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CRITICAL REVIEW OF TRANSPORT MODELLING TOOLS

National Transport Modelling Working Group

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National Transport Modelling Working Group

CRITICAL REVIEW OF TRANSPORT MODELLING TOOLS

Final Report

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Executive Summary

Traffic congestion is an ongoing concern in major urban areas around the world and Australian capital cities are facing similar challenges. Most Australian states and territories have developed strategic transport modelling tools to better understand the influences on rising urban traffic congestion in their capital cities and to help them respond by testing and improving approaches to congestion management.

There is a range of congestion management interventions which can complement road improvements by influencing patterns of demand on our roads. Interventions might include increased provision of public transport services, public behavioural change programs, careful land use planning to reduce travel demand, staggering of work hours, and application of road user charges. This report considers the latter option of road user charging as a means of achieving better use and productivity from the transport network.

Road pricing tools are not new. Parking charges are now familiar in most Australian city centres, while toll charges apply on key transport links in Melbourne, Sydney and Brisbane. Many cities also vary public transport fares between peak and off-peak periods. As urban areas and congestion management have become more complex, so it is important to examine the capabilities of modelling tools to help decision-makers better examine and assess the impacts of demand-side interventions. This is part of the continual evolution of modelling to ensure they reflect good practice.

This review was commissioned by the Commonwealth Department of Infrastructure, Transport, Regional Development and Local Government, as a member of the inter-jurisdictional National Transport Modelling Working Group. It is a collaborative exercise between the Commonwealth and those states and territories experiencing significant congestion pressures. The task was to undertake a critical review of state and territory strategic transport modelling in relation to their capacity to model pricing approaches to congestion management, in order to improve decision-making tools.

This report focuses on strategic modelling tools. Strategic transport models are used for assessing the broad impacts of infrastructure upgrades and policy decisions on road and public transport operation. These tools have some capacity to model mitigation measures to rising urban traffic congestion. Strategic models may be used in tandem with detailed project models, which consider the smaller-scale impacts of changes to the network.

Road Pricing Schemes

Although there are many ways of implementing road pricing, this report concentrates on five forms of direct pricing:

- **distance-based charging** – where drivers are charged on the basis of the distance travelled on certain parts of the road network;
- **link-based charging** – where vehicle trips attract tolls on specific road links;
- **parking charges** – as are already implemented in most Australian cities;
- **cordon charges** – where vehicles that enter a defined central city area are charged each time they cross the boundary of the area (in and/or out); and
- **area charges** – as implemented in London and Stockholm, drivers are charged whenever they travel anywhere within a specified area (typically this charge is capped on a daily basis).

International Case Studies

In Australasia, road pricing options have been studied extensively in Auckland and Wellington. In these New Zealand studies, it was found that particular elements in the design of the pricing schemes had a significant impact on their effectiveness. Modelling showed that the critical factors were the choice of location of the schemes, time of day when charges were applied, price levels, exemptions and provision of alternatives for travellers who were **“**priced off” the road.

Strategic Modelling in Australia

Most strategic transport models adopt a four-stage approach for determining transport demand. Each major Australian model also implements these four stages:

- **trip generation** – calculating the number of trips originating from each geographical area – based on land use, population and employment forecasts;
- **trip distribution** – determining the linkages between trip origins and destinations;
- **mode choice** – estimating the proportion of travel by each transport mode (eg. car, public transport) between each origin and destination;
- **assignment** – determining the roads and public transport services used by each traveller between each origin and destination.

At each stage of the modelling, an estimate of the cost of travel is required. The travel costs (which may include road charges) drive the decision-making aspects of the models.

Importantly, costs are perceived differently by each part of the population. For example, business travellers may place a higher value on a quicker route, whereas shoppers’ main preference can be for the cheaper but not necessarily the shortest route. The segmentation of the travelling population is a key element in the recommendations of this study.

Conclusions

All of the Australian models include the basic functionality needed to model road-pricing schemes successfully. Several of the models require simple upgrades to incorporate tolling into their structures, as tolls are currently only implemented in Melbourne, Sydney and Brisbane. Once these are implemented, each model will be capable of estimating the fundamental impacts of the schemes described earlier.

While the models can estimate basic responses to road pricing, each model is limited in its ability to:

- differentiate the responses of different population segments;
- calculate the potential transfer of trips between peak and off-peak periods; and
- consider capacity constraints on public transport.

These limitations mean that it will be difficult to model more sophisticated pricing schemes where charges are varied by type of road user and time of day. In cities where the public transport system is operating near its capacity during the peak periods, the models may over-represent the shift of trips from car to public transport modes.

Each model is capable of providing the basic information needed for further environmental and socio-economic analyses. For example, changes in vehicle kilometres of travel might be used to evaluate potential greenhouse gas reductions resulting from congestion mitigation measures. The impacts of road pricing on travellers from various geographic regions and the changes in trip patterns within household income groupings could be assessed. Often such evaluations would be carried out by separate models using the basic outputs supplied by the transport model.

Recommendations

Table 1 (next page) lists the recommended updates to each of the strategic models.

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Table 1 – Recommended Improvements

Recommended Improvement	Technical Considerations	Benefits
Inclusion of link-based charges in model costs (SA, WA and ACT)	▪ Inclusion of charges in travel costs is a relatively simple addition to each model. ▪ Sensitivity tests should be carried out to check that the model's response to road charges is reasonable.	▪ Allows proper representation of link-based and cordon-based charges in models.
Segmentation of road users at all stages of the modelling process (including assignment)	▪ Each model already includes segmentation of trips in the generation, distribution and mode choice stages. ▪ Extension of the segmentation to assignment will require more complex assignment inputs and may increase model running time. ▪ Consideration of how the segmentation is carried out (by road user group) will be needed. Segmentation is unlikely to be compatible across the jurisdictions. ▪ Implementation will require some structural changes, but should not require a major overhaul of each model.	▪ Allows the effects of differential charges for road user groups to be modelled more accurately. ▪ More accurate estimation of charging impacts on each segment of the population.
Modelling of capacity constraints on public transport	▪ In cities where public transport is not operating near capacity, there may be less need to implement this improvement. ▪ Modelling crowding is relatively complex, and the two main software platforms implement it differently. ▪ Revalidation of each model would be required, with sensitivity tests to check the reasonableness of the model's response.	▪ Produces more accurate estimates of public transport uptake from the application of road pricing interventions.
Modelling of time-period choice (peak spreading)	▪ Each model currently assumes fixed proportions of travel in each time period for each mode and trip purpose. ▪ Time-period choice models are relatively difficult to implement, and would require substantial restructuring of each jurisdiction's model, as well as further data collection. ▪ Simplified methods might be investigated as an alternative in the short term.	▪ Allows the effects of differential time-of-day charges to be modelled more accurately. ▪ Allows the re-timing of trips from peak to off-peak periods to be modelled.

- **Table 1 continued**

Recommended Improvement	Technical Considerations	Benefits
Modelling of key junctions	▪ Junction modelling is supported by the main software platforms. ▪ Modelling of all junctions is not necessary. Instead, junctions should be selected at key route divergence points where road charges may affect driver routes.	▪ More accurate estimation of traffic flow and delay impacts at major junctions in response to road charging.

1. Introduction

Traffic congestion is an ongoing issue in urban metropolises around the world and most Australian capital cities are facing similar challenges. In some major cities internationally various forms of road pricing (sometimes known as congestion pricing) have been introduced to manage demand and to encourage greater use of alternate (and more sustainable) transport modes. Notable cities include London, Stockholm, Singapore and Hong Kong.

The Australian Transport Council (ATC) is advised on these matters of urban congestion by a cross-jurisdictional Urban Congestion Working Group which in turn is advised by the National Transport Modelling Working Group (NTMWG). The NTMWG comprises members from each of the government agencies with ownership of the transport models for the respective capital cities; the Department of Infrastructure, Transport, Regional Development and Local Government (DITRDLG); and the Bureau of Infrastructure, Transport and Regional Economics (BITRE).

The NTMWG has commissioned this study (through DITRDLG) to review the current status of the modelling tools available through each of the government agencies in relation to the various models' capability to model alternate road pricing options in each capital city. The study is informed by data provided by the agencies together with an independent assessment of the model capabilities and past experience in the development and application of road pricing models.

2. Background to the Study

2.1. Purpose

The purpose of this study is to undertake a review of the transport models currently owned by the various state and territory authorities. The review assesses each model's suitability to model various road pricing options and the consequent impacts on network congestion.

2.2. Background

The project Brief provided the following background to the study.

> *On 7 November 2008, the Australian Transport Council (ATC) agreed to progress the transport modelling of congestion pricing scenarios. Ministers agreed that jurisdictions will cooperate in the transport modelling of congestion, transport network performance, socio-economic and emissions outcomes of various targeted congestion pricing scenarios (with the scenarios to be determined within the project). This work will significantly improve understanding of the full range of potential impacts, under Australian conditions, of the types of congestion pricing scenarios that have been employed overseas.*
>
> *The ATC decision is consistent with the 2007 COAG Congestion Review, which concluded that while each Australian capital city faced different congestion contexts and each jurisdiction should deploy congestion management measures as it felt appropriate, there was significant merit in all governments cooperating to lift Australia's congestion management capabilities and decision-making tools, to ensure the best congestion management outcomes from any given level of infrastructure investment.*
>
> *The transport modelling work is being undertaken by a National Transport Modelling Working Group (NTMWG), comprising experts from jurisdictions and the Bureau of Infrastructure, Transport and Regional Economics (BITRE) working to the ATC's cross-jurisdictional Urban Congestion Working Group (chaired by Victoria). The aim is to provide a robust progress report to ATC in May 2009, including:*
>
> - *results of the transport modelling of some congestion pricing scenarios; and*
> - *outcomes of a critical review of the capability of existing transport models to model congestion pricing scenarios (the subject of this services contract).*
>
> *Jurisdictions are currently undertaking a consistent stock take of current transport modelling capabilities. Practical understanding of current capabilities will also be improved by the application of the available transport models in each jurisdiction to a common sample of the congestion pricing scenarios, which jurisdictions are preparing concurrently. The potential list of congestion pricing scenarios includes: cordon pricing, link pricing, area pricing, parking pricing and pay-as-you-travel.*

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2.3. Agencies and Models Involved

The States and the related jurisdictions and the titles of the models involved in the study are shown in Table 2.

- **Table 2 – Jurisdictions and Models Included in Study Assessment**

Jurisdiction	Authority	Model Name
New South Wales	Ministry of Transport – Transport Data Centre (MoT)	Sydney Strategic Transport Model (STM)
Victoria	Department of Transport (DoT)	Melbourne Integrated Transport Model (MITM)
South Australia	Department for Transport, Energy and Infrastructure (DTEI)	Metropolitan Adelaide Strategic Transport Evaluation Model (MASTEM)
Western Australia	Department for Planning and Infrastructure (DPI)	Strategic Transport Evaluation Model (STEM)
Queensland	Department of Main Roads (DMR)	Brisbane Strategic Transport Model – Multi-Modal (BTSM-MM)
Australian Capital Territory	Department of Territory and Municipal Services (TAMS)	Canberra Strategic Transport Model (CSTM)

The study is being administered through the Commonwealth Department of Infrastructure, Transport, Regional Development and Local Government (DITRDLG).

2.4. Scope of Study

The scope of the study as set out in the Description of Services and Tasks outlined in the Project Brief stated:

Description of Services

1) *A critical review is sought of jurisdictions' urban transport models, to complement the work being undertaken to fulfil ATC's November 2008 directive. The review should:*

   Assess the development, operation and performance of the models, and whether the transport modelling of congestion pricing scenarios using these models is robust and effective, with respect to good practice. The assessment should, at a minimum, and in relation to each transport model, cover the following:

   - *key assumptions;*
   - *how key transport model components are derived;*
   - *the type and form of the transport modelling outputs and how they are produced;*
   - *data inputs and requirements; and*
   - *any comments provided by jurisdictions.*

2) *Comment on any significant differences in key capabilities and parameters between the transport models, in the context of good practice; and*

3) *Identify areas for enhancement, in regard to 1) to 2) and suggest most effective ways of securing those improvements (short, medium and long term solutions).*

Tasks

The tasks to be undertaken by the Contractor for this project are:

- *Attend the Inception Meeting with the client;*
- *Submission of a Draft Report on the 'Critical Review of Transport Modelling Tools' to the client;*
- *Attend a meeting with NTMWG representatives to present and discuss the findings of the Draft Report; and*
- *Submission of the Final Report on the 'Critical Review of Transport Modelling Tools', incorporating any feedback from the jurisdictions.*

2.5. Outline of Approach

The key to this assessment is to consider the actual needs of the congestion pricing analysis and how each of the models is able to respond to the design/structure of each alternative and how the models are able to inform the post-modelling analysis in a consistent and comparable manner.

Accordingly it was necessary to understand the capability of each model as it currently stands, particularly as it relates to road pricing options. The Stocktake of Modelling Specifications/Capabilities issued to the various jurisdictions (prior to commencement of this study) provides an excellent basis for this assessment.

SKM supplemented the stocktake with a further set of interviews that specifically targeted the issues necessary for the evaluation.

In summary the key steps in the process involved:

- Review of jurisdictions' transport model stock takes;
- Development of specification to identify the key elements of an 'ideal' congestion pricing model to be used as the benchmark for the consideration of the capabilities of the models;
- Development of a questionnaire to supplement the stocktake responses specifically to target the ability of the various models in comparison to the 'ideal model';

- Contact with the various jurisdictions by phone to discuss the ideal model and the questionnaire;
- Analysis of the responses and compilation of the results into a draft report;
- Conduct of a technical working session to discuss the draft report and any related matters; and
- Incorporation of comments from the NTMWG into the final report.

3. International Approaches to Road Pricing Models

3.1. Background Data

To gain an appreciation of international modelling practices, information was sought from recent road pricing modelling projects in Australasia, as well as published international modelling guidelines. Relevant information reviewed in this study included:

- **Auckland Road Pricing Evaluation Study** – Interim Project Report: Traffic Demand Management Impacts; Technical and Financial Feasibility (Preliminary Results Only) – NZ Ministry of Transport (Deloitte and Hyder Consulting report) – July 2005;
- **Wellington Region Road Pricing Study Stage 2** – Technical Report – Greater Wellington Regional Council (SKM report) – March 2007; and
- **UK Department for Transport - Transport Analysis Guidance (WebTAG)**.

3.2. Auckland Road Pricing Evaluation Study

The Auckland Road Pricing Evaluation Study (ARPES) was completed for the NZ Ministry of Transport by Deloitte and Hyder Consulting in 2005. ARPES developed an evaluation framework to assess the feasibility and desirability of a number of road pricing alternatives including Cordon, Area, Strategic Network (i.e. Link), Parking and Full Network charging options. More details are provided in the project reports that are included on the NZ Ministry of Transport website (http://www.transport.govt.nz/arpes-index/). The following extract from the Executive Summary Report[1] outlines some of the background to the project and identifies some of the issues associated with road pricing that need to be considered in the evaluation of any road pricing options.

> ***Background***
>
> *Preliminary work on road pricing and parking charges was undertaken as part of the Joint Officials' Group (JOG) work on Auckland Transport Strategy and Funding in 2003. JOG was established following a May 2003 agreement between ministers and the Auckland Mayoral Forum to examine transport strategy and funding issues in the Auckland region, and comprised officials from central government and Auckland local authorities. Its aim was to develop a funding package to enable the timely implementation of an agreed network strategy, having assessed the fit of the Auckland Regional Land Transport Strategy (RLTS) with the NZTS and other public policy outcomes.*

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[1] http://www.transport.govt.nz/arpes-index/arpes-exec-summary.pdf

JOG identified and assessed a range of policy options including road pricing. Road pricing was found to have significant demand management and revenue potential, and the ability to make a major contribution towards the achievement of the NZTS objectives. The major concern was the potential for road pricing to cause adverse social impacts (e.g. in terms of access and mobility). Accordingly, this study has focused on social and economic impacts of road pricing, along with the identification of feasible mitigation measures such as additional public transport (PT).

This report builds on the interim report (July 2005) which presented a preliminary assessment of potential road pricing and parking scheme designs and assessed initial outcomes in terms of the viability of technical and systems options for the:

- *implementation of each scheme;*
- *reductions in congestion levels across the Auckland region; and*
- *revenue-raising potential of each scheme.*

This final report evaluates five schemes modified in response to those initial findings, and assesses the social, economic and environmental impacts of each of these schemes, and also considers public acceptability. The report takes into account proposals for mitigation of the social impacts such as enhanced public transport, and these have been incorporated into the final results.

