from our experience this is likely. The objective of ME is to refine the estimate of the OD trips which are not observed in surveys by synthetic matrices. We will monitor the changes brought by ME by comparing the prior and post ME matrices by scatter plots of matrix zonal cells and zonal trip ends, trip length distribution analysis and sector to sector level matrices analysis.

The benchmark criteria of changes brought by ME will be in accordance with TAG Unit M3.1. The validation of the post ME matrices will be similar to the prior matrices mentioned earlier. If the TAG criteria are not met for all or nearly all screenlines and cordons, remedial action will be considered.

Assignment calibration will be taken into consideration if the first three processes do not produce an acceptable validation of link flows and journey times. Further network improvements will be undertaken on those links and node junctions to meet TAG criteria. Assignment validation will include traffic flow links mentioned in the trip matrix validation section and comparison of modelled and observed journey time accordance to TAG criteria and guidelines for journey times.

A 'stress test' (by increasing the numbers of trips in the matrices by 10% or 20% and reassigning) will also be introduced as part of the process. This will reveal faults in the network, which previous checks may not have detected, such as junction performance with some junctions becoming over-loaded whilst others showing no queues despite the increased demands. Another test that could be considered is coding a 'dummy' highway scheme such as a bypass alternative to congested corridor or substantial change to highway standard in a corridor and review whether sensible and realistic outcomes from the model result. The comparison of assignment flows and journey times will be examples of outputs to be checked.

### 6.5.2. Public Transport Assignment Model

The PTAM will provide the following outputs covering:

Assignment of trips providing allocation of persons to bus, rail and mixed mode trips

Generalised cost skims of costs of travel for use within demand modelling

Interaction with highway mode on travel speeds i.e., congested travel times on the highway have an influence on bus travel times.

Details of the specific coding requirements, parameter derivations and assignment methods are stipulated in the relevant guidance from TAG (Unit M3) and this will be followed.

The level of accuracy associated with PT trips is necessarily lower than that of highway demands resultant from the lower market share associated with the former.

The DfT's recommendation is that across modelled screenlines, modelled flows should, in total, "be within 15% of the observed values. On individual links in the network, modelled flows should be within 25% of the counts, except where observed hourly flows are particularly low (less than 150 passengers per hour)".

#### 6.5.2.1. Public Transport Model Validation

The following three types of validation criteria will be assessed to the public transport passenger assignment model

- Validation of the Trip Matrix
- Network Service Validation
- Assignment Validation.

The validation of the trip matrix involves comparisons of assigned and observed passengers across complete screenlines and cordons. The criteria states that 95% of the assigned and observed flows should be within +/-15% of one another.

The validation of the network and service refers to the checking on the accuracy of the coded geometry and journey times of the services within the PT model. This also includes the comparison of the modelled flows of public transport vehicles with observed counts.

The assignment validation will be undertaken by comparing modelled and observed passenger flows across screenlines and cordons and boarding and alighting's at stops and station. The number and locations of validation sites will be agreed in discussion with CPCA. Fewer sites are anticipated than for the highway model and will be chosen based on the relative importance of public transport as a mode by location. The completion of these calibration and validation checks will demonstrate that the model is sufficiently robust in areas of detailed modelling to test known interventions and will demonstrate the extent to which model outputs in other areas relating to other locations can be relied upon and the extent of further work required to improve further the model.

### 6.5.3. Realism and Sensitivity Testing

The purpose of developing CaPCAM is to have a model which can be used with confidence to examine how potential changes to the transport systems will change travel patterns and support economic prosperity. The base year model, once calibrated and validated, will be tested further to demonstrate that the three components: the demand model; highway model; and PT model, behave in a realistic manner.

The sensitivity of the model to several input assumptions will also be tested, again to demonstrate that the model is a robust and reliable starting point for forecasting. Change to transport conditions will, in principle, cause a change in demand and we will predict and quantify these changes. TAG states that if a model behaves realistically to changes in travel costs and time that it is more likely to be a good predictor of the demand responses to these changes.

We will run the tests, which are recommended in TAG, on the base year to identify how it performs and consider where changes in demand have occurred and whether these are within the expected magnitude of change. Where the model does not return results showing it is behaving in a manner which is consistent with guidance, we will adjust the parameter values controlling its responsiveness as recommended in the guidance until an acceptable response is achieved.

# 7. Demand model

## 7.1. Model form

The TAG unit M2.1 guidance recommends that integrated demand and supply models should operate incrementally. This means for forecasting a variable demand model (VDM) is used to provide incremental changes to validated base matrices. Two alternative approaches may be used to achieve this:

- an incremental pivot point model where the VDM only forecasts the change in demand;
- an absolute model applied incrementally where the VDM forecasts the total demand, with changes between two runs of the VDM (base and forecast) being applied to the validated base matrices.

There are advantages and disadvantages with each approach. The incremental pivot point model requires an additional step to handle new developments and new modes and requires base matrices for all modes to be assigned or where the analysis requires the total use of a mode not just the changes. The absolute model approach enables the base and forecast years to be handled in the same way, for developments to be treated consistently with other areas, and for outputs to be generated on the total travel by all modes included. However, this approach results in two sets of demand matrices: “synthetic” matrices from the demand model and the validated base matrices. It is important these two sets of matrices are sufficiently similar in the base year so forecast changes are not distorted by the process.

Due to the number of new development areas in the County, and to facilitate the creation of total travel demand for active modes for walk and cycle mode share metrics, the new VDM will take the form of an absolute model, applied incrementally (AMAI).

The majority of transport models in the UK use trip-based matrices. The guidance recommends P/A trips, or production/attraction modelling is adopted, as in CSRM; where the direction from home to work (and back) is known and improves forecasting changes associated with changes in land use activity and developments. A “tour” is defined as any round trip, starting and finishing at home, and may contain stops at several different destinations. Journeys between non-home destinations are handled automatically in these models. Tour-based modelling is increasingly applied but still not widely used in the UK. Tour-based modelling is a natural step towards activity-based modelling.

The new model will consider the merits of adopting a simple tour-based model with a limited set of activity chains, should this be feasible in the timescales available without major household interview data collection exercise. The fallback position is using the CSRM approach of P/A trip modelling with a linkage between home-based trip attractions and non-home-based trip generation (as also applied in DfT’s national trip end model, NTEM). To develop a robust tour based model would require local data on travel patterns / trip chains which could only be obtained from household interview surveys including travel diaries.

## 7.2. Segmentation

### 7.2.1. Overview

Travel demand segmentation will be used within the model to represent differences in travel behaviour by trip purpose and type of traveller. This is helpful both for representing travel choices, and to allow for forecasting different rates of future growth for different traveller types and trip purposes.

The travel demand is segmented in the VDM by trip purpose and traveller type and will be aggregated into assignment user classes which are used in the assignment models to represent differences in routing choices.

The sections below discuss the proposed segmentation at each stage and the relationship between them.

### 7.2.2. Trip purpose

TAG unit M2.1 states that there should be at least three categories of trip purpose (commuting, employer’s business and other) as “these categories are likely to have different elasticities and different distributions in both time and space, and substantially different values of time”.

The proposed VDM segmentation is based on DfT’s NTEM (National Trip End Model) dataset and hence the trip purpose definitions will be aggregations of those within NTEM. NTEM includes eight home-based (HB) and seven non-home-based purposes (NHB) as set out in Table 7 below.
This level of segmentation is not appropriate for demand modelling, hence some aggregation is proposed to manage the scale of the model while retaining sufficient segmentation to differentiate travelling to alternative types of activity. The existing local models operate at the level of segmentation set out in TAG of commuting

business and other. For the VDM model we propose to retain the CSRM definitions with the trip purposes from NTEM aggregated as follows:

1. HB Shopping and HB Personal Business;
2. HB Recreation / Social, HB Visiting friends & relatives and HB Holiday / Day Trip; and
3. NHB Work, NHB Education, NHB Shopping, NHB Personal Business, NHB Recreation / Social and NHB Holiday / Day trip.

This will give five home-based trip purposes and two non-home-based trip purposes in the VDM as shown in Table 7, which can be aggregated to the purpose definitions embedded in the existing models.

**Table 7-1 – VDM and NTEM trip purposes**

| Home-based Purpose | | Non-home-based Purpose | |
|---|---|---|---|
| **DfT NTEM** | **Proposed VDM** | **DfT NTEM** | **Proposed VDM** |
| HB Employers Business | HB Employers Business | NHB Employers Business | NHB Employers Business |
| HB Work | HB Work | NHB Work | NHB Other |
| HB Education | HB Education | NHB Education | |
| HB Shopping | HB Shopping and personal business | NHB Shopping | |
| HB Personal Business | | NHB Personal Business | |
| HB Recreation / Social | HB Leisure | NHB Recreation / Social | |
| HB Visiting friends & relatives | | | |
| HB Holiday / Day trip | | NHB Holiday / Day trip | |

### 7.2.3. Traveller Types

Segmentation of traveller types is desirable to reflect their different travel behaviour in terms of:

- Numbers of trips made by purpose (trip generation)
- Where trips are going (workplaces / shops / schools etc)
- Opportunities / preferences on mode (levels of car ownership / availability)

The segmentation in NTEM has been designed to best capture variations in trip generation and consists of a combination of 11 person types based on gender, age and employment status, and 8 household types, based on household size and number of cars available. These combine to provide 88 combinations of person household types, which are termed traveller types.

Retaining much of the NTEM segmentation at the trip generation stage is desirable to maximise consistency with NTEM and enable the NTEM trip rates to be applied. We propose to exclude the gender segmentation from NTEM as there are relatively small differences in behaviour and trends over time suggest these will diminish rather than increase.

The generated trip ends will then be aggregated for input to the choice model which will operate with fewer traveller type segments for efficiency.

The existing CSRM2 choice model includes segmentation by socio-economic group / household income at different stages of the model. This level of segmentation is important when considering responses to pricing scenarios and the future model will look to retain some form of income segmentation akin to CSRM unless this proves prohibitive in terms of model scale or data requirements. Due to the nature and focus of the other existing models, they do not include additional traveller segmentation.

