Salisbury Transport Models

DRAFT PD 2.1 Model Specification

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Notice

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Contents

Section **Page**

List of Tables

List of Figures

1. Introduction

Commission

1.1 Wiltshire County Council commissioned Atkins to develop Transport Models for Salisbury in September 2008. The commission was a response to a need to test the impact of significant proposed development in the Salisbury area.

1.2 This Model Specification Report is the second deliverable in this commission and describes our approach to and specification of the following models:

- Variable Demand Model;
- Highway Model;
- Public Transport Model;
- Micro-simulation Model;
- Parking Model; and
- Public Transport Cost Model.

Background

1.3 The Secretary of State's modifications to the South West Spatial Strategy shows that Salisbury City is required to accommodate a 8,700 new dwellings and provide 13,500 new employment opportunities by 2026. A range of potential sites have been identified. In addition, in Wilton there is the potential major site currently used by the MOD (Land Command) that may be vacated by 2010 and be available for re-use. The strategy identifies sites in and around Salisbury, including potentially major changes in land use through the redevelopment of Churchfields and new developments to the north-west and south of the City.

1.4 As such, the Salisbury Transport Model (STM) must be able to:

- identify the impact on the transport network of locating development in each of the strategic residential and employment sites;
- identify the potential for maximising the use of public transport (PT), walking and cycling for movements to from and within sites;
- identify the potentially significant switches in travel patterns arising from major changes in employment type and location – specifically Churchfields, the Netherhampton Road site and the MOD site at Wilton (if vacated);
- assess the potential impact on movements to/from Salisbury arising from the location of development outside Salisbury and Wilton; and
- support the District Council through the Local Development Framework (LDF) process and any subsequent statutory processes.

1.5 Our response to these needs is to develop a fully up-to-date and appropriately validated area-wide traffic model of the Salisbury and Wilton area, supported by a demand model that is capable of representing the effect of mode switching and re-distribution of travel patterns as land uses change (macro modelling) and a detailed micro-simulation model of specific areas to view the impact of changes to land use and transport provision in more detail (micro modelling)

1.6 The "macro-level" multi-modal model of Salisbury that represents movements to the city from its rural hinterland; through traffic, particularly that using the A36; and public transport movements including rail and park-and-ride.

1.7 This model will be able to represent the impact of land use changes on travel demands and network performance – specifically being able to asses the impact of different development locations, scales of development and type of development including the impact of sustainable development principles. The model must also assess the impact of different trip distribution patterns arising from in-commuting from the City's hinterland.

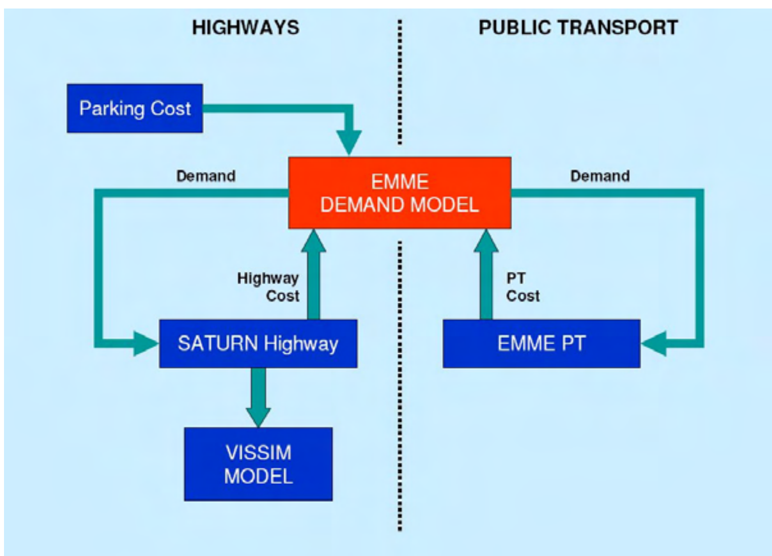
1.8 Our approach to this "macro-level" model is developed using:

- SATURN to represent the highway network and highway travel demands;
- An EMME model representing the public transport network – with individual bus, rail and park and ride services coded. This will link to a public transport cost model that will permit the additional costs and revenues of bus service changes to be derived (which will be critical for the business case for public transport enhancements);
- An EMME demand model representing modal switching and redistribution effects – including a mechanism for representing transfer to walk and cycle for short-distance trips; and
- A specially developed parking supply model to represent the cost and supply of off street and central area on-street and private non-residential parking supply. This will link to the demand model to ensure that parking restraint impacts upon choice or mode and destination.

1.9 The "micro-level" simulation model of central Salisbury and the Eastern Gateway/Southampton Road that enables different traffic management options to be explored and designs developed and assessed; acts as a design and consultation tool that can assist in the development and implementation of the Vision's urban realm strategy. For this we will be using a micro-simulation model that will be developed using VISSIM – linked to the SATURN highway network and making use of 3-D visualisation tools.

1.10 Figure 1.1 displays the linkages between the modelling framework.

Figure 1.1 - Modelling Components and Linkages



1.11 The model study area is shown in Figure 1.2. The core area covers the entire Salisbury and Wilton urban area. The hinterland extends beyond this area, but in considerably less detail.

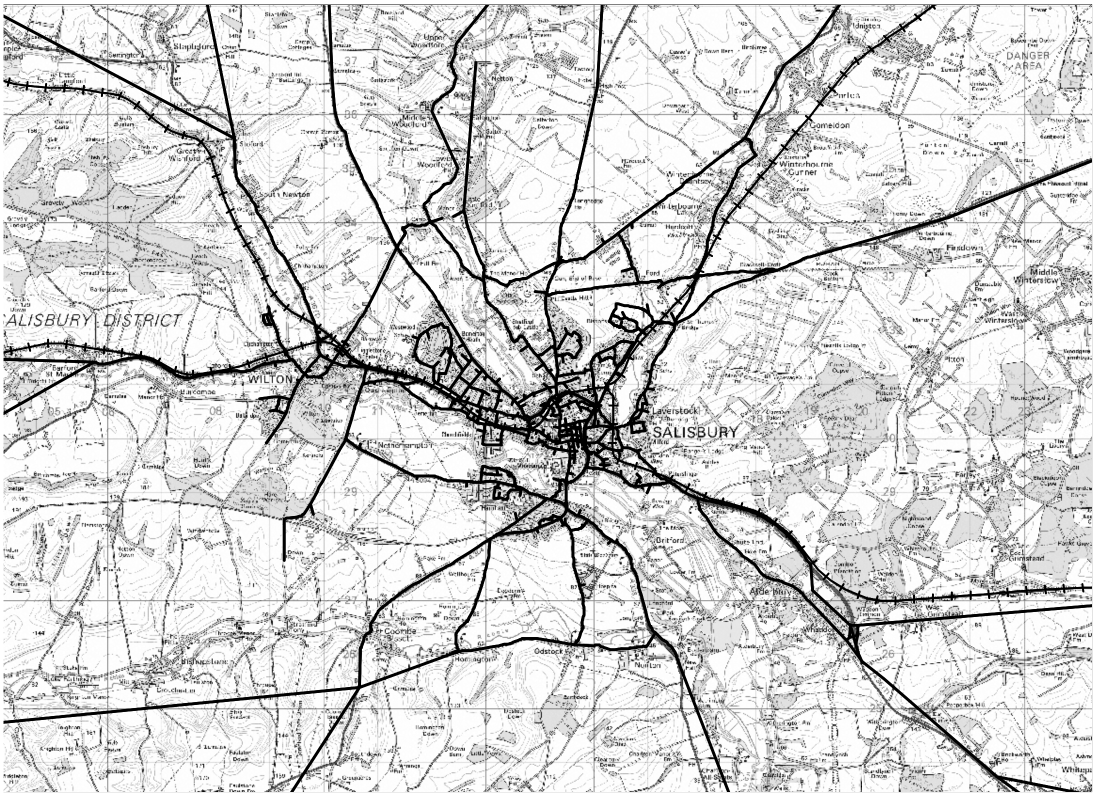


Figure 1.2 – Core Study Area

This Report

1.12 This report will define the multi-modal modelling framework required as part of the 2008 Salisbury Transport Models (STM) and forms project deliverable PD2.1 Model Specification. This report contains chapters that describe the specification of the STM, the components of which, and subsequent project deliverables, are shown in Table 1.1.

Table 1.1 - Model Components

Model Component	Sub Component	Product
Highway Models	Strategic Highway Model	PD2.2 Highway Model Validation Report
	Local Micro-simulation Model	PD2.5 VISSIM Model Development Report
Public Transport Model	none	PD2.3 Public Transport Validation Report
Demand/Mode Choice	Demand Model	PD2.4 Demand Model Development Report
	Parking Demand Model	
	Public Transport Cost Module	

1.13 The report is understandably technical by nature. It could be seen as a series of Technical Notes that describe modelling processes and methodologies to be adopted. The following chapters are included in the report:

- Chapter 2 describes the demand model specification;
- The highway model specification is contained within Chapter 3;

- The public transport model specification is contained within Chapter 4;
- Chapter 5 describes the development of the micro-simulation models;
- Chapter 6 describes the parking model; and
- The public transport cost model is described in Chapter 8.

2. Demand Model Specification and Development

Introduction

2.1 For this commission a variable demand model element is critical in order to examine the impacts of measures such as demand management and the impact of land use changes on travel patterns.

2.2 In order to understand the impact of future application options, a multi-modal variable demand modelling framework is required. One that is compliant with latest DfT appraisal guidance would provide confidence in modelling outcomes.

DfT Modelling Guidance

2.3 The DfT has recently introduced detailed WebTAG guidance and advice to cover the development of transport models. WebTAG sets out procedures to be followed in building variable demand models, including illustrative sensitivity parameter ranges for incremental hierarchal logit formulation.

2.4 According to the WebTAG, the following demand responses will need to be considered:

- Trip frequency, as slow modes are not considered as suggested by WebTAG;
- Choice of mode, including car, bus, rail, park and ride, and possibly park and walk; and
- Destination choice, which is considered to be a more sensitive response than main mode choice and should therefore be modelled below it in the demand hierarchy.

2.5 WebTAG provides illustrative demand model parameter ranges against which the model calibration may be checked. WebTAG also now strongly recommends the use of an incremental Production/Attraction (PA)-based form. The key advantages of this is that choice mechanisms underpinning these models reflect the linkage of outbound and return trips (i.e. they start and finish at the same location and use the same mode across the day).

Technical Response

2.6 In order to realise the practicalities of the guidance above, the proposed modelling framework encompasses a traditional four stage structure, drawing upon three core models;

- trip end model;
- demand model, and;
- supply (network assignment) model.

2.7 Figure 2.1 outlines the proposed model framework to be developed for the Salisbury Multi-Modal Study alongside a traditional four stage process.

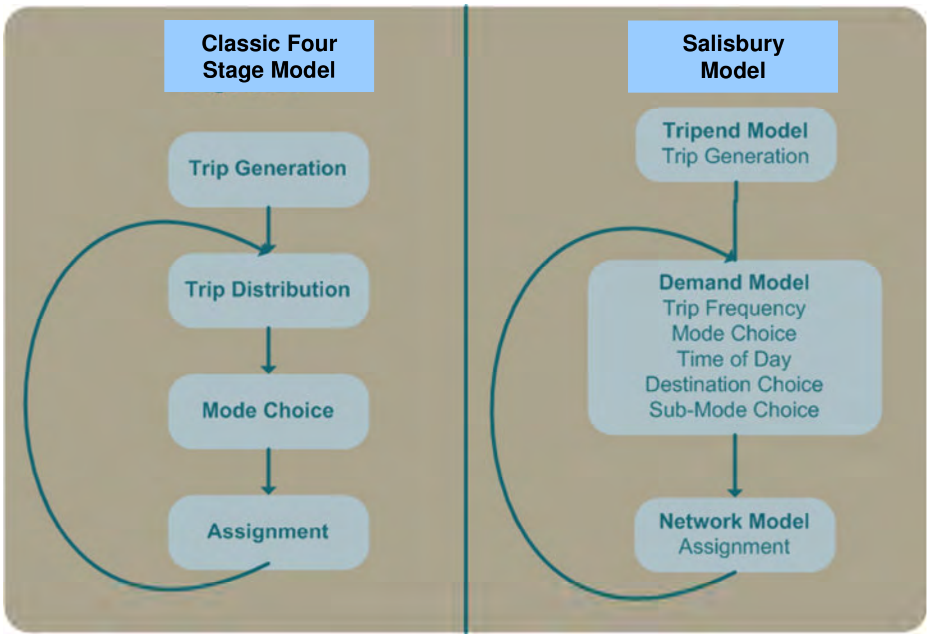
2.8 The model framework will be developed through a combination of EMME3 and the SATURN suite of assignment programmes. Both suites of software are widely used throughout the UK for developing WebTAG-compliant modelling systems, and their integration into the proposed framework will be as follows;

- trip generation – input from spreadsheet model to EMME3;
- demand model – EMME3;
- supply model:
  - Highway – SATURN;
  - PT – EMME3.