Feasibility and Desirability

This report presents the findings on feasibility and desirability in terms of each area of analysis. It then summarises on a scheme by scheme basis each of the key performance indicators. Although conclusions are reached in the report as to the scheme which appears best based on a comparison across all of the indicators, no recommendations are made as to the next steps.

This report emphasises the desirability of implementing a road pricing scheme in Auckland. Feasibility is examined at a high level only, as technical "implementability" is largely found to be proven for the types of schemes considered, given that many free-flow toll roads (i.e. toll roads where there is no requirement to slow or stop to make payment) and several road pricing schemes are in operation internationally. That said, technical issues would need more detailed examination should any particular scheme be progressed further.

Study Objectives and Approach

This study aims to show:

- *how much the proposed schemes would reduce congestion at peak times;*
- *what the positive and negative social, economic and environmental impacts of the schemes are, and the extent to which the negative impacts can be mitigated;*

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- *whether there is a financial business case for each of the schemes, and assuming there is, how much net revenue might be generated over time;*
- *whether the schemes are technically feasible to implement;*
- *whether the schemes are acceptable to the public; and*
- *whether the schemes are consistent with central and regional government policies and development strategies.*

The scope of assessment of all impacts (transport, social, economic and environmental) included in the study evaluation methodology are described in the table below:

- ***Figure 1 Auckland Road Pricing Evaluation Framework***

<table>
<tr><td colspan="2">1. Social, economic and environmental impact assessment
(including equity and efficiency dimension)</td></tr>
<tr><td colspan="2">2. Evaluate scheme against NZTS objectives:</td></tr>
<tr><td>▪ assisting economic development
▪ assisting safety and personal security</td><td>▪ improving access and mobility
▪ protecting and promoting public health
▪ ensuring environmental sustainability</td></tr>
<tr><td>3. Identify and assess:
▪ revenue potential
▪ demand management
▪ social distributional effects
▪ consistency with Auckland Regional policy Statement land-use policies
▪ privacy issues</td><td>▪ technical feasibility/implementation issues (including establishment and operating costs, enforcement)
▪ administrative simplicity
▪ public acceptability
▪ legislative implications</td></tr>
<tr><td colspan="2">4. Identify and assess mitigation proposals
(e.g. additional public transport services, discounts/exemptions from potential charges)</td></tr>
<tr><td colspan="2">5. Re-assess 1-3 in light of mitigation proposals</td></tr>
</table>

The modelling undertaken for ARPES was based on the Auckland Regional Transport (ART) model as it existed at the time and was considered to be quite a well developed and thoroughly researched model that incorporates a number of important elements that are useful in a road pricing modelling assessment such as:

- linked distribution and mode shift models that ensure rational responses to model changes;
- mode shift model that facilitates modelling of public transport network enhancements as key mitigation measures; and

- peak spreading model that discards trips from the peak periods when the costs of travel in the peak periods exceed the cost of travel outside those periods using a logit model approach.

While the ART model has since been further developed (by SKM) it was considered to provide a reasonable modelling framework for the comparative assessment of road pricing options but needed some enhancements to enable the model to better reflect the impacts of the application of road pricing. These modifications principally involved further segmentation of the model to better reflect different values of time (or willingness to pay) for different trip purposes (i.e. commuter trips, business trips, and other trips such as recreation/shopping). The model was then verified against the ART model to ensure the model operation and response was consistent with the previously calibrated ART model.

The Revised ART model (or RART) was then used to test various road pricing alternatives and contribute model output information into the evaluation framework set up to assess the various alternatives.

ARPES used the available modelling tools for the road pricing study but even though the ART model was quite a well developed model that incorporated key elements it was recognised that the model was not ideal and ARPES adapted the model to ensure that the model was able to better reflect the effects and outcomes of the various road pricing options being considered.

The RART model outputs were used as the key inputs to a number of the other workstreams including the environmental assessment, the social assessment and the economic assessment. In order for the model results to be considered appropriate for reporting to the Minister it was necessary for the team to progress through a structured process to develop the schemes and understand the likely impacts in relation to each of the assessment factors in the evaluation framework. This involved a significant iterative process of scheme development, testing and evaluation through a process that included a number of team workshops where options and issues were debated at length.

Key factors that were found to be critical in the ARPES work related more to the design of the schemes than to the actual modelling of the schemes. While the transport modelling was considered to be the ‘heart’ of the study it was only as good as the inputs used to define the schemes. It was found that the design of the schemes has a significant impact in the consideration of the options and the related impacts of each.

Critical factors that affected the assessments included:

- The **physical location and design of the road pricing scheme** – cordon location, area coverage, link pricing extent – all have a significant impact on the outcomes of the road pricing option modelling and the resulting environmental, economic and social outcomes;

- The **temporal application of the road pricing scheme** – such as the application to peak hours only, 5-hour, 12-hour or 24-hour charges – has a significant impact on the modelling and analysis, particularly mode shift considerations, peak spreading and trip suppression outcomes (as well as the resulting environmental, economic and social outcomes);
- The **level of charge to be applied in the road pricing scheme** – including consideration of how to compare 'equivalent' charges for the different schemes, based on average charge per vehicle or charge per transaction or total revenue received;
- The consideration of any **exemptions from the pricing scheme** – whether residents in the area scheme are exempt and whether taxis, buses, emergency services vehicles are exempted – this has implications on a number of the key factors such as the revenue return and the congestion outcomes;
- The **design of mitigation measures** – to ensure that alternatives are provided for the persons that are 'priced off' the road – to ensure public transport services are provided to service the areas affected and the key groups affected by the schemes;
- The **key objectives of the road pricing scheme** – whether the purpose is to reduce congestion in particular areas, to manage growing travel demand, to generate additional revenue to supplement the transportation systems or other social or economic objectives.

3.3. Wellington Region Road Pricing Study (Stage 2)

SKM completed the 2007 Wellington Region Road Pricing Study based on the model developed by SKM for the Greater Wellington Regional Council. The study had a similar technical scope to the Auckland study, requiring evaluation of a similar range of alternate road pricing alternatives. The model was developed to ensure that it provided the information necessary for the evaluation of the alternatives. More details are provided on the Greater Wellington Regional Council website http://www.gw.govt.nz/story23667.cfm.

The following extract from the Executive Summary of the report[2] outlines some of the background to the project and identifies the road pricing objectives and options considered.

[2] http://www.gw.govt.nz/story23667.cfm/4407_WellingtonRegion_s8746.pdf

Road Pricing Objectives and Performance Measures

The brief for this study stated that the "…main purpose of road pricing in the Wellington region is network efficiency. However, revenue generation is considered a useful secondary benefit", and that road pricing options should be evaluated against the objectives of the Draft Regional Land Transport Strategy (RLTS), which are as follows:

- *assist economic and regional development;*
- *assist safety and personal security;*
- *improve access mobility and network reliability;*
- *protect and promote public health;*
- *ensure environmental sustainability; and*
- *consider economic efficiency and affordability.*

Specific performance measures were developed to enable different pricing options to be evaluated against the objectives, and compared. A Planning Balance Sheet approach was used to undertake the evaluation.

Option Development and Definition

A number of generic road pricing concepts were considered along with the cordon and screenline charging options developed as part of the Stage 1 work. These included:

- *Toll Lanes / High Occupancy Toll (HOT) Lanes*
- *New Toll Roads*
- *Area Charges – where all trips into, out of, or within a particular area are charged*
- *Full Network Charges – where all trips on the whole road network are charged*
- *Strategic Network Charges – where all trips on the strategic road network (e.g. State Highways and arterial roads) are charged*
- *Parking Charges – where additional charges (above those already charged commercially) are levied for parking in specific areas such as the CBD*

A large number of tests were carried out to identify the potential the concepts had to provide an effective efficient road pricing option for the greater Wellington region. Through a screening process using key performance measures and assessments of the technology and cost implications, some of the options above were found to be deficient and were removed from further consideration. The remaining options were either retained as they were or refined to make them more useful.

Road pricing has very significant impacts on road users and voters, quite different from those of infrastructure improvements which form the backbone of most transport appraisals. The reasons for investigating such strategies are also different. It follows that it is vital that the objectives for such a strategy are clearly identified and based on these objectives, a detailed set of performance and evaluation criteria can be designed to enable alternative strategies to be appraised against the objectives. This formed the first stage of the Wellington Study.

In the second stage of the Wellington study there were three main initial tasks:

- option development and definition;
- setting up the evaluation procedures; and
- setting up the modelling framework.

Following these initial tasks the main part of the work involved the assessment of the identified options There is a range of feasible methods of road pricing and the different options were reviewed in regards to suitability in a Wellington context and practicability (in technology and local terms). Additionally, a main objective was the relief of traffic congestion and therefore a study of the distribution of congestion around the regional highway network was made to identify the nature, spread, locations and severity of congestion. Based on the review of methods and the appreciation of the spread of congestion, broad road pricing options could be defined.

Once the performance and evaluation criteria were identified, setting up evaluation procedures was straightforward.

SKM had previously developed the Wellington Strategic Transport Model (WSTM) and this was reviewed for its ability to model the various pricing options. It should be noted that some are not easily represented in conventional models. However, the greater strength of the WSTM was that it had been designed to international best practice standards and included a simplified procedure for modelling peak spreading (one of the important outcomes of congestion pricing). The model was therefore very well suited to the strategic nature of the study. The evaluation and performance criteria being different from more conventional studies meant much initial effort was needed to set up standard model output reports encompassing these criteria.

Similar to ARPES, the Wellington study found that a further issue in assessing the options was that each alternative road pricing strategy had to be developed in an 'equivalent' sense in order that its potential could be fairly assessed against other options. In particular, where the strategy involved differential pricing (particularly by location), methods were needed to identify the best spread of pricing and the appropriate pricing levels. This is not difficult when simple pricing mechanisms are used, such as parking charge supplements, higher fuel taxes or uniform cordon or area charges. But the Wellington study, tests of peak pricing also involved combinations of a series of priced screenlines and cordons, with the pricing being able to vary by location. Optimisation procedures were needed to search for a near optimum solution while making sensible use of modelling resources.

3.4. United Kingdom Transport Analysis Guidance (WebTAG)

The UK Department for Transport has published specific road pricing modelling guidance in its WebTAG Draft 2007 Guidelines. Relevant extracts from the Guidelines are reproduced below with our commentary.

Modelling Techniques

> *"The form of road pricing to be considered will affect the way in which it is represented in modelling. While the form of road pricing has a substantial effect on the way it is represented on the modelled highway network used for assignment, the way it is included in the formulation of generalised cost is common to all."*

In other words the generalised cost formulation should include a road pricing term that is consistent whichever form of road pricing is being modelled. How the road pricing term is derived is dependent on the policy being modelled. These are discussed in

Table 3 which is extracted from the Guidelines.

Table 3 – WebTAG Guidelines for Modelling Road Pricing Options

Pricing Scenario	WebTAG
Cordon & Link Pricing	Each link in the highway network that is to be priced is assigned a price. For screenline and cordon pricing, the price on all links will usually be the same, though it may, in principle, vary from link to link and some links may be unpriced. Prices may be represented as applying in one direction only, or in both directions. Prices will usually be set outside the model.
Distance Pricing	Each link to be priced must be identified and assigned a price depending on the link length. The price for each link is dependent only on the link length – it is unaffected by the link flow or other model outputs. Thus, the price may be estimated within the assignment model, or it may be set outside the model – both approaches are acceptable. The rate per unit distance may be the same for all links, or it may vary from link to link.
Area Licences	Area licences, as implemented in the London Congestion Charging scheme, are more difficult to model, for two reasons. First, one payment allows the vehicle to be used for as many journeys as the driver wishes. This means that the cost per journey is difficult to estimate. Second, a payment (possibly at a lower rate than for those entering the area) is levied on vehicles based within the priced area if they use the roads, even though they may not cross the cordon. Modelling area licence schemes also depends on the form of the assignment and demand models. The following paragraphs outline an approach that has proved successful, but the precise method adopted will need to be tailored to the model structure that is available. An area licence scheme can be modelled by a combination of an inbound cordon price applied to trips generated outside the charged area ('non-residents') and a penalty price applied to all trips generated within the charged area ('residents'). To facilitate this, it is necessary to segment the demand and supply models into residents and non-residents. The need for this segmentation, which is in addition to the segmentation required as part of the core requirement. It is reasonable to assume that most trips are part of a daily 'tour', comprising, as a minimum, an outbound and return trip. Therefore, the price of an area licence should be 'shared' across all the trips in a typical daily tour. Ignoring non-home based trips would lead to a halving of the price to obtain the price per trip. However, an allowance for non-home based trips should be made. The resulting price per trip is suitable for use as an in-bound only cordon charge, applicable to non-residents only, for use in the assignment model. Used in this way, it will ensure that alternative routes for through trips are appropriately priced and hence ensure that diversion is correctly modelled. Costs skimmed from the network for through trips will also be suitable for use in demand modelling and in appraisal.

Modelling Outcomes

> *"Models should be fit for the purpose, in that they should be capable of reflecting the outcome of road pricing schemes in a way which allows their impacts to be satisfactorily assessed"*

The primary impacts modelled by road pricing models may include:

- mode shift;
- trip distribution;
- time of day (if pricing is time specific);
- trip suppression; and
- route choice.

The secondary impacts represented by such models may include:

- vehicle speeds;
- public transport crowding; and
- changes in car occupancy.

Demand and Assignment Models

> *"As a core requirement, properly formulated variable demand and traffic assignment models are required to refine the preferred options and to support the business case. The variable demand model should include modules representing trip frequency, mode choice, macro time of day and trip distribution. The assignment model should include capacity restraint and junction simulation."*

There are two key issues for the modelling of road pricing that are of particular importance. These are:

- enhanced segmentation definition, to ensure that variations in willingness to pay road prices are fully reflected in the modelling; and
- representation of road pricing, including capability to estimate marginal social cost based prices.

Other Elements of Road Pricing Schemes

As policy is refined, more detailed models may be required to represent:

- prices that vary by vehicle type (straightforward);
- pricing by time of day (requires a time of day model – mostly not done); and
- exemptions (should be handled by segmentation)

Network Detail and Assignment

Where cordon/area schemes are likely to cause ‘differential re-routing’ – user class segmentation is required.

> *“Where that is the case, standard highway assignment techniques will be satisfactory. However, where differential re-routeing is considered likely, it will be important to ensure that it is satisfactorily represented.”*
>
> *“To ensure that differential re-routeing responses are satisfactorily represented, the highway assignment model must be segmented by user class, with a separate value of time for each user class. The core requirement for assignment segmentation is to ensure that the number of user classes is sufficient to represent the heterogeneity of values of time. It is recognised that, for practical reasons, the number of user classes is likely to be smaller than the number of segments used in demand modelling. However, it will usually be helpful for the user classes to be consistent with the segmentation adopted in the variable demand model. A user class structure based on vehicle class (lights and heavies), journey purpose (business and other), and, for those purposes representing a major proportion of trips within a modelled period (usually ‘other’), by income has proved to be practical in past studies.”*

The road network should take into account delays at all key junctions, otherwise diversion may be over estimated.

4. Optimal Requirements for Road Pricing Models

For a model to be appropriate to test various road pricing options it should have a certain level of functionality to ensure that it can adequately model the options considered and provide sufficient and suitable information on which to base an evaluation of the options considered.

On the basis of our interviews with the jurisdiction modelling groups, international review and our past experience in the development of four-step multi-modal models, the team has identified a number of elements that would be required for an ideal road pricing model. It should be acknowledged that not all of these elements are straightforward to implement, nor are they all needed for simple road pricing scenarios. However, incorporation of these elements into the jurisdiction models would allow more sophisticated road pricing schemes to be evaluated.

An outline of the ideal model elements is presented in the following bulleted list.

Model Structure

- Capable of modelling trip generation, distribution, mode choice and vehicle routing (assignment).
- AM peak, PM peak, inter-peak period models (as a minimum).
- Segmentation of trip purposes at each step of the model (including light and heavy commercial vehicles).
- Future year models should ideally be available for forecasting horizons of, say, 10 and 20 years (or to meet the local economic evaluation time frames).
- Network costs should be fed back to earlier steps in the modelling process. Ideally, costs would feed back to the trip generation step but, as a minimum, to the distribution and mode choice steps.
- Peak spreading should ideally be included, ie. modelling of the shift in trips to adjacent time periods.
- Ability to incorporate car parking charges on a zonal basis for both on-street and off-street parking, and consider whether the individual or employer pays.
- Ability to change land use patterns (ideally in response to charging, but ability to change as an input to model is acceptable).

