Development of a New Strategic Transport Planning Model for Adelaide

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1   Introduction

The task of modelling travel demand patterns in metropolitan Adelaide is important to assist in transport management for both current and future travel patterns.   Stakeholder needs are no longer met by the previous transport modelling approach (developed in 1992), prompting the then Department of Transport and Urban Planning (DTUP) in cooperation with the Transport Systems Centre (TSC) to initiate the development of a new suite of multimodal travel demand models for metropolitan Adelaide.

The newly developed Metropolitan Adelaide Strategic Transport Evaluation Model (MASTEM) is based in the Cube Voyager transport planning software environment and addresses stakeholder issues associated with multimodal modelling. It is a powerful tool for the medium to long range strategic planning of metropolitan Adelaide's transport system and the estimation and assessment of travel patterns and behaviour across the network. MASTEM also assists in the analysis of traffic patterns with components dedicated to a range of output types and scales.

This paper provides a general description of the background for MASTEM and the overall aims of the modelling. It details the strategic Adelaide metropolitan transport model and the structure of the developed MASTEM software. In addition, the features of the model and the potential for future developments are examined.

2   The Need for a New Model and Model Requirements

The needs for a new transport model for Adelaide were determined thorough a two-stage review process. An initial strategic review (Taylor and Scrafton, 2003a) of the current status of travel demand analysis and transport planning modelling undertaken by the then Department of Transport and Urban Planning (DTUP) established the extent to which the previous models and modelling capability met user business needs, and identified the means by which they could be enhanced. DTUP's expressed aims were to:

- enhance its capability for integrated multi-modal travel demand analysis and transport planning
- increase ease of use and transparency of modelling
- better model freight transport and commodity movements
- improve its ability to account for present and emerging issues in policy development, and
- generally ensure that its travel demand analysis and transport planning modelling capability meets current international best practice.

An important result of the first stage of the review was that there were needs for a suite of connected models, for application at different levels of detail, and capable of multimodal analysis.

The second stage of the Adelaide model review then involved:

- the development of a detailed functional specification for a suite of integrated multimodal travel demand models for metropolitan Adelaide that fulfils the requirements identified in the review, particularly the needs of the various stakeholder groups in the department, and
- the development of curriculum for a program of basic and advanced training aimed at ensuring that the portfolio agencies maintain and continuously improve their internal travel demand modelling and analytical capabilities and expertise.

The second stage of the review is described in Taylor and Scrafton (2003b).

3   Hierarchy of models

A useful concept for identifying specific modelling needs and for illustrating differences in scope and similarities in application between models is that of the hierarchy of models. This concept proved an ideal vehicle for identifying and connecting the modelling needs of different stakeholders, and thus in defining the required functional specifications for the proposed suite of models for Adelaide. The hierarchical perspective reconciles model applications for analysis over a range of levels of detail, from sketch planning to detailed local area studies. It provides an overall framework which defines different levels of detail for travel demand modelling and indicates the specific forms of models to be applied at those levels, as discussed in Taylor (1991, 1999) amongst others. The hierarchy combines:

(a)   relevant modelling theories and concepts, to identify the ideas and relationships that area directly applicable to a given problem
(b)   appropriate levels and detail of input data
(c)   appropriate choice of computing methods and capacity, and
(d)   relevant model outputs that describe the performance of the system under study at an accuracy commensurate with the validity of the theories used and the input data.

The following seven-level hierarchy has been found useful for traffic analysis and modelling (Taylor, 1991, 1999). Starting at the most detailed (micro-) level, the hierarchy is:

(1)   *microscopic simulation* of individual units in a traffic stream, for example, for the assessment of vehicle performance at a junction or along a link, or the movements of pedestrian traffic at a railway station or an airport terminal
(2)   *macroscopic flow* models in which the flow units are assumed to behave in some collective fashion on some element of a transport system, for example, aggregate models of flows on a link or at an intersection
(3)   *simulation* models of flows in network for the optimisation of network performance for fixed route choice. In this condition of fixed level and distribution of travel demands, the simulation model can suggest the likely effects on delays and queuing that will occur as different system variables (e.g. traffic signal timings or bus service frequencies) are altered. The model thus indicates the changes in system performance – on the assumption that the intensity and distribution of travel demand are unchanged
(4)   *dense network* 'high resolution' models, including both trip assignment models and models for creating synthetic origin-destination matrices. This level of the hierarchy introduces a direct demand response to changes in system performance, e.g. deviations in route, destination, mode and trip timing choices as the characteristics of the transport system are modified. As well as indicating the likely changes on system performance (as in (3) above), the dense network model will also suggest how travellers will react to the altered system, through changes in the pattern and intensity of travel demands
(5)   *strategic network* 'medium resolution' models, typically involving the 'four step' process of trip generation, trip distribution, modal choice and trip assignment. In modern applications a 'fifth step' – trip timing – can be added to this model type, to indicate the

       temporal pattern of travel demand over the hours of the day. This level is that of the typical travel demand network analysis package

(6)   *strategic network* 'low resolution' models for analysis of the impacts of transport infrastructure projects and to provide data for project planning, and for study of the local and regional impacts of new land use facilities, or the redevelopment of existing facilities. These models use similar approaches to those of the 'level (5)' models but are designed to produce coarser level outputs (e.g. for Perth, at 'level (6) STEM provides corridor and screenline flows, whereas the 'level (5) ROM model produces link volumes)

(7)   *sketch planning* models of land use-transport interactions. At this level the spatial connections between spatial elements may only occur as notional representations These models have application in broadbrush planning decision making – e.g. the decision to proceed or not with a particular policy initiative, with at initiative then to be tested using analysis at the more detailed levels (i.e. (6), (5), (4), (3), (2), (1)) as appropriate

The hierarchy provides a means of classifying and comparing transport models. Its levels may be distinguished on the bases of spatial aggregation and time duration, with both area and duration tending to increase as one moves from level (1) to level (7). Areas increase from the isolated junction or road section (individual site), to areas of several hectares (district centre), to several square kilometres (dense network), and to an entire metropolitan region. Study period durations for the microscopic simulations are generally of the order of a few minutes, increasing to a peak 'hour' for the local area models and a 24-hour period (or indeed much longer) for the sketch planning models.