The proposed traveller type segmentation for the choice model is as follows:

- Retain age to differentiate those at school from adult population. Retaining an “elderly” population segment based on age will also be considered since the ageing population means this group become increasingly important when forecasting further into the future.
- Retain working status segmentation from NTEM for the adults (not for children and elderly): working full-time, working part-time, students (not working), other (not working / studying).

- Include income / socio-economic segmentation, maximum of three categories to reflect variations in willingness to pay (relating to road pricing), and/or ability to work from home.
- Household car availability to improve mode choice modelling, aggregate NTEM categories to three segments:
  - No Car (NC): No cars available in the household;
  - Partial Car (PC): Fewer than one car available per adult in the household;
  - Full Car (FC): One or more cars available per adult in the household.

This leads to a maximum of 18 person types (6 working status and age combinations, 3 income/socio economic) and three levels of car availability, and hence 54 traveller types. However, the model will consider only valid combinations of traveller type and trip purpose. The precise combinations allowed will be considered during the development stage of work. At this stage we envisage commuting and business trips will only be included for those in full and part time employment.

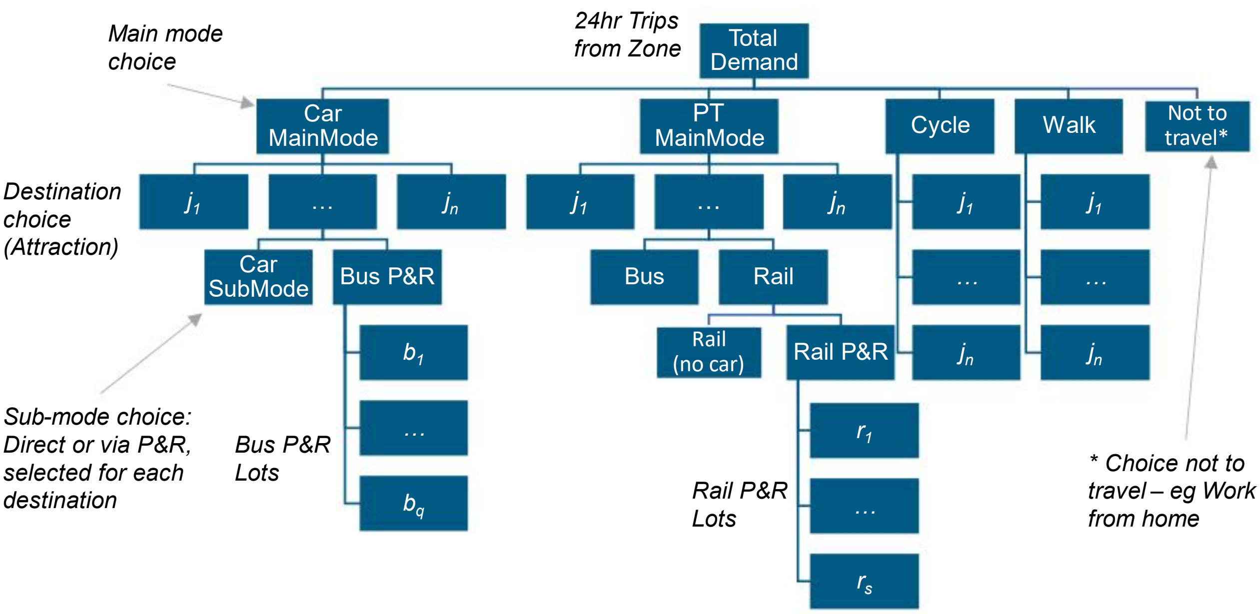
## 7.3. Choice structure

The VDM will include mode and destination choices. A macro time of day choice model could be included but our recommendation at this stage is to assume fixed time of day profiles by trip type, with the option to include time of day choice at a later stage.

In line with TAG guidance, it is assumed by default that the main mode choice is less sensitive than destination choice and hence is positioned above it in the choice hierarchy. Sub-mode choice is positioned below destination choice, with the lowest level choice being for choice of P&R site or station (see Section 7.4).

Working from home has become an increasingly important aspect for many employees. We propose including working from home as a choice in the VDM, but will start the task by reviewing the evidence and guidance emerging on post-Covid trends and the approaches typically being adopted in transport models in other parts of the UK.

**Figure 7-1 - Indicative choice hierarchy**

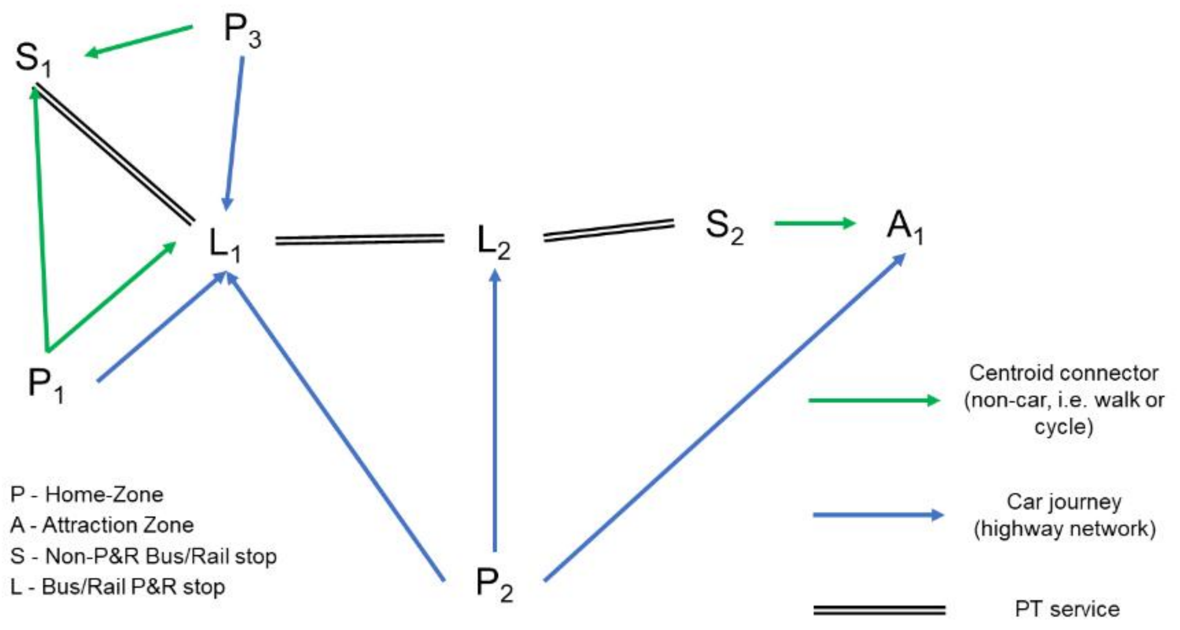



## 7.4. Approach to Park and Ride

The main software packages being considered (CUBE and PTV Visum) allow modelling of park and ride via ‘Lots’ in a similar (but more straightforward way) to the approach embedded in CSRM. The approach described here is specific to Visum as the recommended software. Any PT boarding point can be designated as a P&R Lot, ether bus or rail. Within the PT and highway assignment models, each P&R Lot is treated as a zone: the drive leg to/from the P&R Lot and the PT leg between the P&R Lot and the destination are separated by Visum and can be incorporated with the other car and PT trips respectively for assignment. The option of using walk/cycle leg to access the PT boarding point remains where appropriate.

The functionality and connectivity that can therefore be provided in Visum is represented in Figure 7–2.

**Figure 7–2 - Approach for Park and Ride modelling**




### 7.4.1. Key elements of P&R approach

TAG Unit M5.1 sets out guidance on the treatment of park and ride trips within a VDM. It is advised that park and ride modes are treated as a sub-mode of either car or PT, depending on the relative length of each leg of the trip. Hence, bus P&R is treated as a sub-mode of car, whereas rail is treated as a sub-mode of rail. This separation will be implemented with main modes for car (comprising sub-modes for car only and bus P&R) and PT (comprising bus, rail and rail P&R sub-modes).

- The choice to use Park & Ride is determined in the VDM, as a sub-mode choice, rather than a routing choice (to ensure travellers return home from the same site they arrived and parked at);
- Both bus and rail have separate Park & Ride sub-modes, most likely bus as a sub-mode of car and rail as a sub-mode of PT;
- Each P&R Lot will be designated a zone number, most likely a high number with reserves for future P&R zones. This zone will not have any trip ends, and will not be specifically recognised by the VDM at all, but will be used by the HAM and PTAM (exactly as in CSRM2);
- The software used will create the generalised cost for each P&R sub-mode, by adding the costs of each leg (car and PT);
- The software will also split the P&R sub-mode demand into Home->Lot and Lot->Destination. This 24hr P/A movement will then be pivoted against the assignment.

Note that TAG unit M3.2 specifies modelling the use of car access to PT services in two general forms, namely:

- **Kiss and Ride:** public transport user is driven to station and picked up again on the return journey
- **Park and Ride:** which may involve either the use of a designated park-and-ride site, parking at stations, or informal parking in streets surrounding stations

The P&R function within the model will not differentiate these two modes, so that implicitly any P&R trip could be in the form of Kiss and Ride. The cost-sharing aspect of this is dealt with via occupancy factors in the generalised time equations. This also has implications for parking capacity at P&R sites. As with all escort trips within the model, the next leg of the driver trip (onward to a further destination or home) is not explicitly handled within the VDM, but is assumed to be represented in the validated HAM assignment matrices. Hence using the incremental approach, growth in trips to/from the P&R zone should deliver growth in the appropriate vehicle trips in the HAM.

### 7.4.2. P&R catchment areas

The structure of the P&R approach means that travellers have a choice between all P&R sites and can select the one with the lowest generalised time for their specific P/A trip. It is not therefore strictly necessary to define specific catchment areas for each P&R site. However, it may prove convenient to do so, to prevent odd/infeasible trip patterns or improve model stability. If required, this can be implemented during model calibration, but should be applied so as not to overly restrict changes in travel behaviour in future years.