2.9 The model framework will be formalised and "wrapped" together using a combination of EMME3 macro files, SATURN key files (which both automate the key processes required to run the software) and DOS batch files. Using version and testing conventions will allow the model to be fully automated, thus ensuring consistency for the forecasting procedures.

2.10 The remainder of this section focuses on each of the three core components of the Salisbury transport model in turn.

Figure 2.1 – Proposed Model Framework



Trip End Model

2.11 WebTAG advises that a land-use/transport interaction model should be considered where:

- the potential solutions are likely to cause significant shifts in the scale and pattern of economic activity, including jobs;
- the investigation of alternative land-use policies is a matter of key concern; or
- there is likely to be a significant interaction between transport and land-use strategies.

2.12 However, whilst land-use issues are of direct relevance for this study, we believe that it will be more important to determine the implications of proposed developments on the performance of future transport networks and thus to identify infrastructure improvements and policy initiatives that would be necessary to manage the impact of this growth, rather than to predict the possible constraining and redistributive effects of the existing or improved networks on development locations.

2.13 The model will relate zonal based land-use planning and demographic assumptions at both a base year and for each forecast year using the latest TEMPRO and land use projections. Together, these will forecast the number of trips, disaggregated by journey purpose and time period. Trips generated by housing zones will be forecast based on household characteristics (for example the number of employed and school-aged residents, car ownership, and household income) whereas a trip attraction module would forecast the number of trips attracted to a zone based on the number and type of employment places, school places, shopping and leisure facilities.

2.14 WEBTAG guidance recommends using Production/Attraction (P/A) format matrices for demand modelling rather than Origin/Destination (O/D) matrices. This distinction is most important when forecasting travel patterns in the future due to possible non-uniform growth at either the production end or the attraction end. As put in WebTAG, "*change in workplace distribution may well be different from those in employee's residence. This can, in most circumstances, lead to different forecasts of trips depending on which of the two trip matrix definitions is used*".

2.15 Practically, the P/A form is easier in implementation for the mixed mode demand modelling; for example, there is no need to distinguish the direction of from-home trips and to-home trips in the P&R choice mechanism. The trip end model will be based on 24-hour productions and attractions.

Demand Model

2.16 The demand model will be formed as an incremental hierarchical logit choice model, fully compliant to the WebTAG guidance. The incremental model will be pivoted from the base year situation.

Modelled Time Periods

Weekday Model

2.17 The scope of the full model framework will be a 24 hour period of an average weekday. Within the full model framework three time periods are specifically modelled, namely;

- AM peak 07:00 to 10:00, with assignment peak hour of 08:00 to 09:00;
- Inter-peak (IP) period of 10:00 to 16:00, with an assignment covering an average hour within this period, and;
- PM peak 16:00 to 19:00, with assignment peak hour of 17:00 to18:00; and
- Off-Peak period (OP: 19:00 to 07:00).

2.18 The demand model will operate as a 24 hour model, explicitly using the costs from these time period models as input. This is to facilitate the use of production-attraction modelling format, as discussed below.

2.19 It is necessary to have an off-peak period to form a 24hr day but there is no need for an OP assignment model. The base OP demands and costs, with sensible reasons being mostly with free-flow traffic conditions, will be referred from the base IP demands and costs with approximation.

Saturday Model

2.20 The Saturday model would focus on the busiest time only, reflecting the period between 11:00 and 14:00.

2.21 The demand model would not have time period choice but would cover the other modelling elements and be capable of determining the impact of changes to transport network and parking supply on a Saturday peak.

2.22 The Saturday model would also be origin/destination based rather than production/attraction based.

Model Segmentation

2.23 The DfT's WebTAG Units 3.10 'Variable Demand Modelling' and 3.11 'Modelling Public Transport Schemes' set out guidance for the level of segmentation needed for models to be able to robustly assess major schemes.

2.24 To ensure compliance with this latest guidance, the following personal travel demand segmentation will be used:

- **car availability** split by car available (CA) and non-car available (NCA);
- **trip purpose** split as follows:
  - HBW (Commuting);

- HBO (Home Based Other);
- NHBO (Non Home Based Other);
- HBEB (Home Based Employers business); and
- NHBEB (Non Home Based Employers business)

Highway Assignment Segmentation

2.25 The segmentation of users in public transport and highway assignment models will include the following, as many of the purposes can be combined as they would have the same generalised cost parameters in the assignment models:

- total non-work (HBW+ HBO+ NHBO); and
- total work (HBEB+ NHBEB).
- light goods vehicles (LGV); and
- heavy good vehicles (HGV).

Representation of Traveller Responses in the Demand Model

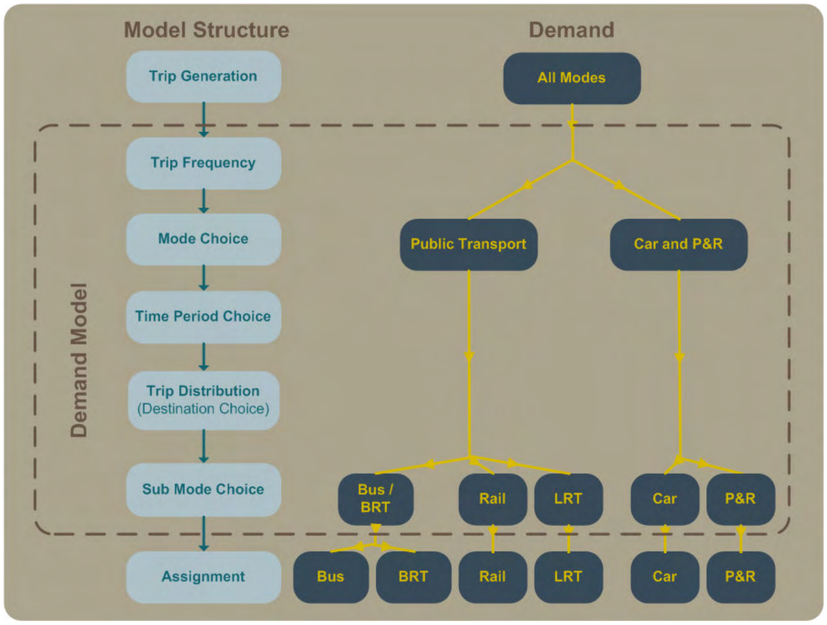
2.26 In general, WebTAG recommends an incremental logit-based approach for each stage of multi-modal demand modelling, pivoted off the base year. The development of the demand model will follow the guidance closely and illustrative sensitivity spreading parameters and tree structure parameters will be used in the implementation and subsequently adjusted as suggested by the DfT. The following choice response mechanisms will be considered:

- frequency modelling;
- main mode choice modelling between car and public transport (PT);
- destination choice modelling; and
- sub-mode choice modelling between rail and bus for PT, and sub-mode choice modelling between car and P&R for highway.

2.27 Each element of the enhanced behavioural response is discussed in the remainder of this section.

2.28 The proposed demand model structure is illustrated in Figure 2.2 following the recommendation of WebTAG, where the main mode choice precedes destination choice. WebTAG (Unit 3.10.2, para. 1.7.13) suggested that macro time period choice parameter values should be similar in magnitude to main mode choice parameter values. The sensitivity parameters used for the macro time period choice will be set to the same values as used in main mode choice – in mathematical terms, they are modelled simultaneously in a multinomial form.

Figure 2.2 – Demand Model Choice Hierarchy



Trip Frequency Modelling

2.29 WEBTAG recommends that TEMPRO and other locally and/or regionally available forecasts are used in such a modelling framework. As such, trip generation models based on detailed socio-economic variables are not considered, although we propose to include a mechanism that allows the model to be sensitive to different assumptions on the impact of 'Smarter Choices'.

2.30 As stated earlier, slow modes will not be modelled explicitly in the Salisbury model. Instead, the trip frequency model will be implemented in order to model potential mode diversion from slow modes to mechanised modes (induced traffic) or from mechanised modes to slow modes (trip suppression). This will be achieved through the application of elasticity's based on research and evidence gained locally and elsewhere.

Main Mode Choice

2.31 The mode choice for the model will be divided into two parts: the main mode choice between car (including P&R) and public transport and, the secondary (sub mode choice) for public transport (if required) and for highway journeys (car and P&R).

2.32 Applied at the trip end level and placed just below the frequency modelling, the main mode choice model would operate in a 24-hour modelling framework with P/A form of matrices, for car available persons only.

2.33 Non-car available persons would be assumed to be captive to public transport, and therefore would not be considered in the main mode choice.

Time of Day Choice

2.34 WebTAG Guidance states that "time of day choice is likely to be important if there is substantial traffic congestion in the area of interest, … or if some form of differential charging or access is to be examined".

2.35 As congestion increases it is important to ensure that the macro time choice, i.e. between the AM and IP time periods is adequately modelled. WebTAG suggests that the position of the macro time period choice in the decision hierarchy is placed at a similar level to main mode choice for most purposes.

2.36 Non-car available persons would not be considered in the macro time period choice model as the main purpose of this modelling framework is to estimate driver response to future congestion, infrastructure improvements and road pricing where included as a future development.

Destination Choice Modelling

2.37 Destination choice models spread the forecasts of generated trips by mode and time period over the available destinations for each time period modelled, depending on the change of generalised cost of reaching that destination over the base year, when modelled in an incremental form.

2.38 WebTAG (Unit 3.10.2, para, 1.7.11) recommended that the destination choice should be modelled as singly (origin) constrained distribution for trips with HBO, NHBO, NHBEB or HBEB purposes. In contrast, WebTAG recommended that the destination choice for HBW needed to be modelled as doubly (ie origin-and-destination) constrained distribution. To meet this requirement, a rectangular furnessing procedure was developed to undertake the HBW distribution modelling.

2.39 The doubly-constrained destination modelling is much more complicated than singly-constrained destination modelling to guarantee that each zone attracts and generates a fixed total trips. The models are generally developed with an iterative procedure via a set of balance factors for each of the production/attraction trip end. For the proposed model structure, the balancing procedure is much more complicated since the production totals produced from the mode choice stage and the time period modelling stage are subjected to change at the distribution stage.

The Sub-Mode Choice

2.40 The sub-mode choice is considered to be most sensitive apart from the re-assignment and is therefore placed at the bottom of the choice hierarchy.

2.41 The public transport sub-mode choice is considered as follows:

- bus; and
- rail;

2.42 The highway sub-mode choice is considered as follows:

- car; and
- park and ride (P&R).

2.43 All choice mechanisms above the sub-mode choice will be modelled incrementally as required by WebTAG. Whilst the choice of sub-mode mechanism is not clearly specified in the guidance, incremental sub-models would be a preferred approach over the absolute models for consistency.

2.44 The overall model stages including the assignment stage is summarised in Table 2.1 and described as:

- frequency modelling (stages 1) is undertaken for HBO and NHBO trips only as suggested by WebTAG;
- the main mode choice (stage 2) between car and PT operates for Car Available (CA) person type only;
- the demand model operates at the 24-hour level until the time of day choice (stage 3) is undertaken;
- for destination choice modelling (stage 4), the demand model considers all four time periods AM/IP/PM/OP for all person types in parallel;
- the resulting PA matrices are converted into OD matrices after the sub mode choice (stage 5); and
- individual highway and PT assignments (stage 6) are undertaken.

Table 2.1 - Six Stage Transport Model

Stage	Model	Temporal Scope	Form	Person Type
1	Frequency Modelling	24-hour	PA Tripends	All (CA & NCA)
2	Main Mode Choice	24-hour	PA Tripends	CA
3	Time Period Choice	Translate 24-hour to AM (3hr), IP (6hr), PM (3hr) and OP (12hr) periods	PA Tripends	CA & NCA
4	Destination Choice	3hr (AM), 6hr (IP), PM (3hr) and OP (12hr)	Translate PA Tripends to PA matrices	All (CA & NCA)
5	Sub Mode Choice	3hr (AM), 6hr (IP), PM (3hr) and OP (12hr)	PA matrices	All (CA & NCA)
6	Assignment	1-hour	OD matrices	All (CA & NCA)

Generalised Cost Definition

2.45 TAG Unit 3.10.2 (Para 1.10.8) defines the highway Generalised Cost for private car person and elements relating to:

- fuel cost;
- in-vehicle time;
- parking costs;
- access/egress time; and
- tolls or other user charges.

2.46 The Salisbury model follows the WebTAG formulae for the definition of generalised costs for cars: G_{car}, measured in units of time-minutes:

$$G_{car} = V_{wk}*A + T + D*VOC/(occ*VOT) + PC/(occ*VOT)$$

where:

- V_{wk} is the weight applied to walking time (assumed 0 currently);
- *A* is the total walk time to/from the car (minutes);
- *T* is the journey time spent in the car (minutes);
- *D* is the motorised journey length (kilometres);
- *VOC* is the vehicle operating cost (pence per km): including the fuel and non-fuel operating cost for work purpose but only the fuel operating cost for non-work purpose;
- *occ* is the occupancy (i.e. the number of people in the car) whom are assumed to share the cost;
- *VOT* is the appropriate Value of Time (pence per minute); and
- *PC* is the parking cost and tolls (if and when incurred), in monetary units (pence).