Figure 1 provides a pictorial representation of the spatial dimension represented by the hierarchy. In this figure, we can see the spatial relationships between models at levels 1-6 inclusive, and some implications for the higher level (7) too.
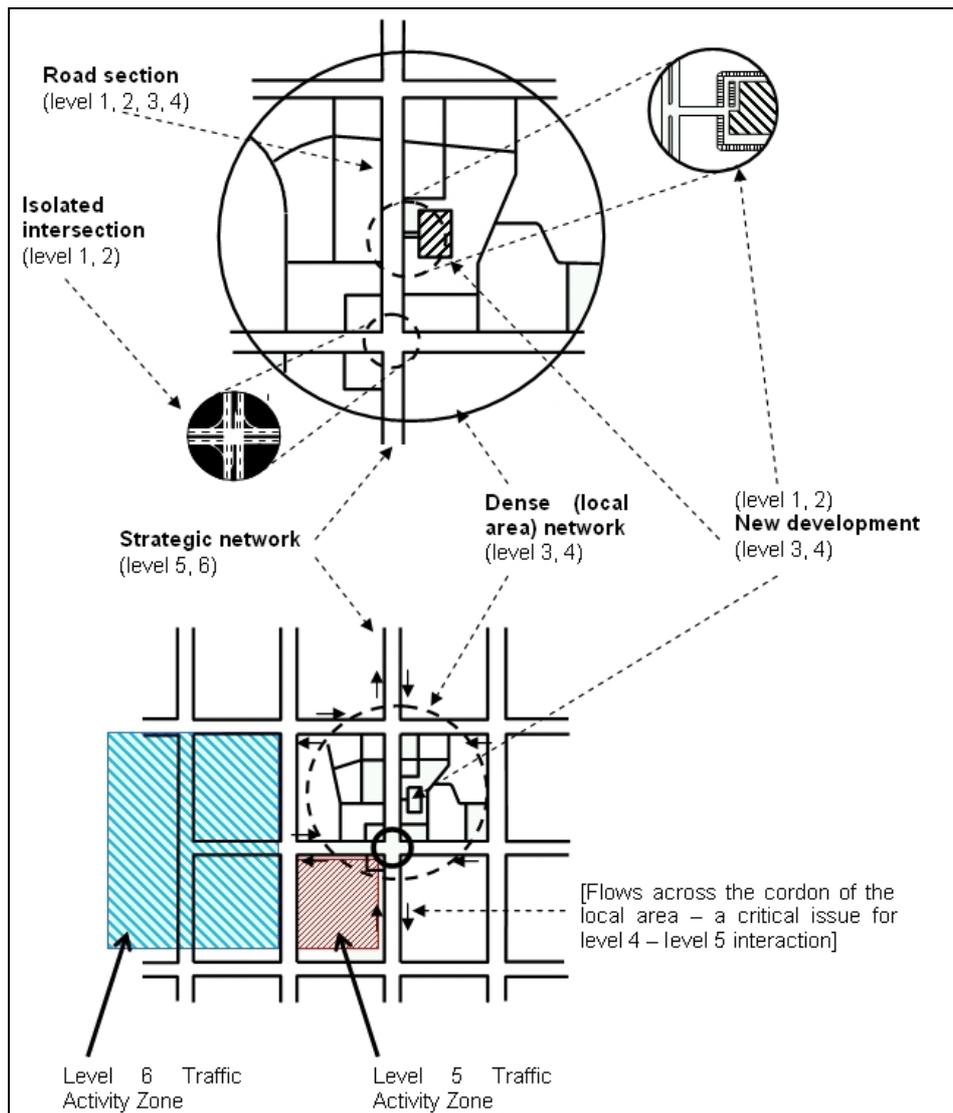
Figure 1: Spatial representations of level (1)-(6) models in the modelling hierarchy.

The hierarchical approach to modelling offers a practical, integrated methodology for examining transport systems models. It provides a framework for judging the appropriate position and use of a particular model, and its relationships with other models. The framework allows the development of a comprehensive strategy for the use of models in transport analysis and provides one plank for the definition of acceptable model performance.

Data needs in the hierarchy and integrated databases permitting data flows between models at different levels in the hierarchy are discussed in Thompson-Clement, Woolley and Taylor (1996). The use of Geographic Information Systems (GIS) approach to database integration for a region (e.g. a metropolitan area or a sub-area within it) is an important consideration in the process of developing and implementing an integrated modelling suite. This may involve the use of standard GIS packages linked to the travel demand modelling packages, the use of travel demand modelling packages that have GIS functionality, or the use of GIS specifically developed for transport planning applications ('GIS-T'). All of these are viable alternatives. Further discussion on the integration of GIS and travel demand analysis models is given in Affum and Taylor (1999) and Thill (2000).

4   Results and recommendations of the review

As discussed in the first stage report for the Adelaide review (Taylor and Scrafton, 2003a), the key result of the discussions across the agencies of the department was that a modern, integrated, multimodal model for metropolitan Adelaide was an essential resource for strategic and tactical transport planning. This model was needed both for its technical capabilities and as a demonstration of the department's strong commitment to a multimodal urban transport system. The model should serve the needs of the department as a whole. Thus the constituent agencies of DTUP needed to be aware of the relevance of their specific databases for use in the model, to prepare their data in formats suitable for inclusion in the model, and to keep the databases up to date. Those responsible for the model itself need to espouse its role and capabilities to the agencies, and facilitate a wide understanding throughout the department of the usefulness of the model to specific agencies. This includes the capability to model the effects of policies or projects that seek to induce mode shifts, to established alternative modes such as public transport or to other alternative modes, such as cycling, that have considerable potential to attract more usage. The ability for future models to represent changes in people's travel behaviour (e.g. trip timing decisions) also needs to be recognised. Other issues such as peak spreading, trip chaining, trip timing, induced traffic and elastic travel demands (changes in the total amounts of travel measured either in terms of numbers of trips or distances travelled) are also of concern.