Generalised Cost Parameters

- Vehicle operating costs (VOCs) should reflect the cost perceived by the road user. This may be fuel price only, or a combination of fuel price and direct costs (such as operating & maintenance, purchase, registration and insurance).
- Value of time (VOT) or value of travel time savings (VTTS) should be applied separately for each trip purpose or market segment.
- Generalised costs should include VOC, VOT, public transport fare and toll/cordon/parking charges (at a minimum).
- Generalised costs should be segmented by user classes (segments) and included in the distribution and mode choice models.

Networks

- Road and public transport model networks should provide a reasonable representation of current transport networks and associated levels of congestion.
- Road network should include any toll roads, pricing points and tolling structures.
- Public transport should desirably include capacity constraints (ie. crowding models).
- Junction modelling of key route diversion points.

Model Sensitivity

- Model should be checked to understand the range of 'accuracy' in sensitivity tests of key parameters. Elasticity results should be reviewed to understand model responsiveness to key parameters.
- Sensitivity tests should include understanding of impacts of pricing changes on demand (and through distribution and mode choice models).

Model Reporting

High Priority Items

- Changes in mode share – car, light and heavy commercial vehicles, public transport, pedestrian and cycle trips etc.
- Changes in total trips (i.e. trip suppression) by mode.
- Changes in vehicle kilometres travelled (VKT), trip times and vehicle hours travelled (VHT)
- Changes in emissions/environmental factors, preferably with speed-related emissions analysis (possibly using post model analysis techniques).

- Changes in safety outcomes (eg. accident rates) based on changes in speeds, congestion, travel time and travel distance (possibly using post model analysis techniques).
- Understanding of social impacts (e.g. by comparison of affected households with socio-demographic characteristics such as income structure).
- Changes in overall network level of service, including changes by area and link type (eg. motorway/non-motorway).
- Changes in conditions at boundary of pricing area (e.g. increased local congestion impacts).

Lower Priority Items

- Changes in trip patterns (i.e. sector to sector trips).
- Changes in trip length and distribution.
- Changes in travel speeds (i.e. average speeds), including changes by area.
- Changes in public transport passenger trip times and passenger hours of travel.
- Changes in travel times to key employment centres (i.e. commuter travel times).
- Changes in travel times to key commercial vehicle destinations (i.e. ports etc).
- Changes in costs of travel by user class.

Specific Road Pricing Capabilities

- Distance-based charging
- Link-based charging (toll roads)
- Cordon charging
- Area charging
- Parking charges

Other Desirable Attributes

- Ability to handle capped charges and multiple cordon crossings.
- Ability to model varying charges applied at different times (or periods) of the day.
- Capable of applying different charges to different areas (i.e. geographic based charges) and/or link types (i.e. road category/classification charges).
- Able to apply different charges across different user classes (i.e. car vs CV trips).

- Ability to treat residents within a charging area separately from other users (for example, in the London congestion charging scheme, residents within the charging area receive a substantial discount on the congestion charge).
- Modelling of trip suppression, mode shift, time of day travel shift and changes in trip distribution in response to road charges.

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5. Comparison of Models

5.1. Overview of Models

This chapter discusses the capabilities of each jurisdiction's model, drawing on information provided in the stocktake questionnaire (Appendix A) and follow-up interviews (Appendices B and C). Table 4 compares the key components of the agencies' models that influence their ability to model various hypothetical road pricing schemes.

Table 4 – Comparison of Models

Model Components	ACT	NSW	QLD	SA	VIC	WA
Model Structure						
Four-step model	●	●	●	●	●	●
Iterative feedback of assigned travel costs	●	●	●	●	●	●
Number of zones	800	2715	1509[16]	304	2272	484
Number of time periods	1	4	4	3	3	4
Number of trip purposes	6	7	8	8	14	5
Segmentation of generation, distribution and mode choice	●	●	●	●	●	●
Commercial vehicle trips included	×	●	●	●	●	●[1]
Number of assigned vehicle matrices	1	1	3[12]	2[13]	2[14]	2[15]
Trip-making unit	Trip	Tour	Trip	Trip	Trip	Trip
Land use modelling	×	×	×	×	×	×
Peak spreading	×	×	×	×	×	×
Model running time (hours)	2	24	24	2	30	1
Vehicle Operating Costs (VOCs)[17]						
Fuel cost and efficiency	●	●	●	●	●	●
Other direct costs (maintenance, oil, tyres)	●	×	×	×	●	●
Standing costs (registration, insurance)	●	×	×	×	●	×
Value of Time (VOT)						
VOT varies by market segment/trip purpose	×	●	○[5]	×	×	●[2]
Networks						
Public transport network	●	●	●	●	●	●
Capacity constrained public transport (crowding)	×	×	×[6]	×[7]	×	×
Junction modelling	○	×	×	●	×	○
Road Pricing Modelling Capability						
Distance-based charging	●	●	●	●	●	●
Link-based charges (tolls)	×[9]	●	●	○[10]	●	×[3]
Parking charges	●	●	●	●	●	●
Cordon charges	×[9]	●	●	○[10]	●	×[3]
Area charges	×	×	×	×	×	×
Trip suppression due to charging	×	○[4]	×	○[8]	×	×
Trip re-timing due to charging	×	×	×	×[11]	×	×
Mode shifts due to charging	●	●	●	●	●	●
Vehicle re-routing due to charging	●	●	●	●	●	●
Commercial vehicle demand affected by charging	×	×	×	×	●	×

● model has this feature ○ model partly implements this feature × model does not include this feature

Notes on Table 4:

[1] The Perth STEM model estimates truck volumes, but excludes light commercial vehicles (eg. couriers, utes).

[2] The Perth STEM model calculates values of time within the model; these are not supplied as external inputs.

[3] The Perth STEM model can be readily modified to model tolls and cordon charges. Toll attributes would need to be added to the model network and travel cost formulations.

[4] The Sydney STM model incorporates accessibility measures into the trip generation module which may suppress trips as travel costs rise. The sensitivity of this process would need to be checked.

[5] The Brisbane BSTM-MM model uses a multi-class highway assignment, as such separate VOTs are applied to Car, Medium CVs and Heavy CVs.

[6] The Brisbane BSTM-MM model has a public transport crowding macro that is not fully developed. This could be further developed if time and resources available.

[7] The Adelaide MASTEM model can incorporate the CUBE Voyager public transport crowding function. There is a current proposal to implement this feature. However this is time consuming and not utilised as standard. Could be used for selected assignments.

[8] The Adelaide MASTEM model includes cost feedback to trip generation and therefore would expect any trip suppression could be observed.

[9] The Canberra CSTM model can be readily modified to model tolls and cordon charges. There are no toll roads in the ACT.

[10] The Adelaide MASTEM model can be readily modified to model tolls and cordon charges but there are none currently in operation on Adelaide roads.

[11] The Adelaide MASTEM model includes both peak period models and peak hour factors. Thus it would be possible to model peak spreading via adjustments to peak hour factors.

[12] The Brisbane BSTM-MM model assigns a single car and two CV matrices simultaneously.

[13] The Adelaide MASTEM model assigns a single car and single CV matrix sequentially.

[14] The Melbourne MITM model assigns a single car and single CV matrix sequentially.

[15] The Perth STEM model assigns a single car and single CV matrix simultaneously. Note that the CV matrix is assigned to a sub-network.

[16] The Brisbane BSTM-MM model also includes 169 park-and-ride zones which act as “pseudo” zones.

[17] Note that the vehicle operating costs section of this table refers to the VOCs used in the trip distribution and mode choice modelling stages. Some aspects of vehicle costs, including standing costs, may also be included in car ownership models, but these are not covered in this table.

Most of the models include some representation of commercial vehicle (CV) trips. CV trips are typically modelled in a separate sub-model and incorporated into the main model during the traffic assignment stage. All of the models that contain CVs are capable of modelling the effects of route diversion for CVs in response to tolls and other road charges. However, the models do not take road charges into account when determining CV demand matrices (except for Melbourne’s MITM).

None of the models can presently model the re-timing of trips in response to road charges. Most apply fixed time period factors to 24-hour demand patterns and do not specifically model time period choice. Time period modelling would be relatively difficult to add to the models, though the Sydney model’s tour-based approach might lend itself more readily to this than the trip-based approaches in the other models.

Because trip-making is typically calculated on a 24-hour basis before being allocated to time periods, the modelling of varying road charges at different times of day may be difficult. For example:

- using average 24-hour costs to calculate daily travel may not accurately represent costs within individual time periods;
- car drivers often base their decision to use a tolled road on their entire day's travel – in other words, the choice of whether or not to drive is influenced by the total charges paid across the day;
- if toll capping, toll exemptions or one-way tolls are applied then the unit cost of an individual trip may be less if the driver makes a return trip on the tolled road;
- trip purpose is important: commuter trips are more likely to pick up peak-period tolls, whereas shoppers may tend to pick up inter-peak charges;
- differential charges within time periods are generally not handled by strategic models.

None of the models include capacity constraints (crowding) on public transport. In situations where the public transport system is approaching capacity, the introduction of road charges may lead to unrealistic modelled public transport volumes. In the interviews conducted in this study, several respondents thought that crowding models were of lower priority than trip-timing models, particularly in cities where there is capacity to add trains and buses to the existing network.

All of the models are capable of modelling basic road pricing scenarios, although area-based schemes are generally considered more difficult to model.

- **Distance-based charging** can be modelled using simple adjustments to vehicle operating costs. Link-specific or area-specific distance charges will require a slightly more sophisticated approach by distinguishing between charged and non-charged links. A number of the modelling agencies have carried out sensitivity tests on vehicle operating costs and found their models to be relatively insensitive to changes in VOCs.
- **Parking charges** can be modelled using the existing structures within the models, though further segmentation would assist in the development of options. In some models, parking charges are only applied to work trips.
- **Link-based charges (tolls)** are already modelled in Sydney, Melbourne and Brisbane. The Perth and ACT models will need minor modifications in order to incorporate tolls into their road networks. The Adelaide model is toll-enabled though no tolls currently exist in Adelaide.

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- **Cordon charges** can be modelled as a series of point tolls on cordon links. Where charges are capped, it will be slightly more difficult to model multiple cordon crossings, particularly when the crossings occur in different time periods. At the strategic modelling level, an analysis of the average number of cordon crossings per vehicle could be used to determine an appropriate per-crossing cost.
- **Area charges** are more difficult to model, as the model must consider not only trips crossing the area cordon, but also trips made entirely within the charging area. In the London congestion charging scheme, residents within the charging area are given a substantial discount (90%), which introduces a further level of complexity. Intra-zonal trips (i.e. short trips that are not explicitly assigned to the network) will also need to be considered.

Each of the models is capable of modelling all of these schemes at some level. The critical issue will be ensuring that the application of road-pricing modelling approaches is consistent across jurisdictions. This will require careful development of the assumptions for cordon and area pricing options and the mechanisms for representing these in each model.

Similarly, reporting consistency is important in comparative analyses. Each of the models has different processes to conduct economic, environmental and social analysis. The factors and assumptions inherent in these processes (either implemented within the model or as post-model analyses) are important and should be developed through a consensus approach between all of the jurisdictions.

This review has not conducted a detailed assessment and comparison of these processes. It is recommended that the NTMWG consider adopting a single external reporting process that is based on outputs from each of the models (such as VKT, VHT etc) rather than further accentuating the differences between models through different post-model processes.

In the following sections, particular characteristics of each state’s model are discussed in further detail.

5.2. ACT (CSTM)

The ACT CSTM is a four-step strategic transport model covering the entire ACT and is managed by the ACT Department of Territory and Municipal Services (TAMS). Demand matrices are segmented by six journey purposes at the trip generation, trip distribution and mode choice stages. Unlike the other jurisdictions, the CSTM only models a single period (AM peak) and includes just two modes - car and public transport. Slow modes (walking and cycling) are not included in the model and commercial vehicles are excluded on the basis of data availability.

One of the key strengths of this model is the inclusion of junction modelling within the Canberra Central Area. This functionality provides added robustness to any vehicle re-routing impacts that may be generated by a road pricing scheme; in particular link based pricing (toll roads). Depending on the geographical area of any specific scheme that is tested, it would be desirable to extend the junction modelling capability to other areas of the network.

Parking cost is included as a variable in the generalised cost equation and is applied on a zonal basis via a macro in EMME. A 'toll' is not currently a variable within the generalised cost equation but this can be readily changed in order to model cordon and link pricing. Distance based charges would be implemented in the model through changing the fuel cost parameter. This limits the ability to vary the charge by geography, link type etc. It should be noted that unlike most of the strategic models, the vehicle operating cost reflects overhead costs as well as fuel costs.

The public transport network is "quite basic" and forecasts of public transport require improvement – this is important for the model to accurately represent mode shift effects of road pricing schemes. However the model is in the process of being recalibrated to a 2006 base year and the accuracy of the public transport model is being addressed. The recalibration also includes the updating of parameter values to be in line with the ATC Guidelines for Transport System Management in Australia (2006).

The CSTM has limitations to its modelling capabilities in comparison to the other jurisdictions as a result of being an AM peak only model and only including car and public transport. It should be noted that the resources allocated to modelling are more limited than the other jurisdictions, with ACT having no dedicated modelling team. However, with the updates to the model from the re-calibration together with the functionality for junction modelling, CSTM is a suitable model to test road pricing impacts on private vehicles at the strategic level.

In order for CSTM to be capable of providing analysis and results that are sufficient to understand the impacts and effectiveness of various road pricing schemes in a comparable and consistent format to the other models, a number of model enhancements are recommended including:

- The most beneficial upgrade to CSTM for road pricing is the implementation of a multi-class assignment. This should be introduced, together with differential market segmentation (with purpose-specific VOT) in the model assignment to enhance the ability of the model to reflect the response of different user classes and trip purposes, especially in the case of differential pricing by user class (cars and CVs);
- CSTM has only been developed for an AM peak period model and it would be beneficial to introduce models for other time periods and include a peak spreading module at the same time. This would enable CSTM to be tested and analysed on a comparable basis to the other models of the other jurisdictions;
- The CSTM public transport model should be further developed to ensure that it reflects the actual service provision. A capacity constrained public transport or crowding module is worth considering in the longer term as a further enhancement to the public transport model; and
- CSTM appears to have capability to produce all of the necessary reporting to enable the analysis of economic, environmental and social aspects of the various road pricing schemes. It may be necessary to ensure that the parameters and analysis of these factors is undertaken in a consistent and compatible approach with the other models. Again the issue is the single time period model that means that AM peak results need to be factored to produce daily results compared to other models that incorporate additional models to reflect daily travel.

5.3. Sydney (STM)

The Sydney Strategic Transport Model (STM) was originally set up to coincide with the 1996 Census and has been regularly updated with land use, network, demographic and commercial vehicle data since then. The Transport Data Centre (TDC) manages the model, with network inputs provided by the NSW Roads and Traffic Authority (RTA). The model has already been used to model road pricing scenarios; principally in studies of Sydney's toll roads.

The Sydney model differs from the other jurisdictions' models in its use of tour-based demand modelling. The tour-based approach models the full round trip of a traveller (for example, home-work-home), rather than individual trips as in a traditional production-attraction trip-based approach.

The tour-based approach may offer scope for TDC to develop a peak spreading (time-of-day choice) model, which could be used to assess the level of trip re-timing in response to road pricing. Implementing a peak spreading model, however, would require recalibration and restructuring of the present model – a moderately complex and time-consuming process.

The STM combines the trip distribution and mode choice components into a single destination and mode choice module – a slightly different structure than the other state models.

The Sydney model has a relatively extensive coverage of parking charges across the metropolitan area. As well as the Sydney and Parramatta CBDs, the model applies parking costs to many other employment centres and parking areas. Most other Australian metropolitan models tend to represent parking charges mainly within CBDs (which may reflect less widespread charging for parking in these cities).

STM also takes into account refundable and non-refundable tolls on Sydney's toll road network. Since 1997, private motorists have been able to claim a government refund for tolls paid on the M4 and M5 motorways (excluding GST). Currently, only some motorists claim toll refunds, so it is uncertain whether the distinction between refundable and non-refundable tolls is still relevant in the model.