2.47 TAGUnit 3.10.2 (Para 1.10.9) defines the Generalised Cost for public transport users and includes elements relating to:

- fares;
- in vehicle time;
- walking time to and from the service;

- waiting times; and
- interchange penalty.

2.48 The WebTAG formula for PT generalist cost G_{PT}, measured in units of time (minutes) is given as:

$$G_{PT} = V_{wk}*A + V_{wt}*W + T + F/VOT + I$$

where:

- V_{wk} (=2) is the weight applied to time spent walking;
- *A* is the total walking time to and from the service;
- V_{wt} (=2.5) is the weight applied to time spent waiting;
- *W* is the total waiting time for all services used on the journey;
- *T* is the total in-vehicle time;
- *F* is total fare;
- *VOT* is the appropriate Value of Time, in pence per minute; and
- *I* (=10 minutes) is the interchange penalty if the journey involves transferring from one service to another.

2.49 It is noted that the impact of rail (or bus) crowding will not directly be considered.

Modelling Park and Ride

2.50 Modelling park and ride (P&R, a highway sub mode) raises a number of issues as it requires linking highway and public transport elements of the model. In summary, there will be four key stages in the P&R modelling following what has been implemented in the GBMF:

- derivation of park and ride generalised costs;
- estimation of park and ride demand in the demand model;
- site allocation of park and ride demand to competing sites; and
- assignment of highway and PT legs of park and ride trips to the networks

Value of Time (VOT) Variation with Distance

2.51 Unrealistically larger elasticities would normally be derived for long distance trips given the nature of logit formulation. The introduction of VOT variation with distance for non-work trips into the demand model will help to achieve the recommended WebTAG elasticities.

2.52 It is noted that the VOT variation by distance will be applied to all non-work purposes for non-car available users, but only to the HBO and NHBO demand segments for car available users. Based upon our GBMF experience, desired elasticities can be obtained for the HBW segment with the fixed VOT central value primarily because this segment is doubly-constrained.

Production-Attraction (PA) Formulation

2.53 Within the demand model, the key issue was to determine the appropriate travel demand and associated costs of return-legs of home based trips coherent and consistent manner given that the return-leg journeys were constrained by the nature of their outward journeys. Whilst WebTAG recommends that this functional form should be adopted, it does not provide any guidance on how it may be implemented.

2.54 For this study, a PA-based formulation used for the Greater Bristol Modelling Framework will be used. The fundamental assumption underpinning the approach was the use of fixed return proportions whereby *for outward trips leaving home within each time period, the proportions of trips returning in subsequent time periods remain fixed by purpose over the base year and future forecast years*.

2.55 Accordingly, for the PA formulation, only the outward from-home trips in each time period are explicit variables within the demand model. The return-leg demands were calculated from the initial outward-leg demands factored by the associated return proportions. The return proportions will be derived from the information supplied by DfT.

Demand Model Convergence and Realism Tests

2.56 It is important that the demand model achieved a high level of supply-demand convergence. The five-stage Salisbury model will employ an iterative method to achieve convergence between the assignment models (i.e. SATURN highway and EMME public transport) and the EMME-coded demand model. Convergence will be achieved by passing costs from the assignment models to the demand model and subsequently passing trips from the demand model to the assignment models; the process terminates once the convergence criterion has been met.

2.57 The main purpose of realism tests is to ensure the chosen model parameters (either locally calibrated or adopted from the nationally recommended parameters) replicate long-term elasiticities derived from empirical observations and/or best practice. The target elasticities for the realism tests, as defined by WebTAG, are:

- *car fuel cost* - recommended elasticity between -0.1 to -0.4, with an overall target value of -0.3 across all segments*;*
- *car journey time* - recommended elasticity less than -2.00; and
- *public transport fare* - recommended elasticity between -0.1 to -0.4 up to 0.9.

2.58 WebTAG recommends the use of locally calibrated demand parameters if they are available from Revealed Preference and Stated Preference data. If these are not available, as with the Salisbury study, WebTAG recommends the use of illustrated sensitivity parameters provided in TAG Unit 3.10.3. In either case, the robustness of the demand model validation will be demonstrated through the application of a set of realism tests.

Demand and Supply Model Outputs

2.59 The output from the demand model after the sub-mode choice (stage 4) included two sets of updated matrices for use in the highway and PT assignments namely:

- highway AM peak hour OD matrices (08:00 – 09:00), Inter-Peak average hour matrices (10:00 – 16:00), and PM peak hour OD matrices (17:00 – 18:00), segmented by car user class in vehicles; and
- public transport AM peak hour OD matrices (08:00 – 09:00), Inter-Peak average hour matrices (10:00 – 16:00), and PM peak hour OD matrices (17:00 – 18:00), aggregated over person types and journey purposes and PT mode.

2.60 It should be noted that the demand model does not forecast changes in HGV trips. These will need to be manually changed.

2.61 The output from the PT and Highway assignment models were a set of cost skimming matrices, produced by the assignment model to feedback into the demand model, namely:

- *Highway matrices*: skimmed time, distance, and toll matrices; and
- *PT matrices*: demand by mode, skimmed in-vehicle time, wait time, penalties, and number of interchanges.

2.62 Both highway and PT skims were converted from OD format into the equivalent PA format within the demand model along with the conversion of PA demand matrices into OD matrices.

Zoning System

2.63 The development of the zone system began by taking the previous zoning used for the 2002 model. In the first instance existing zones were adjusted to TEMPRO (**T**rip **E**nd **M**odel Presentation **PRO**gramme) boundaries. This stage is necessary for forecasting future year trip rates from the National Trip End Model data extracted from TEMPRO. Figure 2.3 displays the TEMPRO district and ward boundaries for Salisbury and Wilton.

2.64 Following the review of TEMPRO boundaries each existing zone was considered for current land use and likely public transport (PT) catchments. As an example a supermarket site is expected to have different trip patterns to a residential area. If combined within an existing zone, different land uses were divided into two separate zones. To consider public transport catchments and their influence on zone definition, bus services and stops were plotted in a GIS to allow likely access stops to public transport services to be identified. The fact that many residential services are ‘hail and ride’ would not affect this as the catchment is principally based on routes rather than bus stops.

2.65 The zoning in areas also being modelled in micro-simulation was carefully considered for the loading of trips to the network. Trips within the micro-simulation model are loaded at the location of zone to network connectors in the SATURN network. To accommodate this, zones must be of a suitable size that connections to the network give an accurate representation of trips in the micro-simulation model. As a general principle smaller zones are required in such cases.

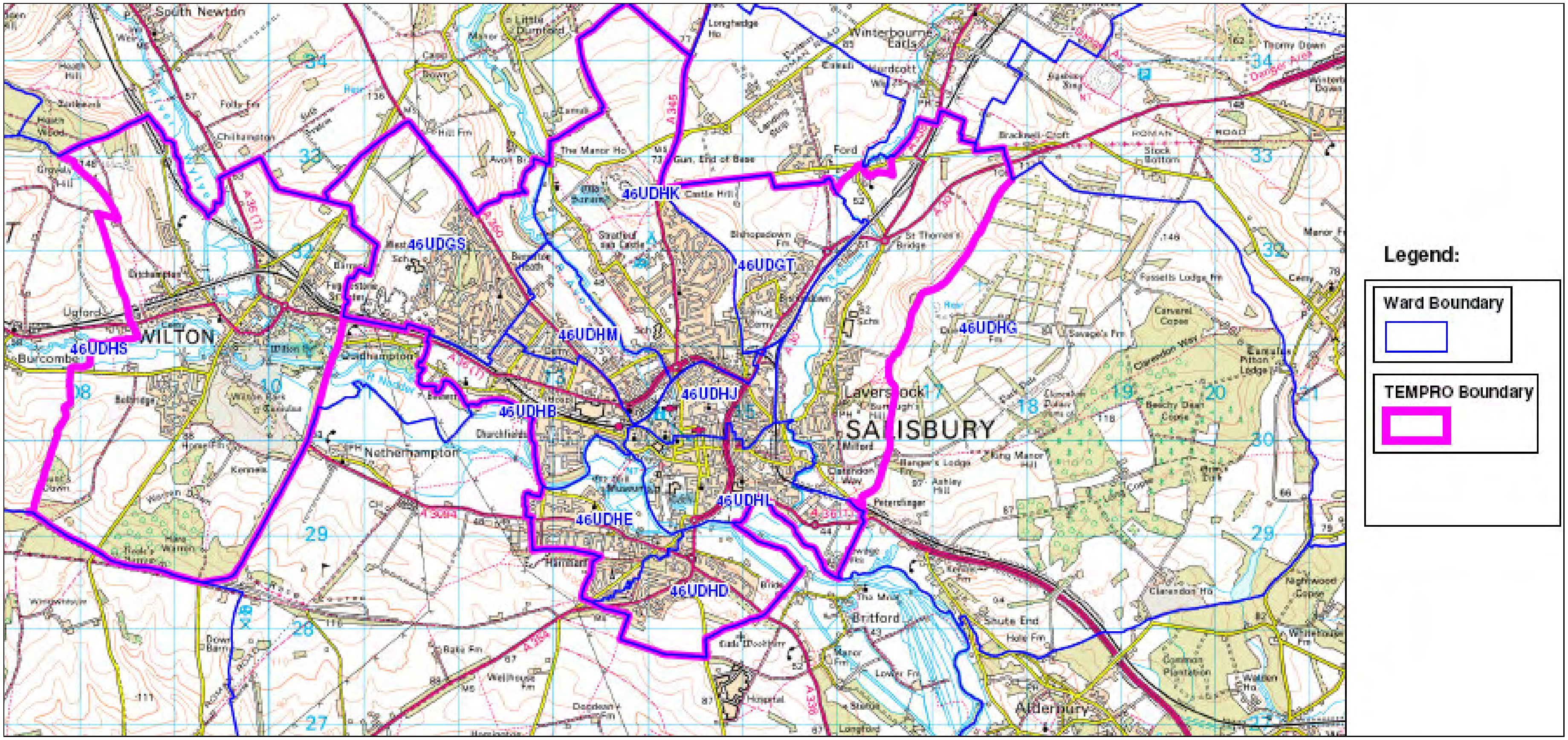


Figure 2.3 – TEMPRO Boundaries Salisbury and Wilton

3. Highway Model - SATURN

Introduction

3.1 The highway model is a key element of the model framework. It is an integral part of the demand model as it undertakes the highway assignment that in turn provides highway costs to the demand model, which ultimately determines the highway and public transport demand. The highway model can also stand alone and be used to test small schemes that would be unlikely to change demand.

3.2 The highway model has two components, a supply side that represents the highway network and a demand side that represents trip patterns. The two sides combine during assignment. The SATURN model assignment process is shown below.

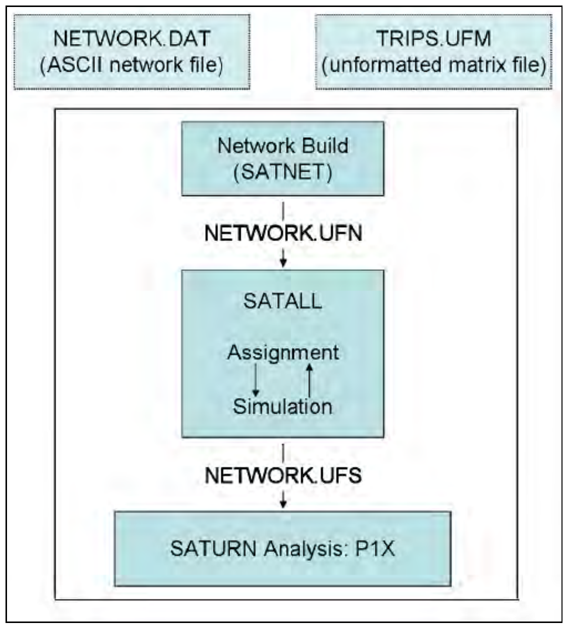


Figure 3.1 – SATURN Assignment Process

3.3 This chapter discusses the derivation of both the supply and demand components. This section also reviews assignment and model calibration and validation requirements.

Supply

3.4 The SATURN network is coded in to a ASCII file. It is divided into a number of parts, a summary of which are shown below and described in more in this section:

- Options, titles and parameters;
- Network coding (network inventory);
- Public transport networks; and
- Generalised cost functions.

Options and Parameters

3.5 The key options and parameters to be coded in the network file are shown in Appendix A.

Network Inventory

3.6 The SATURN network will be a representation of the highway network in and around Salisbury. In SATURN it is not necessary to include all roads within Salisbury, merely the main arterial and distributor roads. Local access roads tend to be combined and are represented by the centroid connector, although local access roads that are also bus routes will be included in the model.

3.7 SATURN is a node based model and is able to represent junction characteristics in considerable detail. The accurate representation of junctions is a key feature of the network inventory. Details of the inventory process and coding procedures are described below.

Nodes

3.8 Junction type has been confirmed using aerial photography during the network inventory stage. Turning movements have also been deduced using aerial photography and site visits to determine any obscured highway markings.

3.9 Lane capacity has been determined using appropriate in-house spreadsheet tools for calculating capacity of roundabouts and priority junctions.