In general, the main need determined for travel demand modelling was for system and project planning, which included the need for information pitched at a detailed level (e.g. routes and road segments, intersection turning movements, individual public transport services and routes, or access to public transport interchanges by foot, bicycle or car). 'Strategic' analysis (i.e. policy appraisal) was certainly no less important but was seen as probably a less frequent need. Thus there was a need for modelling aimed at levels that require more detail than may normally be provided by a metropolitan-wide model, but in addition these detailed models may require inputs from the metropolitan model. This requires suitable modelling tools for the specific levels of application and the means to link models at different levels of detail so that relevant data can be moved between them[1]. In the case of public transport studies, the models must be able to perform some kind of scheduling analysis, to provide outputs on service performance variables such as bus-hours or seat-hours, bus-km, and peak buses in service. This is essential information for estimating the costs of proposals for public transport service operations.

In terms of policy analysis, there is also a need for simplified 'sketch planning' models that do not require the description of a physical transport network for their application. Sketch planning models have an increasingly important role in transport policy (and related urban, retail and employment policy) appraisal. The department had investigated a number of sketch planning models in recent years, including GENIE and TRESIS, and has a copy of TRESIS.

The AIMSUN traffic microsimulation model has been adopted by the department for the more detailed analysis of road improvement proposals, particularly complex intersections for which there is a high level of public interest and debate.

Whilst there was some interest in the development of an integrated model of transport and land use within the travel demand modelling suite, this was not seen as being of high priority. Suitable model platforms exist for this, but overseas studies (e.g. Simmonds and Echenique, 1999) had indicated that considerable resources are required for full implementation of land use-transport interaction (LUTE) models. Available resources may be better committed to the refinement and extension of existing travel demand modelling capability, especially in

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[1] The 'hierarchy of models' described previously in this paper is one way to achieve these outcomes

terms of enhanced capability to model public transport projects. Choice of a suitable modelling framework that allowed for the future incorporation of a land use-transport interaction model would assist in the long term.

A significant general issue, observed acutely in Adelaide, was that many urban and transport planners have a lack of knowledge and understanding about the nature and use of transport models. In some quarters this has led to reluctance to use model results or, in the extreme, a rejection of those results. What the models can do, how they do it, what outputs they can provide and how those outputs can be applied is poorly understood. This led to a recommendation for the development of a set of awareness and training course on transport modelling.

The functional specifications determined by the review and adopted for the new model development are given in Table 1.

Table 1: Functional specifications for the new metropolitan Adelaide travel demand modelling suite (source: Taylor and Scrafton, 2003b).

1.	Comprise a suitable, soundly based, well established and supported commercial travel demand modelling software suite the developers are committed to continuously developing and improving the suite to enhance its capabilities and functionality by incorporating new modelling developments as they occur, thereby maintaining the value of DTUP's investment over time.
2.	Be 'user friendly' with a clear structure and transparent methodology and parameters (overall and for its component parts) and not require the informed (suitably trained and experienced) user to possess advanced computer programming knowledge or skills to operate its component parts or the suite as a whole.
3.	As far a possible use a common database of socio-economic, demographic, employment, transport system and operational and other related data which are capable of being used by the various elements of the model suite without the need for the development of duplicate data sets or manual re-entry of data.
4.	Be capable of operating on a stand-alone (i.e. not networked) basis on the standard high performance personal computer platforms operating within DTUP and be capable of being interfaced seamlessly with associated Geographic Information Systems operated within DTUP to, inter alia, enable the display of model inputs and outputs.
5.	Be multimodal, enabling the integrated analysis of walking, cycling, train, bus and tram passenger transport travel and private and commercial (i.e. car, light and heavy) vehicle travel individually and collectively.
6.	Fulfil the particular analytical and planning needs associated with public passenger transport (train, tram and bus travel) in terms of the level of detail required and the multimodal characteristics of passenger transport travel (e.g. park-and-ride, walk, interchanging, cycling, etc).
7.	Enable travel demand analysis to be undertaken at the detailed (local area/ link/ intersection) level, the strategic (metropolitan-wide, area and corridor) level and at the sketch planning level on a consistent basis (i.e. so that results obtained at one level are consistent with those obtained at a different level).
8.	Enable a range of freight transport and logistics scenarios to be analysed at the detailed and strategic level.
9.	Be calibrated and validated using the data from the 1999 Metropolitan Adelaide Household Travel Survey and other supplementary and complementary data as required to produce a demonstrably valid model of the metropolitan multimodal transport system.
10.	Enable information required for economic and investment analysis to be produced either as part of the model suite or linked to special purpose external models.
11.	Enable integrated, multimodal medium and long-range projections of travel demand (for each mode separately, for groups of modes or all modes combined) to be produced for different transport-land use and other scenarios to form the basis for detailed, strategic and sketch level analyses and infrastructure, service and investment planning of the metropolitan transport system.
12.	Enable trip timing and the temporal distribution of travel demand to be analysed.
13.	Enable household activity based analysis to be undertaken for a range of different policy scenarios (e.g. changing school and shopping hours, etc).
14.	Enable travel demand management measures, road pricing, congestion pricing, parking (supply and charging), tolls, fares, subsidies, trip timing, trip chaining and other identified transport policy measures and issues to be analysed effectively and used to formulate policy advice to Government.
15.	Provide the required travel and transport system performance data to allow road safety and environmental impact analysis to be undertaken for different policy scenarios.