With the implementation of tolls, parking charges and commercial vehicle trips, the STM has many of the capabilities needed to model many of the common road pricing scenarios being considered by the NTMWG. As with the other Australian models, however, peak spreading and area-based charging will be challenging to implement within the STM framework.

In order for the STM to be capable of providing analysis and results that are sufficient to understand the impacts and effectiveness of various road pricing schemes in a comparable and consistent format to the other models, a number of model enhancements are recommended including:

- The most beneficial upgrade to STM for road pricing is the implementation of a multi-class assignment. This would incorporate market segmentation (with purpose or income-specific VOT) in the assignment to reflect the routing responses of different user classes, especially in the case of differential pricing by vehicle class (cars and CVs) or time of day. Some thought will be needed on how best to incorporate this into the existing model structures – for example, choice of VOT segments for assignment and the segmentation of toll costs in the destination/mode-choice model.

- A peak spreading module would be the next most suitable enhancement in the short term to enable the model to reflect the changes that pricing would produce if applied only in peak periods, or if differential time-of-day charges were applied.
- Capacity constrained public transport or crowding module is worth considering in the longer term as a significant enhancement to the model response and the ability of the model to consider the actual capacity and the supply-demand equation on the public transport system.
- Junction modelling in the vicinity of the charging areas can be beneficial for cordon and area type schemes as it enables the model to better reflect the local capacity constraints and the effectiveness of the schemes.
- STM appears to be able to produce all of the necessary reporting to enable the analysis of economic, environmental and social aspects of the various road pricing schemes. It may be necessary to modify some aspects of the reporting and analysis so that the results are consistent and compatible with the other jurisdiction models.

5.4. Brisbane (BSTM-MM)

The Brisbane BSTM-MM originally developed by Brisbane City Council with input from Queensland Department of Main Roads and Queensland Transport, and the model was partially based on the Western Australian DPI Perth STEM model. The BSTM is now the responsibility of Main Roads, Queensland Transport and Translink Transit Authority.

The model forecasts demand for a 24-hour period and applies fixed time-period factors to allocate trips to the AM peak, inter peak, PM peak and off-peak. Demand is segmented by eight resident trip purposes at trip generation, trip distribution and mode choice stages. BSTM-MM benefits from a mode choice model that includes seven modes: car driver, car passenger, walk to public transport, park and ride, kiss and ride, cycle and walk.

The BSTM also models medium and heavy commercial vehicles; these are included separately and assigned to the highway network, together with the private vehicle traffic, via a multi-class assignment. The advantage in terms of modelling road pricing is that separate values of time are applied within the model, thereby enhancing the understanding of the model's response to policies. Assessing the impact of different charges by vehicle type can therefore be readily undertaken.

The generalised cost formulation includes a 'toll' term and therefore modelling cordon and link based pricing schemes is straightforward and differential tolls by geography and link type can be readily implemented. In addition the model also includes Alternative Specific Constants (ASCs) to reflect the perceived benefit to the user of travelling on tolled facilities. Values range from 5 minutes on the Gateway Bridge to 10 or 12 minutes on

Airport Link. Queensland is the only jurisdiction to include this facility in their strategic model.

BSTM currently includes parking charges applied in the CBD and surrounding area; separate charges are input for peak and off-peak periods. Sensitivity tests have been undertaken by doubling, tripling and quadrupling the parking charges with the results yielding elasticities consistent with the literature. Similar sensitivity tests have been undertaken on vehicle operating cost. It should be noted that the BSTM only applies parking charges to five of the eight resident trip purposes (ie. those most likely to attract charges).

In line with the other jurisdictions, public transport crowding is not included in the model as standard. However the BSTM-MM does have a crowding macro that, with time and resources, could be developed for routine use. This functionality would greatly improve the robustness of the mode-choice impacts from a road pricing scheme; in particular a CBD area or cordon charge.

Modelling different time periods separately (eg. alternative peak and off-peak charges) is possible within BSTM-MM but would require some updates to the model such as the mode choice parameters. Overall, this model has the functionality to accurately model congestion pricing schemes at the strategic level.

In order for the BSTM-MM to be capable of providing analysis and results that are sufficient to understand the impacts and effectiveness of various road pricing schemes in a comparable and consistent format to the other models, a number of model enhancements are recommended including:

- The BSTM-MM is best placed to model road pricing as it already incorporates a multi-class assignment (cars and commercial vehicles), though the car purposes are still combined. It would be beneficial to incorporate multiple car purposes in the model assignment to reflect willingness to pay more effectively.
- Again, a peak spreading module would be the next most suitable enhancement in the short term to enable the model to reflect the changes that pricing would produce if applied only in peak periods, or if differential time-of-day charges were applied.
- A capacity constrained public transport or crowding capability exists in the model and it should be activated as a significant enhancement to the model response and the ability of the model to consider the actual capacity and the supply-demand equation on the public transport system.

- Junction modelling in the vicinity of the charging areas can be beneficial for cordon and area type schemes as it enables the model to better reflect the local capacity constraints and the effectiveness of the schemes.
- BSTM-MM appears to be able to produce all of the necessary reporting to enable the analysis of economic, environmental and social aspects of the various road pricing schemes. It may be necessary to modify some aspects of the reporting and analysis so that the results are consistent and compatible with the other jurisdiction models.

5.5. Adelaide (MASTEM)

The Adelaide MASTEM is the responsibility of the Department for Transport, Energy and Infrastructure (DTEI). The model forecasts demand for a 24-hour period and applies fixed time-period factors to allocate trips to the AM peak, PM peak and off-peak periods. Demand matrices are segmented by six home based trip purposes (further segmented by four car ownership categories) and two non-home based purposes. The mode choice model includes five modes: car 1 occupant, car 2 occupants, car 3 occupants, public transport, walk and cycle. Freight demand is modelled by a separate freight model with the volumes added to the MASTEM assignment.

Parking cost is included as a variable in the generalised cost equation and the input parking charges incorporate assumptions (based on 1999 data) regarding the proportion of people who have free parking and employer-paid parking. Tolls are not currently included in the generalised cost but this would be straightforward to implement. Toll road options have been modelled using MASTEM.

A key strength of the MASTEM is that the assignment methodology includes junction modelling with all signalled intersections modelled in the network. This provides added robustness to pricing schemes that cause significant route diversion. The model makes use of the CUBE Voyager network database function whereby individual nodes and links can be switched on/off by period and year. This functionality could have additional benefits in terms of applying different link attributes (eg. toll) by time of day.

MASTEM uses both peak period and peak hour models (AM peak, PM peak and Off peak periods sum to daily assignments with separate AM and PM peak hours via factors). This raises the potential to model congestion charging and peak spreading via adjustments to peak hour factors.

CUBE Voyager includes a public transport crowding function that is not currently employed by MASTEM. There is a proposal to develop a new version of the model with this function activated. Including this function significantly adds to the model run time. However given this function exists it would be desirable to employ it in tests of congestion pricing where material mode shift impacts are expected. It should be noted that sensitivity tests have indicated that vehicle operating costs need to be doubled in order for the model to show any significant impact.

MASTEM feeds costs back into the trip generation stage of the model and hence any trip suppression outcomes from road pricing should be observed. Overall MASTEM is well equipped to model a range of pricing schemes at the strategic level although, as is the case with most of the models, accurate representation of complex schemes would require additional model development.

In order for MASTEM to be capable of providing analysis and results that are sufficient to understand the impacts and effectiveness of various road pricing schemes in a comparable and consistent format to the other models, a number of model enhancements are recommended including:

- As with the other models, the most beneficial upgrade to MASTEM for road pricing is the implementation of a multi-class assignment. This would incorporate market segmentation (with purpose-specific VOT) in the assignment to reflect the routing responses of different user classes, especially in the case of differential pricing by vehicle class (cars and CVs) or time of day. Some thought will be needed on how best to incorporate this into the existing model structures.
- Peak spreading module would be the next most suitable enhancement in the short term to enable the model to reflect the changes that pricing would produce if applied only in peak periods, or if differential time-of-day charges were applied.
- Capacity constrained public transport or crowding module is being considered at present and should be implemented.
- MASTEM appears to be able to produce all of the necessary reporting to enable the analysis of economic, environmental and social aspects of the various road pricing schemes. It may be necessary to modify some aspects of the reporting and analysis so that the results are consistent and compatible with the other jurisdiction models.

5.6. Melbourne (MITM)

The Melbourne Integrated Transport Model (MITM) is managed by the Victorian Department of Transport (DoT). The model was originally based on the 2001 Census and a major travel survey conducted between 1994 and 1999. The model has since been updated with more recent land use, network and cost information. A stand-alone freight forecasting module was developed in 2007 which provides commercial vehicle inputs to the main model. At the time of writing, the DoT is about to embark on a major recalibration of the model using data collected from the 2007/08 Victorian Integrated Survey of Travel and Activity (VISTA).

MITM uses a standard four-step approach with segmentation of trip purposes throughout the generation, distribution and mode choice stages. Vehicle operating costs include not only fuel costs, but also maintenance, insurance and registration costs. This formulation differs from most of the other state models, which generally assume that fuel cost is the dominant component of the perceived vehicle operating cost.

Parking charges are implemented in the Melbourne CBD and surrounding inner suburbs, and tolls are modelled on the CityLink and EastLink tollways.

As with the other state models, MITM does not specifically model the re-timing of trips in response to road charges. The model does allow different tolls and parking charges to be applied in each time period. The routing and distribution effects of charges can therefore be assessed separately for each period.

MITM has many of the features needed to model common road-pricing scenarios, including distance, link, parking and cordon-based charges. These capabilities will be further enhanced with the recalibration of the model during 2009. In common with the other jurisdictions, the Victorian model does not model peak spreading and would require some modification to handle area-based charging.

In order for the MITM to be capable of providing analysis and results that are sufficient to understand the impacts and effectiveness of various road pricing schemes in a comparable and consistent format to the other models, a number of model enhancements are recommended including:

- The most beneficial upgrade to MITM for road pricing is the implementation of a multi-class assignment. This should be introduced, together with differential market segmentation (with purpose-specific VOT) in the model assignment to enhance the ability of the model to reflect the response of different user classes and trip purposes, especially in the case of differential pricing by user class (cars and CVs);
- Once again a peak spreading module would be the next most suitable enhancement in the short term to enable the model to reflect the changes that pricing would produce if applied only in peak periods, or if differential time-of-day charges were applied;
- A capacity constrained public transport or crowding module is worth considering in the longer term as a significant enhancement to the model response and the ability of the model to consider the actual capacity and the supply-demand equation on the public transport system;

- Junction modelling in the vicinity of the charging areas is particularly beneficial for cordon and area type schemes as it enables the model to better reflect the local capacity constraints and the effectiveness of the schemes; and
- MITM appears to be able to produce all of the necessary reporting to enable the analysis of economic, environmental and social aspects of the various road pricing schemes. It may be necessary to modify some aspects of the reporting and analysis so that the results are consistent and compatible with the other jurisdiction models.

5.7. Perth (STEM)

The Perth Strategic Transport Evaluation Model (STEM) is managed by the Western Australian Department for Planning and Infrastructure (DPI). STEM is a full multi-modal model with representation of road and public transport networks. It uses a strategic-level land use zoning system[3].

STEM uses a standard four-step approach in common with many of the other state models. Rather than using a traditional generalised cost formulation, however, the model calculates a composite disutility which comprises behavioural variables as well as time and monetary costs. The composite disutility approach may offer the potential to incorporate behavioural responses to road pricing in the model, although this would probably require significant restructuring and recalibration of the model.

Traveller values of time are obtained from mode choice calibrations based on a travel survey, rather than using standard values supplied as external inputs to the model.

STEM implements parking charges in the Perth and Fremantle CBD areas. These are applied to all trips and are implemented at the zonal level. Western Australia does not have any toll roads, and tolls are not yet a standard part of the STEM framework. DPI modellers are currently working to represent tolls within the model to enable link and cordon-based pricing to be investigated.

A commercial vehicle sub-model provides estimates of light and heavy truck trips. Light commercial vehicles (such as couriers and trade vehicles) are not included in the model. Commercial vehicles and private cars are assigned to the road network using a multi-class assignment.

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[3] Alongside DPI's STEM model, Main Roads has developed a road-based model which is used for more detailed evaluation of road projects. The Road Operations Model (ROM) has a more detailed zoning system and road network than STEM, but does not include public transport. The ROM model has not been evaluated in this study.

STEM model has many of the basic capabilities needed to model the common road pricing scenarios being considered by the NTMWG. With the inclusion of toll attributes in the model, it will be capable of modelling distance-based, link, cordon and parking charges. As with the other models, peak spreading and area-based charging will be challenging to implement within the STEM framework.

In order for STEM to be capable of providing analysis and results that are sufficient to understand the impacts and effectiveness of various road pricing schemes in a comparable and consistent format to the other models, a number of model enhancements are recommended including:

- The most beneficial upgrade to STEM for road pricing is the implementation of a multi-class assignment. This should be introduced, together with differential market segmentation (with purpose-specific VOT) in the model assignment to enhance the ability of the model to reflect the response of different user classes and trip purposes, especially in the case of differential pricing by user class (cars and CVs). At the same time it would be beneficial to ensure that the VOT reflect actual VOT through empirical data, rather than the implied/calculated approach currently adopted;
- Again a peak spreading module would be the next most suitable enhancement in the short term to enable the model to reflect the changes that pricing would produce if applied only in peak periods, or if differential time-of-day charges were applied;
- A capacity constrained public transport or crowding module is also worth considering in the longer term as a significant enhancement to the model response and the ability of the model to consider the actual capacity and the supply-demand equation on the public transport system;
- Junction modelling in the vicinity of the charging areas is particularly beneficial for cordon and area type schemes as it enables the model to better reflect the local capacity constraints and the effectiveness of the schemes; and
- STEM appears to be able to produce all of the necessary reporting to enable the analysis of economic, environmental and social aspects of the various road pricing schemes. It may be necessary to modify some aspects of the reporting and analysis so that the results are consistent and compatible with the other jurisdiction models.

6. Conclusions and Recommendations

This study reviewed the transport models currently operated by the various state and territory authorities. The review was based on a desktop assessment of information provided by each jurisdiction. The review assessed each model's suitability for modelling road pricing options and determined the areas where each model could be developed further.

All of the Australian models include the basic functionality needed to model road-pricing schemes successfully. Several of the models require simple upgrades to incorporate tolling into their structures, as tolls are currently only implemented in Melbourne, Sydney and Brisbane. Once these are implemented, each model will be capable of estimating the fundamental impacts of the schemes described in this report.

While the models can estimate basic responses to road pricing, each model is limited in its ability to:

- differentiate the responses of different population segments;
- calculate the potential transfer of trips between peak and off-peak periods; and
- consider capacity constraints on public transport.

These limitations mean that it will be difficult to model more sophisticated pricing schemes where charges are varied by type of road user and time of day. In cities where the public transport system is operating near capacity during the peak periods, the models may over-represent the shift of trips from car to public transport modes.

Each model is capable of providing the basic information needed for further environmental and socio-economic analyses. For example, changes in vehicle kilometres of travel might be used to evaluate potential greenhouse gas reductions resulting from congestion mitigation measures. The impacts of road pricing on travellers from various geographic regions and the changes in trip patterns for different household income groupings could be assessed. Often such evaluations would be carried out by separate models using the basic outputs supplied by the transport model.

The following table summarises the recommended improvements to each model, the amount of technical effort required and the benefits that could be achieved through these improvements.

SKM

▪ **Table 5 – Recommended Improvements**

Recommended Improvement	Technical Considerations	Benefits
Inclusion of link-based charges in model costs (SA, WA and ACT)	▪ Inclusion of charges in travel costs is a relatively simple addition to each model. ▪ Sensitivity tests should be carried out to check that the model's response to road charges is reasonable.	▪ Allows proper representation of link-based and cordon-based charges in models.
Segmentation of road users at all stages of the modelling process (including assignment)	▪ Each model already includes segmentation of trips in the generation, distribution and mode choice stages. ▪ Extension of the segmentation to assignment will require more complex assignment inputs and may increase model running time. ▪ Consideration of how the segmentation is carried out (by road user group) will be needed. Segmentation is unlikely to be compatible across the jurisdictions. ▪ Implementation will require some structural changes, but should not require a major overhaul of each model.	▪ Allows the effects of differential charges for road user groups to be modelled more accurately. ▪ More accurate estimation of charging impacts on each segment of the population.
Modelling of capacity constraints on public transport	▪ In cities where public transport is not operating near capacity, there may be less need to implement this improvement. ▪ Modelling crowding is relatively complex, and the two main software platforms implement it differently. ▪ Revalidation of each model would be required, with sensitivity tests to check the reasonableness of the model's response.	▪ Produces more accurate estimates of public transport uptake from the application of road pricing interventions.