## 7.5. Parking

The availability and price of parking, as well as the availability of alternative modes such as bus, influences people's decisions on whether to use the car for their journey and whether to interchange at a park and ride site. In CSRM2 the likely costs associated with parking in different urban areas are included, based on analysis of parking charges in Cambridge city and each of the towns within the model. The new model will also include a representation of parking charges which can be adjusted for forecast scenarios.

The new model will also include a parking capacity function. TAG unit M5.1 sets out two main reasons for modelling urban parking:

- to ensure that the forecasts of the demand for travel to the urban centre by car are consistent with the forecasts of the available parking spaces; and within that constraint
- to ensure that the car vehicle trips end at zones containing car parks as opposed to zones where the activities of the occupants take place and where there might be insufficient parking

The demand modelling element will address the first of these to limit overall demand by car to reflect the constraints associated with parking space. The second is a function of the assignment modelling approach.

To achieve this a parking sub-model will be developed for areas with limited capacity. Zones where parking charges or capacity limits apply will be grouped into:

- parking districts: contiguous sets of zones with identical charges and/or a single total parking capacity; and
- Park & Ride sites: single (assignment model) zones used to represent bus P&R sites or railway stations (see section 7.4 on Approach to P&R).

The costs and the locations of the associated car parks will be considered, and an approach developed to allow the most appropriate charges to be applied by parking district, time period and trip purpose taking into account the proportion of drivers expected to pay a charge. Parking districts will be defined for each urban centre (Huntingdon, St Neots, Ely etc) as a whole with two (possibly more) areas for Cambridge and Peterborough.

Parking costs relevant for specific bus Park & Ride sites (if any) and railway stations will also be sourced and treated in a similar manner, with the parking cost determined according to the expected length of stay by trip purpose (at a 24hr level).

### 7.5.1. Parking Capacity Function (PCF)

A parking capacity function (PCF) will be included in the model to represent cases where journey choices are impacted by the availability of parking space.

Most public car parks (general or P&R) have a known capacity, and this might be considered as a hard limit on the number of vehicles able to travel to those zones during a 24-hour period. However, these hard constraints may not in practice apply within the model, due to car park turnover rates throughout the day, escort/Kiss & Ride trips, and the potential for on-road parking to be also used. Furthermore, the capacity for parking in many areas will not be certain, due to the existence of private non-residential parking (eg at workplaces) and on-street parking (which will be partly occupied by residents' cars).

An early task will be defining how to measure parking capacity for each site / district taking into account the likely availability of space outside designated car parks and turnover rates. A pragmatic approach will be adopted considering parking capacities alongside evidence of car park occupancy where data on this can be obtained, and the total number of vehicle trips to each area in the base year. If parking is thought to be at or close to capacity across a wide area, then the latter may be the most appropriate measure of car park capacity.

A parking capacity function will be developed to represent an additional generalised cost (penalty) where parking capacity is limited. As outlined above, this will apply in specific parking districts and P&R sites. The function will be derived as a time penalty which is a function of the number of cars trips arriving in the previous iteration, and the defined capacity of the parking district or P&R site. This will count total 24-hour attractions for car (vehicle) trips.

The penalty will operate at a 24-hour level, so will not explicitly consider length of stay or turnover of parking, and residential parking (home-based production end) will not be considered. For this reason, the 'capacity' must be a nominal one determined during calibration. The aim of the parking capacity function will be to apply a small penalty (parking search time) whilst car arrivals are below the defined capacity and increase rapidly at a threshold above which no further parking is judged to be feasible. The penalty derived by the PCF will be added to the car generalised time to represent the constraints and additional cost associated with limited parking capacity.

## 7.6. Model integration

### 7.6.1. Overview

Network skims will be available to the VDM from the highway and PT assignment models (HAM and PTAM). The skims will be provided by time period and Origin-Destination (O-D) pair, and hence relate to the individual out and return sections of a P/A trip. The method for producing P/A trips from the O-D skims is outlined in Section 7.7.

### 7.6.2. Car

The HAM skims will be available separately for distance, time and tolls of each O-D pair and period, skimmed directly from the HAM as a flow-weighted average across all paths between an OD pair, by AUC and time period. Functionality to pass tolls will be implemented for scenario testing.

Note whilst intrazonal skims provided by the HAM are typically zero (as these trips are not assigned to the network), these will be re-calculated for the VDM initially as half the zonal minimum row or column value for use in the VDM. This may be altered based on evidence during the calibration stage.

The HAM skims are refreshed in the VDM following each iteration between the assignment models and VDM, to allow for responses to highway congestion to be incorporated in the VDM.

### 7.6.3. Bus and Rail

Bus and rail skim information will be provided separately for each mode in the form of in-vehicle time, wait time, and number of interchanges for each origin-destination trip, by PTAM AUC. Where access/egress modes are used the time on these will need to be identified separately.

Given that alternate routes may exist, flow weighted averages will be calculated in the PTAM before passing values to the VDM. Fare information may come from the public transport assignment model, or may be input specifically for the VDM. This depends on primarily on the nature of the fare structure applied. A zone / matrix based fare structure independent of the services used has no impact on route choice, whereas a fare paid per boarding stage or varying by routes. In addition, the public transport assignment model is unlikely to include detailed segmentation by traveller type (detail not required for routing and would significantly increase model run time), hence variations in the fare paid will be applied for the demand model.

Intrazonal skims provided by the PT assignment model will also be zero. For most zones, intrazonal bus or rail movements will not be possible, so these will be set to an ‘infinity’ value or otherwise disallowed. Where intrazonal movements are judged to be possible, these will initially be re-calculated as half the zonal minimum row or column value for use in the VDM, though changes to this assumption may be made during calibration.

The PT skims may be calculated at each demand-assignment iteration, to take account of the impact of changing road congestion on on-road bus journey times, and also changes in the demand strata using PT, which can alter routing decisions and hence journey skims. However, this option may not be used in every run or every iteration, since it is likely to be more efficient to iterate the highway assignment and demand model each iteration, and update the public transport (and active mode) assignment at the start and end of a model run. This would not be possible if public transport crowding is included and one of the reasons PT crowding is not proposed for CaPCAM.

To summarise, the PTAM will pass skims to the VDM by time period at OD and PTAM AUC level, flow-weighted across routes, comprising the following components:

- access/egress time (total for all access/egress modes),
- in-vehicle time (dominant mode),
- total wait time (all journey stages),
- number of interchanges,
- total journey fare (all stages).

### 7.6.4. Walk and Cycle

For the walk and cycle main modes, walk and cycle networks will be prepared and weighted travel times skimmed from this prior to model running.

Walk and cycle access modes for PT will also be determined using the walk and cycle networks, and particular attention will be paid to the bus stop and railway station access routes.

Skims will be based on the shortest perceived travel time between each origin-destination pair and will not vary by time period.

Due to the size of the model, walking and cycling will not be relevant for many of the zone pairs. A cut-off distance will be considered to avoid O/D calculations being carried out should this significantly improve model performance.

### 7.6.5. O-D to P/A Conversion

The skims that are input to the VDM to derive the generalised times are mainly calculated during the assignment models and hence are defined for average hour O-D trips. For the VDM, 24hr P/A costs are required and hence a conversion must be carried out. For each home-based purpose, the typical P/A costs will be calculated by summing out and return O-D costs for relevant time periods.

## 7.7. Generalised time

### 7.7.1. Definition

TAG unit M2-1 states that *"all transport modelling should recognise that people's travel choices depend upon the cost, in both time and money. It is important to combine time and money into a single disincentive to travel ("disutility"), so that demand can be assumed to rise or fall with reductions or increases in either. To do so, it is necessary to apply appropriate weights to the time and money components of this combined cost so that travellers can trade money for time, such as in choosing between a faster but more expensive mode or a slower but cheaper mode."*

In transport models, the disincentive to travel is usually represented with a generalised cost or time. The new model will follow the recommendation that units of time are used. The VDM will work with generalised time in units of minutes combining the time components of a trip with the monetary costs, which are converted into time units using appropriate values of time (VoT). Additional constants will be required to reflect un-modelled attributes influencing travellers' behaviour. These will be derived during model calibration to improve the ability of the model to reflect observed travel patterns and behaviour.

$$Generalised\ Time = Total\ travel\ time + \frac{total\ cost}{value\ of\ time} + calibration\ constants$$