3.10 Turn bans have been applied to the model in accordance with Traffic Restriction Orders supplied by WCC.

3.11 Nodes have been correctly located using GIS to determine the location of each junction.

Links

3.12 Link lengths have been calculated using GIS.

3.13 Speed flow curves are not being used unless it is not possible to correctly match observed and model link delay through junction performance alone. This is typically the case on long semi-urban and rural links. It may also be the case on urban links where incidence of bus stops, parking and side roads reduce link capacity without affecting junction capacity. Where this is the case, speed flow curves will be selectively used and used in accordance with DMRB guidelines.

3.14 Speed limits have been assigned and checked against WCC information and Traffic Restriction Orders supplied by WCC.

Bus Networks

3.15 Buses have been coded in the SATURN network. The addition of buses to the network ensures that highway network has the most accurate representation possible.

3.16 All buses serving Salisbury have been included in the highway network including school specific services.

3.17 Detailed of the bus services cosed can be found in Appendix B.

Values of Time and Distance

3.18 The values of time and distance are essential parameters for determining route choice in highway models. The processes for determining these values are shown below:

- Value of Time:
  - 1. WebTAG Values of Time taken from Unit 3.5.6 Tables 1 (Working Time) and Tables 2 (Non-working Time);
  - 2. Calculate vehicle occupancies using Unit 3.5.6 Tables 4, 5 and 6 - car occupancies vary between 2000 and 2036;
  - 3. Apply vehicle occupancies obtained from step 2 above to values of time from step 1 to obtain values of time per vehicle;
  - 4. Apply value of time growth from Table 3 to determine work/non-work value of time growth for required year;
  - 5. Apply RPI adjustment to convert price base (if required) from current default of 2002 to required year;
  - 6. Check that the output 2002 values of time are the same as those in WebTAG 3.5.6 Table 9; and

- 7. Check that the output 2003/4 values of time are logical compared with the 2002 values.

- Value of Distance:
  - 1. Use the parameters supplied in WebTAG 3.5.6 table 10 to calculate fuel consumption in l/km in 2002;
  - 2. Apply "webtag 3.5.6 VOT" contains expanded WebTAB 3.5.6 Table 11 Fuel Costs, Fuel Duty and VAT rates in 2002 prices and Table 12 Proportion of Car Fleet using Petrol or Diesel;
  - 3. The fuel costs and fuel duty are finally updated in line with RPI. VAT is assumed to remain constant;
  - 4. WebTAG 3.5.6 Table 15 contains the parameter values used in calculating non-fuel costs; and
  - 5. Combine to determine cost per km.

Demand

Time of day

Within the highway model the following three time periods are specifically modelled:

- AM peak 07:00 to 10:00, with assignment peak hour of 08:00 to 09:00;
- Inter-peak (IP) period of 10:00 to 16:00, with an assignment covering an average hour within this period, and;
- PM peak 16:00 to 19:00, with assignment peak hour of 17:00 to18:00.

3.19 In addition, the Saturday model will cover an average hour between 11:00 and 14:00.

Trip Purpose

The segmentation for car users in highway assignment model will include:

- total non-work (HBW+ HBO+ NHBO); and
- total work (HBEB+ NHBEB).

Additionally except cars, in the highway assignment there will be a goods vehicle segmentation, which will be split by:

- light Goods Vehicles (LGV); and
- heavy Good Vehicles (HGV).

Therefore, there are in total four user classes in SATURN highway assignment:

- total non-work (HBW+ HBO+ NHBO);
- total work (HBEB+ NHBEB);
- LGV; and
- HGV.

Matrix construction

3.20 The data collection exercise for this study has ensured that the following data is available for matrix construction:

- road side interview surveys around Salisbury;
- car park surveys at Central and Maltings car parks; and
- school travel data.

3.21 The data will provide the components of the matrix shown in Figure 3.2. Each component provides the following features:

- the Salisbury RSI provides a near-complete cordon around Salisbury and thus should provide observations for all internal to external (outbound) and external to internal (inbound) movements;
- the Wilton RSI provides partial data for internal to external, external to internal and external to external movements. It is unlikely that the Wilton RSI will provide and internal to internal movements;
- the Salisbury Car Park data provides partial data for internal to external, external to internal and internal to internal movements; and
- the School Travel data provides further partial data for internal to external, internal to internal movements. However, this will provide a complete sample of all travel to and from home and state schools.

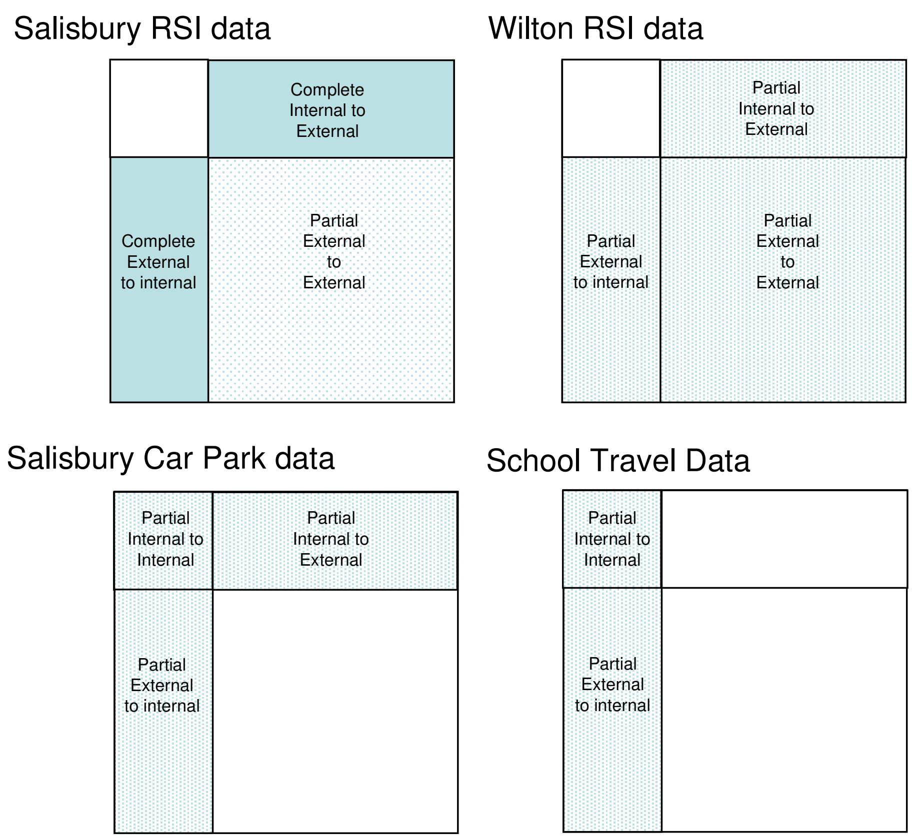


Figure 3.2 – Contribution of Data to Matrix Elements

3.22 The nature of the RSI sampling method means that it is highly likely that we have not observed all movements between OD pairs. WebTAG (3.10.3) recommends that some form of synthetic infilling should be undertaken to overcome the problem of partial sampling with the model matrices created using a mixture of observed and synthesised data.

3.23 The use of weighted average of observed and synthetic matrices will remove potentially empty cells and a greater weight is given to cells where there are more observed trips than expected from a locally-calibrated synthetic model. WebTAG recommends that the relative weights should reflect the accuracy of the two forms of estimates, when this information is available, otherwise a 90% / 10% split between observed and synthetic forms is recommended.

3.24 As a result, the approach to matrix construction shown in Figure 3.3 is proposed.

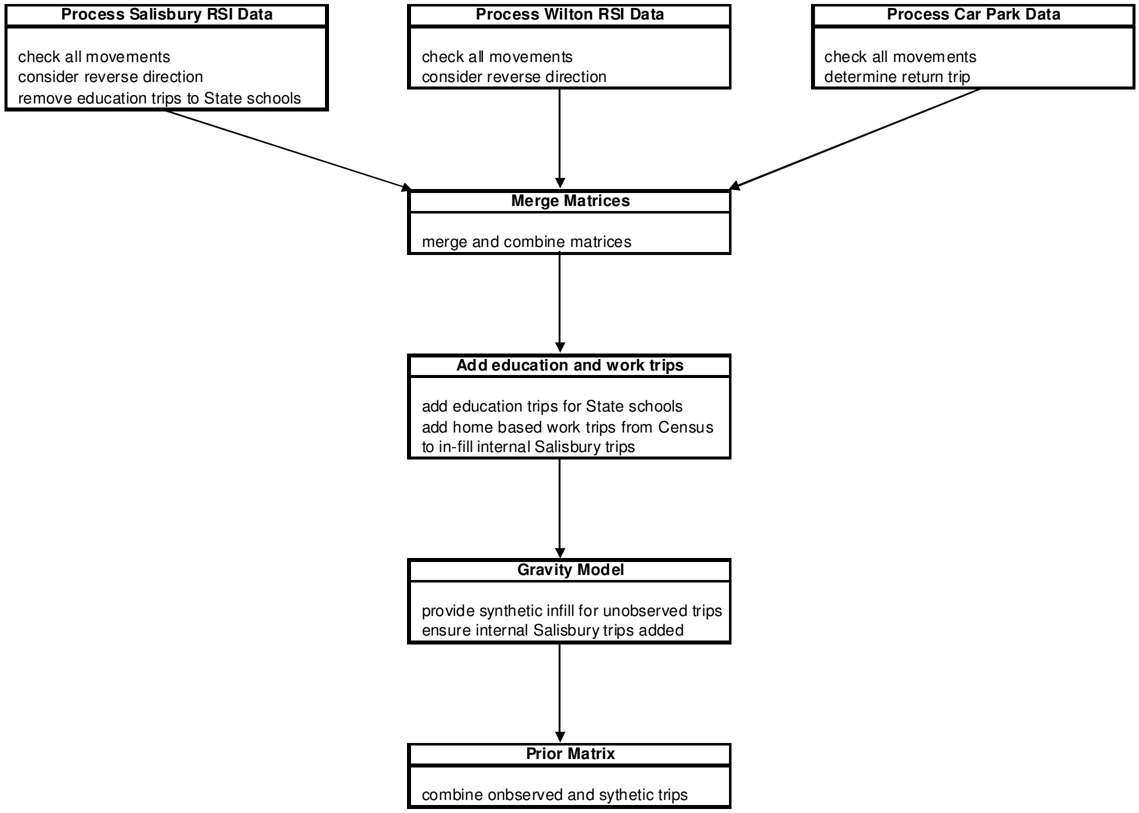


Figure 3.3 – Matrix Building Process

PCU Factors

3.25 The model represents vehicles in the form of passenger car units (PCU) when calculating the impact of traffic through the model network. The light vehicle matrix has one vehicle equating to one PCU whilst a heavy goods vehicle equates to 2.3 PCU.

Assignment

3.26 Model assignment of trips to the highway network was undertaken using a standard ‘Wardrop User Equilibrium’ approach, which seeks to minimise travel costs for all vehicles in the network. The Wardrop User Equilibrium is based on the following proposition:

> *‘Traffic arranges itself on congested networks such that the cost of travel on all routes used between each origin-destination pair is equal to the minimum cost of travel and unused routes have equal or greater costs.’*

Pre-Peak

3.27 For SATURN to adequately represent network performance in congested urban conditions it needs information on the amount of traffic queuing in the network at the start of the modelled hour. The PASSQ option in SATURN enables this feature and requires information about queuing from the previous hour.

3.28 The PASSQ option is only used for the AM peak and PM peak models and is based on factoring the prior matrix as follows to represent the previous model hour (07:00-08:00) and (17:00-18:00) respectively. The factors were derived based on the 2005/2006 volume counts.

3.29 A review of flows will be undertaken to determine whether a pre-peak assignment is required.

Model Calibration and Validation

Matrix Estimation

3.30 The matrix estimation process forms part of the calibration process and is designed to modify the origin-destination volumes by reference to the observed traffic counts. Trips are adjusted in the matrix to produce the estimated matrix, which is most likely to be consistent with the traffic counts. The equation used may be written as:

$$T_{ij} = tij \, \Pi_a X_a^{Pija}$$

Where:

- T_{ij} is the output matrix of OD pairs ij;
- tij is the prior matrix of OD pairs ij;
- $\prod_a$ is the product over all counted links a;
- X_a is the balancing factor associated with counted link;
- ^{Pija} is the fraction of trips from I to j using link a.

3.31 This process is dependent on other factors, and therefore must be monitored closely to ensure that:

- the trip matrix is converging to a stable solution;
- travel patterns at a sector level are reasonable; and
- trip length distributions are reasonable.

3.32 When applying matrix estimation techniques, care must be taken to ensure that the quality and consistency of the input count data is high. Checks were undertaken to ensure that this was the case, especially where counts on adjacent links were being used. The matrix estimation process was examined to ensure that the estimated matrix converged to a stable solution.

3.33 A comparison of the matrix totals before and after estimation indicates the impact of traffic counts on the matrix estimation. The post matrix should reflect more closely the pattern of observed traffic on the network and as such provide a better representation of travel patterns in the area.