- **Table 5 continued**

Recommended Improvement	Technical Considerations	Benefits
Modelling of time-period choice (peak spreading)	▪ Each model currently assumes fixed proportions of travel in each time period for each mode and trip purpose. ▪ Time-period choice models are relatively difficult to implement, and would require substantial restructuring of each jurisdiction's model, as well as further data collection. ▪ Simplified methods might be investigated as an alternative in the short term.	▪ Allows the effects of differential time-of-day charges to be modelled more accurately. ▪ Allows the re-timing of trips from peak to off-peak periods to be modelled.
Modelling of key junctions	▪ Junction modelling is supported by the main software platforms. ▪ Modelling of all junctions is not necessary. Instead, junctions should be selected at key route divergence points where road charges may affect driver routes.	▪ More accurate estimation of traffic flow and delay impacts at major junctions in response to road charging.

Appendix A Stocktake Responses

Prior to the appointment of SKM to undertake this study, the DITRDLG issued a stocktake form to each of the six agencies to capture information on the current state of the models. A copy of the responses provided by the various agencies is included in this appendix and summarised in the following table.

The responses and follow-up interviews were compiled into a detailed assessment of the road pricing capabilities of each model (see Chapter 5).

Table 2 – Summary of Stocktake Form Responses

	Australia Capital Territory Canberra Strategic Transport Model (CSTM)	New South Wales Sydney Strategic Transport Model (STM)	Queensland Brisbane Strategic Transport Model – Multi-Modal (BSTM – MM)	South Australia Metropolitan Adelaide Strategic Transport Evaluation Model (MASTEM)	Victoria Melbourne Integrated Transport Model (MITM)	Western Australia Strategic Transport Evaluation Model (STEM)
Model Basics						
Model Type	**4-stage** **Feedback** – loop to trip distribution and transport assignment – (not generation)	**4-stage** - travel demand tour model **Feedback** – loop to all modules except licence holding **Car Ownership?** – YES plus licence holding	**4-stage** **Feedback** – loop to trip distribution and model choice – (not generation) **Car Ownership?** - YES	**4-stage** **Feedback** – loop to car ownership, trip generation, trip distribution and mode choice **Car Ownership?** - YES	**4-stage** strategic transport demand model **Feedback** – loop to trip distribution, mode choice and assignment – (not generation) **Car Ownership?** - NO	**4-stage** **Feedback** – Highway times feedback **Car Ownership?** - YES
Model Time Periods	(No response)	**AM peak**, **inter peak**, **PM peak** and **Evening** (through to 7am) **Unable to model** time of day choice - fixed time period factors	**Unable to model** time of day choice – fixed time period factors	**AM peak**, **off peak**, **PM peak** and **Daily** (sum of three periods) **Temporal impacts** of policy changes can be identified	**AM peak** , **inter peak** and **PM peak** **Unable to model** time of day choice – fixed time period factors	**AM peak** , **inter peak**, **PM peak** and **evening** (through to 7am) **Unable to model** time of day choice – fixed time period factors
Model Coverage	Entire ACT	Sydney Greater Metropolitan Area (Includes Sydney, Newcastle and Illawarra Statistical Division)	Brisbane Statistical Division	Adelaide Statistical Division	Melbourne Statistical Division	Perth Greater Metropolitan Area (includes Perth Statistical Division plus Mandurah and Murray Statistical Local Areas)
Model Software	EMME	EMME	EMME	CUBE Voyager and Cube Analyst	CUBE TRIPS & Voyager	EMME
Outcomes (of modelling congestion pricing scenarios)						
Congestion Impacts	While the model is link based assignment, the city CBD has been specified with junction characteristics and enables nodal delays are calculated and used in the assignment process	All traffic can travel between and O-D pair, even if volume exceeds capacity. Travel time on links determined by volume delay functions	Vehicle hours travelled. Average speeds by link type. Average trip length	Uses an iterative, volume averaging capacity restraint assignment model incorporating junction modelling. Midblock capacity constraint effects are modelled using a series of Akcelik travel time/ flow relationships	Change in interzonal travel times; vehicle kilometres of travel; V/C ratios; trip length distribution (distance and time)	Elastic in mode shares and trip distribution. Average car trip distances reduced by significant car trip length re-distribution
Network Performance	Forecasts for PT "require improvement"	The factors influencing behaviour are assumed to remain constant. Changes in demand result from changes in capacity, cost etc	Changes in mode share.	Shifts in mode choice, destination choice and trip length distribution.	Changes in mode share and trip destination/trip distribution	PT mode shares applied to person trips on a zone to zone basis then PT trips assigned to PT network. Small increase overall in PT mode share, significant changes in commuting to CBD
Socio-economic	(No response)	Whilst demand is calculated for different socio-economic groups, results by group are not retained	Not included. May be able to test geographical effects. Car ownership might also be examined	Limited to impacts on car ownership market segments and trip purposes	Limited, but can consider impacts on travel purposes	(No response)
Emissions	(No response)	Not undertaken as standard but post processing procedure could be implemented	Not included. "Bolt-on" package known as 'TRAEMS' has been used	Can be computed via Economic, Environmental, and Road Safety (EERS) model linked to MASTEM	Post-processing, using custom-built Excel application to calculate the tonnages of CO_2, HC_4, NO_x, SO_2, PM_{10}, and $PM_{2.5}$	(No response)
Economic cost/benefit	(No response)	Not undertaken as standard but post processing procedure could be implemented	Not included	Can be computed via Economic, Environmental, and Road Safety (EERS) model linked to MASTEM	Post-processing in Excel to derive global benefit/cost ratios; costs of congestion	(No response)
Scenarios (capacity to model these scenarios)						
Cordon pricing	May be possible	Network coding needs to be modified to capture the additional costs from crossing a cordon	Could be modelled by applying a link based toll on links forming the cordon. Users would be charged for each crossing.	Can be modelled via generalised cost formulation applied to roads crossing defined cordon	Can be modelled via generalised cost formulation applied to roads crossing defined cordon	(No response)
Link pricing (tolling)	It is possible to test the effects of link pricing	Model already incorporates tolled links	Model already incorporates tolled links. ASC values used to model perceived benefit of using the tolled facility	Tolls can be modelled as a link attribute via generalised cost formulation	Tolls can be modelled as a link attribute via generalised cost formulation	(No response)
Area pricing	May be possible	Requires modification to calculate the "toll" costs. Methodology required to toll 'intra-area' trips. (Eg outside to inside area treated like a cordon charge)	Probably too difficult to model within current model. A pseudo parking charge could be applied to achieve indicative estimates	Can be modelled via generalised cost formulation	Can be modelled via generalised cost formulation with pricing applied to the transport zones that comprise the specified area	(No response)

	Australia Capital Territory Canberra Strategic Transport Model (CSTM)	New South Wales Sydney Strategic Transport Model (STM)	Queensland Brisbane Strategic Transport Model – Multi-Modal (BSTM – MM)	South Australia Metropolitan Adelaide Strategic Transport Evaluation Model (MASTEM)	Victoria Melbourne Integrated Transport Model (MITM)	Western Australia Strategic Transport Evaluation Model (STEM)
Parking policy/charging	Some analysis has been undertaken to assess the impact of parking policy and pricing	Demand is responsive to parking cost. Parking costs (full and half-day) are inputs to the model on a zonal basis. Parking capacity cannot be input	Charges generally only applied in CBD, previous model runs have yielded parking elasticities within range of literature. Parking charges only applied to some purposes. Parking supply not implemented except for 'park & ride'	Can be modelled by varying parking cost assumptions (parking charges in Adelaide primarily confined to the CBD)	Pricing applied to the transport zones that comprise the specified parking area and modelled via the generalised cost formulation	(No response)
Distance-based pricing	It is possible, should be similar to the analysis of fuel pricing	An additional cost per km can be readily input to the model	Tests have already been undertaken	Can be modelled via the formulation of the vehicle operating cost parameter and generalised cost formulation	Pricing applied to all transport links (highway) and modelled via the generalised cost formulation	(No response)
Change in urban form	Can test changes in land use assumptions	The model has been used many times to examine changes in the location of population and employment	Can be tested through demographic input changes	Can be modelled by varying input demographic and land use data. Difficult to model TODs if located out suburban zones.	Can test changes in land use assumptions	(No response)
Other						
Comments	New model (calibrated to 2006) due to be established February '09				New model (calibrated to 2006) due to be established October '09	

ATC Urban Congestion Working Group

NATIONAL TRANSPORT MODELLING WORKING GROUP
Congestion Pricing Modelling Project

Stocktake of Modelling Specifications/Capabilities

Jurisdictional model (general and contact information)	
Jurisdiction name	ACT
Model name (eg Strategic Transport Model STP)	Canberra Strategic Transport Model (CSTM)
Type of model[1] (e.g. 4-stage with cost feedback)	Four step model. Generalised cost (GC) functions have been established for private transport and public transport. GC feeds back into trip distribution and transport assignment
Model coverage[2]	The mode covers the entire ACT (i-e Canberra and Queanbeyan)
Model assumptions/parameters[3]	The current model has the following values: Value of time: $11.47, VOC (excl fuel): $0.13/ VKT, Fuel cost $/ ltr: $1.03 The establishment of GC (public transport) weights for work purpose trips are: walk time (1.3), wait time (1.3), in vehicle travel time (1.0). Similarly weights for tertiary education and secondary educations were established. The above values are to be updated. All of these values are currently being reviewed to align them to the parameter values of ATC Guideline for Transport System Management in Australia (2006). This review and the new model will be established in February 2009.
Software[4]	EMME 3
Responsible organisation[5]	ACT Department of Territory & Municipal Services (TAMS)
Primary contact (name, phone, email)	Kuga N Kugathas 02 6207 1755 kuga.kugathas@act.gov.au

[1] 4-stage strategic demand model; extent of feedback of generalised costs
[2] The geography of the model: city-wide model, area-specific (local area model only)
[3] Value of time; vehicle operating cost rate; other parameter values
[4] E.g. CUBE, EMME/2
[5] Responsible for all or some of the following: model development, model maintenance, model operation.

Alternate contact [1] (name, phone, email)	Paul.isaks@act.gov.au

Notes:

[1] At least one of the contacts is to be available for providing any further information during the period of the proposed consultancy to review each jurisdictional model, which is expected in February. Please note if during that time, the nominated contact people will not be generally available.

ACT being small jurisdiction, congestion charges options have not been considered suitable. There has been some analysis undertaken in relation parking pricing and fuel pricing. However, the model has the capacity to test those scenarios.

Outcomes (of modelling congestion pricing scenarios)				
	Key assumptions *Specify* (e.g. elastic supply of alternative transport modes)	**How are outcomes calculated?** *Describe in words* (high level)	**Data requirements** *Specify* (high level)	**Comments**
Congestion impacts *Specify:* (e.g. time and operating cost savings)				
Network performance *Specify*:(e.g. behaviour change such as public transport usage)				
Socio-economic *Specify*:(e.g. impacts on different socio-economic groups)				
Emissions *Specify*:(e.g. tonnes of carbon, noise, particulates)				
Economic cost/benefit (of introducing a congestion pricing scheme)				
Supporting components				
Component (e.g. demand elasticity, modal split, average cost per journey)	**Key assumptions** *Specify* (e.g. value of time) [2]	**How are supporting components calculated?** *Describe in words* (high level)	**Data requirements** *Specify*	**Comments**
(specify):				
(specify):				
(specify):				
(specify):				
(add more lines as necessary ...)				

Notes:

[2] Include details of how modal split is handled (e.g. will a road price increase result in extra PT patronage in the results, or has the model largely fixed splits by mode?)

Scenarios (capacity to model these scenarios)	
Cordon pricing	*(insert comments)* It may be possible to test the impact of cordon pricing although in the ACT this is unlikely within the foreseeable future.
Link pricing (tolling)	*(insert comments)* With the CSTM, it is quiet possible to test the effects of link pricing.
Area pricing	*(insert comments)* It may be possible to test the impact of area pricing although in the ACT this is unlikely within the foreseeable future.
Parking policy/charging	*(insert comments)* With the CSTM, it is quiet possible to test the effects of link pricing. There has been some analysis undertaken to assess the impact of parking policy & pricing on the public transport.
Distance-based pricing	*(insert comments)* With the CSTM, it is quiet possible to test the effects of distance based pricing. This should be similar to the analysis of fuel pricing.
Change in urban form	*(insert comments)* CSTM being a land use- transport model, it is possible to test the impacts of change in urban form.

Overall comments

(specify): e.g. strengths and weaknesses of the approach, special features, comparison with other possible approaches, application considerations

Note: include comment, if deemed relevant, on the capabilities for straightforward extensions to current model output i.e., even though any extra large scale modelling will tend to be out of the current scope, some models may possibly be able to address pricing issues better with the addition of some 'off-the-shelf' or 'bolt-on' software component

Strengths:

The CSTM has the ability to change the GC components. This enables the testing of various form of pricing. CSTM's trip matrices have been dis-aggregated six trip purposes. While CSTM is link based assignment, the City CBD has been specified with junction characteristics and enables nodal delays are calculated and used in the assignment process.

Weakness:
The current model is calibrated to 2001. This is dated. A recalibration based on ABS 2006 data is currently underway and is expected to be completed by February 2009.
The accuracy of the estimation in the south part of Canberra is not as good as north Canberra. Re-calibration is expected to fix the issue.

Whilst, CSTM is multi-modal, the forecasts of PT still require improvement. This is being addressed in the current re-calibration.

ATC Urban Congestion Working Group

NATIONAL TRANSPORT MODELLING WORKING GROUP
Congestion Pricing Modelling Project

Stocktake of Modelling Specifications/Capabilities

Jurisdictional model (general and contact information)	
Jurisdiction name	NEW SOUTH WALES
Model name (eg Strategic Transport Model STP)	Sydney Strategic Travel Model (STM)
Type of model[1] (e.g. 4-stage with cost feedback)	4-stage strategic travel demand tour model. Also includes car ownership and licence holding models. Multiple person segments for each model purpose. Feedback (via logsums) to all modules except licence holding model.
Model coverage[2]	Sydney Greater Metropolitan Area, including: Sydney Statistical Division, Newcastle Statistical Sub-Division and Illawarra Statistical Division
Model assumptions/parameters[3]	Too many to list. Full details in reports available from http://www.transport.nsw.gov.au/tdc/publications.html Values of Travel Time vary for different income segments. These also vary for the different travel purposes.
Software[4]	EMME
Responsible organisation[5]	TRANSPORT DATA CENTRE NEW SOUTH WALES MINISTRY OF TRANSPORT
Primary contact (name, phone, email)	Frank Milthorpe Senior Manager Transport Modelling Phone (02) 9268 2945 frank.milthorpe@transport.nsw.gov.au
Alternate contact [1] (name, phone, email)	Dr Peter Hidas Manager Transport Modelling Phone: (02) 9268 2946 Email: peter.hidas@transport.nsw.gov.au

Notes:

[1] At least one of the contacts is to be available for providing any further information during the period of the proposed consultancy to review each jurisdictional model, which is expected in February. Please note if during that time, the nominated contact people will not be generally available.

[1] 4-stage strategic demand model; extent of feedback of generalised costs

[2] The geography of the model: city-wide model, area-specific (local area model only)

[3] Value of time; vehicle operating cost rate; other parameter values

[4] E.g. CUBE, EMME/2

[5] Responsible for all or some of the following: model development, model maintenance, model operation.