### 7.7.2. Generalised Time Damping

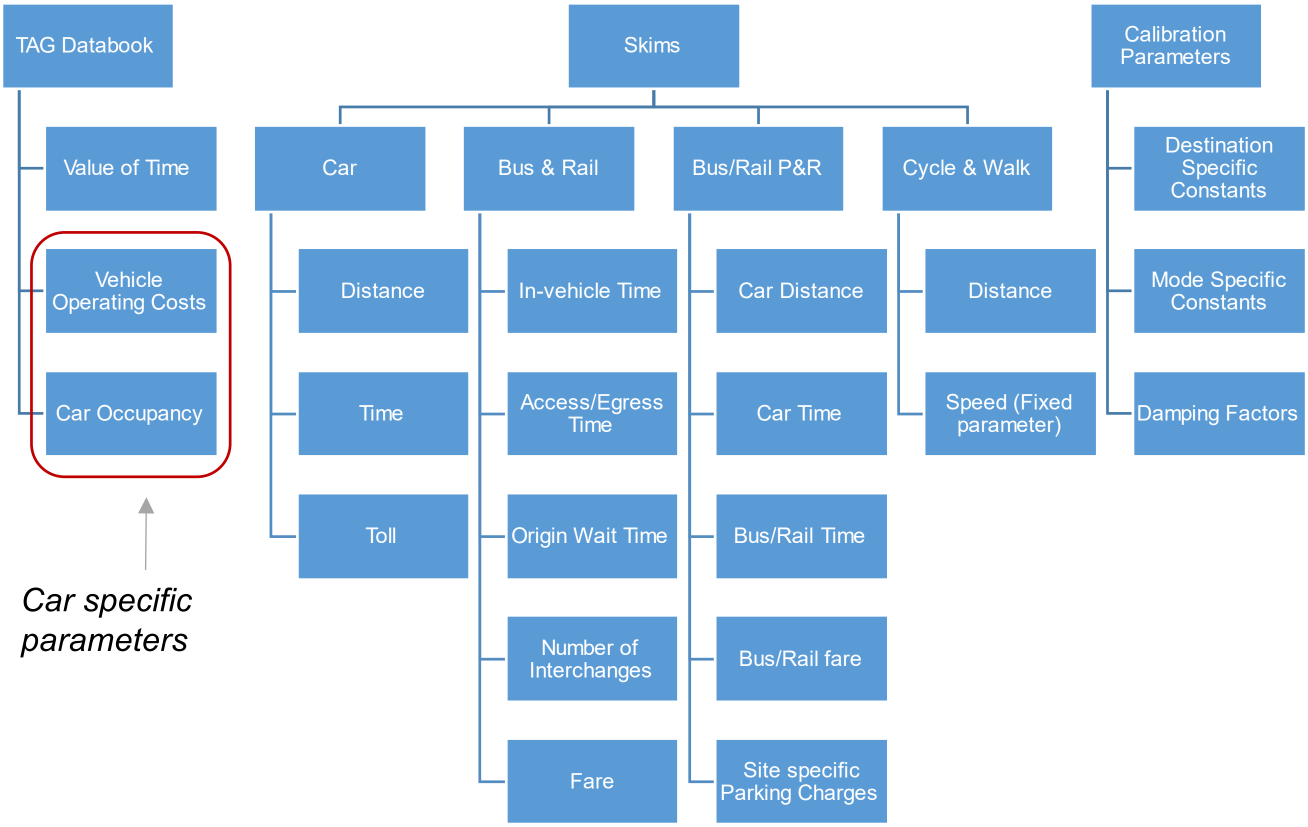
TAG unit M2-1 suggests that damping is considered as a means of representing the fact that demand responses become less strong as trip length increases. A variety of methods for damping are set out to either vary the VoT by distance or raise the generalised time to a power.

The need for damping will be reviewed as part of the model calibration.

### 7.7.3. Components

Figure 7–3 shows the various components likely to be used in generalised journey time formulation. The figure is categorized based on the data type or source. TAG databook and calibration parameters are more generic and apply across all the modes, except for car specific TAG values. Parking capacity and parking charges used in extracting network are derived from secondary sources, with the remainder of the attributes being obtained from the relevant assignment model by time period.

**Figure 7–3 - Components of Generalised Time**




The vehicle operating costs (VOCs) will be calculated for the VDM using the standard formulation set out in the TAG databook using the time and distance skims from the HAM, and values of time appropriate to the VDM traveller type segmentation. In line with guidance, fuel costs will be included for all trip purposes, whilst non-fuel costs will only be perceived by the employer's business trips.

## 7.8. Calibration

The calibration of the VDM will be carried out in line with TAG unit M2-1 (Variable Demand Modelling). M2-1 advises that ideally local data should be used to calibrate the parameter values within the variable demand model, in order to produce a model which replicates observed base year data. However, no firm criteria are set for this, and it is noted that this is less of an issue for incremental models such as proposed here. The guidance also advises that effort should be proportionate to the quality and relevance of available data. Therefore, the aim will be to calibrate the model parameters to produce a reasonable match against observed local data, whilst also ensuring that the model responses in realism tests meet the advised standards.

An iterative process will be taken of reviewing the model outputs against observed data and using judgement to adjust model parameters to produce a better fit against independent data sources. The checks carried out and reported will include:

- Mode shares and trip length distributions will be compared against both local Census JTW and local NTS data;
- Origin-Destination distributions for HBW will be compared against the Census JTW;
- Car, bus and rail trips will be compared against validated HAM and PTAM assignment matrices;
- Where available, PT ridership and station usage data will be compared against observed totals;
- Where available, car destinations will be compared against parking occupancy data.

Calibration will take place through an iterative process involving a hierarchy of checks and adjustments as follows:

- Checks on the model inputs in terms of trip ends and network skims, to ensure these are not the cause of any differences to comparator data;
- Checks on the model implementation and processing;

- Adjustments to sensitivity parameters and cost damping, particularly to alter mode shares and trip lengths;
- Introduction of alternative specific constants for main and sub-modes, and specific areas;
- Calibration of the Parking Capacity Function and adjustments to P&R VDF function.

## 7.9. Demand-supply convergence

Each time the VDM is run, the difference to the VDM results from the previous iteration will be checked. Any differences will be caused by changes in highway congestion based on the revised VDM outputs. This is therefore termed the 'supply/demand convergence'.

The standard measure of supply/demand convergence known as %GAP will be applied as specified in TAG Unit M2.1 Section 6.3. This tests the cost-weighted difference between the current and previous VDM matrices at 24hr P/A level. The supply/demand process will be capable of terminating when a user specified threshold is reached, which is normally 0.1% but may be set as appropriate to the nature of the model scenario testing. Quicker runs can be completed with looser convergence for preliminary assessments, while scheme appraisal requires levels of convergence to be commensurate with scheme benefits and may require tighter convergence. Alternatively, a maximum number of iterations can be set, and the convergence achieved reported.

## 7.10. Realism testing

### 7.10.1. TAG requirements

Three standard realism tests are specified in the guidance to demonstrate that the responsiveness of the VDM to changes in costs and times meets the evidence available. The three tests are:

- Car fuel cost changes
- Public transport fare changes
- Car journey time changes

These three tests will be carried out as part of the calibration of the new VDM as set out below. Additional realism or sensitivity tests may also be carried out to demonstrate the plausibility of the model, although evidence of the level of response expected is widely available. Sensitivity tests on responses to parking cost or capacity changes will also be considered.

### 7.10.2. Car fuel cost elasticity

The car fuel cost elasticity required is the change in car vehicle-kilometres with respect to the change in fuel cost. The calculations should be carried out for a 10% or a 20% fuel cost increase. Car fuel cost elasticities are established using both matrix vehicle kilometres and network vehicle kilometres and are based on an iterated supply-demand model result in the base year. TAG unit indicates that the fuel cost elasticity **within the range of -0.25 to -0.35 (overall, across all purposes)** is acceptable and suggests to provide reasons if the elasticity is outside this range.

TAG states that target elasticities are considered more plausible if:

- the pattern of annual average elasticities shows values for employers' business trips near to -0.1, for discretionary trips near to -0.4, and for commuting and education somewhere near the average
- the pattern of all-purpose elasticities shows peak period elasticities which are lower than inter-peak elasticities which are lower than off-peak elasticities

### 7.10.3. Public transport fare elasticity

The public transport fare elasticity required is the change in public transport trips by all public transport modes with respect to the change in public transport fares. The calculations should be carried out for a 10% or a 20% public transport fare increase, applied to all public transport modes equally.

Public transport fare elasticities are calculated on a matrix basis, by time period and trip purpose. Elasticities of public transport trips with respect to public transport fares are expected to lie typically in the range **–0.2 to -0.9** for changes over a period longer than a year.

The elasticities are considered more plausible if:

- Discretionary purposes expected to have a stronger response than non-discretionary purposes
- Stronger response expected for trips with car available than those without a car available.

## 7.10.4. Journey time elasticity

The car journey time elasticity required is the change in car trips with respect to the change in journey time i.e., as travel time increases it is expected to have a reduction in trips. These journey time elasticities are calculated using a single run of the demand model. TAG states that:

*"The output elasticities should be checked to ensure that model does not produce very high elasticities (no stronger than -2.0)"*.

## 7.10.5. Parking constraint elasticity

An additional sensitivity test will be carried out during calibration on the impacts of limiting parking capacity and the scale of response achieved. While no evidence is likely to be available, it will be important to ensure the scale and nature of response is intuitively sensible.

# 8. Data requirements

## 8.1. Introduction

This chapter covers the data sources expected to be used for the model development along with the potential surveys and datasets for model calibration and validation.

## 8.2. Overview of data sources and uses

An overview of the data sources and their intended uses is provided in Table 8 including RAG ratings of both the importance of the data source and its suitability for use in model development as set out in Table 8. It discusses about both the primary and secondary data sources. Further details about the datasets are discussed in the subsequent sections of this chapter.

