11

Future of modelling

At a glance

This section of the report considers the commonly used, four-step approach to strategic transport modelling and the scope and limitations of existing models.

This section goes on to examine the potential to improve strategic models through:

- The consideration of new mobility and the implications of new technology
- Improved data accuracy and consistency
- Use of scenarios to look beyond averages
- New and emerging data sets
- Enhancing model capability.

11.1 Our approach to modelling

The Zenith model used for the *Australian Infrastructure Audit* is consistent with contemporary best practice in terms of strategic transport models. However, like any modelling exercise, there are limitations to the accuracy of its findings and their application.

Transport models need to adapt to changes in the way that people live, work and move. New technology and data present opportunities to improve the way that infrastructure and services are planned for communities. The following sections discuss some of the current limitations of strategic models and explore opportunities for developing the next generation of predictive models.

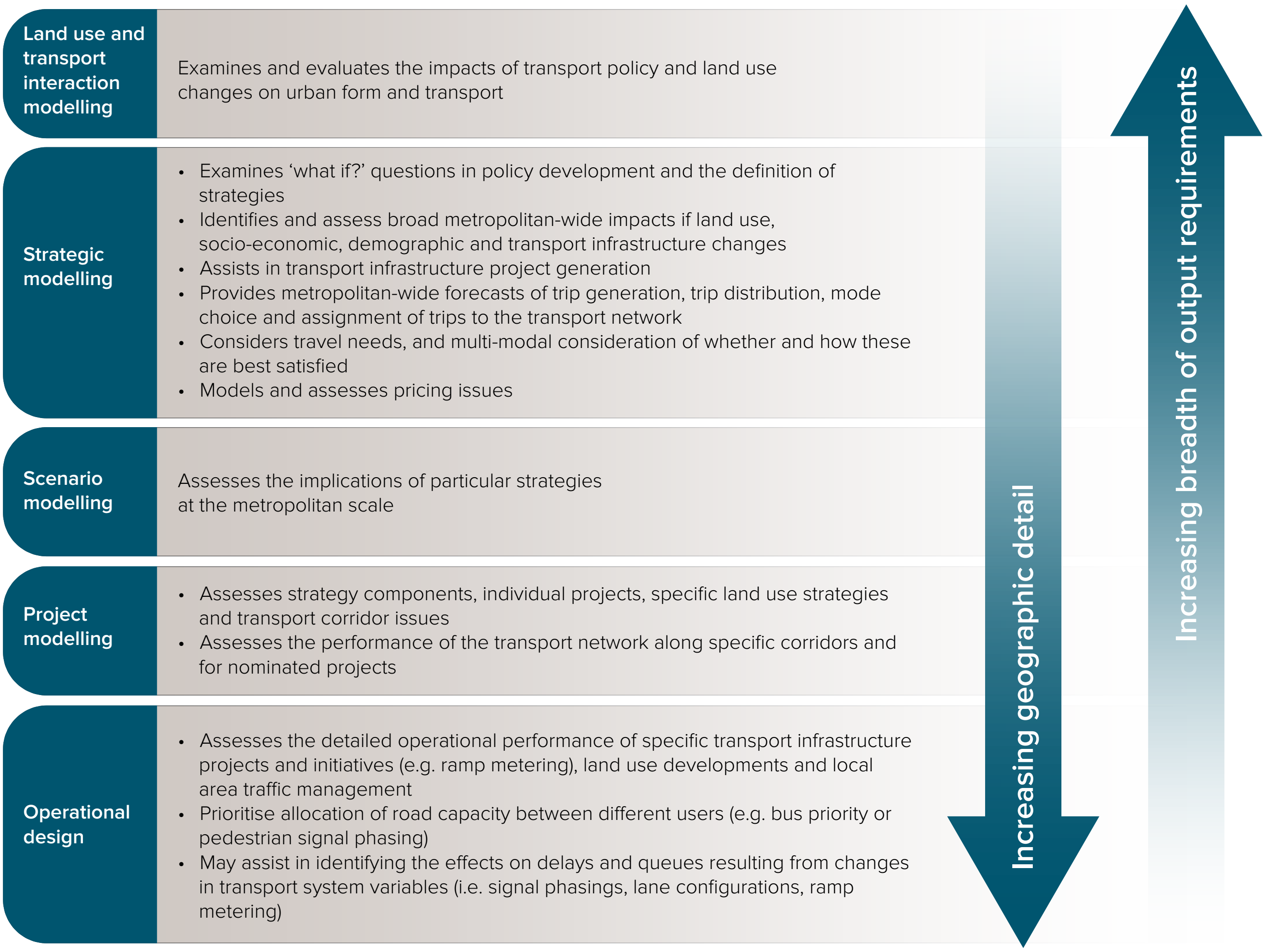
11.2 Overview of strategic models

Transport models consist of demand models and supply models. Demand models predict travel patterns and demand for infrastructure and services, while supply models simulate passenger and vehicle flows and determine their level of service.[240] Various types of models are used by transport planners (Figure 136). These include strategic metropolitan-scale transport models (referred to hereafter as strategic models) which estimate levels of travel activity within a metropolitan area, and models that consider demand within smaller geographic areas, including the impacts of changes in infrastructure, services and operations for individual modes (often referred to collectively as 'project-specific' models). This discussion focuses on strategic transport models – a best practice tool used by governments across Australia and internationally for evaluating transport policy and planning transport infrastructure and services.