Outcomes (of modelling congestion pricing scenarios)				
	Key assumptions *Specify* (e.g. elastic supply of alternative transport modes)	**How are outcomes calculated?** *Describe in words* (high level)	**Data requirements** *Specify* (high level)	**Comments**
Congestion impacts *Specify:* (e.g. time and operating cost savings)	All traffic can travel from an origin to a destination, even if volume exceeds capacity.	The volume delay functions determine the travel times on links.	Congestion is a result of the interaction of the transport supply and the predicted demand.	The vehicle operating costs are calculated on a per km basis. Any tolls are an additional cost.
Network performance *Specify*:(e.g. behaviour change such as public transport usage)	The factors influencing behaviour is assumed to remain constant. The changes in usage are a result of changes to services, road capacity, costs or etc.	From the demand models.	Transport network (including PT services).	
Socio-economic *Specify*:(e.g. impacts on different socio-economic groups)	Average values within a segment are implied.	From the demand models.	The number of people in each group for each zone is a standard input	Whilst demand is calculated for the different socio-economic groups, the results are not retained for each group in the current implementation of the model.
Emissions *Specify*:(e.g. tonnes of carbon, noise, particulates)	Specification of the conversion factors.	Application of conversion factors to model outputs.	Conversion factors to convert model estimates of minutes, kms, speeds and etc. No additional data requirements to undertake a model run.	Not undertaken as part of a standard model run. Post processing of the model outputs would be required to obtain results. Can extract spatial details to determine where the x kms of a trip occurs (more emissions may be associated with the start of a trip from a cold start.
Economic cost/benefit (of introducing a congestion pricing scheme)	Specification of the cost benefit model, especially the impact of less travel, people switching mode and destination.	Depends on the specification of the economic cost benefit model.	No additional data requirements to undertake a model run	Not undertaken as part of a standard model run. Post processing of the model outputs would be required to obtain results. Many cost benefit models assume fixed demand matrices.

Supporting components				
Component (e.g. demand elasticity, modal split, average cost per journey)	**Key assumptions** *Specify* (e.g. value of time) [2]	**How are supporting components calculated?** *Describe in words* (high level)	**Data requirements** *Specify*	**Comments**
Common Requirements			Household Travel Survey, Census data, road networks, public transport networks and services, demographic forecasts.	
Licence Holding	Licence holding is independent of the transport system. Same rates for each age-sex cohort for each zone	Proportions for each age-sex cohort.		Proportions vary between model years.
Car Ownership	Accessibility (logsum) from mode – destination choice model impacts on car ownership	Probability of a household owning 0, 1, 2, 3+ vehicles is calculated using a number of household level socio demographic variables and accessibility.		
Tour Frequency	Accessibility (logsum) from mode – destination choice model impacts on frequency of travel	Probability of a individual making 0, 1, 2, 3, 4 or 5 tours calculated using person level socio demographic variables and accessibility. .		There are more person segments in the tour frequency model than there are in mode-destination choice as these calculations are only undertaken on an origin zone basis.
Mode – Destination Choice	The choice of mode and destination of travel is a combined decision and is modelled jointly.	Probability of a individual using a mode (7) to travel to a destination (2690) using person level socio demographic variables and characteristics of the modes (times, costs and etc).		There are fewer person segments in this model than in the tour frequency model as calculations are undertaken on an origin and destination zone basis.

Notes:

[2] Include details of how modal split is handled (e.g. will a road price increase result in extra PT patronage in the results, or has the model largely fixed splits by mode?)

Scenarios (capacity to model these scenarios)	
Cordon pricing	Model already incorporates toll costs in addition to vehicle costs. Network coding needs to be modified to capture the addition costs from crossing the various cordons.
Link pricing (tolling)	Model already incorporates toll roads.
Area pricing	To implement area pricing requires modification to calculate the "toll" costs. For travel from outside into the Area or vice-versa this can be treated in the same manner as cordon pricing. However, travel wholly within the Area also needs the Area pricing applied. It is necessary to undertake this as a two-step process to ensure that trips from an origin outside the Area to a destination outside the Area do not travel into the Area.
Parking policy/charging	Parking costs (full day and half-day) on a zonal basis are a standard input to the travel model. Parking restrictions, say only xxx places are available within a zone can't be input to the model. By adjusting the parking cost the demand will either increase or decrease.
Distance-based pricing	An additional cost of travel per km can be readily input to the model.
Change in urban form	The model has been used many times to examine changes in the location of population and employment.

Overall comments

(specify): e.g. strengths and weaknesses of the approach, special features, comparison with other possible approaches, application considerations

Note: include comment, if deemed relevant, on the capabilities for straightforward extensions to current model output i.e., even though any extra large scale modelling will tend to be out of the current scope, some models may possibly be able to address pricing issues better with the addition of some 'off-the-shelf' or 'bolt-on' software component

The basic unit of modelling is a daily tour. These tours are converted to trips for the different time periods. These conversion factors are fixed, ie there is no peak spreading.

Within the mode-destination choice model Car Driver is represented as a single alternative with the same travel times and costs for all income groups, ie a single set to network skims are obtained. Different cost parameters (ie values of time) are applied for the different income segments. The model does not have separate car tolled and car non-tolled alternatives. In reality there are faster (tolled) and slower (non-tolled) options available to potential car users.

The car travel times are derived from link and node delay functions consistent with a strategic travel model specification. It is possible for volumes on links to exceed capacity unlike detailed micro-simulation implementations. Also it is not possible to obtain estimates of travel time reliability and incorporate this within the model system.

The model cost parameters have been estimated using household travel survey (revealed preference) data. If pricing regimes are introduced which are very different to those currently observed the model parameters may be not reflect the behavioural choices that people will make.

The public transport times are not influenced by demand, ie there is no representing of pt congestion (crowding).

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Congestion Pricing Modelling Project

Stocktake of Modelling Specifications/Capabilities

Jurisdictional model (general and contact information)	
Jurisdiction name	QLD DEPARTMENT OF MAIN ROADS & QLD TRANSPORT
Model name (eg Strategic Transport Model STP)	Brisbane Strategic Transport Model – Multi-Modal
Type of model[1] (e.g. 4-stage with cost feedback)	4-stage model, with cost feedback
Model coverage[2]	Brisbane Statistical Division (city-wide model)
Model assumptions/parameters[3]	Value of time: Car = \$11.20/hr, Medium CV = \$24.30/hr, Heavy CV = \$58.60/hr Car running cost = 7.5cm/km (used for assignment); 15c/km (used for mode choice/distribution) Variety of parking costs for peak and off-peak periods PT Assignment parameters: Node-specific boarding times (values 6, 9, 99 used),node-specific wait times used (0.25,0.5 used) Wait time weight = 2.0; Auxiliary transit time weight = 1.4; Boarding time weight = 2.0
Software[4]	Emme3 (can be run in EMME/2 or Emme3)
Responsible organisation[5]	QLD DEPARTMENT OF MAIN ROADS, QLD TRANSPORT, TRANSLINK TRANSIT AUTHORITY ORIGINAL BSTM DEVELOPED BY BRISBANE CITY COUNCIL WITH MAIN ROADS & TRANSPORT. BSTM-MM PARTLY BASED ON WESTERN AUSTRALIA DPI PERTH STEM MODEL.
Primary contact (name, phone, email)	Matt Ryan (07) 3834 2888 matthew.j.ryan@transport.qld.gov.au
Alternate contact [1] (name, phone, email)	Jason Kruger (07) 3834 5561 jason.n.kruger@mainroads.qld.gov.au

[1] 4-stage strategic demand model; extent of feedback of generalised costs
[2] The geography of the model: city-wide model, area-specific (local area model only)
[3] Value of time; vehicle operating cost rate; other parameter values
[4] E.g. CUBE, EMME/2
[5] Responsible for all or some of the following: model development, model maintenance, model operation.

Notes:

[1] At least one of the contacts is to be available for providing any further information during the period of the proposed consultancy to review each jurisdictional model, which is expected in February. Please note if during that time, the nominated contact people will not be generally available.

Outcomes (of modelling congestion pricing scenarios)				
	Key assumptions *Specify* (e.g. elastic supply of alternative transport modes)	**How are outcomes calculated?** *Describe in words* (high level)	**Data requirements** *Specify* (high level)	**Comments**
Congestion impacts *Specify:* (e.g. time and operating cost savings)	The model uses fixed time period factors based on household travel survey data. Distribution parameters hold in the future.	Vehicle hours travelled. Average speeds by link type. Average trip length.		
Network performance *Specify*:(e.g. behaviour change such as public transport usage)	Fixed time period factors PT is not capacity constrained.	Changes in: mode shares; VKT (private vehicle); VHT (PT); PKT (PT); PHT (PT)		
Socio-economic *Specify*:(e.g. impacts on different socio-economic groups)				Not included in our model – although may be able to test geographical effects (changes in travel time and so on). Car ownership might also be examined.
Emissions *Specify*:(e.g. tonnes of carbon, noise, particulates)				Not included in our model
Economic cost/benefit (of introducing a congestion pricing scheme)				Not included in our model

Supporting components				
Component (e.g. demand elasticity, modal split, average cost per journey)	**Key assumptions** *Specify* (e.g. value of time) [2]	**How are supporting components calculated?** *Describe in words* (high level)	**Data requirements** *Specify*	**Comments**
(specify):	Only those variables that were statistically significant in the estimation were included. Travel costs were not statistically significant for HBE (primary/secondary), HBE (tertiary) or HBO trip purposes.	The HBW (white collar) & HBW (blue collar) trip purposes use a nested logit model. A MNL model is used for other trip purposes. The preference was for nested, but the data didn't always support this preference. Seven modes are included in the choice: car driver, car passenger, walk to PT, park & ride, kiss & ride, cycle and walk.	The logit models were estimated from household travel survey data from 2003-2004. Inputs include travel time and cost components for each mode, employment density, retail employment density, adults per HH, persons per HH, tertiary students per HH, school students per HH, vehicles per HH.	Employment density affects mode choice for HBW, HBS, WBW & ONHB purposes. Car availability affects mode choice for all HB trip purposes. Car availability is included as a difference or ratio between vehicles per HH and either adults or persons per HH.
(specify):	Assumes that car	For each HH segment,	Census data: Number	Uses the

	ownership varies with accessibility to employment. HHs are allocated to 10 segments based on number of adults, employed / unemployed & dependents / no dependents.	the difference from the regional average for the proportion of HHs with a particular number of vehicles is calculated. The input variables are: the number of jobs within 30/40/50/60 minutes PT travel time; the number of jobs within 10/15/20/30 minutes walk time; & the proportion of jobs within a 2.5/5/7.5/10 km highway distance.	of HHs in each HH segment and vehicle ownership category by zone. Model: Jobs within 30/40/50/60 minutes PT travel time; jobs within 10/15/20/30 minutes walk; proportion of jobs within 2.5/5/7.5/10 km highway distance.	methodology adopted for the Perth STEM.
(specify):				
(specify):				
(add more lines as necessary ...)				

Notes:

[2] Include details of how modal split is handled (e.g. will a road price increase result in extra PT patronage in the results, or has the model largely fixed splits by mode?)

Scenarios (capacity to model these scenarios)	
Cordon pricing	Could be modelled by applying a link based toll on a cordon around the CBD and/or other principal activity centres. Users would be charged for each crossing of these links (represented by a toll converted to minutes which is added to the generalised time for that link). The BSTM-MM does not include a 'park & walk' mode which may result from this scenario. The model may capture some of this as 'park & ride'.
Link pricing (tolling)	Already have several tolled links in the model, with the toll cost being converted to a time in mins. Uses various ASC values to model the perceived benefit of using the tolled facility (no toll choice logit model). Note that HOT lane tolling may only be possible if all users have access to the tolled facility. If only high occupant vehicles could use the HOT lane then it would be too complex to model (for the current model methodology). We would need to develop a methodology to generate HOV (T2, T3) OD matrices from our car driver matrix.
Area pricing	Probably too difficult to model within current model methodology. A pseudo parking charge could be applied/added to get some idea of the impact. However this would only apply to certain trip purposes (according to mode choice equations) and would be charged for each return trip to the 'priced' area (that is, could not model a 'daily charge per vehicle).
Parking policy/charging	Have already tested options to double, triple and quadruple parking charges (which are only generally applied in the CBD). Results gave elasticity's that were within the range of suggested values from past literature. Note that parking charges in BSTM-MM only affect some trip purposes (HBW white & blue collar; HBS, WBW & ONHB) according to mode choice equations. Parking supply is not yet implemented apart from 'park & ride'.
Distance-based pricing	Have already undertaken some distance-based tolling tests, by applying set rates of 15c/km for private vehicles and 30c/km for trucks across all time periods, for several motorway facilities in the study area. Results appeared to be reasonably intuitive. (Note again there is no toll choice logit model in BSTM-MM – for these tests the ASC value was set to 0 for all distance based toll links). Not sure about 'capping' the charge paid for distance travelled.
Change in urban form	Can be tested through demographic input changes – model is currently being used to test 'Greenfield' site population scenarios for 2026. However this testing requires substantial demographic input data modifications which we would require others to perform. Then there would be a need to modify the road network and PT network and services to suit.

Overall comments
(specify): e.g. strengths and weaknesses of the approach, special features, comparison with other possible approaches, application considerations *Note: include comment, if deemed relevant, on the capabilities for straightforward extensions to current model output i.e., even though any extra large scale modelling will tend to be out of the current scope, some models may possibly be able to address pricing issues better with the addition of some 'off-the-shelf' or 'bolt-on' software component* Strengths: Logit mode choice models for 7 modes (car, PT & non-motorised) with inputs from the car ownership model Car ownership model based on HH segmentation and access to jobs HH segmentation model calculating households in each segment based on standard model HH demographic inputs *Weaknesses:* Inability to model walk egress for car driver trips to allow for parking location choice. No capacity constraint for city parking locations No PT capacity constraint

Simplistic toll modelling (not true toll choice module)
Inability to model time of day choice
No feedback to trip generation rates (rates are all fixed)

The BSTM-MM can be used to test a variety of pricing scenarios, however there are limitations to the possible behaviour changes within the model. For example, trip generation and time of day of departure cannot be adjusted within the current methodology. Values of time are constant for all purposes however these probably should be modified and may be able to be implemented fairly easily.

A “bolt-on” package known as “TRAEMS” has been used for some emission type analysis using link volumes and so on. Also the EPA is looking at using model outputs for emissions modelling. Cost-benefit analysis may also be possible with some sort of bolt-on software.

ATC Urban Congestion Working Group

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Congestion Pricing Modelling Project

Stocktake of Modelling Specifications/Capabilities

Jurisdictional model (general and contact information)	
Jurisdiction name	SOUTH AUSTRALIA
Model name (eg Strategic Transport Model STP)	Metropolitan Adelaide Strategic Transport Evaluation Model (MASTEM)
Type of model[1] (e.g. 4-stage with cost feedback)	4- stage with cost feedback to car ownership/ trip generation, trip distribution and mode choice (see separate paper on MASTEM)
Model coverage[2]	Adelaide Statistical Division (282 internal TAZ and 21 External loading points on ASD boundary) (see separate paper on MASTEM)
Model assumptions/parameters[3]	VOT (car and PT): $11.28/ person hour VOC: 11.4c/km (see separate paper on MASTEM for other assumptions and parameters)
Software[4]	CUBE Voyager and Cube Analyst (V5.0.2)
Responsible organisation[5]	Department for Transport Energy and Infrastructure, Policy and Planning Division
Primary contact (name, phone, email)	Mr Lindsay Oxlad; (08) 82048805, 0401 125 000; Lindsay.Oxlad@saugov.sa.gov.au
Alternate contact [1] (name, phone, email)	As above

[1] 4-stage strategic demand model; extent of feedback of generalised costs
[2] The geography of the model: city-wide model, area-specific (local area model only)
[3] Value of time; vehicle operating cost rate; other parameter values
[4] E.g. CUBE, EMME/2
[5] Responsible for all or some of the following: model development, model maintenance, model operation.

Notes:

[1] At least one of the contacts is to be available for providing any further information during the period of the proposed consultancy to review each jurisdictional model, which is expected in February. Please note if during that time, the nominated contact people will not be generally available.