**Table 8-1 - Data Source Importance and Suitability RAG Status**

| Importance | | Suitability (Quality and Quantity of Data received) | |
|---|---|---|---|
| (green) | Nice to have | (green) | Excellent / Very Good high sample rate and quality |
| (amber) | Preferred | (amber) | Reasonable / Good enough |
| (pink) | Required | (pink) | Some concerns / risks |
| (red) | Critical | (red) | Very Low confidence / high risk |
| - | | - | Unknown at this stage (to be collected) |

**Table 8-2 – Summary of data sources and purpose**

| Data type | Sources | Importance | Year | Purpose | Suitability |
|---|---|---|---|---|---|
| Planning data and Demand model | | | | | |
| Travel Demand Data | National Travel Survey | | 2011-2019 | Matrix build: Purpose splits by time period and trip length distribution by purpose and time period split by urban and rural locations<br>VDM: calibration dataset for mode share and trip length distributions | |
| | NTEM v8 Trip Ends | | 2011-2061 | Potential dataset for developing or constraining forecast trip ends | |
| | NTEM v8 Households & Population | | 2011-2061 | Potential dataset for developing forecast trip productions | |
| | Census JTW | | 2011/2021 | Understanding CPCA internal / external interactions; calibration dataset for mode share and trip distribution for the home-based work (HBW) purpose. Data from 2011 is expected to be used as Census day for 2021 dataset from March of 2021 likely to show high proportions of home working as the COVID-19 travel restrictions were in place. | |
| Productions (housing) Planning Data | AddressBase Data | | 2011-Latest | Observed data for spatially detailed internal housing growth 2011-2023 | |
| | ONS Mid year population estimates and Annual Population Survey | | 2011-2020 | Observed data for population estimates | |
| | Annual Monitoring Reports / LA reports / Gov Live Tables | | 2011-Latest | Observed data for CPCA internal housing growth 2011-2023 | |
| Attractions (Employment) Planning Data | School Census | | Latest available | Observed school capacity data to develop home-based education (HBEd) attractions | |
| | BRES Data | | 2011-Latest | Observed jobs data for home-based work (HBW) and employers' business purposes (HBEB, NHBEB) | |
| | NTEM v8 Jobs & Attractions | | 2011-2061 | To undertake sense checks against locally available data | |

| Data type | Sources | Importance | Year | Purpose | Suitability |
|---|---|---|---|---|---|
| | Jobs data locally available with the districts | | 2023 | Dataset for developing trip attractions for CaPCAM | |
| Trip matrix and Distributional data | | | | | |
| Car Matrix Data | Mobile network data | | 2023 | Develop car prior matrices for CaPCAM | |
| LGV Matrix Data | INRIX OD data | | 2023 | Develop van prior matrices for CaPCAM | |
| HGV Matrix Data | Mobile network data | | 2023 | Develop HGV prior matrices for CaPCAM | |
| | CSRGT | | Latest available | Independent verification of HGV mobile network data. Although this dataset is available at a highly aggregated level and only HGVs registered in the UK. | |
| Bus Data | Operator bus ticket data | | 2023 | Derive bus matrix demand and distribution. Limited information on alighting. | |
| | Face-to-face surveys | | 2023 | Survey data to be used in conjunction to electronic ticketing machine data to understand the distribution pattern, mode of access to bus stop, trip purpose, time of travel and ticket type. | |
| Rail Data | LENNON/MOIRA | | 2023 | Derive rail matrix demand and distribution at station level | |
| | National Rail Travel Survey (NRTS) | | 2004/2005 | To understand the catchments, mode of access, trip purpose at rail stations. Although the dataset is rich in detail, it is outdated. Hence, needs to be used in conjunction with other complementary data sources for the recent years such as station travel plans, face-to-face surveys where available | |
| | Face-to-face surveys | | 2023 | Survey data to understand the distribution pattern, mode of access to rail stop, trip purpose, time of travel and ticket type. | |
| Network data | | | | | |
| Highway Network Data | Existing Models described in chapter 3.1 | | Various | Starting point for defining the highway network | |
| | OS MasterMap Highways - Road | | 2023 | Used to inform new network and check existing network | |

| Data type | Sources | Importance | Year | Purpose | Suitability |
|---|---|---|---|---|---|
| | Traffic Signals Specification | | 2023 | Used to inform junction capacities in highway network assignments | |
| Parking Data | Local Authority Car Park Data | | 2023 | Capacity and charging data to input to the demand model | |
| Public Transport Network Data | GTFS data | | 2023 | Used to inform bus and rail scheduling data. Bus GTFS data will be sourced from Bus Open Data Service (BODS) portal. Rail GTFS data will be sourced from Association of Train Operating Companies (ATOC) | |
| | Fare data (BODS – NeTEx data, ATOC rail fare data) | | 2023 | Development of fare models from NeTEx and ATOC for bus and rail respectively | |
| | OS MasterMap Rail | | 2023 | To define the required rail network | |
| | NaPTAN | | 2014 | Verify GTFS stop locations and infill missing coordinate data where required | |
| | Bus and Rail Timetables from operators | | 2023 | Independent verification of bus and rail scheduling data from GTFS | |
| Supplementary Data | TAG Databook | | Latest available | Provide generalised cost parameters | |
| Highway calibration and validation data | | | | | |
| Traffic Count Data | WebTRIS Counts | | 2023 | National Highways traffic flows on motorways and link roads for model calibration and validation | |
| | ATC Counts | | 2023 | To calibrate matrices and validate model. Use of both existing and newly commissioned. | |
| | MCC Counts | | 2023 | To calibrate matrices and validate model. Use of both existing and newly commissioned. | |
| Journey Time Data | INRIX Journey Time Data | | 2023 | Calibrate CPCA network speeds and validate the model | |
| Public Transport calibration and validation data | | | | | |
| Rail Calibration/Validation Data | MOIRA | | 2023 | Rail station origin-destination data and boardings/alightings | |
| | ORR | | Various – 2023 | Validate rail usage – but only annual | |

| Data type | Sources | Importance | Year | Purpose | Suitability |
|---|---|---|---|---|---|
| | Entry/Exit surveys at major terminals | | 2023 | Validate rail usage at key stations | |
| | Station travel plans | | Latest | Trip Purpose split, catchments and mode of access for rail stations where available | |
| Bus Calibration/Validation Data | Bus ETM data | | 2023 | Validate bus boardings. Alighting information is accurately only for selected ticket types | |
| | Entry/Exit surveys at major terminals | | 2023 | Validate bus boardings/alightings | |
| | Occupancy surveys across cordons/screenlines | | 2023 | To calibrate and validate bus passenger flows | |
| P&R Data | P&R Patronage Data | | 2023 | Calibrate P&R use in model. Use of both ticketing and parking sensor data. | |

## 8.3. Planning data and demand model

The National Trip End Model (NTEM) offers a valuable source of most of the data required to predict changes in trip ends, both trip productions based on household characteristics and trip attractions based on employment etc, as well as car availability forecasts. For planning and demand data, guidance states *"It is highly desirable that the planning data used should at some level be consistent with the DfT NTEM (National Trip End Model) projections."*. As outlined in Section 7.2, the model will seek to maintain consistency of demand segmentation with NTEM.

NTEM will also be used as a starting point for the base year land use and planning assumptions, as it essentially provides an update to 2011 Census data taking into account projected trends in housing, employment and demographics. NTEM is however a high-level projection which is recently updated in 2022, and can be complemented and enhanced using the following datasets:

- Office for National Statistics mid-year population estimates: provides more detailed age breakdowns, to be used to differentiate children and elderly (see Section 7.2.3);
- The Business Register and Employment Survey (BRES) employment data and Annual Population Survey available via NOMIS website: estimates of employment, population and certain demographic/economic segments are available, and can be used to improve NTEM projections for 2023 in the study area;
- Ordnance Survey AddressBase data for land use information: provides address-based information on residential and commercial properties, which can be used to provide spatially precise information on development levels;
- Information from Local Authorities about the housing and employment development sites between 2021 census to 2023

The NTEM, Census (2011 or 2021 based on the availability) and ONS data are freely available though special licences are required for some BRES data, whilst AddressBase should be obtainable via CPCA. The datasets will be combined with information readily available from the Local Authorities to create the best possible estimate of land use and planning data for the base year.

Travel demand in the base year, in the form of trip productions, will then be calculated using trip rates from NTEM 8.0 or derived from NTS data.

School Census data for 2022 will be downloaded from the Government statistics website https://www.gov.uk/government/statistics/ for maintained and independent schools to understand the distribution of education attractions within the internal area.

### 8.3.1. NOMIS statistics

NOMIS is a collection of population and labour market statistics maintained by the Office for National Statistics (ONS). The NOMIS website has been used to access:

- Population Estimates: Mid-year population estimates are the official source of population sizes in-between censuses, rolling forward the population found by the previous census, one year at a time by accounting for births, deaths, international migration and internal migration; to accomplish this multiple registration, survey and administrative data sources are used. It adopts census definition of people who are “usually resident” in the UK for 12 months, excluding short-term migrants, and counting students at their term-time addresses. It covers populations of local authorities, counties, regions and countries of the UK by age and sex. The estimates below LAD level are a bit drifting and therefore less reliable.
- Annual Population Survey (APS): The APS is a continuous household survey, covering the UK. The topics covered include employment and unemployment, as well as housing, ethnicity, religion, health and education. It provides the estimates of the number of people in employment or unemployed.
- Business Register and Employment Survey (BRES): The BRES is an annual employer survey of the number of jobs held, broken down by industry. It is the official source of employee and employment estimates by detailed geography and industry and can be used as an observed comparator dataset for the forecast jobs growth provided by other datasets e.g., NTEM. It should be noted however that BRES is a sample survey and subject to some variation between years which is understood to be due to sample size. Therefore, it is important to analyse and observe trends before using the data and to use the data at a suitably aggregate spatial level.
- Job density: The total number of jobs estimated by Job Density is a workplace-based measure and comprises employee jobs, self-employed, government-supported trainees and HM Forces.

Population Estimates as well as APS estimate population and their economic activities at residence end whilst BRES and Job density measure jobs and employees at workplace end.

These are useful in helping to understand the change in population (either residents or workplace population) since the 2011/2021 Census, as they are the only empirically based annual measures currently available and can be used to adjust both Census and NTEM data. It is important to note, however, that NOMIS statistics are estimated from samples of the population, and as such cannot be considered a definitive, or completely accurate representation of patterns (and less representative than a full census dataset).

### 8.3.2. National Travel Survey (NTS)

The NTS is an ongoing household interview and travel diary survey designed to provide regular, up-to-date data on personal travel and monitor changes in travel behaviour over time. The survey provides detailed information on different types of travel: where people travel from and to, distance, purpose and mode. The NTS records personal and socio-economic information to distinguish between different types of people, and the differences in the way they travel and how often they do so.

Available NTS data ranges from 2002 to 2021 and covers personal travel by residents of England travelling within Great Britain, from data collected via interviews and a seven-day travel diary.