5 MASTEM Structure

The aim of the MASTEM software is to meet the functional specifications derived from the strategic reviews described in the previous sections. Based on the widely used traditional four-stage modelling process (Ortuzar and Willumsen, 1994), MASTEM derives the person-trips produced and attracted throughout the study region, distributes the trip productions to the attractions, assigns the trip to a mode of travel and to a network route to facilitate travel from origin to destination. In addition, traffic from external loading points and freight demands are included. Beyond this process, MASTEM allows for an assessment of environmental, economic and safety impacts as well as the development of demands for microsimulation assessment.
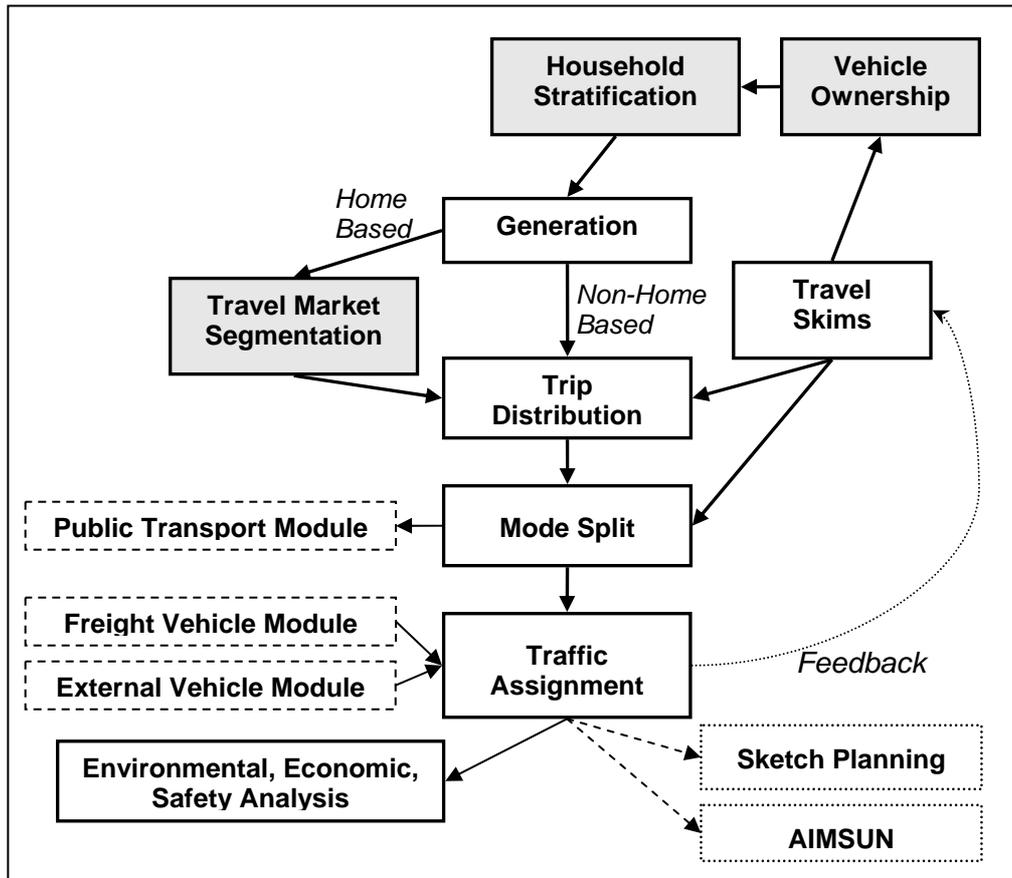

Figure 2: MASTEM operational flowchart.

Figure 2 illustrates the modules and interaction methodology in MASTEM. The processes of the traditional four-stage modelling routine can be clearly identified.

5.1 The Metropolitan Adelaide Household Travel Survey

The Metropolitan Adelaide Household Travel Survey (MAHTS) conducted in 1999 by Transport SA provides a detailed database of travel behaviour in Adelaide. The interview survey process was aimed at a two percent sample of all households in the Adelaide ASD, equating to approximately 9000 households. Face to face interviews achieved responses concerning the household attributes, all individual attributes and travel characteristics of all members of each household. This comprehensive database forms the basis for the calibration procedures. The methodologies employed by the MASTEM modules are therefore heavily dependant on the data types included in the survey response database.

5.2   Zoning

The Travel Activity Zone (TAZ) configuration adopted for the Adelaide metropolitan study region in MASTEM is based in the Census journey to work zoning structure for Adelaide. In addition, external loading points around the metropolitan perimeter incorporate external demands.

In total there are 283 internal zones of various sizes and 21 external loading points. The passenger demand modelling applies to the internal zoning only. Demands at external loading points are calculated in separate routines.
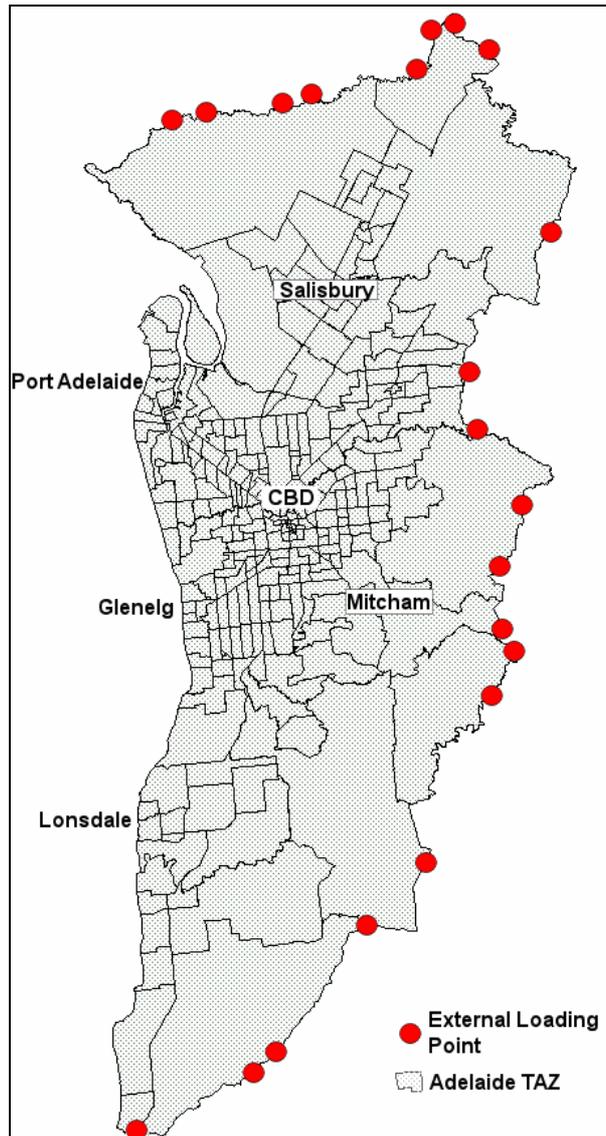

Figure 3: Map of Adelaide TAZ and external loading point locations.