Outcomes (of modelling congestion pricing scenarios)				
	Key assumptions *Specify* (e.g. elastic supply of alternative transport modes)	**How are outcomes calculated?** *Describe in words* (high level)	**Data requirements** *Specify* (high level)	**Comments**
Congestion impacts *Specify:* (e.g. time and operating cost savings)	See separate report on MASTEM methodology and assumptions	Changes in interzonal trips, trip (generalised) cost, vehicle km and vehicle hours; changes in V/C and delays mid-block and at signalised intersections. Changes in trip length distributions (time and distance).	Road network and signalised junction details along with public transport network, routes and services (see separate paper on MASTEM)	
Network performance *Specify*:(e.g. behaviour change such as public transport usage)	ditto	Shifts in mode choice from car driver alone to car passenger, rail, bus and tram passenger, walk and cycle, plus changes in network operating characteristics like delay, travel time, etc Shifts in destination choice and changes in trip length distributions (time and distance)	See separate paper on MASTEM for details	
Socio-economic *Specify*:(e.g. impacts on different socio-economic groups)	Ditto but limited to impacts on car ownership market segments and trip purposes	Shifts in destination and mode choice by car ownership market segments and trip purpose groups (eg zero, 1, 2 and 3+ car owning households and 8 trip purposes)	Ditto	
Emissions *Specify*:(e.g. tonnes of carbon, noise, particulates)	Can be computed via Economic, Environmental and Road Safety (EERS) model linked to MASTEM	See EERS model which uses outputs from MASTEM as inputs to its calculations.	Ditto	
Economic cost/benefit (of introducing a congestion pricing scheme)	Ditto	Ditto	Ditto	
Supporting components				
Component (e.g. demand elasticity, modal split, average cost per journey)	**Key assumptions** *Specify* (e.g. value of time) [2]	**How are supporting components calculated?** *Describe in words* (high level)	**Data requirements** *Specify*	**Comments**
(specify): See separate report on MASTEM for details	See separate report on MASTEM for details of sub-models forming the MASTEM suite	See separate report on MASTEM for details of sub-models forming the MASTEM suite	See separate report on MASTEM for details of sub-models forming the MASTEM suite	

of sub-models forming the MASTEM suite.				
(specify):				
(specify):				
(specify):				
(add more lines as necessary ...)				

Notes:

[2] Include details of how modal split is handled (e.g. will a road price increase result in extra PT patronage in the results, or has the model largely fixed splits by mode?)

Scenarios (capacity to model these scenarios)	
Cordon pricing	*(insert comments)* MASTEM can model cordon pricing via generalised cost formulation applied to roads crossing defined cordon.
Link pricing (tolling)	*(insert comments)* MASTEM can model tolling as a link attribute via the generalised cost formulation
Area pricing	*(insert comments)* MASTEM can model this via the generalised cost formulation
Parking policy/charging	*(insert comments)* MASTEM can model this by varying its parking cost assumptions (parking charges in Adelaide primarily confined to the CBD)
Distance-based pricing	*(insert comments)* MASTEM can model this via the formulation of the VOC parameter and generalised cost formulation for car and truck travel.
Change in urban form	*(insert comments)* MASTEM can model this by varying the input demographic and land use data for each TAZ but difficult to model TODs if located in larger out suburban zones.

Overall comments

(specify): e.g. strengths and weaknesses of the approach, special features, comparison with other possible approaches, application considerations

Note: include comment, if deemed relevant, on the capabilities for straightforward extensions to current model output i.e., even though any extra large scale modelling will tend to be out of the current scope, some models may possibly be able to address pricing issues better with the addition of some 'off-the-shelf' or 'bolt-on' software component

The strengths of MASTEM and special features:

- The reiterative process is adopted to achieve overall balance (or equilibrium) between transport supply and demand which captures the network and system wide impacts of changes in either supply (through transport system changes) or demand (through changes in demography or land use).
- The temporal impacts of policy changes can be identified through the use of am , pm and off peak and daily travel behaviour and travel patterns.
- The model covers all travel modes (car, train, tram, Obahn and other bus, walking and cycling) as well as Commercial/ Freight vehicles (light and heavy trucks) and External traffic (cars, light and heavy trucks).
- The component models of MASTEM and MASTEM itself has been rigorously developed, calibrated and validated at the detailed level (not just at the overall metropolitan level) and model performance has been extensively tested and improved to maximise its capability as the main strategic transport planning tool.
- Operating within the Cube Voyager platform it is relatively simple to update and enhance the MASTEM suite to allow it to be used to test a range of different transport policy options.
- The model includes junction modelling which means that path building and trip assignment is carried out on a more realistic basis taking account of the impacts of traffic congestion not only mid-block but at intersections as well.
- The CUBE Voyager model allows specific, special purpose applications to be developed and integrated with the main MASTEM suite to carry out, for example, sub-area analyses (eg Northern Expressway Sub Area Model which is bolted on to MASTEM)

The weaknesses of MASTEM:

- Uses a relatively coarse zoning system for the outer zones which limits its ability to model TODs in outer suburban areas. This means that transport policy options that have mainly local impacts (eg localised travel demand management policies, TravelSmart, etc) which affect local travel patterns and travel behaviour which are concentrated within TAZ as intrazonal travel movements cannot be successfully modelled.

- It was developed as a strategic level model for medium to long term transport infrastructure and operational planning and is not really suitable for Local Area Transport Planning – models such as AIMSUN and SATURN are better suited to such local area planning.
- The temporal aspects of the model are confined to the am, pm and off peak and daily travel.
- The Commercial/ Freight vehicle and External traffic models are External applications that are based on Fratar growth factor models which are not affected by changes in road network congestion levels.
- Limited in geographic scope to the Adelaide Statistical Division but future growth projected to occur in the Outer Adelaide Statistical Division and travel demand from that area determined from the External Traffic model which is a less than optimal situation.

Other Applications allied to MASTEM:

- Northern Expressway Sub Area Model (NESAM) sub-area model developed with Cube Voyager and integrated with MASTEM to carry out more detailed traffic assignment for larger geographic area using refined/ smaller zone system.
- SIDRA small area intersection planning and analysis model for intersection design.
- AIMSUN micro simulation model used for small, local area traffic analysis and intersection planning and design but has the potential to be used for local area traffic planning fro private vehicles, buses and trucks. Contact JohnYates (Ph: (08) 82048370; john.yates@saugov.sa.gov.au).

ATC Urban Congestion Working Group

NATIONAL TRANSPORT MODELLING WORKING GROUP
Congestion Pricing Modelling Project

Stocktake of Modelling Specifications/Capabilities

Jurisdictional model (general and contact information)	
Jurisdiction name	VICTORIA
Model name (eg Strategic Transport Model STP)	Melbourne Integrated Transport Model (MITM)
Type of model[1] (e.g. 4-stage with cost feedback)	4-stage strategic transport demand model with feedback to trip distribution, mode choice and assignment
Model coverage[2]	The MITM coves the Melbourne Statistical Division (MSD). It comprises 2,253 internal transport zones and 19 external transport zones. It covers the public transport network and services (train, tram, buses), and the highway network (freeways, tollways, major and minor arterials and 80% of collector roads).
Model assumptions/parameters[3]	See provided documentation.
Software[4]	CUBE operating in both TRIPS and VOYAGER platforms.
Responsible organisation[5]	Department of Transport
Primary contact (name, phone, email)	Fotios Spiridonos (03) 9655 8536 fotios.spiridonos@transport.vic.gov.au
Alternate contact [1] (name, phone, email)	Neville Wood (03) 9655 6106 neville.wood@transport.vic.gov.au

[1] 4-stage strategic demand model; extent of feedback of generalised costs
[2] The geography of the model: city-wide model, area-specific (local area model only)
[3] Value of time; vehicle operating cost rate; other parameter values
[4] E.g. CUBE, EMME/2
[5] Responsible for all or some of the following: model development, model maintenance, model operation.

Notes:

[1] At least one of the contacts is to be available for providing any further information during the period of the proposed consultancy to review each jurisdictional model, which is expected in February. Please note if during that time, the nominated contact people will not be generally available.

Outcomes (of modelling congestion pricing scenarios)				
	Key assumptions *Specify* (e.g. elastic supply of alternative transport modes)	**How are outcomes calculated?** *Describe in words* (high level)	**Data requirements** *Specify* (high level)	**Comments**
Congestion impacts *Specify:* (e.g. time and operating cost savings)	Travel Time and Vehicle operating cost savings Change in congestion intensity	Change in interzonal travel times; vehicle-kilometres of travel; volume-to-capacity ratios; trip length distribution (distnae & time) - all relative to a defined Base Case	Value of time; vehicle operating cost rate; transport network definition (public transport & highway) See provided documentation.	
Network performance *Specify*:(e.g. behaviour change such as public transport usage)	Mode shift effects (public transport & private car)	Mode choice model can model/identify shift in mode choice (motorised & non-motorised; car & public transport). Change in destination/trip distribution. Changes in transport network operating characteristics. See provided documentation.	See provided documentation.	
Socio-economic *Specify*:(e.g. impacts on different socio-economic groups)	Limited, but can consider impacts on travel purposes.	Change in mode choice and trip purposes.		
Emissions *Specify*:(e.g. tonnes of carbon, noise, particulates)	CO, HC_4, NO_x, SO_2, PM_{10}, $PM_{2.5}$	Post-processing, using custom-built Excel application, to calculate the tonnages of CO, HC_4, NO_x, SO_2, PM_{10}, $PM_{2.5}$	Se provided documentation.	
Economic cost/benefit (of introducing a congestion pricing scheme)	Benefits and costs can be derived – post-processing of modelled outputs	Post-processing in Excel to derive global benefit/cost ratios; costs of congestion.		
Supporting components				
Component (e.g. demand elasticity, modal split, average cost per journey)	**Key assumptions** *Specify* (e.g. value of time) [2]	**How are supporting components calculated?** *Describe in words* (high level)	**Data requirements** *Specify*	**Comments**
See provided documentation.	See provided documentation	See provided documentation	See provided documentation	

Notes:

[2] Include details of how modal split is handled (e.g. will a road price increase result in extra PT patronage in the results, or has the model largely fixed splits by mode?)

Scenarios (capacity to model these scenarios)	
Cordon pricing	Cordon can be readily defined and pricing applied to each of the crossing points (in both directions) and modelled in the MITM via the generalised cost formulation.
Link pricing (tolling)	Applied to specified links to which tolling applies and modelled in the MITM via the generalised cost formulation.
Area pricing	Pricing applied on the basis of transport zones that comprise the specified area and modelled in the MITM via the generalised cost formulation.
Parking policy/charging	Pricing applied to the transport zones that comprise the specified parking area and modelled in the MITM via the generalised cost formulation.
Distance-based pricing	Pricing applied to all transport links (highway) and modelled in the MITM via the generalised cost formulation.
Change in urban form	Can be modelled in the MITM by varying the demographic and land use data related to a particular urban form.

Overall comments
(specify): e.g. strengths and weaknesses of the approach, special features, comparison with other possible approaches, application considerations *Note: include comment, if deemed relevant, on the capabilities for straightforward extensions to current model output i.e., even though any extra large scale modelling will tend to be out of the current scope, some models may possibly be able to address pricing issues better with the addition of some 'off-the-shelf' or 'bolt-on' software component*

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Stocktake of Modelling Specifications/Capabilities

Jurisdictional model (general and contact information)	
Jurisdiction name	WESTERN AUSTRALIA
Model name (eg Strategic Transport Model STP)	Strategic Transport Evaluation Model (STEM)
Type of model[1] (e.g. 4-stage with cost feedback)	4 stage with highway times feedback. Four time periods modelled - am peak (7-9), off peak, pm peak (4-6), evening (effectively through to 7 next morning). Multimodal - car driver, car passenger, public transport (three access modes - park and ride, kiss and ride, walk), cycle, walk. Demand forecasts are for average weekday in the school term.
Model coverage[2]	Perth Greater Metropolitan Area - Perth Statistical Division plus the Statistical Local Areas of Mandurah and Murray. 472 strategic transport zones, 12 external zones.
Model assumptions/parameters[3]	Value of time varies from trip purpose to trip purpose. Derived from nested logit mode choice models, one for each of five trip purposes, at the zone level. Marginal cost of running a car (essentially fuel, oil and tyres) on a per km basis. For 2008 base year model runs currently set at 17.6 cents/km. CBD commuter parking costs (by transport zone) and public transport fares (by fare zone). All costs in 2001 dollars.
Software[4]	EMME3
Responsible organisation[5]	Department for Planning and Infrastructure (DPI)
Primary contact (name, phone, email)	Peter Lawrence 08 9264 7726 Peter.Lawrence@dpi.wa.gov.au available Tuesdays to Thursdays
Alternate contact [1] (name, phone, email)	Renlong Han 08 9264 7863 Renlong.Han@dpi.wa.gov.au

[1] 4-stage strategic demand model; extent of feedback of generalised costs
[2] The geography of the model: city-wide model, area-specific (local area model only)
[3] Value of time; vehicle operating cost rate; other parameter values
[4] E.g. CUBE, EMME/2
[5] Responsible for all or some of the following: model development, model maintenance, model operation.

Notes:
[1] At least one of the contacts is to be available for providing any further information during the period of the proposed consultancy to review each jurisdictional model, which is expected in February. Please note if during that time, the nominated contact people will not be generally available.

Outcomes (of modelling congestion pricing scenarios)				
	Key assumptions *Specify* (e.g. elastic supply of alternative transport modes)	**How are outcomes calculated?** *Describe in words* (high level)	**Data requirements** *Specify* (high level)	**Comments**
Congestion impacts *Specify:* (e.g. time and operating cost savings)	Elastic in mode shares and trip distribution. Average car trip distances reduced by significant car trip length re-distribution.	Mode shares are derived from a series of nested logit models using a composite disutility (=generalised cost?) function for each trip purpose. Distribution functions, again one for each trip purpose, are based on a Tanner-like function (combined power/exponential).	Disutility calculated from network times and costs, household demographics and behavioural constraints.	
Network performance *Specify*:(e.g. behaviour change such as public transport usage)	Small increase overall in pt mode share, more significant changes in commuting to CBD	PT mode shares applied to person trips on a zone to zone basis then the PT trips assigned to PT network	Calibrated vehicle and PT networks.	
Socio-economic *Specify*:(e.g. impacts on different socio-economic groups)				
Emissions *Specify*:(e.g. tonnes of carbon, noise, particulates)				
Economic cost/benefit (of introducing a congestion pricing scheme)				

Supporting components				
Component (e.g. demand elasticity, modal split, average cost per journey)	**Key assumptions** *Specify* (e.g. value of time) [2]	**How are supporting components calculated?** *Describe in words* (high level)	**Data requirements** *Specify*	**Comments**
(specify):				
(specify):				
(specify):				
(specify):				

(add more lines as necessary ...)				

Notes:

[2] Include details of how modal split is handled (e.g. will a road price increase result in extra PT patronage in the results, or has the model largely fixed splits by mode?)

Scenarios (capacity to model these scenarios)	
Cordon pricing	*(insert comments)*
Link pricing (tolling)	*(insert comments)*
Area pricing	*(insert comments)*
Parking policy/charging	*(insert comments)*
Distance-based pricing	*(insert comments)*
Change in urban form	*(insert comments)*

Overall comments
(specify): e.g. strengths and weaknesses of the approach, special features, comparison with other possible approaches, application considerations *Note: include comment, if deemed relevant, on the capabilities for straightforward extensions to current model output i.e., even though any extra large scale modelling will tend to be out of the current scope, some models may possibly be able to address pricing issues better with the addition of some 'off-the-shelf' or 'bolt-on' software component*

Appendix B Interview Questionnaire

This document sets out a specification for an “ideal” strategic road-pricing model and also includes questions about how each of the state transport models might deal with particular road pricing modelling issues. The document is not intended as a critique of existing models; rather, it is intended as a discussion starter to assess the amount of effort needed to incorporate road-pricing features into each of the state models.

Model Specification	Questions
Model Structure	
▪ Four-step model. ▪ AM peak, PM peak, inter-peak period models (as a minimum). ▪ Segmentation of trip purposes – at least three car categories plus LCV and HCV. Carriage of trip purposes through each step of the four-step model is desirable. ▪ Future year models should (ideally) be available for forecasting horizons of say 10-year and 20-year horizons. ▪ Network pricing changes should be iterated back to distribution and mode choice. Peak spreading should ideally be included – including shift to adjacent time period models. ▪ Zoning system should include ability to price car parking charges for both on-street and off-street parking, and consider whether the individual or employer pays. ▪ Ability to change land use patterns (ideally in response to charging, but ability to change as an input to model is acceptable).	▪ What is the current level of segmentation applied in the generation, distribution, mode choice and assignment models?

Generalised Cost Parameters	
▪ Vehicle operating costs (VOCs) should reflect the cost perceived by the road user. This may be fuel price only, or a combination of fuel price and direct costs (such as operating & maintenance, purchase, registration and insurance). ▪ Value of time (VOT) or value of travel time savings (VTTS) should reflect the value that the users place on their time (or their willingness to pay to achieve a travel time saving). ▪ Generalised costs should include VOC, VOT, public transport fare and toll/cordon/parking charges (at a minimum). ▪ Generalised costs should be segmented by user classes (segments) and included in the distribution and mode choice models.	▪ How robust are the VOT values currently applied in the model? When and how were they derived? ▪ What segmentation is applied to generalised costs in the distribution, mode choice and assignment models?
Networks	
▪ Road and public transport model networks should provide a reasonable representation of current transport networks and associated levels of congestion. ▪ Road network should include any toll roads, pricing points and tolling structures. ▪ Public transport should desirably include capacity constraints (ie. crowding models). ▪ Model should include ability to enhance public transport networks to reflect any 'mitigation' works. ▪ Junction modelling of key route diversion points.	
Model Sensitivity	
▪ Model should be checked to understand the range of 'accuracy' in sensitivity tests of key parameters. Elasticity results should be reviewed to understand model responsiveness to key parameters. ▪ Sensitivity tests should include understanding of impacts of pricing changes on demand (and through distribution and mode choice models).	