The Special Licence version (SN 7553) contains more detailed travel, demographic and socio-economic data, and the geographic level is Local Authority/Unitary Authority. This licence will be requested and obtained so that NTS data related to the study area / similar areas may be used. The NTS data sample is very small and geographical breakdowns are particularly weak. Hence data will need to be aggregated across a wide area and multiple years to ensure an adequate sample size. NTS data would be used to provide:

- Trip rates by person type (if not using NTEM directly);
- Time of day profiles by purposes, mode and traveller type;
- Trip length profiles by purpose and mode; and
- Mode choice profiles by purpose and traveller type by home area type (urban / rural);

National data is published by the DfT online. Detailed analysis of the raw NTS dataset for CPCA will be conducted as part of model development. As noted the sample size within CPCA region will be limited. Accordingly, our use of the raw data will be limited to trip rates, mode shares, trip lengths and other useful aggregate measures.

### 8.3.3. Census data

Data from the 2011 Census still provides an extensive source of data on the breakdown of population in the county, and economic circumstances that inform travel patterns, though it is now very dated and unlikely to be representative of commuting patterns in areas which have undergone significant changes in the past ten years.

The Census 2011 Journey-to-work (JTW) data is a vital component of the base year model building and calibration. This data provides a complete picture of the home and work locations of employed people, as well as the method of travel to work, for 2011. It is noted that the data represents the home location, usual workplace and their usual mode of travel to work. No information is provided on actual daily individual trips. The total volume of people in the Census JTW data is greater than observed daily trips as not everyone goes to their usual workplace every day. These are compiled to allow calibration of mode share, trip lengths and patterns of travel in the demand model as well as being used as a comparator dataset during base matrix development. Census JTW data can be downloaded for each MSOA within England and Wales. This dataset details how individuals completing the 2011 Census stated that they travel to their regular place of work.

The first results of Census 2021 are now available and more data is expected to be released over the next year. Where feasible, an attempt will be made to use the 2021 data. However, as for the 2021 Census the COVID-19 travel restrictions/advice was still in place, the data is expected to show very high levels of home working.

### 8.3.4. AddressBase database (ABD)

AddressBase Data (ABD) provides a source of residential and commercial property data which allows identification of individual properties, including year of first occupancy or change of use. This can be used to understand the change in land use (from 2011 to the 2023 base year) at a spatially detailed level.

### 8.3.5. Annual Monitoring Reports (AMRs)

Annual Monitoring Reports (AMRs) are produced annually by local authorities to review progress against their latest adopted Local Plan. A range of measures are reported on, including the number of dwellings that have been built out or demolished over the course of the year within the local authority. These provide a clear record of the residential growth (and demolitions) the Local Authority is aware of within their district and can be used as a comparator dataset, along with the AddressBase data, to validate the NTEM household data.

AMRs for the historic years will be obtained for each of the local authorities within CPCA.

### 8.3.6. School capacity data

The school census is carried out each year and every school is required to submit information, including capacity data, to the Department for Education. School capacity data for the latest available year will be downloaded for all of England and then filtered to only include schools within CPCA.

## 8.4. Trip Matrix and Distributional Data

### 8.4.1. Base year demand

There is no single source of data which would provide all the information required for satisfactory trip matrices. It is therefore critical to maximise the quality of the trip matrices by integrating information from a range of data sources, including:

- Mobile network data (MND) for trips intercepting a cordon containing the study area (i.e. trips within, into, out of or through the study area for a neutral period in 2023). TAG advises to collect data over 3 months if day-to-day variability needs to be studied. The time period, days of the week, segmentation required will be agreed with CPCA before commissioning the data collection. A mobile network data (MND) provider will be chosen by competitive tender to provide demand data for a matrix of movements covering the study area (in detailed zones) and the rest of GB at a more aggregate level.
- Public transport ticket data from bus and rail companies;
- Face-to-face public transport surveys
- National Rail Travel Survey (NRTS) data
- INRIX (formerly Trafficmaster) LGV OD data;
- Continuing Survey of Road Goods Transport (CSRGT) for HGV;
- National Travel Survey (NTS) data;
- Planning data used to derive trip-end estimates;
- The DfT's National Trip-End Model (NTEM);
- Existing and new traffic counts for trunk and motorway networks and for local authority roads; and
- ANPR data available for the Cambridge Area from 2017.

If deemed suitable, 2011 Census data will be further used in matrix development and verification as follows:

- Census population totals and Journey to Work (JTW) totals to compare against MND trip ends
- Census JTW trip distributions

This data is provided by Office for National Statistics (ONS). Census Data Census journey to work data can be downloaded from the Government data website http://data.gov.uk/ and also at http://www.nomisweb.co.uk/.

### 8.4.2. Time period profiles – NTS / traffic counts

Trip time of day profiles will be derived from existing and collected data sources, such as:

- National Travel Survey (NTS) data;
- Traffic counts for trunk and motorway networks and for local authority roads; and
- ANPR data available for the Cambridge Area from 2017.

## 8.5. Network Data

The following are the key data sources that will be utilised to develop the CPCA model network:

- Existing models described in chapter 3.1;
- OS MasterMap Highway Layer (available via DfT as part of licence for INRIX)
- Traffic signal specifications
- OpenStreetMap walk and cycle link data (from https://www.openstreetmap.org);
- National Rail network shapefile
- National Public Transport Access Nodes (NaPTAN);
- Bus and Rail timetables (BODS and ATOC):
- Basemap TRACC;
- MOIRA Rail timetables;
- Aerial photographs
- Online mapping and satellite imaging such as Google Maps and StreetMap

### 8.5.1. Signal timings

Data will be required for signal-controlled junctions. This will be based on staging plans provided by the local authorities where possible. Where average green time data exist, these data will be used in the model directly, with averages or assumptions required for some junctions. Intergreen times will be taken directly from signal timing sheets.

As level crossings wil be modelled as a form of signalised junction, data will be required on barrier down times during the modelled periods and the impact on the flow of traffic.

### 8.5.2. Parking costs and supply

Car park data will focus on the following key areas for the internal model area. No parking information will be collated for the external model area.

- Railway station parking – capacity, occupancy counts (if available) and parking charge information;
- P&R sites – capacity, usage counts (if available) and parking charge information; and
- Area-wide parking charge information (with capacity information for major parking locations).

Requests for the above car park data will be sent to the Local Authorities. If no data can be provided, data will be trawled from the open source Parkopedia website: https://en.parkopedia.co.uk/

P&R usage data will be requested for Local Authority operators for all existing formal P&R sites. Usage and occupancy data for Major station car parks will be requested from Network Rail. This information will be used both to develop base year highway and PT matrices (so that they reflect both car and bus trips to and from the P&R sites) as well as in calibration of the base year P&R model choice model.

### 8.5.3. PT service information / timetables

The information on bus rail routes and service schedules will be obtained from Bus Open Data Service[3] (BODS) in General Transit Feed Specification (GTFS) format to build the model network.

The primary dataset for rail schedules will be sourced from Association of Train Operating companies (ATOC) in GTFS format. Rail schedules will be checked against MOIRA and operator websites, particularly regarding routing and for services where possible.

Timetable data defines bus routes as a sequence of stops along the route but does not provide details of the route between stops. Modelling software typically selects the shortest/fastest route between stops which can be different to the route actually taken. Exact routing between stops don't define the travel time as it is based on scheduled information, but the route course will have an impact on bus vehicular flows transferred to highway assignment. So, once the stopping patterns of routes have been established on the network it is necessary to manually check and edit where necessary the routing between stops.

### 8.5.4. PT fares

Fare systems and charging rates will be obtained from BODS in NeTEx format and will be sense checked against the data available from the operator websites. Public transport assignment softwares typically allow a

[3] https://www.bus-data.dft.gov.uk/

range of fare systems including distance based, station-station, cordons and flat fares. A detailed evaluation of different fare types available in the study area and appropriate fare systems will be used in the assignment model. We have automated processes to extract numerous station to station rail fares for different ticket types. Operator data will be obtained to undertake an analysis of concessionary fares available and used so that fares charged represent typical average fares paid for each journey purpose. Fares will be varied by time period and trip purpose (concessionary fare for education trips for example).

### 8.5.5. TAG databook – values of time, vehicle operating costs

VoTs and VOCs will be derived from the TAG databook current at the time of implementation, the forthcoming version of which is November 2022. The base year vehicle operating costs (VOCs) will be calculated using the standard formulation set out in the TAG databook. In line with guidance, fuel costs will be included for all trip purposes, whilst non-fuel costs will only be perceived by the employer's business trips.

## 8.6. Highway model data

### 8.6.1. Traffic count surveys

TAG recommends long-term count data to be used in model development due to the greater level of accuracy that such data provides compared to two-week automatic traffic count data or one-day manually observed counts for links and turns. However, traffic surveys are essential to fill the data gaps. Additionally, manual observed count surveys provide valuable information in terms of vehicle composition. Manual turning count surveys need more time and effort but are useful for validation of junction turn flows. Turning counts are caried out in the same manner as manual counts for each turn. The existing permanent counter data will be collated and mapped to understand the data gaps before commissioning these traffic surveys.

All survey data will be checked for bias due to any unusual events and investigated thoroughly for outliers.

### 8.6.2. Definition of set of screenlines and cordons for highway calibration and validation

All the available count data will be collated and mapped to design a series of screenlines and cordons to assist the model calibration and validation. Additional traffic data surveys will be commissioned to fill the gaps in designed screenline and cordons. These collections of counts, when aggregated to form boundaries along or around areas, provide useful measures of total volumes entering or leaving areas in the model. TAG unit M3.1 advises a minimum of 5 counts for each screenline with comparisons to be presented with and without motorway counts included for each screenline.

### 8.6.3. Highway journey time routes

It is not proposed that any form of travel time surveys will be undertaken as part of the primary data collection activities.  Data from INRIX will be available for travel time across most roads derived from Global Positioning Systems (GPS) data from in-vehicle technology. This data will have much larger sample-sizes than any form of Moving Car Observer (MCO) based primary data collection that may otherwise be undertaken; however, this does not remove the requirement to review and understand the level of confidence in the data.