3.34 WCC have provided us with the number of houses and employment floor space in Salisbury. This has been provided at a fairly large zone level.

3.35 We will calculate the number of trip ends in the large zones provided by WCC and check that the model has produced approximately the right number of trips in these zones. This is a check only and should not take precedence over link flow validation.

Traffic Count Calibration and Validation

3.36 Throughout the model development, a series of calibration and validation checks were undertaken. These primarily consisted of comparing the observed and modelled link flows. The calibration and validation link flow comparison used the guidelines set out in DMRB, Volume 12, Section 2, “Traffic Appraisal in Urban Areas”. The traffic flow data that had not been used as part of the model development (matrix estimation) was independent data and was used as part of the validation process. The traffic flow data used as input to the matrix estimation process was used only for calibration of the model.

Acceptability Guidelines

3.37 The acceptability guidelines as outlined in DMRB are shown in Table 3.1. 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 3.1 - DMRB Acceptability Guidelines

	Criteria and Measure	Acceptability Guideline	
DMRB Flow Criteria			
1	Observed flow < 700vph	Modelled flow within ± 100vph	
	Observed flow 700 to 2700vph	Modelled flow within ± 15%	> 85% of links
	Observed flow > 2700vph	Modelled flow within ± 400vph	
DMRB GEH Criteria			
2	Total screen line flows (normally > 5 links) to be within ± 5%		All (or nearly all) screen lines
3	GEH statistic for individual links <5		> 85% of links
4	GEH statistic for screen line totals <4		All (or nearly all) screen lines

GEH Statistic

3.38 The GEH statistic included in Table 7.3 is a generally accepted value used as an indicator of 'goodness of fit', i.e. the extent to which the modelled flows match the corresponding observed flows. This is recommended in the calibration guidelines contained in the Design Manual for Roads and Bridges (DMRB) Volume 12 and is defined as:

$$GEH = \sqrt{\frac{(M-C)^2}{0.5 \times (M + C)}}$$

Where:

- M = modelled flow and
- C = observed flow

Journey Time Validation

3.39 The DMRB journey time validation criterion states that modelled journey times over the whole survey route should be within +/- 15% of observed times (or +/- 1 minute if higher) on 85% of routes

Convergence

3.40 The Traffic Appraisal in Urban Areas (DMRB Vol. 12a) advice recommends two criteria for Wardrop User Equilibrium assignment to ensure a satisfactory model convergence where Delta - should be less than 1%, or at least stable, with convergence fully documented and all other criteria met.

Journey Time Validation

3.41 Where the modelled journey time is not within 15% of the observed journey time, it is generally related to the variability of the observed data or the limited number of timing points available along the route. As previously highlighted, if the reliability of the observed journey time data on a number of routes for the AM peak is less than ideal, due to either the variability experienced in the morning peak and/or the very small sample size on certain surveyed routes, there is likely to be a lower degree of correlation between the modelled and observed journey times.

Route Choice Validation

3.42 Checking the routing of traffic is a key final sense check on model validation. This process will focus on the route choice offered between eastern Salisbury and Wilton along:

- the A36 for the duration;
- the city centre and then the A36; and
- the Netherhampton Road.

3.43 Automatic number plate recognition between the A36 Southampton Road and the Park Wall junction in Wilton should provide a very reasonable indication of the proportion of vehicles travelling between those two points on each of the available routes. The validation process will aim to match these proportions within reasonable tolerances.

4. Public Transport Model – EMME

Introduction

4.1 The public transport model is also a key element of the model framework. It is an integral part of the demand model as it undertakes the public transport assignment that in turn provides public transport costs to the demand model, which ultimately determines the highway and public transport demand. The public transport model can also stand alone and be used to test small schemes that would be unlikely to change demand.

4.2 Like the highway model, public transport has two components, a supply side that represents the local rail network and the highway network for walk access and for bus routes to follow and a demand side that represents trip patterns. The two sides combine during assignment.

The base year Salisbury public transport model will be developed to represent three public transport modes:

- bus;
- rail; and
- bus-based park-and-ride.

4.3 This chapter discusses the derivation of both the supply and demand components. This section also reviews assignment and model calibration and validation requirements.

Supply

4.4 The public transport network is made up of modes, nodes, links and transit lines. All of which will be created in the EMME databank to create an accurate representation of public transport network in Salisbury.

4.5 Networks within EMME are hierarchical, as shown in Figure 4.1. The hierarchy demonstrates that in order to run a public transport service (transit line) it is necessary to create vehicle types, and modes of transport in addition to a network to run the service on, which must contain nodes, links and turn information. To aid further reading, a brief overview of EMME terms are presented below.

4.6 EMME/2 differentiates between the following mode types, all of which will be used in the STM:

- Auto mode: auto links are used to specify the network accessible to private vehicles;
- Transit modes: transit lines may be defined on the links that allow a transit mode i.e. bus, train, tramway; and their speed is given by a transit time function that may depend on the auto speed for each transit line segment; and
- Auxiliary transit modes: auxiliary transit links (footways) are used to model access to the transit lines and transfer between lines that do not pass through the same node.

4.7 The base network in EMME consists of nodes and links. A regular node may correspond to a junction or a transit stop. Whilst a link is a directional connection between two nodes. In addition to nodes, it is necessary within EMME to code turn information, such as turn bans or time penalties.

4.8 Transit vehicles correspond to vehicles or combinations of vehicles that may be used by a transit line. Distinguishing between vehicle types enables judgements to be made relating to overcrowding of particular services.

4.9 Transit lines correspond to regular transit services and the information required includes vehicle type, mode, headway, speed and stopping patterns en-route.

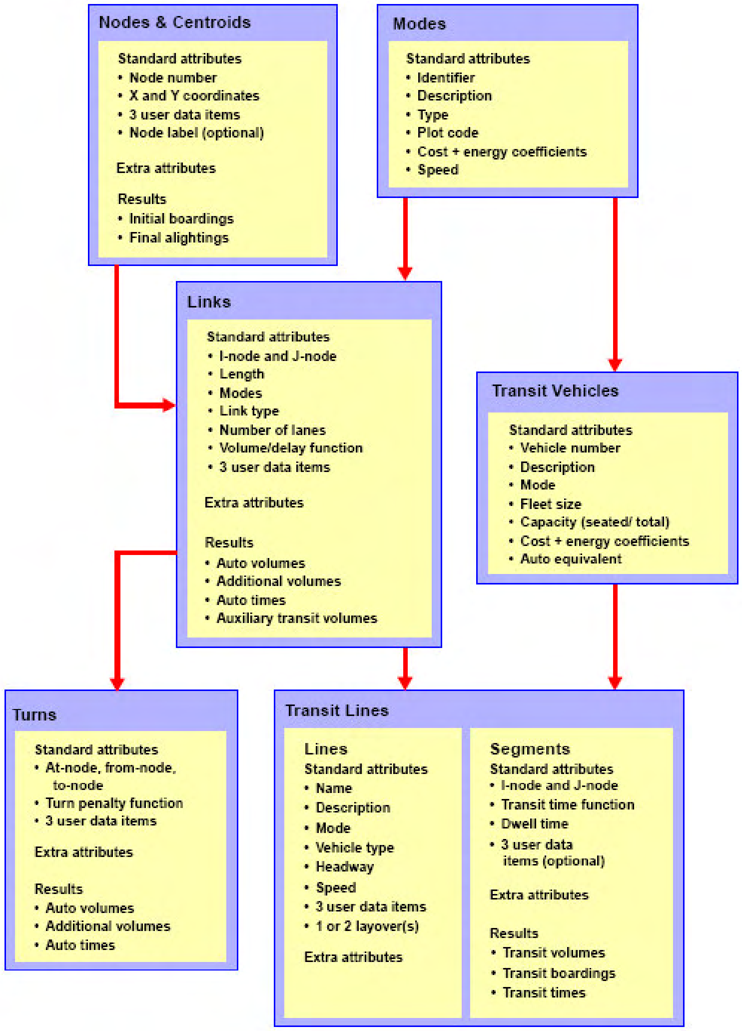


Figure 4.1 – EMME Network Hierarchy

Modes

4.10 The modes are listed in Table 4.1 will be used in the STM. Bus and rail services operated by different operators will be coded with different modes to enable operator specific analysis post modelling if required. The car mode is only used in EMME to transfer highway times from SATURN which in turn determines bus speeds.

Table 4.1 - Example Mode Table

Mode	Description	Mode Type	Vehicle Type	Default Speed	Description
c	car	auto			
q	quick walk	aux transit		5kph	
b	W&D urban	transit	1		Wilts & Dorset Bus
p	Park & Ride	transit	2		Park & Ride
o	other operators	transit	3		Other Operators
r	rail	transit	10		Rail-142

4.11 The quick walk mode (q) will be allowed on all bus links to reduce the number of walk connectors needed to link the node/bus stops to the bus network.

Nodes

4.12 EMME requires a list of network nodes and centroids before any links or transit lines can be added. Nodes and centroids should be specified as follows to add them to the EMME databank:

Table 4.2 - Example Node Coding

Node Type	Action	Node No.	X Coord	Y Coord	User Attribute 1 (ui1)	User Attribute 1 (ui1)	User Attribute 1 (ui1)	Node Label
Centroid	a*	1000 0	35000	17000	0	0	0	SALI
Node	a	1000	35050	17050	0	0	0	

4.13 Unlike SATURN, the same node numbers cannot be used for network nodes and centroids, therefore it should be insured that, in order to create consistency, this does not occur in the SATURN network. Similarly, the rail nodes should use node numbers 6000-6999 so they are easily identifiable and thus not used in SATURN.

4.14 EMME uses a 5 digit coordinate system, omitting the last of the Ordnance Survey grid reference (OSGR) digits.

4.15 Bus stops will be coded as nodes on the bus/highway network, since the majority of the SATURN highway network nodes will be at junctions, the nodes will be representative of the bus stops in the surrounding area, rather than their specific locations.

4.16 Rail nodes will be specified by the OSGR of stations within the extended study area.

Bus Network

4.17 The bus network will be imported from the SATURN network. EMME requires only the link distance, A and B node information from SATURN extracted via SATDB.

4.18 The modes which can travel on a particular links will be defined as follows:

- cbpow for a bus link;
- r for a rail link;
- q for a centroid connector or walk link.

4.19 To represent the effect of highway congestion on bus speeds, the transfer of highway journey times from the SATURN model will be undertaken within the demand model process. Therefore all bus links will include mode c and the modelled bus network will be consistent with the modelled highway network.

4.20 There are several attributes that need to be taken into account when transferring highway information to the bus network:

- bus vehicle detection
- bus only lanes
- real time information

4.21 All these attributes feed into the bus journey times. The total journey time for a bus service is calculated as bus link time plus bus turn time.

4.22 The link and turn times are calculated using inputs from the SATURN model. Table 4.3 shows the attributes in the SATURN model will be imported into the EMME model.

Table 4.3 - SATURN / EMME Attributes

SATURN Code	Filename	EMME Attribute	Description
2033	*.blk	@bol	Bus Only Lane Marker
4023	*.clk	@clkp	Congested Link time
1633	*.ctu	@tup	Congested Turn Time
1803	*.flk	@flkp	Free flow link time

4.23 The congested link time is used when the bus mixes with general traffic. The free flow link time is used when the bus is in a bus-only lane. The bus only lane marker is used to differentiate within EMME which link time is used. The turn time is added to the link time to provide the total journey time.

4.24 However, there are some additional complexities that need to be incorporated into the calculation to ensure an accurate representation of the journey time, namely delays to bus run time occurring through boarding and alighting. Typical boarding times are as follows[1]:

- 3 seconds (where majority of tickets are off-vehicle);
- 6 seconds (where a high proportion involve cash transactions);
- 9 seconds (where almost all ticketing involves cash transactions and change-giving).
- Alighting times are typically 1 to 1.5 seconds per person[1] and alighting times do not have as dramatic an impact as boarding times.

4.25 Additional attributes within EMME are used to calculate bus journey times, shown in Table 4.4.

Table 4.4 - Additional EMME Attributes

EMME Attribute	Description
@svd	Marker for SVD at Signalised Junction
@bsd	Bus Stop Density. Number of bus stops per km

@svd = 1 if there is selective vehicle detection for buses at a given node (signalised junction).
@bsd will be calculated from empirical data for a number of bus routes in Salisbury. This is, in effect, the number of bus stops per kilometre.

4.26 The following formulae will be used to calculate the bus journey time on links:

Bus Link time = a(Link time + Link length*BSD*delay)*

Where:

- Link time = SATURN congested link time (if no bus lane)
- Link time = SATURN free-flow link time (if a bus lane exists)
- BSD = Bus Stop Density per km (urban and rural) – based on SATURN link types – derived from actual bus stop intervals).
- Delay = 20 seconds

4.27 The factor *a* will be derived from a comparison between bus and car journey times on coincident links from the most recent surveys.

4.28 The following formula will be used to calculate the bus delay at turns:

Bus turn time = SATURN turn time

[1] The demand for public transport – TRL Report 593, 2004

4.29 However, there are a number of complications to this formulae, depending on the presence of a bus lane that leads up to the stopline and if SVD exists. Little information exists as to the effects on turn times for buses at such facilities. The figures in Table 4.5 are considered a best estimate.