Figure 3 illustrates the zoning configuration employed for the Adelaide metropolitan region modelled in MASTEM.

5.3   Inputs

The input for the operation of MASTEM is composed of land use data, zonal household attribute information and network layout with associated descriptive information.

The land-use data used in the development of zonal trip attractions and productions includes zonal averages of household attributes such as persons, workers, and dependants per household as well as the total number of households within the zone. Other inputs are employment levels across a range of industries including retail, service and transport industries in addition to zonal population numbers. Also included are enrolment numbers for all education levels.

As MASTEM models transport patterns on both road and public transport networks, it requires descriptive information concerning the configuration and operation both networks. The road network is represented as a strategic transport network, containing major roads only.   The modelling attributes associated with this network include link travel speed, capacity and speed-flow relationship under congested traffic conditions. Figure 4 displays the representative networks for the Adelaide metropolitan region.
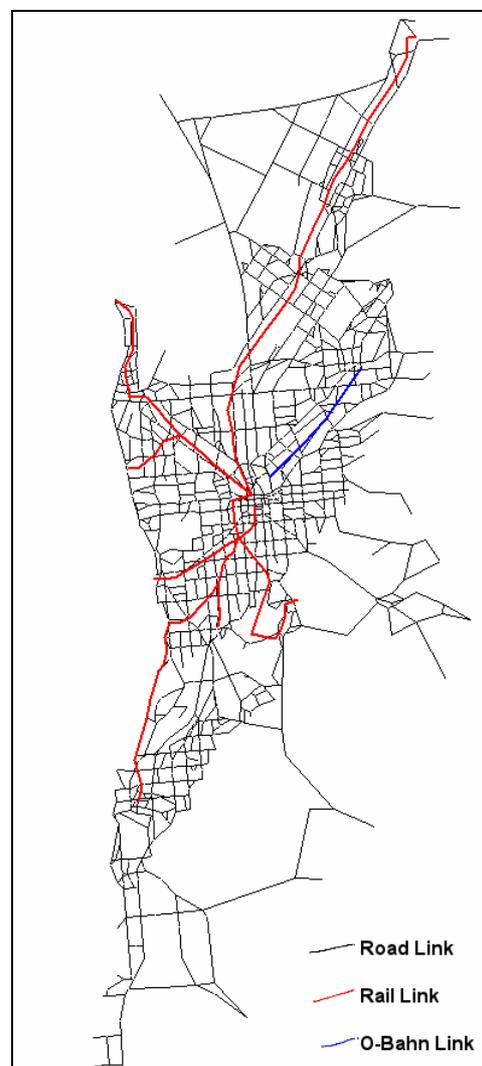

Figure 4: Adelaide strategic road, rail and O-Bahn links in MASTEM.

The public transport network includes most of the metropolitan bus routes (excluding only irregular or low service level routes), all rail services and the O-Bahn bus service (Bray and

Scrafton, 2000). In support of the route information are the service descriptives, including fares, service frequencies and penalties associated with the use of public transport systems such as waiting and walking times.

5.4   Travel Skims

To determine the initial cost incurred by travelling on the Adelaide transport networks, MASTEM conducts a travel skim. This skim produces a matrix, representing the cost of travel between all origin and destination pairs in the Adelaide metropolitan region. A travel time cost is determined for the trip distribution phase of MASTEM whilst a generalised cost is calculated as input to the mode split procedures.

The generalised cost calculation incorporates the travel time, parking charges, value of time with a recognition of work and non-work trip purposes. Non-motorised travel times are also a component of the network skims.

5.5   Vehicle Ownership

Vehicle ownership is an important factor in the generation of network trip ends. This module estimates the zonal average number of vehicles that belong to a household. Estimates are based on the zonal average workers per household, dependants per household and a measure of accessibility to the CBD.

The vehicle ownership module uses a simple regression technique to estimate the vehicle ownership level, utilising the 1999 MAHTS database for calibration.

5.6   Household Stratification

The household stratification module refines the original data inputs by disaggregating the zonal average estimates. This data is subsequently provided to the trip production procedures. Stratification of household descriptives involves estimating the percentage of households belonging to a stratified household classification from the zonal household averages.

As an example, a zone may have an average of 1.7 workers per household. From this information, the household stratification process may estimate that 15% of households will have no workers, 25% will have one worker, 40% will have 2 workers and the remaining 20% will have three or more workers. Similar calculations are conducted for household residents, dependants and cars using a logistic function to estimate the stratifications.

5.7   Trip End Generation

In the traditional four-stage modelling process the trip end generation is a first step, calculating the amount of productions and attractions within each TAZ. In MASTEM, the stratified trip household attributes along with zonal land-use information are utilised to estimate trip productions and attractions for eight trip purposes. A regression technique calibrated using the 1999 MAHTS database is used in this phase. Home and non-home based trip purposes include:

- Home based work

- Home based education
- Home based shopping
- Home based social/recreation
- Home based personal business
- Home based other
- Non-home based employers business
- Non-home based personal business

The trip ends are subsequently balanced to ensure that the total productions are equal to total attractions.

5.8   Travel Market Stratification

Travel market stratification within MASTEM disaggregates home-based trip productions into three car-ownership classifications. Trips will belong to households with no cars, one car or two or more cars. The introduction of car ownership classifications increases modelling accuracy as the trip production definition is further disaggregated. This is achieved by employing a regression technique calibrated on 1999 MAHTS data.