Checks will be undertaken on speeds within the proposed model time periods, against free flow speeds (off peak speeds as well as posted speed limit data) to ensure that the expected patterns of speed changes are observed between modelling time periods. INRIX data also provides confidence intervals around link travel times; this will be investigated and any data uncertainty reporting in the data collation report.

These INRIX travel times will be used to validate the modelled highway journey times in the model.  The data will be interrogated on a link basis and the observations for a sequence of links making up a determined journey time route will be summed to provided junction-to-junction (model link) travel times.

## 8.7. Public Transport model data

### 8.7.1. Rail station usage data

The Office of Rail and Road (ORR) publishes rail statistics about rail performance, usage and safety on an annual basis. This data is publicly available via the ORR website (http://orr.gov.uk/statistics), with detailed data accessed via an online portal. Relevant data for Cambridgeshire area will be downloaded from the ORR website including station usage statistics and regional rail usage statistics, summarising the level and distribution of annual passenger journey. The station usage data provides an estimate of annual railway station passenger entries/exits and interchanges for each financial year from 1997/98 to 2021/22 (except 2003/04).

### 8.7.2. Rail passenger data

Greater Anglia's (GA) version of MOIRA will be procured for this study. Both the demand (ticket sales) and supply (timetables) will be procured from the Rail Delivery Group for year 2022/23. Demand data is available as annual datasets of "Year to March" and "Year to September" and the timetables are available as summer and winter versions. Further, the ticketing data is split by ticket type (full, reduced and season). Wednesday, December 2019 train timetabling data from MOIRA is used to provide the profile of demand by time of day (AM peak, inter-peak, PM peak and evening/overnight).

MOIRA journeys data specific to the Greater Anglia's franchise area can be obtained. The dataset is commercially sensitive and will be used with permission from Rail Delivery Group, subject to following conditions.

- Journeys only, not revenue data, is provided;
- Data to be used for the CaPCAM model development current work only, and deleted once the work is complete;
- All outputs are treated confidentially and only aggregations are published.

### 8.7.3. National Rail Travel Survey (NRTS)

None of the rail ticketing datasets provide information about the true origin/destination (home or attraction end) of the trip as they all focus on the station-to-station travel patterns. However, it is helpful to understand the rail station catchments, mode of access/egress and purpose splits for the rail matrix development rather than relying entirely on synthesised results from the VDM.

National Rail Travel Survey (NRTS) data will be obtained from the DfT and reviewed to inform the rail station catchments and mode of access/egress to rail stations in CPCA area. This data is very old and based on a sample of passengers surveyed and hence will be of limited value particularly given the opening of Cambridge North station. The majority of the data was collected in 2001 from London Area Travel Survey (LATS) project, with newer national data collected between 2004 and 2005. The data represents weekday travel outside school holiday periods. Although the NRTS surveys were undertaken in 2000s, the dataset provides the most granular information for rail travel. Given that the data is old, care will be taken to ensure it is used sensibly for the rail matrix development. Also, necessary sense checks will be undertaken by comparing it with aggregate information available for the most recent years.

### 8.7.4. Bus Electronic Ticketing Machine (ETM) Data

Bus ETM data will be acquired from major bus operators in the study area. These datasets provide useful information about the boardings by route, time, ticket type and farestage (a small group of bus stops). It is to be noted that alighting fare stage is unavailable for significant proportion of ticket sales such as season ticket sales, day riders etc. and is only accurate for ticket types such as Single, Return tickets.

Data variability analysis will be undertaken to identify any unusual events and extreme outliers.

### 8.7.5. Public Transport Surveys

After discussions with the client, public transport surveys will be commissioned to facilitate a robust model build. It is essential understand travel patterns, mode of access/egress, station catchments and trip purpose to realistically represent the demand in the model. It is expected that the surveys will be commissioned at both rail and bus stations. Different types of public transport surveys that can be commissioned are listed below-

- Entry/Exit surveys
- Occupancy surveys
- On-board face-to-face/self-completion surveys
- At station face-to-face/self-completion surveys

Each of these surveys have their own advantages and disadvantages. TAG unit M1.2 advises about the preferred approach for the public transport surveys and due consideration will be given to this advice depending upon the other constraints. This survey data is expected to be used in conjunction with the ticketing machine data.

### 8.7.6. PT Screenlines/Cordons

Validation of public transport trip matrix involves comparison of assigned flows against passenger counts across complete screenlines and cordons. Bus occupancy surveys will be commissioned to arrive at passenger counts at service level aggregated to link level. Occupancy surveys can sometimes be combined with on-board surveys with enumerators recording the total passengers within the bus along with total boarders/alighters at each stop.

Estimates of passengers counts made by observers standing at the roadside are not generally accepted as they are not sufficiently accurate for modelling purposes, and it is essential to seek permission from operators to stop the service and enumerator records the total passengers by boarding the service at required cordon/screenline points. Screenlines and cordons will be designed to understand the total volumes entering and leaving key areas with due consideration for major public transport hubs and corridors.

### 8.7.7. P&R site usage – cars, bus passengers, other modes (park & cycle, walk & bus)

To robustly model park & ride sites, it is essential to understand the public transport ridership, the supply of parking and fares. Ticketing information from the operators will be acquired to understand the boardings at each P&R site. Information from electronic parking payment machines or vehicle loop detectors (where available) will be requested to understand the parking usage. Duration of stay by trip purpose and number of vehicles entering and leaving the P&R site for each modelled time period will be studied. If needed, interviews will be conducted to understand the mode of access, true origin/destination (catchment), trip purpose and duration. The information needed is similar for both bus P&R and rail stations.

### 8.7.8. Cycle counts – screenlines

CCC's annual cycle route monitoring sites provide pedestrian and cycle counts at key locations and the classified counts for the Cambridge radial cordon and river screenline provide data which can be use for active mode calibration and validation.

At this stage it is not anticipated that the walk and cycle assignment would be validated outside Cambridge. Should this be required, eg for Peterborough, additional data and resource would be required.

# 9. Forecasting

## 9.1. Introduction

This chapter summarises the plan for the forecasting and the treatment of uncertainty in relation to supply and demand changes. Our proposal is for two main scenarios to be built initially which are expected to act as the point of reference for scheme development and appraisal.

1. The Local Plan scenario
2. NTEM growth scenario

It also discusses about the potential sensitivity tests (section 9.4) that can be undertaken to understand the model behaviour ahead of using the model for scheme appraisal. These sensitivity tests are not included in the current scope of the work and could be commissioned post discussing with the client close to the completion of the base model build.

## 9.2. Forecast scenarios

### 9.2.1. Local Plan scenario

The Local Plan scenario is assumed to be the "default" forecast for future travel demand and supply for CaPCAM, including:

- Development sites and schemes in line with a managed Uncertainty log;
- Growth in employment, housing and population in CPCA authorities in line with locally agreed variants (e.g., Local Plan);
- Trends in demographics, car ownership, household size and types of employment in line with current NTEM;
- External development growth in line with the current NTEM forecasts, or variants agreed with neighbouring authorities where appropriate; and
- Economic inputs and cost parameters4 following 'default' TAG assumptions.

### 9.2.2. NTEM growth scenario

The NTEM growth scenario is based on the forecasts contained in the Department for Transport National Trip End Model (NTEM) dataset. The NTEM V8.0 Core Scenario growth trends will be used for this forecast scenario development. It is expected that the local plan scenario forecasts will form the patterns of growth for the NTEM Growth scenario where the growth will be constrained to NTEM forecast growth at either district level or for the modelled area (Cambridgeshire and Peterborough).

It is to be noted that NTEM V8.0 also provides several other scenarios such as low, high, behaviour change and a regional scenario. The proposed scope of work includes the assessment based on the NTEM Core scenario and if there is a need, forecast scenarios based on the other NTEM scenarios will be discussed with the client and commissioned as necessary.

### 9.2.3. Purpose of the scenarios

Depending on the context of the scheme appraisal, either the Local Plan scenario or the NTEM growth scenario is expected to act as a 'Do Minimum', though it is likely that some adjustment will normally be needed. The purpose of these scenarios is:

- To provide a common reference point from which other scenarios can be created, including Do Minimum cases for testing specific policies/schemes;
- To facilitate the creation of the necessary processes and logs to create and manage future CPCA scenarios; and
- to illustrate credible operation of the model, mainly in respect of its response to future demand drivers (changes in population and employment).

[4] Vehicle operating costs and values of time based on national GDP growth assumptions

## 9.3. Uncertainty and other assumptions

### 9.3.1. Treatment of Uncertainty

The Local Plan Scenario would seek to represent a “Default” scenario which can act as the point of reference for investigation, scheme development and appraisal. As such, following TAG Unit M4 guidance it should look to include all developments and schemes either complete since the base year or classified as either ‘Near Certain’ or ‘More than Likely’ (as per definitions set out in TAG unit M4 Table A2). These known future changes would be compared against growth projections in the NTEM Version 8.0 dataset to understand the key differences. The aim would be to compare specific growth information available locally (e.g. developments in the Uncertainty Log, and any local projections of employment and demographics) with the information in NTEM.

As such, the Local Plan Scenario aims to be:

- Unbiased (as likely to be over or under achieved, given existing plans and evidence)
- Coherent and self-consistent (if X is unlikely to go ahead unless Y also goes ahead, then X should only be included if Y is also included); and
- Realistic and plausible.

In short, it will represent a scenario based on the most unbiased and realistic set of assumptions that will form the point of reference for further investigation (such as scheme appraisal, development of lane use strategy or analysis of behaviour change).

For the NTEM Growth Scenario, the Local Plan growth will be constrained in line with NTEM V8.0 core projections (as required for scheme appraisal work seeking funding from / approval by DfT). This would be agreed following the comparison of Uncertainty Log assumptions against overall projections within NTEM V8.0.