Table 4.5 - The Assumed Effect of Bus Priority on Turn Times

Bus priority measure		Factor on turn time
Bus Lane	**SVD**	
N	N	1
Y	Y	0.05
Y	N	0.15
N	Y	0.90

Transit Lines

4.30 For each of the time periods, bus timetable information will be used to derive the headway for each of the bus services which operate within the modelled time period.

4.31 Similarly, rail timetables will provide the headways for the rail services and rail speeds which will be coded in the user attribute us3 will be derived from the timetabled journey times.

4.32 Timetables will also provide the service stopping patterns. Bus routes will be plotted on an Ordinance Survey background, and the nodes closest to the bus stops on that route identified.

4.33 Each bus and rail service will be identified by (a maximum of) 6 alphanumeric characters including the route number and direction of the service, as below:

- 002_N_
- 025AS_

4.34 The service id will be retained in the SATURN network for ease of route checking and network compatibility. For ease of transfer of buses routes between SATURN and EMME, all nodes in the route path should be included in both sets of line specifications.

4.35 The default dwell time at each bus stop will be 0.01 minutes since the dwell time is taken into account when calculating the bus journey times.

Rail Network

4.36 The rail network will be a series of straight lines between the stations in the modelled area. It is important to have the correct distance on these links since speed will be used to calculate the time on the link during the assignment process.

4.37 This makes the addition of new stations, if required, in the future year easier since rather than having to calculate the new time on a link, the speed and distance are used to automatically do this.

4.38 Walk links from the railway stations will be coded with mode q to join the rail network to the bus network to allow interchange between modes.

Demand

4.39 The zoning system is common between the public transport and highways elements of the matrix and has been described in Chapter 2.

4.40 The data collection exercise for this study has ensured that the following data is available for matrix construction:

- Wayfarer Ticketing data;
- Park and Ride survey data; and

- Rail Passenger Surveys

Prior Matrix Development

Bus Matrix

4.41 For the each of the AM, IP and PM peaks, Wayfarer ticketing data for bus services in Salisbury has been supplied on a stage-by-stage basis by Wilts & Dorset Bus Group.

4.42 In order to use these data to create the most robust bus matrix possible, the Wayfarer data will be processed as follows:

- each of the stages in a route will be plotted in MapInfo for all services provided
- a buffer of 400m[2] will be drawn around each of the stages
- by overlaying the stage buffers on the Salisbury zone map, demand for each stage will be split to the relevant zones; this will be based on a function of zone population and density of bus stops.

4.43 Trips with unknown destinations (as recorded in the raw Wayfarer data set) will be distributed across the stages using the same distribution for the known destination trips from that stage.

4.44 This will become the matrix representing the Wilts & Dorset bus patronage.

4.45 The P&R matrix will be established from the P&R site counts provided and will be added to the bus matrix in prior to bus assignment.

Rail Matrix

4.46 Rail surveys with OD information are available for 2007, with additional 2008 boarding information.

4.47 The rail surveys were handed out at all the Salisbury station so information about trips leaving Salisbury station going to internal and external stations was collected. However, no information about trips either arriving at Salisbury station or external to external trips was collected.

4.48 In order to create an accurate OD matrix for passengers using the Salisbury rail network this data will be geocoded and mapped to the Salisbury zones

4.49 The rail survey data will be cleaned and processed and a matrix of Internal to Internal (I-I) and Internal to External (I-E) trips created from them. The I-E trips will then be transposed to create the External to Internal trips. External to External (E-E) trips will be distributed using information from the PLANET Strategic Model (PSM)

4.50 The resulting matrix will be furnessed to the number of passengers boarding/alighting in 2008.

Matrix Estimation

Bus Matrix Estimation

Public transport matrix estimation uses a similar approach to that used in the SATME2 process for highway matrices. Patronage information derived from the service routes provided by the Wilts & Dorset Bus Group will be used as inputs for the process. This includes

- boarding/alighting stop information;
- total service volume; and
- passenger Link flow information.

Rail Matrix Estimation

4.51 Patronage information derived from the rail surveys will be used as inputs for the rail matrix estimation. This includes

- boarding/alighting stop information;

[2] The recommended maximum distance to walk to a bus stop from a residential area.

- total service volume; and
- passenger Link flow information.

4.52 The matrix estimation process seeks to minimise the 'objective function', which is a measure of 'distance' between observed and assigned volumes. The measure used is simply the square sum of the differences.

Fares

4.53 The fares matrix will be calculated according to the number of bus boardings and the number of fares zones crossed derived from published fares information.

4.54 This matrix will be cross-checked against current fares on twenty routes across Salisbury. For each of these journeys the current single and return fares have been obtained from Wayfarer data provided by Wilts & Dorset Bus Group.

4.55 In order to take account of multi-journey tickets the distribution of ticket types provided by Wilts & Dorset Bus Group will be used. This distribution will be used to derive an "average" fare for each of the twenty routes taking account of concessions and multi-trip tickets.

Assignment

4.56 The standard public transport assignment in EMME is a **multipath** assignment, based on the computation of **optimal strategies**. The concept of **strategy** is a generalization of the concept of path and is based on the following observation:

> *Due to the waiting involved in a transit network, a traveller may choose from elements that are more complex than a simple path toward a destination. For instance, the traveller may choose a set of paths, and let the vehicle that arrives first at a stop determine which of these paths to take to get to the destination. (EMME/2 Manual)*

4.57 The **optimal strategy** is the one that minimizes the total **expected** travel time (including waiting, riding, walking, etc.).

4.58 The derivation of optimal strategies in EMME assumes perfect knowledge of service timetables and confidence that the service will arrive on time. This can result in significant interchanging and the distribution of demand between any origin/destination pair along a path of optimal routes.

4.59 To counter unrealistic levels of interchange during the assignment a number of penalties are applied to achieve a sensible and calibrated assignment. The penalties include:

- Wait time factor – reflects the distribution of arrival time for a public transport service and in the STM it is assumed that passengers wait on average half of the headway;
- Wait time weight – reflects the fact that passengers prefer to be moving rather than waiting for a service and is set at 2.5 in the STM;
- Walk time weight – reflects the desire to complete as much of the journey as possible by transport rather than walking and is set to 2 in the STM; and
- Interchange penalty – prevents frequent changing of service and reflects a passenger's desire to remain on one service.

4.60 The generalised cost of a public transport journey is thus:

GC = (WT x walk time factor) + (H x wait time factor x wait time weight) + IP

Where:

- WT = walk time
- H = headway
- IP = interchange penalty

Model Calibration

4.61 In order to check that the public transport model is accurately representing the base year scenario and number of calibration checks will be performed:

- Journey times based on timetables will be compared with the modelled bus and rail service times;
- Flows on links will also be matched to counts derived from the bus and rail data;
- Number of modelled passengers will be compared to the figures provided by both the Wayfarer data and the rail survey information;
- Boarding/Interchange time at nodes will be adjusted to prevent excessive interchange and create realistic passenger movements.

4.62 The model will comply will the following validation/calibration criteria:

4.63 For individual links; modelled passenger flows within 25% of observed, except for links with observed flows of less than 150. On these links the GEH value should be less than 5. As with highway validation we will aim to get 85% of links meeting these criteria.

5. Micro-Simulation Model - VISSIM

Introduction

5.1 The micro-simulation model is linked to the highway model. It does not form part of the demand modelling process but receives traffic volumes from the highway model.

5.2 Like the macro highway model, the micro-simulation model has two components, a supply side that represents the highway network and a demand side that represents trip patterns. The two sides combine during assignment.

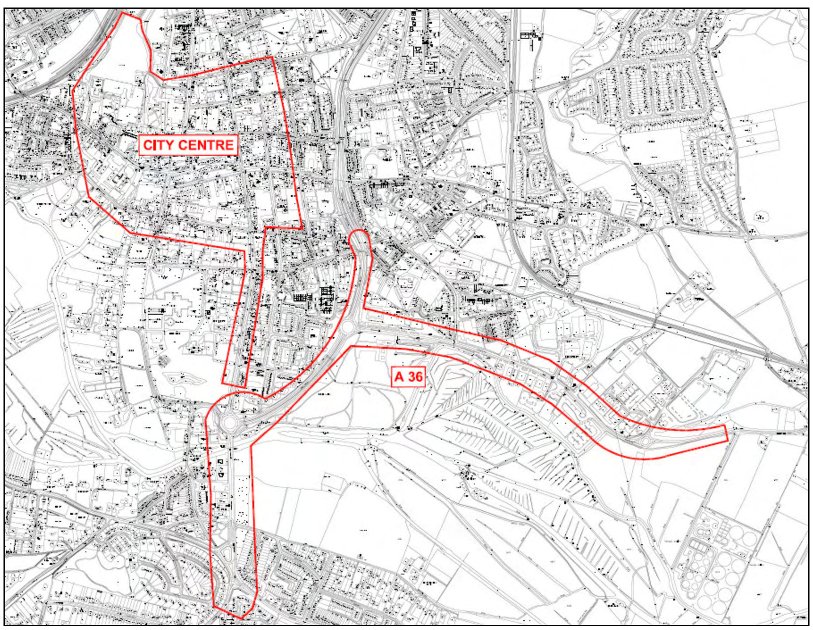
5.3 Two separate VISSIM networks have been specified as part of this commission:

- A city centre network focusing on the Market Square and
- A network along the A36 Southampton Road approach to Salisbury, including the A36 Churchill Way and extending to the Harnham Gyratory. Figure 5.1 displays the two network cordons.

5.4 In broad terms the city centre model is required to assess changes to the road network and parking stock such as the prioritisation of space for public transport and the closure of car parks.

5.5 The A36 Southampton Road model will become a test bed to evaluate the operation of the network in this area. This approach towards Salisbury is characterised by high levels of delay, particularly during the morning peak hour.

Figure 5.1 – Salisbury Micro-simulation Network Cordons



5.6 Both networks will be built using VISSIM micro-simulation software. VISSIM is a micro-simulation model that features a more detailed assessment of junction and link operability, particularly in urban areas. Unlike SATURN, VISSIM undertakes micro-simulation modelling by simulating individual vehicle interactions.

5.7 The transport networks between VISSIM and SATURN will be very similar and as a result traffic demand for scenario runs will be taken directly from the SATURN model through a conversion of the assigned traffic flows.

Model Specification Standards

5.8 Micro-simulation models are complex, containing a large number of separate model parameters or settings such as speed distributions, vehicle type and route choice. Atkins will adopt the Transport for London (TfL) guidance note; **M**odel **A**pproval **P**rocess (VISSIM – **VMAP**) guidance and best practice document to support the development of the VISSIM networks. VMAP is designed to ensure high quality VISSIM models that refer to best practice and promote high standards of modelling fit-for-purpose for testing of scheme options and appraisal.

5.9 VMAP is structured into three parts

- Within **Stage 1** is an agreement of the scope and coverage of the model is made,
- **Stage 2a** outlines the development of the skeleton VISSIM network and model parameter such as speed distributions,
- **Stage 2b** describes covers the build up of network data such as signals and priority rules, and
- **Stage 3** describes validation criteria to ensure the model is fit for purpose.

Linkage with SATURN model

5.10 Traffic flows in VISSIM will originate from the SATURN model. The key advantage of this approach is to capture the reassignment of traffic within the larger strategic model before a more localised modelling assignment in the micro-simulation model.

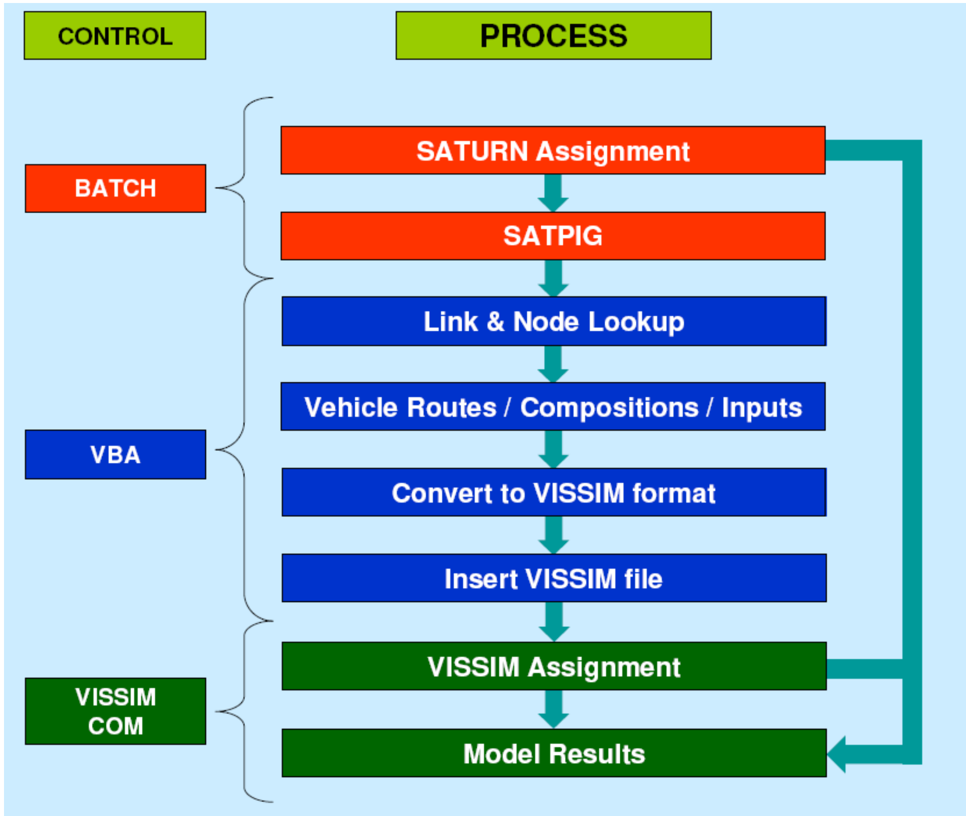
5.11 A VISSIM 'assignment' will take a total of three components from the SATURN model.