5.9   Distribution

At this stage of the modelling process, MASTEM has determined trip productions and attractions for a disaggregate set of trip purposes and car ownership groups. To assign the trip productions to the attractions the trip distribution process employs a gravity model. A set of calibrated friction factors are used to represent the cost distribution for travelling between TAZ's, which are applied within the gravity model. The friction factor estimates are based on data reported in the 1999 MAHTS. An example of a friction-factor plot is provided in Figure 5:
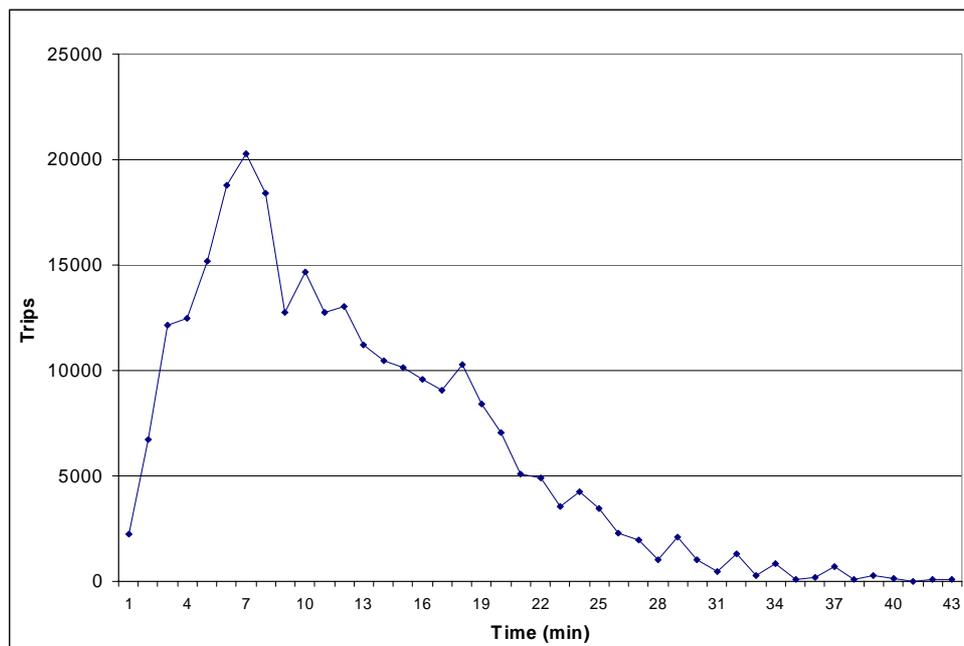

Figure 5: Friction factor plot for home-based work.

5.10   Mode Choice

The appointment of modes for each person-journey in MASTEM is accomplished in the mode split phase. This is an important phase of the modelling process that requires particular attention to calibration and model structure. A range of hierarchical structures were investigated in the development of this process with the resultant model dependant dictated by the nature of the 1999 MAHTS database. The optimum solution was found to be a multinomial choice between car driver occupancy 1, car driver occupancy 2, car driver occupancy 3+, public transport, walk and bicycle. The structure of the logit model is provided in Figure 6.
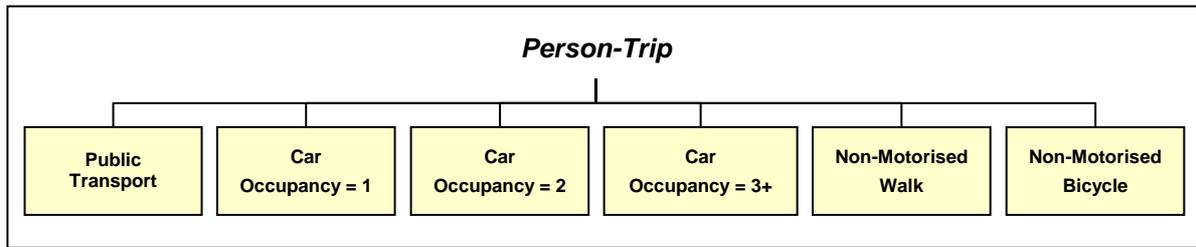

Figure 6: Structure of the MASTEM mode choice model.

Utility coefficients and functions used in the mode split process were evaluated and calibrated using the ALOGIT program. The variables used in the estimation of the model are provided in Table 2.

Table 2: Variables included in the mode split utility functions.

	IVT	Walk Time	VOC	Parking Cost	PT Fare	PT Wait Time	PT Walk Time	PT Inter-changes
Car Occupancy 1	Y		Y	Y				
Car Occupancy 2	Y		Y	Y				
Car Occupancy 3+	Y		Y	Y				
Public Transport	Y				Y	Y	Y	Y
Bicycle	Y							
Walk		Y						

Variables concerning the mode choice decisions can be categorised as travel time and monetary travel charges.

5.11   Freight Demand

Metropolitan freight demand for internal TAZ is estimated within the MASTEM structure separate to the passenger demand forecasting. Estimation of freight traffic utilises historical data, business interviews, a production and consumption model and a matrix estimation technique. The result is a commercial vehicle trip matrix which is subsequently added to the car trip matrices after an appropriate passenger-car equivalence is applied.

5.12 External Demand

To supplement internal traffic demands estimated within the study region of metropolitan Adelaide, the external demand model estimates trips crossing the 21 external loading points identified in Figure 3. Calibration of the external demands is largely based on historical survey data and takes account of freight traffic entering and exiting the network at the 21 external loading points. As with the freight module, the external traffic module adds these demands to the other estimated trip matrices in preparation for assignment phases.

5.13 Assignment

The assignment phase contains separate procedures for the allocation of highway and public transport trips to appropriate networks. Both procedures operate separate routines to account for motorised journeys.

The highway assignment routine utilises an equilibrium process as part of the congested assignment function. This involves the use of calibrated Akçelik speed flow functions (Dowling, Singh and Cheng, 1998) to account for the influence of traffic congestion on travel time. The Akçelik function has the following functional form:

$$c = t_0 + \left\{ \frac{r_f}{4} \left[(x-1) + \sqrt{\left((x-1)^2 + \frac{8 J_A}{Q r_f} x \right)} \right] \right\}$$

Within the travel time function, t_0 represents free-flow travel time on the road link, r_f is the ratio of the flow (analysis) period to free-flow travel time, x is the volume-capacity ratio, Q is the link capacity and J_A is a delay parameter. Equilibrium iterations adjust traffic flows until each journey is accomplished with a minimal cost to the user considering the effects of congestion on travel times.

Modelled public transport demand is allocated to the public transport network using a separate set of algorithms and a unique program in MASTEM. In this procedure, demand at representative stop locations are catered for by the public transport services including the coded bus, train, tram and O-Bahn routes. Interchanges, wait times, fare charges and boarding penalties are included in the modelled network operation and influence the modelled traveller behaviour during route selection.