There is of course considerable uncertainty about how the transport system will evolve in the future, particularly with the potential for emerging trends in behaviour and technology to drive significant change over time. To ensure decision making is resilient to future uncertainty, decision makers need to understand how the outcomes of spending and policy proposals may differ under varying assumptions about the future. Analysis and presentation of uncertainty enables analysts, scheme promoters, and the decision makers they support, to better recognise and account for the uncertainty they face.

### 9.3.2. Uncertainty log

It is assumed that CCC and PCC will collate the information from the local authorities and provide us with an uncertainty log of committed local supply and demand changes. The Log should include all known developments regardless of their likelihood then categorised in line with TAG unit M4 definitions (set out in Figure 9–1). It is assumed that all committed “supply” scheme designs or model assumptions, and location and scale of demand (development) will be provided as well.

This work includes the provision of the Uncertainty Log, and selection / clarification of the developments and schemes to be included in the forecast scenarios with sufficient detail as per model needs. Processes for the management and upkeep of the Uncertainty Log are advisable but are not included here.

It is expected that uncertainty log provided below information shown in Table 9 to realistically represent them in the model. An example template will be shared with CCC and PCC.

**Table 9-1 – Uncertainty log information**

| Type | Required Information |
|---|---|
| Housing development | Location, Number of dwellings, Opening year, Phasing schedule, Population (optional), Planning application status, Uncertainty |
| Employment/Retail development | Location, Number of jobs, Gross Floor Area, Type and classification of landuse, Opening year, Phasing schedule, Planning application status, Uncertainty |
| Schools | Location, number of school places, Primary/Secondary/Tertiary, Uncertainty |
| Road schemes | Opening year, Detailed Scheme Plan with lane allocation, Signal plans if available, Uncertainty for both local and national schemes |
| Car Parks | Location, number of spaces, fare, restrictions (if any), Uncertainty |

| Type | Required Information |
|---|---|
| Public Transport Schemes | Opening year, Detailed scheme plan, Dedicated right of way/ shared use, Service Frequency, Stopping frequency, travel times, Fare structure, Uncertainty for both local and national schemes |
| Park & Ride | Refer PT schemes + parking spaces, parking fee, restrictions or incentives for users (if any) |
| Cycle infrastructure | Opening year, Dedicated right of way/ shared use, Gradient, Crossings, Advanced stop lines |

Figure 9–1 – DfT TAG Uncertainty Log definitions[5]

**Table A2 Classification of Future Inputs**

| Probability of the Input | Status | Core Scenario Assumption |
|---|---|---|
| Near certain: The outcome will happen or there is a high probability that it will happen. | Intent announced by proponent to regulatory agencies.<br>Approved development proposals.<br>Projects under construction. | This should form part of the core scenario |
| More than likely: The outcome is likely to happen but there is some uncertainty. | Submission of planning or consent application imminent.<br>Development application within the consent process. | This could form part of the core scenario [Refer to Section Developing the Core Scenario] |
| Reasonably foreseeable: The outcome may happen, but there is significant uncertainty | Identified within a development plan.<br>Not directly associated with the transport strategy/scheme, but may occur if the strategy/scheme is implemented.<br>Development conditional upon the transport strategy/scheme proceeding.<br>Or, a committed policy goal, subject to tests (e.g. of deliverability) whose outcomes are subject to significant uncertainty | These should be excluded from the core scenario but may form part of the alternative scenarios |
| Hypothetical: There is considerable uncertainty whether the outcome will ever happen. | Conjecture based upon currently available information.<br>Discussed on a conceptual basis.<br>One of a number of possible inputs in an initial consultation process.<br>Or, a policy aspiration | These should be excluded from the core scenario but may form part of the alternative scenarios |

### 9.3.3. Forecast years

It is assumed that three forecast years will be included for both the Local Plan and NTEM Growth scenarios, this will be determined after discussing with CPCA. Based on the initial discussions, forecast years are expected to be 2031, 2036 and 2041.

### 9.3.4. Supply assumptions

We have assumed that there is a moderate amount of change from the base year in both the highway and public transport supply (network) changes. It is assumed that this might require coding up to 10 corridor changes. If schemes that require considerable time inputs are identified within the uncertainty log, scope and budget will be additionally agreed with CPCA.

### 9.3.5. National forecast parameter assumptions

The latest DfT TAG databook values will be assumed as the starting point for any data unless it is locally available. DfT NTEM8 "core" scenario is assumed as the basis for the NTEM Growth scenario. Any amendment will be clear and transparent and will be agreed with CPCA. The nature of changes which could be adjusted are presented in section 9.4 as part of one of the sensitivity tests.

[5] Source: TAG unit M4 - Forecasting and Uncertainty

## 9.4. Sensitivity Tests

It is essential that there is a clear and well-managed process for creating alternative scenarios. It is envisaged that over time a variety of scenarios for development, demand, infrastructure, and other aspects will be created. These would preferably be available to re-use in whole or part for future studies, and the Local Plan Scenario itself will be expected to evolve over time.

To establish a robust process for scenario generation and understand the model behaviour in advance of the scheme testing, type of sensitivity tests that can be undertaken are set out in shown in Table 9.These tests will demonstrate how the model responds to user specified changes in inputs, model strengths/weaknesses and ensure that model responses are satisfactory. The sensitivity tests are intended as “softer” tests compared with the more rigorous validation and realism testing. These are not designed to exhaustively test all model functionality, or responses to all possible tests, but to demonstrate overall model functionality and responsiveness.

Additionally, the DfT Uncertainty Toolkit (published August 2022) states that analysis should not focus exclusively on a “Core Scenario” and the consideration of wider “what if” scenarios should be undertaken. It introduces the six Common Analytical Scenarios – which are central to how the DfT intends to approach uncertainty in transport analysis. This includes:

- High Economy
- Low Economy
- Regional
- Behavioural Change
- Technology
- Decarbonisation – Vehicle led
- Decarbonisation – Mode-balanced

The Toolkit sets out how these scenarios should be considered and when it is proportionate to do so. It is important to have an awareness of these requirements and to consider the need for these in future scheme appraisal. It may also be necessary therefore to consider whether tests of the Common Analytical Scenarios will be needed.

As well as ensuring that the model runs technically, it is important that the model is demonstrated to produce sensible results and that stakeholders understand, and are satisfied with, the way the model runs and the nature of the results produced.

**Table 9-2 - Sensitivity test summary**

| Test and theme | Description |
|---|---|
| 1 Demand growth | Growth in travel demand including changes in car ownership |
| 2 Highway supply | Changes to highway infrastructure in some areas |
| 3 PT changes | Changes to supply of bus or rail services in some areas |
| 4 Targeted road user charging | Distance based charge on subset of the highway network |
| 5 Urban area | Change to urban areas via speed limits and potentially parking charges, walk and cycle strategies. |
| 6 NTEM Common analytical Scenarios | Wider “what if” scenarios as listed in the DfT Uncertainty toolkit |

It is to be noted that the current scope of work doesn’t include these sensitivity tests and will be agreed additionally with CPCA close to the completion of the base model build.

# 10. Outputs and analysis

## 10.1. Standard analyses

A standard suite of analyses will be produced during the development of CaPCAM that can be used to rapidly analyse model runs and aid interpretation of results.

Inputs of land use (employment and dwellings), trip generation and outputs of mode shares, distribution patterns, trip length distributions, down to detailed analysis of flows assigned to the modal networks and individual junction delays will be generated for each time period modelled and available at the modelled level of segmentation and aggregated summaries.

A suite of standard sector systems with varying degrees of detail will be developed during model development for use in the analysis of model runs.

Where possible this standard set of analyses will be generated by automated processes to aid rapid understand of results.

### 10.1.1. Mapping

Mapping of model outputs will be central to the interpretation of CaPCAM runs and GIS software, Visum's built-in mapping functionality, and the Atkins Data Viz (ADV) tool will be used as appropriate to provide visualisation of model outputs at the node, link, zone and sector level.

There are various GIS packages available on the market. For ease of access, we recommend QGIS as it is open source, widely adopted, and provides all the necessary functionality.

The ADV tool will provide access to visualisation of model outputs via a modern web browser, without the need for specialist GIS or modelling software.

## 10.2. Appraisal requirements

CaPCAM is intended to be used to assess transport interventions using the DfT TAG process. Outputs from CaPCAM may also be required for separate downstream environmental, economic, social and operational assessments. These will typically comprise of standard outputs from the model, however the interface between them and CaPCAM is not included in this specification. It is recommended that CCC engage with the specialist teams who are likely to utilise the outputs and ensure the model will be able to meet their requirements.

### 10.2.1. Environmental assessment

CaPCAM will be capable of highlighting the impacts of changes at a strategic travel, which can be used for input to separate air quality and noise models for appraisal. The model will be capable of outputting actual and demand flow changes, average speeds, and indication as to the levels of congestion on a link-by-link basis. The model will be able to produce outputs in formats typically required by these teams (24-hour Annual Average Daily Traffic and 18-hour Annual Average Weekday Traffic).

In addition to this, the model will be capable of producing carbon emission statistics at the individual link and aggregate zone, sector, district or study area level. Note that the model will not provide embedded carbon values – these will need to be provided externally.

### 10.2.2. Economic appraisal

CaPCAM will be capable of producing outputs for use in typical economic assessment, such as input into the DfT's TUBA and WITA software. It will also be capable of producing outputs to inform COBALT accident assessments and a range of other typical economic appraisal packages.

### 10.2.3. Social impacts

CaPCAM will be capable of highlighting the impacts of changes in strategic travel on social measures. In particular, the visualisation and mapping outputs will provide data which can be used to visualise: speed change, severance, accessibility and distributional impacts.

The demand model will provide more segmented results enabling scenario impacts on modal shift or redistribution to be associated with particular categories of trip.

### 10.2.4. Operational assessment

CaPCAM will be able to act as a donor to local, operational models or cordon regions (such as micro-simulation (PTV Vissim, Paramics etc.) and local junction software including LinSig and ARCADY. Although CapCAM will donate information for more local models, more detailed validation will be required and local enhancements are likely the be required for application to schemes seeking funding.