- vehicle routes
  - the static or defined route for each vehicle through the network
- vehicle inputs
  - the volume of vehicles at each model entry
- vehicle compositions
  - the composition of vehicles i.e. the user class at entry point

5.12 A vehicle route is a defined path for each vehicle that travels through the network. This is extracted from SATURN via a module called SATPIG that gives a complete path between start and end zone and nodes pass through in between. The vehicles that take this route are loading into the model via a vehicle input. This vehicle input is divided into separate user classes via the vehicle composition.

5.13 The process to transfer modelled flows between the two models is typically automated through batch files, Visual Basic Applications (VBA) and Common Object Model (COM). Figure 5.2 displays the proposed process for Salisbury models. The intention of this process is to automate the running of both SATURN and VISSIM models so they can be run and the results viewed side by side. .

Figure 5.2 – SATURN to VISSIM Interface



Zone to Network Connections

5.14 The zoning system within the two VISSIM cordons should be detailed enough that connections to the network are realistic enough to replicate the conditions on the ground. This will be achieved through a detailed enough zoning system and the appropriate use of centroid connections.

Node Numbering

5.15 The node numbering within SATURN should be such that it is possible to identify nodes falling within each of the two micro-simulation networks and those externally so that vehicles potentially routing into and out of the VISSIM network are within the SATURN are captured. It is proposed that this is achieved by numbering nodes at the cordon border with a identifier such as 99XX.

OD Movements

5.16 The matrix development stage of the SATURN should incorporate OD surveys recorded for the VISSIM model in the form of ANPR (Automatic Number Plate Recognition). The routing patterns of trips within the network should also have a degree of control under matrix estimation to not divert away from the observed patterns captured in the ANPR survey.

Model Calibration

5.17 The quality of the SATURN assignment against observed conditions should be as high as possible within the VISSIM cordons. In particular traffic volumes should be as close as possible to observed values. In general GEH values for turns should be below 5 or better in all instances.

6. Parking Model

Introduction

6.1 Parking information will feed into the model at two points. At the beginning of each model run, average parking costs for trips occurring for each purpose in each time period will be estimated on the basis of proposed parking charges and spaces available in each car park. This information will feed into the main demand model to contribute to the highway generalised costs used in travel choice calculations. The demand model will then produce estimates of highway demand on the assumption that sufficient spaces would be available to accommodate all those who wanted to park.

6.2 A separate parking capacity constraint model run after the demand model will then assess the implications of any shortage of available spaces.

6.3 Figure 2.3 summarises the proposed process and the following paragraphs discuss the modelling stages in further detail.

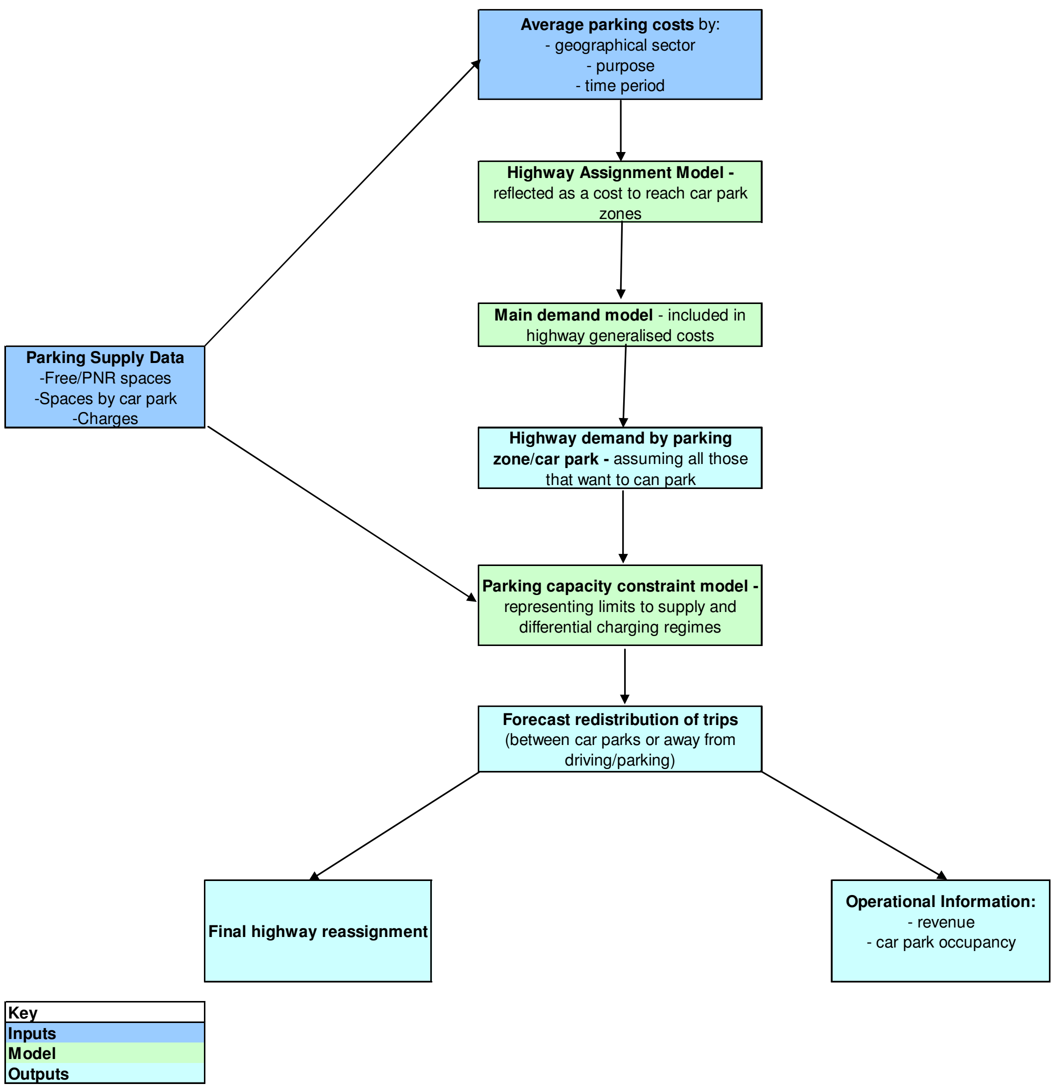


Figure 6.1 - Parking Representation within the STM

Parking Cost Input

6.4 The parking costs input to the demand model will represent the average cost faced by trips to the city centre area, taking into account:

- the proportion of trips paying to park (after allowing for PNR and free parking);
- patterns of duration of stay;
- parking charges;
- average search and egress times.

6.5 Separate costs will be estimated for each purpose to take account of the likely variations in the proportions paying to park and durations of stay. Costs will also be calculated separately for each of 3 or 4 geographical sectors in the city centre. This approach will be adopted in preference to the calculation of individual costs for each car park to accommodate scenarios where individual car parks are either closed or assumed to experience a large increase in parking charges. If costs were to be calculated individually for each car park, costs for trips to the affected car parks would become unrealistically high as they would not reflect the option to use nearby alternative, cheaper car parks. Considering all car parks within one sector together would overcome this issue.

6.6 The costs calculated at this stage will be included as costs to access the relevant car park zones in the highway assignment model and included in the main demand model in the generalised cost calculated for highway trips for use in the travel choice calculations. This will ensure full trip costs are represented, providing a fair comparison with the costs of park and ride and public transport travel options.

6.7 On the basis of this input information, the demand model will forecast the number of trips to each parking zone. The results produced will reflect the situation where costs are consistent between car parks in a sector and each car park is open and has sufficient capacity to cope with all those drivers wanting to use it. This is likely to be a reasonable assumption in many scenarios, however situations could arise in which demand considerably exceeded supply or costs varied significantly between car parks. The potential impacts of these situations will be assessed through a parking capacity constraint model run after the demand model.

Parking Capacity Constraint Model

6.8 The capacity constraint model will represent the impacts of differential charging regimes and the balance between parking demand and available paid parking spaces in more detail. Each central car park will be represented separately in terms of available spaces, fees charged and forecast demand.

6.9 The highway demand forecast by the demand model for each car park zone will be a key input to the model. Survey based arrival and departure patterns will then be used to convert the demand in the modelled hours into demand throughout the day, expressed in terms of arrivals and departures per time interval.

6.10 The cost of different parking options for trips arriving at each car park zone will then be assessed on the basis of:

- Charges faced at each car park (accounting for duration)
- Existing occupancy of each car park (influencing search/wait times). Search times increase with occupancy levels as shown in Figure 3.1 (based on research undertaken by MVA[3]). As

[3] The graph shown is assumed to apply to a car park of 250 spaces. Below 100% occupancy it is assumed that search time for a given occupancy varies with the size of the car park i.e. drivers have to drive further to find spaces in larger car parks. Above 100% it is assumed that every extra 1% increase in occupancy causes the same increase in search/wait time (1 minute) in all car parks on the

occupancy increases people take longer to find a space and when occupancy exceeds 100% search times become very long as drivers effectively have to wait for a space to become free. The calculated search and wait times will be converted into monetary values using the standard Webtag values of time.

- Additional travel times involved with using a car park other from the original choice (assuming that the original is the most convenient). Again, these times will be converted into monetary values using the standard Webtag values of time.

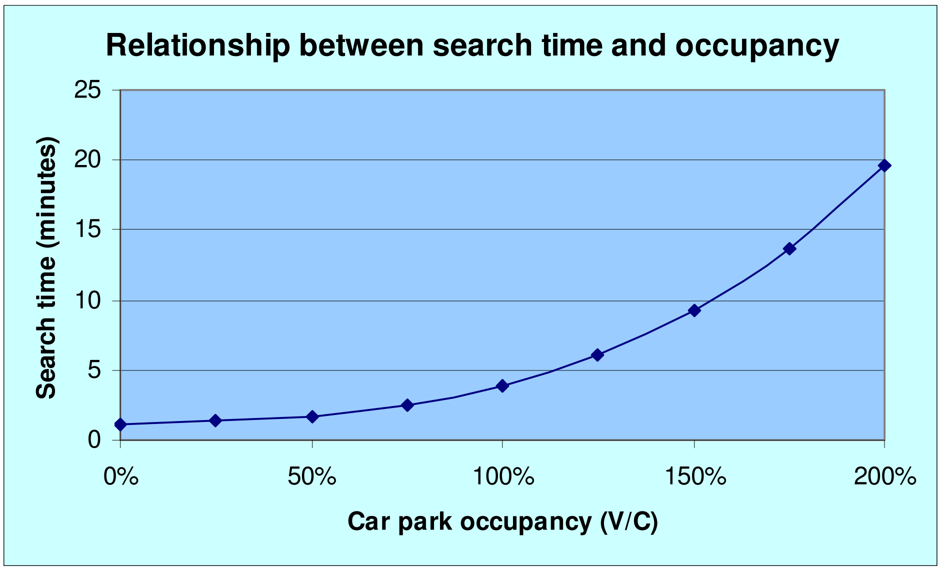


Figure 6.2 - Typical Relationship between Search Time and Occupancy

6.11 Costs will be calculated separately for drivers arriving in each interval of the day (to account for varying car park occupancy) and for each category of intended duration of stay (to account for varying charges and car park options available).

6.12 The car park chosen for each trip will be based on the assumption that, on average, drivers choose the cheapest option available (accounting for time and monetary costs). In most cases this is likely to be the original car park choice. However, in circumstances where demand for the car park greatly exceeds available spaces or charges have been substantially increased, the model will allow the trip to switch to an alternative car park, effectively choosing to drive and/or walk further to save money or searching/waiting time.

6.13 Allowance will also be made for the fact that as overall parking costs increase some drivers may choose to use a different mode to reach the town centre or to stop making the trip altogether. These responses will be represented using elasticities drawn from the responses modelled in the main demand model.

6.14 The final output from the model will be

- a range of graphs and tables summarising forecast car park utilisation/occupancy and revenue (as illustrated below).
- estimated changes to the highway trip matrix, reflecting changes in final car park destination and potentially some mode switch or trip suppression. These changes could then be fed back into a final assignment of the highway model to assess potential traffic and congestion impacts of trips ending in different car parks.