5.14 Feedbacks

As the assignment of traffic to the highway network concludes, the resulting congested link travel times are a more accurate estimate than times utilised in the proceeding stages of the model. It is therefore appropriate to update these travel time estimates and re-run the modelling operation. The feedback mechanisms in MASTEM allow for this process as updated link travel times are input to the *travel skims* routine, and subsequently to all other processes that continue on from this part of the modelling. Iterations may converge on a specified target accuracy or can simply run a user-defined number of times.

5.15   Impact Analysis

The principle outputs from the final highway assignment routine are the traffic flow volumes and travel times on each link in the strategic network. From this information, it is possible to estimate the environmental, economic and safety impacts of the modelled travel patterns. This is conducted in a separate module that conducts and analysis including estimates on the following:

- Vehicle operating costs
- Fuel consumption
- Vehicle emissions
- Benefit cost ratios
- Crash rates

Results of this analysis are summarised in a separate MASTEM module.

6   MASTEM Operation

The modelling platform for MATEM is the Cube Voyager software package (Citilabs, 2005). Cube Voyager is an integrated collection of software modules that provide a travel forecasting system with capabilities in the planning of transportation systems. It is comprised of base elements and add-on libraries of planning functions incorporating a hierarchy of models in the same platform.   This structure allows for the addition of functions without learning an entirely new interface and without the need to create multiple planning databases.

An additional advantage gained from the use of the Cube software suite is the integration of the ESRI ArcGIS (ESRI, 2005) Geographic Information System (GIS).   This provides the user with data management and access tools and the ability to present spatial data in a format that is easily interpreted.   Data may be presented in a range of summary types utilising the GIS thematic mapping capabilities.   This is especially important in presenting outputs and validation of model results and reflects the functional specifications.

Structured in Cube Voyager, MASTEM also allows for the arrangement of scenario options for modelling and easy interpretation of results. The scenario manager allows the model to allocate scenario specific input files, output files and variables.   Interaction with the model operation, including the key variables, files, and optional modules is a possibility with the construction of a user interface.

The GIS functionality within Cube also assists in the output display of modelling results. Figure 7 is an example of the output display types available in MASTEM.

Figure 7: Example of a MASTEM output type.

In this figure, the line width is representative of link flow volume with the shading an indication of traffic congestion (volume to capacity ratio). The GIS capabilities within Cube allow for range of visual output and interaction with the results data. There is also flexibility with MASTEM outputs in regard to the types, formats and export formats available.

7   MASTEM Features

Components of the MASTEM model allow for detailed modelling to be achieved with accuracy and flexibility in application. Some of these are presented in more detail in the following.

7.1   Mode Split

Policy testing is an important requirement of MASTEM in strategic planning applications for Adelaide by all stakeholders. It is possible to employ various types of policy related tests at all points in the four-stage modelling procedure, but the mode split stage offers many possibilities for the transport planner to assess demand management strategies.

The MASTEM mode split offers motorised and non-motorised mode options to the user, all of which are sensitive to travel times and other mode-specific attributes as listed in Table 2. This is a considerable improvement over past modelling procedures that allowed only for a simple car and public transport split of motorised travel demands.

Some examples of policy options that may be tested are:

- Car occupancy – high occupancy vehicle (HOV) strategies, which may follow onto the assignment of HOV only lanes.
- Public transport – policy testing may include fare structures, service routes and frequencies or network interchange provisions.
- Non-motorised – travel time improvements due to cycling and walking network priorities.

The mode split offers the possibility for testing numerous mode-specific policies with the provision of non-motorised, car at various occupancy levels and public transport modes.

7.2   Public Transport

The public transport modelling in MASTEM addresses several stakeholder issues as it effectively represents public transport travel patterns with the operation of Adelaide rail, O-Bahn bus and tram services.   The modelled services cover the period from 6.00am to midnight. Over 900 different bus routings operate in Adelaide on an average day, including different stopping patterns, start / end points and routes.

This network is simplified to 213 representative services covering 95% of the daily operated services in Adelaide.   Many routes vary throughout the day and rather than model each variant separately, generic routes are determined following the most frequent variant for each route. All generic services that operate more than 9 times a day are modelled.

The assignment processes in Cube is controlled by 'Route Enumeration' and Route Evaluation'. Route Enumeration is a heuristic process, guided by the user through a set of controls. It attempts to identify a set of discrete routes between zone pairs which have some probability of being used by passengers to travel between the zones. There are a number of key controlling parameters and statements which guide this process. Route Evaluation is the process of calculating the 'probability of use' of each of the enumerated routes between zone pairs.

The sophisticated public transport modelling routine allows for policy evaluation of service changes with elements of for example, the fares and service frequency to be assessed. Interchanges are also identified as boarding, waiting, walking and other penalties are represented within the modelling routines.

7.3   Model Iteration

To achieve improved accuracy of travel pattern estimates, the MASTEM procedures include an iterative procedure whereby link travel times resulting from the congested traffic assignment are fed back into the proceeding model components. Initial estimates of travel time, based on the free flow speed of each link are updated to more realistic travel time estimates as delays encountered due to the congestion are included.

This iterative process improves the initial estimates of trip distribution, mode split and assignment as more realistic travel time estimates are involved.   The result is a more accurate overall modelling result.