SKM

Model Reporting	
High Priority Items ▪ Changes in mode share – car, LCV, HCV, PT, ped/cycle etc. ▪ Changes in total trips (i.e. trip suppression) by mode. ▪ Changes in VKT, trip times and VHT ▪ Changes in emissions/environmental factors, preferably with speed-related emissions analysis (possibly using post model analysis techniques). ▪ Changes in safety outcomes (eg. accident rates) based on changes in speeds, congestion, travel time and travel distance (possibly using post model analysis techniques). ▪ Understanding of social impacts (e.g. by comparison of affected households with socio-demographic characteristics such as income structure). ▪ Changes in overall network level of service, including changes by area and link type (eg. motorway/non-motorway). ▪ Changes in conditions at boundary of pricing area (e.g. increased local congestion impacts). **Lower Priority Items** ▪ Changes in trip patterns (i.e. sector to sector trips). ▪ Changes in trip length and distribution. ▪ Changes in travel speeds (i.e. average speeds), including changes by area. ▪ Changes in PT passenger trip times and PT passenger hours of travel. ▪ Changes in travel times to key employment centres (i.e. commuter travel times) . ▪ Changes in travel times to key CV destinations (i.e. ports etc). ▪ Changes in costs of travel by user class.	

Specific Road-Pricing Capabilities	
▪ Distance-based charging ▪ Link-based charging (toll roads) ▪ Cordon charging ▪ Area charging ▪ Parking charges ▪ Urban form change	**Distance-Based Charges** ▪ How does model address distance based charges? **Cordon, Area and Toll Charges** ▪ How does model address cordon and toll charges such as point charges applied to links? ▪ Can this be represented by simply applying a 'toll' to the links that form the toll road? ▪ How does model address charging of trips within the charging area for the Area Scheme? ▪ Any other comments on modelling approach to these road pricing options? **Parking Charges** ▪ How does model address parking (including permit areas)? ▪ Any other comments on modelling approach to these road pricing options? **Urban Form Change** ▪ How does model reflect changes in urban form (as a result of pricing or separate to pricing)?

SKM

Supplementary Questions

- How would the model address the issue of multiple charges per day (i.e. capped charge, or once per day charge)?
- How would the model address differential charges applied at different times (or periods) of the day?
- Is the model capable of applying different charges to different areas (i.e. geographic based charges) and/or link types (i.e. road category/classification charges)?
- Can the model apply different charges across different user classes (i.e. car vs CV trips)?
- How would the model address residential discounts in road pricing areas? Does the model have the functionality to treat residents within a permit area separately from other users?
- How would the model consider trip “suppression” including ...reduction in total demand? ...mode choice? ...time of day travel shift (or peak spreading)? ...changes in trip distribution?
- Does the model incorporate a logit model for toll charges? How does the model reflect the ‘perceived benefits of travelling on toll roads’?
- What are your views on the standardisation of certain model parameters (eg. VOC, VOT) among the state models?

Appendix C Interview Questionnaire – Jurisdiction Responses

Victoria - MITM

Model Structure

- 14 trip purposes at trip generation and trip distribution
- 8 trip purposes at mode choice
- Aggregated at assignment
  - Driven by data availability
  - Scope to improve with VISTSA (10,000+) valid responses
- Includes inner city and CBD parking charge – zonal basis
  - No account of who pays
- Can model AM peak, inter peak and PM peak separately – would like to have peak spreading!

Generalised Cost

- VOC includes fuel plus other costs (as given in Austroads)
  - Fuel is approx 25% of VOC
- VOT derived from consideration of DOI, VicRoads and Austroads recommended values
  - Single value applies to all purposes
  - Value is 'quite old'
- 14 GCs – differentiated by parameters

Networks

- Junction modelling could be incorporated into the model
  - Most likely would do on a project by project basis

Sensitivity

- Fuel price has low elasticity
- Refer to ARUPS report?
- Metro-wide responses to pricing tests in line with expectations
  - Detailed responses not investigated

Road Pricing Schemes

- Distance based charge modelled as $ per km
- Toll and cordon charge modelled as toll attribute on link
- Area could be done like parking – charge on trip end by zone

Supplementary

1) Factor the cost to represent multiple crossings
2) Can model different periods separately
3) Can model different areas separately
4) Can charge car separately from commercial vehicles – not trip purposes. Multi-class assignment can be done – just a bit more work
8) Don't standardise values – accurate documentation and 'normalise results' where necessary/possible

ACT - CSTM

Model Structure

- AM peak only
- Car & PT only (No slow mode or CVs)
  - No CV data available)
- 6 journey purposes at Trip generation, distribution and mode split
  - Combined at assignment
- Parking charges applied through EMME MACRO on a zonal basis

Generalised Cost

- VOC includes Fuel plus parking plus ‘other’ plus factor to represent operation and maintenance costs (ARRB figures)
- VOT also based on ARRB work
  - Model currently undergoing recalibration/validation based on ABS 2006 data
  - Consultants have been asked to update VOT based on ATC guidelines and draft ARRB 2007 report
- No toll component to GC formulation

Networks

- Junctions coded for nodes within the Canberra Central Area (CBD plus adjacent areas)
  - EMME MACRO calculates junction delays and feeds back into assignment
- No PT crowding
  - PT ‘quite basic’

Sensitivity

- Elasticity study conducted 2 years ago
  - Findings fed into model as ‘weighted factors’ to achieve desired outcomes

Reporting

- No safety outputs
- No social outputs

Road Pricing Schemes

- Distance based charge would be modelled by adjusting the fuel cost parameter
- No thought has been given to toll, cordon or area pricing – very unlikely for Canberra

Supplementary

- Respondent believes that each jurisdiction should adopt common parameters, that way a central body (Austroads) could have the responsibility of updating values periodically.
  - Admits that there are differences between jurisdictions but argues these are small.
  - If people are happy with ATC recommended values – these should be adopted
- ACT does not have a dedicated modelling team, resources are scarce. There are therefore gaps and limitations to the CSTM.

NSW – STM

Model Structure

- Model is structured around 24-hour tours at the generation, distribution and mode choice stages. Distribution and mode choice are combined into a single destination/mode-choice model.
- Tours are generated by mode, with a weighted average generalised cost (across time periods) used for destination/mode choice.
- Trip purpose segmentation is maintained through generation, distribution and mode choice. 128 segments (comprising 8 levels licence/car ownership/car availability, 4 levels income, 4 levels job type) are used for work trip purposes. Other segmentations are applied to other purposes.
- Mode choice incorporates 7 choices. Only a single car driver alternative is included, so toll/non-tolled choices are not explicitly modelled. Times and costs are fixed for each segment.
- Commercial vehicle trips are generated by a separate CV model and included as fixed matrices in STM. In theory, CV trips could use a different tolling structure in the traffic assignment stage of the model.
- Peak spreading could theoretically be included within the tour-based framework, although a time period choice module could be quite complex to develop.

Generalised Cost

- Vehicle operating costs – based on fuel price and fuel efficiency (to give cents per kilometre). Other non-perceived costs, such as maintenance, insurance and registration are not included. There are minor difference in the VOC calculation for each trip purpose.
- Value of time – different parameters are used for different segments (model uses log costs rather than direct costs).
- Model was originally based on a 1996 calibration. TDC plans to update parameters in the future.
- Parking costs are incorporated at a zonal level:
  - all major parking centres are included;
  - no distinction between individual-paid or employer-paid parking;
  - parking costs vary depending on the segment (eg. full-time workers tend to pay daily costs, whereas part-time pay only a proportion of daily cost).
- Some toll roads in Sydney have refundable tolls (for private, non-company car travel). These are not taken into account in the model, as the level of refund claims is unknown.

Networks

- RTA codes the network and keeps it up to date.
- The M7 motorway has capped tolls.
- PT capacity constraints are not modelled, though the upcoming Sydney Metro study may develop a specialised crowding model.
- Frank and Peter’s view was that crowding on the bus system was possibly more significant than crowding on trains. Bus drivers often do not stop to pick up passengers if they have exceeded the maximum number of standing passengers.
- Frank and Peter thought that peak spreading was a more significant issue than PT crowding.

Reporting

- Every model is set up as a separate EMME databank. Scenario comparisons are usually done externally with Excel spreadsheets.
- Social impacts could be analysed by reporting results by different income segments.
- Changes in travel times can be tricky to determine, as people may travel shorter distances (particularly with distance-based charges), or trips may be suppressed.

Road Pricing Schemes

- Need to clarify whether cordon-based schemes toll drivers only on entry to the cordon, or exiting as well.
- Area charging could be incorporated into the skimming process (though the current model doesn't allow this).
- Population and employment are fixed (ie. exogenous inputs to the model), so changes in urban form in response to road charges are difficult to model.

Supplementary

- Multiple charges/toll-capping – the skimming process could be adapted to cap tolls. Assignment?
- Time-of-day differential charging – road skims are carried out separately for each time period, and the weighted average is fed back into the 24-hour tour generation process.
- There is an accessibility component in the trip generation module which will potentially suppress trips with charging – though Frank and Peter haven't tested the sensitivity of this process.
- Standardisation of model parameters – probably not a good idea, as there are differences in fuel costs between states (eg. Queensland) and different fleet compositions (eg. heavier vehicles will have higher fuel costs). VOT will depend on the income segments available in the model (segments will differ between states).

Queensland – BSTM-MM

Model Structure

- AM peak, PM peak, day off-peak (inter peak) and night off-peak
- Fixed time period factors
- 8 Resident car trip purposes
    - Generation and mode choice
    - Combined at assignment
- Medium CVs (Rigid) and Heavy CVs (Arctic)
- Parking applied in CBD plus surrounding area
    - Only applied to HBW white & Blue, HBS, WBW & ONHB (Not applied to education)
    - Applied at mode choice stage
    - Charge is an 'average' separately for peak and off-peak
    - No allowance for employees contribution

Generalised Cost

- Only variable component of VOC included
    - Separately VOCs at mode choice/distribution(higher) and assignment (lower)
- VOT derived from SP surveys done for (fairly recent) Gateway Bridge Upgrade Project
- Toll included in generalised cost formulation
- ASC included to model perceived benefit of toll road (-5min for Gateway Bridge)

Networks

- PT modelling generally not included but do have a MACRO that has been used.
    - Could develop it if time and resources available
- Don't have junction modelling but would like it!

Sensitivity

- Parking tests shown to derive elasticities in-line with literature
- VOCs doubled, tripled and quadrupled
    - Elasticities in line with acceptable limits

Reporting

- Environmental package that takes model outputs to estimate environmental impacts
    - Not run by the BSTM team
- Reporting should be consistent across state
- No income data in the model
    - Could look at accessibility for socio-economic impacts

Road Pricing Schemes

- Would model distance based charging like a toll
    - Link attribute rather than part of VOC
- Area charging thought to be 'too difficult'
    - Working Group abandoned testing Area pricing

- Large scale urban model has been developed to model interaction between land-use and transport supply

Supplementary

- Modelling different time periods separately would require separate mode-choice parameters
    - A lot of purposes run off the AM peak
- ASCs as high as 10 t0 12 minutes for airport link.
    - Have tried to match toll road forecasts (by changing ASCs)
- A good thing to standardise parameters but would involve quite a bit of work – recalibration etc
    - Maybe some benefit from standardising household travel surveys in order to standardise models!

South Australia – MASTEM

Model Structure

- AM peak, PM peak and off-peak
  - Sum to 24hrs
  - Peak period factors applied after mode choice
- 4 Car ownership categories
- 8 journey purposes (Lumped together for assignment)
- LCVs and HGV often lumped together due to freight model
- Assignment is a volume averaging assignment – GC path, not time path
- Parking is done by zone
  - Accounts for employer pays
  - Varies by purpose

Generalised Cost

- VOC fuel cost only
- Single value of VOT
  - Taken from Austroads
- Toll term not included in GC formulation but could be

Networks

- Road (and to some degree PT) incorporated into a database
  - Able to switch on/off nodes and links by time period
  - Applied to different years by identification flags
- PT crowding is time consuming in CUBE
  - Could use it on selected assignments
- Junction modelling included
  - All signalised intersection in the network are modelled

Sensitivity

- VOC not sensitive until +100%
- Scott Elaurant may know more

Reporting

- Nothing on social

Road Pricing Schemes

- Thinks they can all be modelled
  - Enhancements may be required however

Supplementary

- Need enhancements to model multiple charges per day
- Model different periods in the assignment
  - Alter link attributes
- Different geographies would require significant re-coding

- Possibly apply to different user charges separately
    - Need re-coding
- Would need enhancements to model residential discounts
- Model feeds back to trip generation
- Nothing for perceived benefits of toll roads
- No problem with standardisation.
    - Need to recognise regional differences however

WA – STEM

Model Structure

- Segmentation of 4 home-based trip purposes and 1 non-home-based purpose are used in the generation, distribution and mode choice stages.
- Time periods: 24-hour production-attraction matrices are determined and fixed proportions are allocated to each time period. Separate time period factors are used for work and non-work trips.
- Zonal car parking charges are applied to the Perth and Fremantle CBDs. This is an all-day parking charge applied to work trips.
- A basic CV sub-model generates a fixed truck matrix (light and heavy trucks). Light commercial vehicles (eg. couriers, utes) are not included. The main four-step model applies the car and CV matrices in a multi-class assignment.

Generalised Cost

- Vehicle operating costs are based on data from RAC. The marginal operating cost is the cost of fuel, maintenance, oil and tyres. Standing costs (registration, insurance, etc) are not included. Fuel price is based on an average annual price per litre, and is combined with fuel efficiency to derive a cents/kilometre value. Current value is 17.6 c/km.
- Value of time is not an input to the model; rather, it is derived from the model's travel time and generalised cost calculations.
- No tolls are currently included in the cost calculations – this would need to be added in.
- Rather than a generalised cost, the model uses a composite disutility for the distribution and mode choice models. The composite disutility includes generalised cost elements, as well as behavioural elements at a zonal level (particularly factors affecting the choice of "green" modes). Sensitivity to road charging may potentially be incorporated into this component.

Networks

- The public transport network is included, with different services and frequencies for each time period. There are no crowding capacity constraints, although this is not really an issue for Perth, given that the rail network is not operating at capacity.
- All signalised intersections are modelled with simple turn penalties.
- Main Roads Western Australia operates its own model ("ROM" – Road Operations Model) that uses a more detailed road network and approximately three times as many zones as STEM. The ROM model is a highway model only – it does not include multi-modal capability.

Sensitivity

- Sensitivity tests have been carried out on VOCs (fuel cost). The model produced reasonable results. There was not much change in mode share, though some change was observed in CBD-based trips. For large changes (eg. 300%), Peter has some doubt about the model's response.
- Sensitivity tests have also been carried out on access and waiting times for PT.

Reporting

- All of the items on the reporting list can be produced, though some (eg. emissions outputs) would usually be analysed by environmental models held by other government departments.

Road Pricing Schemes

- Distance-based charges can be addressed through changes to VOC.
- For link, cordon and area charges, a new toll attribute will need to be added to links.
- Peter has started to look at link and cordon-based charging, but not yet at area-based charging.

Supplementary

- Cordons would be modelled as a series of point tolls – at present cost is added on all cordon crossings (in and out). EMME could handle multiple cordon crossings within a single time period through appropriate scripting, but multiple crossings across multiple periods would require some sort of cost factoring approach.
- Area-based charging could be implemented with an OD matrix of charges (zero elements for no charge; non-zero elements for OD pairs that attract a charge). These charges would need to be added into the composite disutility (possibly using the same coefficient as the parking charge).
- Residential discounts in area-based schemes are unlikely to be needed in Perth, although East Perth now has some residential development.
- Trip suppression due to road charging is not currently implemented but might be incorporated.
- Lukewarm response to standardisation of model parameters, as VOT and VOC will be different between states, and may vary between trip purposes.