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basis that the increased probability of a space being vacated in a larger car park is offset by the greater competition for that space for the same occupancy in larger car parks.

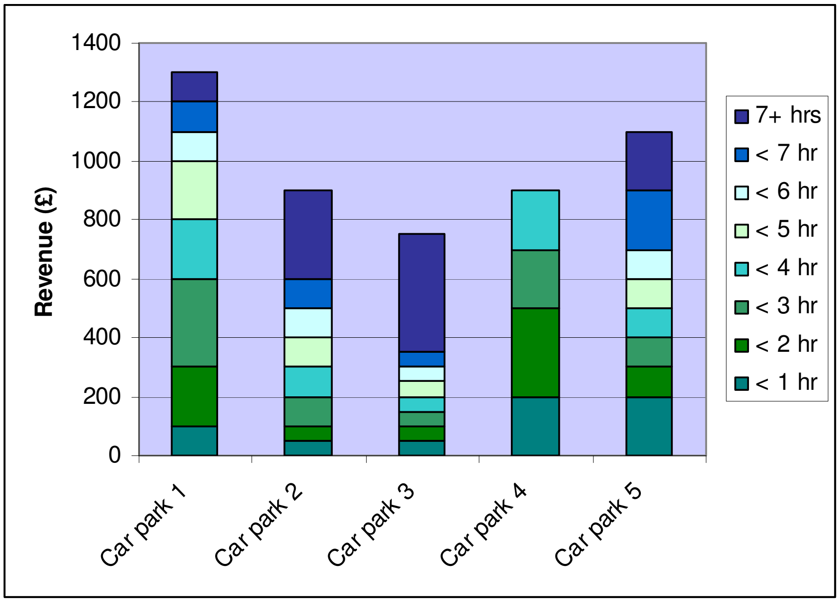


Figure 6.3 - Example of Potential Model Output

6.15 The forecasting model will be based on a base year model which will be developed using current usage patterns derived from ticketing data and the car park surveys. The model will be calibrated to ensure that it reproduces current conditions before being used as a basis for forecasting future responses.

Future Potential Developments

6.16 The parking cost impacts of capacity constraint could theoretically be fed back into the demand model to allow travel choice responses to be forecast there rather than within the capacity constraint model. However, successful implementation would require a substantial extension to the model's functionality and complexity with an additional mode of 'park and walk' included to allow people to choose between car parks as well as between modes. The interaction would also need to be iterative, allowing the impacts of changed traffic flows and search times to feed back into the costs used for the next iteration of the demand model. This could be considered as a potential future development to the model.

7. Public Transport Cost Model

Introduction

7.1 Atkins has developed an in-house application for assessing potential cost of operating a specified bus service. The public transport operating cost (PTOC) Model has been developed and successfully employed on numerous public transport operational assessment projects throughout the UK, including Bristol Transport Innovation Fund bid.

7.2 The model incorporates routing alignment and service details, operating periods, staffing costs, vehicle maintenance, fuel, overheads and vehicle and purchasing/leasing costs to provide a robust and thorough operational cost assessment of a specified service(s).

7.3 The model enables sensitivity testing of altering different aspects of the proposed service provision, such as headway or route alignment changes on annual operating costs. Furthermore it provides the opportunity to batch test numerous operating scenarios.

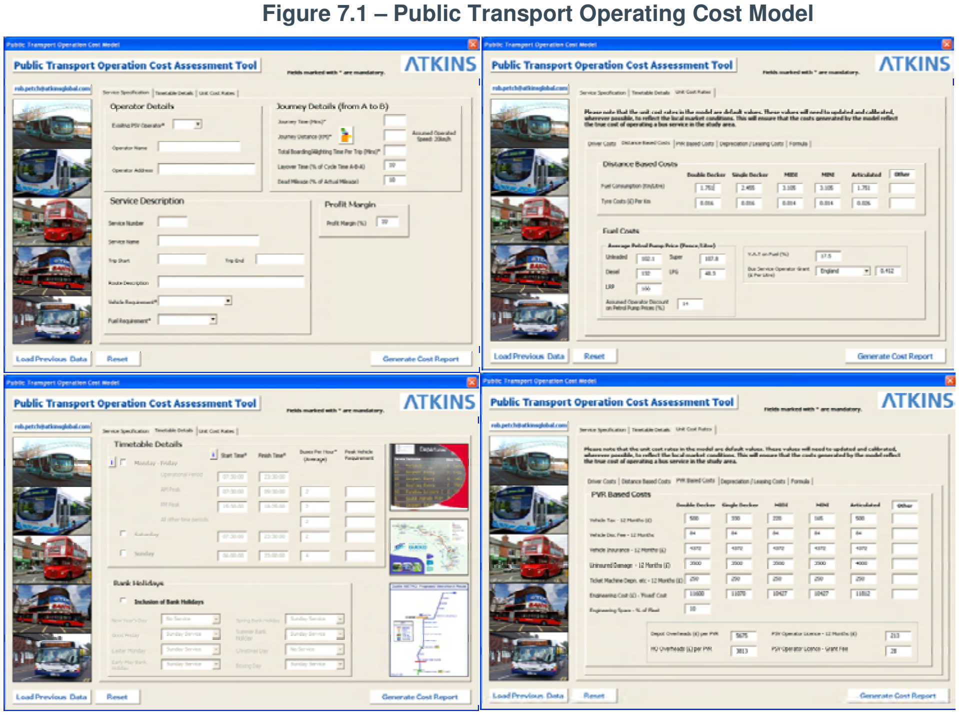
Inputs

7.4 The model includes a range of nationally available data to provide indicative results ahead of more detailed results using local data. If local data is not available (due to commercial sensitivity) then the model can operate using this national data.

7.5 The calibration includes unit cost rates for :

- fuel consumption;
- tyre wear;
- fuel costs;
- insurance; and
- maintenance

Figure 7.1 – Public Transport Operating Cost Model



Appendix A
Highway Model Information

A.1 SATURN Model Parameters

A.1.1 General network parameters

- KPHMIN = 10 * Minimum free flow speed
- KPHMAX = 120 * Maximum free flow speed
- MAXLSF = 2600 * Maximum Lane Saturation Flow
- MAXQCT = 60 * Maximum queue clearance time (min)
- MINLSF = 100 * Minimum lane saturation flow
- MINRED = 8 * Minimum red phase
- MINSAT = 350 * Minimum turn saturation flow
- NOMADS = 2 * Number of user classes 1=Lights 2=Heavies
- ALEX = 5.75 * Average length of a vehicle externally

A.1.2 General give-way, merge gaps

- GAP = 1.00 * Gap accepted at priority and signals
- GAPM = 0.50 * Gap accepted at merges
- GAPR = 1.00 * Gap accepted at roundabouts

A.1.3 Convergence

- UNCRTS = 0.05 * Wardrop assignment stopping parameter - epsilon
- KONSTP = 1 * Assignment stopping criteria are based on %GAP
- STPGAP = 0.05 * Critical Gap Value to stop assignment

A.1.4 Assignment related

- NITA = 10 * Maximum number of assignment iterations
- NITS = 30 * Maximum number of simulation iterations
- NITA_M = 5 * Minimum assignment iterations
- NITA_S = 99 * Number of assignment iterations
- MASL = 120 * Maximum number of assignment / simulation loops

Appendix B
Public Transport Model Information

B.1 Bus Services

Table B.1 – General Bus Services

Number	Service (From/To)	Operator
1	Amesbury to Salisbury	W & D
1	Salisbury to Great Durnford	W & D
2	Salisbury to Devizes	W & D
4	Devizes to Salisbury	W & D
5	Salisbury to Durrington	W & D
6	Salisbury to Durrington	W & D
8	Salisbury to Andover	W & D
24	Salisbury - Warminster	BODMANS
25	Burton to Salisbury	W & D
26	Salisbury to Shaftesbury	W & D
27	Shaftesbury (Hill Farm Estate) to Salisbury	W & D
29	Salisbury to Shaftesbury	W & D
34	Salisbury to Romsey	W & D
36	Salisbury to Romsey	W & D
53	Salisbury - Devizes - Salisbury (via Bemerton Heath)	W & D
55	Salisbury - West Harnham - Salisbury	W & D
57	Salisbury - Bishopdown - Salisbury	W & D
60	Salisbury to Ditchampton (via Skew Bridge)	W & D
60A	Salisbury to Ditchampton (via Lower Bermeton)	W & D
61	Salisbury - Bulbridge - Ditchampton	W & D
62	Salisbury - Pauls Dene - Salisbury	W & D
63	Salisbury to Tidworth	W & D
64	Salisbury to Tidworth	W & D
68	Salisbury to Winchester	W & D
69	Salisbury to Porton Down	W & D
69A	Salisbury to Old Sarum	W & D
71	Stratford Bridge to Harnham Hill	W & D
72	Salisbury to Laverstock	W & D
73	Salisbury to Bishopdown Farm	W & D
89	Salisbury to Winterslow	W & D
184	Salisbury to Weymouth	W & D

285	Salisbury - Winterbourne- Lopcombe - Test Valley School	Tourist Coaches
501	Salisbury (Town Centre) to Beehive P&R	W & D
502	Salisbury to Wilton P&R (Near Salisbury)	W & D
503	Salisbury to Britford P&R	W & D
504	Salisbury (Town Centre) to London Road P&R	W & D
Pulseline	Bemerton Heath to Woodfalls	W & D
Pulseline	Salisbury (District Hospital) to Bemerton Heath	W & D
X2	Salisbury - Lackham College	BODMANS
X 3	Salisbury to Bournemouth	W & D
X 7	Salisbury to Southampton	W & D

Table B.2 - School Services

Number	Service (From/To)	Operator
40	Salisbury to Fordingbridge	W & D
41	Cranborne to Salisbury	W & D
45	Downton to Salisbury	W & D
66	Salisbury to Porton	W & D
78	Salisbury to Ford to Salisbury	W & D
88	Salisbury to Winterslow (Primary School)	W & D
348	Bemerton Heath (Westwood St Thomas School) to Ditchampton	W & D
602	Bemerton Heath (Westwood St Thomas School) to Stapleford	W & D
622	Bishopstone to Broad Chalke	W & D
648	Salisbury to Shaftesbury	W & D
650	West Harnham to Laverstock	W & D
653	Laverstock to Bemerton Heath	W & D
665	Laverstock to Boscombe Down	W & D
666	Allington to Laverstock	W & D
667	Fugglestone to Wilton (Near Salisbury)	W & D
668	Salisbury (South Wilts Grammar School) to Tidworth	W & D
670	Stoford to Salisbury (St Osmunds School)	W & D
678	Salisbury to Laverstock	W & D
679	Ford to Winterbourne Earls	W & D
684	Salisbury to Fordingbridge (Burgate School)	W & D
693	Salisbury to Fordingbridge (Burgate School)	W & D
694	Salisbury to Downton (School)	W & D
696	Petersfinger to Downton (School)	W & D
697	Downton (School) to Salisbury	W & D
699	Salisbury to Downton (School)	W & D
763	Britford to Brockenhurst (College)	W & D
C12	Salisbury to Brockenhurst (College)	W & D
X70	Brockenhurst to Salisbury	W & D
X74	Salisbury to Totton	W & D
X75	Salisbury to Totton	W & D
X87	Salisbury to Andover	W & D

Appendix C
Filename Convention

C.1 File Name Convention

Introduction

Calibrating/validating transport models and subsequent scheme appraisal is a time-consuming process. The number of files and the manipulations involved are significant which widens the scope for errors. This note describes a file naming convention which is to be adopted for all STM modelling work to ensure that subsequent procedures can be automated as much as possible. Such procedures will include the extraction of flows and journey times from model runs for comparison with observed datasets, the preparation of skim matrices for use in economic appraisal and the preparation of input files for the economic appraisal using TUBA.

The naming convention is principally to ensure consistency in matrix file names.

Suggested Naming Convention for Highway Modelling

As the model calibration and validation is a tedious process, it is inevitable that the network and matrix will be continuously modified until model is satisfactorily validated. To avoid confusion in SATURN batch files, it is a good idea to use different file names for network and matrix.

The following convention is suggested for the base year highway model files:

STMb08x&&&$$_%%%^.£££

Where:

STMb08	fixed identifier representing Salisbury Base Year 2008;	
x	represents time period (a=(a)m peak, i=(i)nter peak, p=(p)m peak);	
&&&	using "net" for network file and "mat" for matrix file;	
$$	represents different user classes, e.g. U1, U2 and U3 etc. leaves it as empty for stacked matrix (not relevant for networks)	
_	underscore separator;	
%%%	version number starting from 001;	
£££	represents	file type where, for example:
		UFS = SATURN loaded network
		UFC = SATURN route
		UFM = SATURN matrix (trip/skim)
		CSV = Comma separated values
^	represents	matrix type where:
		(not relevant for networks)
		v = vehicular (i.e. trip matrix – use pcus throughout)
		t = time skim
		d = distance skim
		c = charge (toll) skim

For example, STMb08aNet_001.dat represents version 001 of base year 2008 AM Peak Salisbury highway network; STMb08pMatU1_001v.ufm represents version 001 of base year 2008 PM peak user class 1 trip matrix.