7.4   Output Linkages and Options

As identified previously, the MASTEM model is a strategic model which can be identified as a type 5 model in the hierarchy classification identified in Section 3. It is also possible to develop outputs at other levels in the hierarchy. Sketch planning results are possible (level 7) as trip matrix data is readily aggregated into larger area summaries appropriate for local council areas or traffic study areas for example. A useful output from sketch-planning summaries is a desire-line diagram, such as that illustrated in Figure 8.
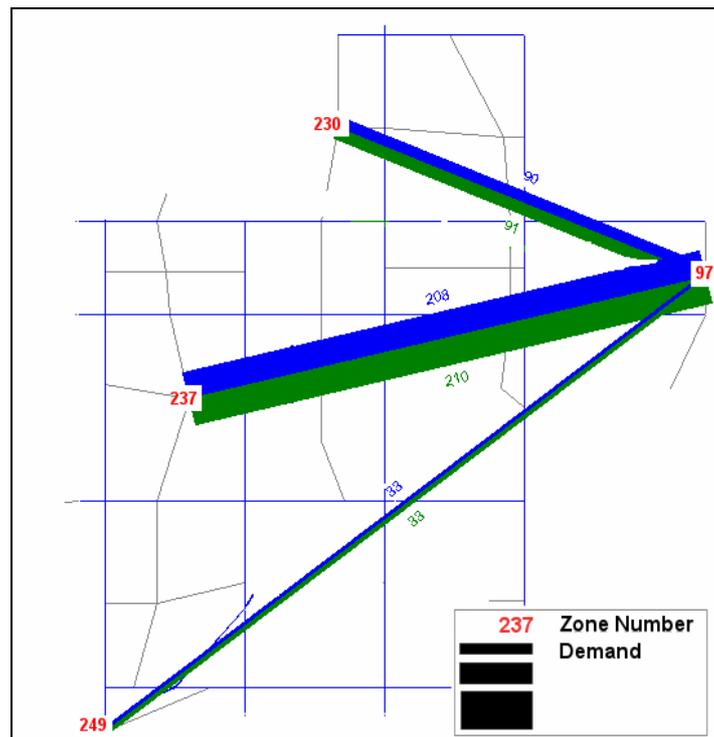
Figure 8: Cube desire line example.

In Figure 8 the line thickness is a representation of the travel demand between regions. It provides for a useful visual assessment of generalised travel behaviour.

In addition to the strategic level of analysis at the core of the MASTEM modelling routine, it is possible to provide data for a more detailed Microsimulation analysis with the assistance of the AIMSUN software (Barceló and Casas, 2002). It is a simple operation in MASTEM to define study regions and extract trip matrices for microsimulation analysis. With the construction of microsimulation networks, this information is used as input to the AIMSUN microsimulation process.

Impact analysis is also a possibility at the conclusion of the MASTEM operation. Travel demand outputs are easily imported into the environmental, economic and safety analysis tool to provide additional information to support travel analysis and appraisal. These output results are particularly valuable when considering the functional specifications summarised in Table 1.

8   Future Development Possibilities

In its present form, MASTEM provides a sound and flexible basis for the analysis of multimodal travel patterns in the Adelaide metropolitan area. It also has the potential to provide a more detailed analysis with the further development of modelling routines.

The incorporation of additional features such as trip timing routines, non-motorised and policy-analysis modules could enhance the output range of MASTEM. Another improvement possibility is the incorporation of mesh-block TAZ configuration. As the Australian Census produces mesh-block level data in the future, the model may be configured to accept and process this disaggregate level data.

9   Conclusions

Review processes have revealed that modelling travel behaviour for metropolitan Adelaide required several functional specifications. This generally reflected the need for a soundly based multimodal transport model with a range of output types.   The development of MASTEM has sought to meet these requirements by providing a user-friendly computer software tool for the transportation professional.

The developed MASTEM model is a strategic analysis package with the possibility of producing outputs at several hierarchies. It includes an assessment of all major travel modes, including public transport, non-motorised and freight travel. It makes extensive use of the 1999 MAHTS in the calibration of model parameters applied in a transparent modelling environment, assisted by GIS capabilities.

The model allows for the testing of supply and demand related transport policies with potential for future developments as the needs of the MASTEM stakeholders dictate.

10   References

Affum, J K and Taylor, M A P (1999). Integration of geographic information systems and models for transport planning and analysis, pp 295-308 of Meersman, H, van de Voorde, E and Winkelmans, W (eds) World Transport Research. Selected Proceedings from the 8th World Conference on Transport Research. Volume 3: Transport Modelling/Assessment Oxford: Elsevier-Pergamon

Barceló, J and Casas, J (2002) Dynamic Network Simulation With Aimsun, International Symposium on Transport Simulation, Yokohama

Bray, D; Scrafton, D (2000) The Adelaide O-Bahn: Ten Years On, Light Rail: Investment for the Future. 8th Joint Conference on Light Rail Transit, Transportation Research Board, Dallas, Texas

Citilabs,   (2005)   Cube   Base   [Online,   accessed   5   May,   2005], URL:http://www.citilabs.com/base/index.html

Dowling, RG, Singh, R and Cheng, WWK, (1998) The Accuracy and Performance of Improved Speed-Flow Curves, Road and Transport Research, Vol. 7, No. 2, pp. 36-51.

ESRI,   (2005)   ESRI   ArcGIS   Website   [Online,   accessed   12   June,   2005], http://www.esri.com/software/arcgis/index.html

Ortuzar, J. de D. and Willumsen, L.G. (1994), 'Modelling Transport', Chichester

Simmonds, D and Echenique, M (1999) Review of land-use/transport interaction models Report to the Standing Advisory Committee on Trunk Road Assessment (SACTRA) London: Department of the Environment, Transport and the Regions

Taylor, M A P (1991) Traffic planning by a 'desktop expert' Computers, Environment and Urban Systems 15 (3), 165-177

Taylor, M A P (1999) Dense network traffic models, travel time reliability and traffic management. I: General introduction Journal of Advanced Transportation 33 (2), 218-233

Taylor, M A P and Scrafton, D (2003a). Travel demand modelling for metropolitan Adelaide Report to the SA Department of Transport and Urban Planning (Adelaide: Transport Systems Centre, University of South Australia)

Taylor and Scrafton, (2003b) Development of a functional specification for a suite of travel demand models for metropolitan Adelaide Report to the SA Department of Transport and Urban Planning (Adelaide: Transport Systems Centre, University of South Australia)

Thill, J-C (2000) Geographic Information Systems in Transportation Research Oxford: Elsevier-Pergamon

Thompson-Clement, S J, Woolley, J E and Taylor, M A P (1996) Applying the transport network relational database to a turning flows study and a traffic noise model, pp 257-270 of Hensher, D A, King, J and Oum, T H (eds) World Transport Research - Volume 2 Modelling Transport Systems Oxford: Elsevier-Pergamon