Strategic models, including the Zenith Model, tend to follow a consistent methodology, often referred to as 'four-step' modelling. Strategic transport models are used for long term strategic planning and to assess projects and services. Strategic models are also used for a more detailed analysis of project proposals in cases where the development of more customised, project specific applications to model smaller parts of a wider network, a project, bus route or a road corridor (such as mesoscopic traffic models) is not available. This approach is not ideal. Microsimulation, or operational design, models provide an even more granular perspective of a network, focusing on an intersection or localised road link.

Strategic models therefore have a critical influence on the infrastructure planning process. The following sections discuss some of the main limitations of strategic models and established processes of modelling transport demand and simulating network flows. Advances in technology and data provide opportunities to overcome these challenges and gain new insights into travel behaviour.

Figure 136: The hierarchy of transport models and their uses



Source: Australian Transport Assessment and Planning (2016)[241]

‘Four step’ modelling

The ‘four step’ model is a commonly used type of strategic transport model. The model involves the following steps:

1. Trip generation estimates the number of trips that originate in particular spatial zones through land use, population and economic forecasts.

2. Trip distribution draws links between trip origins and destinations, forming an origin-destination (OD) pattern or matrix of trips. This pattern is based on the logic that a person is most likely to preference travel to nearby areas of high activity (e.g. services and employment opportunities) rather than low activity.

3. Modal split predicts the travel modes used to complete origin-destination trips, based on trip purpose. The characteristics of the trip maker, the trip itself and travel mode are considered in this step.

4. Trip assignment allocates trips by purpose, mode, origin and destination to a certain transport route and simulates these trips on the network and determines the level of service. This provides an indication of the likely distribution of travel and traffic across the network.

Steps 1 through 3 are part of the demand model while Step 4 describes the supply model. Feedback from the supply model in terms of generalised travel costs (travel times, congestion, toll costs, crowding, etc.) influences travel demand in Steps 1 through 3.[242]

Tour-based modelling, where travel events are defined as starting in one location and returning to the same location, is an alternative to the four-step modelling process, which generates individual trips.[243] Tour-based modelling is a step towards activity-based modelling, which focuses more on how demand arises from the desire for activities[244] (see ‘New types of models’ section).

Source: Australian Transport Assessment and Planning (2016).[245]

11.3 Scope and limitations of existing models

Modelling for the *Australian Infrastructure Audit* provides a perspective on future network performance that helps to allow the comparison of changes in network design and operations. These models provide an insight into the future to inform decision making and to provide the basis for the comparison of different reforms or investment decisions.

However, like all models Infrastructure Australia's modelling was subject to a series of limitations that are common to most contemporary transport models used in Australia. For instance, the modelling was undertaken for a typical weekday and assumed no unplanned disruptions. This meant that congestion was likely to be underestimated, as very few days have no incidents on the transport network. In addition, peak spreading or activity rescheduling could not be tested in the modelling. This meant that trips could not be reallocated outside of the peak, despite high levels of congestion and crowding during the peaks and differential fares in some cities.

The modelling typically undertaking by Australian transport agencies also faces limitations. These limitations can include both access to accurate and consistent data inputs, and the capacity of models to extract insightful results. While large jurisdictions currently operate complex, well-developed models, access to skilled and experienced modellers can be a constraint. The necessary knowledge and experience of models is a critical component of optimising their use and interpretation of results.

Access to relatively modest resources to improve model use is often not adequately prioritised, thereby compromising decisions on multi-billion dollar projects with multi-generational impacts.

Critical to improved decision making must also be an openness to current model capabilities and limitations, as well as the opportunity for enhancement.

As a key component of infrastructure decision making, the limitations in the capacity of transport models also naturally also limit the capacity of infrastructure planners to reach informed, reliable conclusions about future transport network performance. Infrastructure Australia has therefore identified a significant opportunity to improve infrastructure decision making by strengthening existing models and evolving them to respond to future uncertainty.

Focus on network impacts

Over many years, strategic models have been a foundational decision-making tool used by transport agencies for metropolitan transport planning. Fundamentally, they are designed to predict the network flows of people and vehicles between different geographic zones. These models have been designed to meet the needs of transport agencies in their traditional role as network planning authorities, focused on planning and building infrastructure to meet demand.

Strategic models are often used for testing the point at which demand for transport exceeds capacity during peak periods. After the initial step of estimating the total number of trips by origin and destination, that demand is then manually distributed across different time periods (usually split into AM peak, inter peak, PM peak and off peak) as an input to the model.

This is useful for ensuring there is sufficient network capacity to cope with peak demand, and for determining network pinch points and crowding caused by too many people using a particular road or service. Strategic models are particularly useful for estimating aggregate changes in travel activity on networks, such as changes in fuel prices, transport costs or significant changes to the network. Key metrics generated by strategic models include traffic/passenger volume, traffic/passenger volume to capacity ratio, delay hours and average speed.

The ability to test future changes in networks and services against a base case or 'without project' scenarios has made these models well suited to use in cost benefit appraisal (CBA) of major projects.

The models provide a consistent means to assess the network wide impacts of changes in projects and services (e.g. new and improved network links, increased services), controlling for expected future changes in population, workforce and factors that influence decision making. The models have also allowed planners to test the implications of changes in the growth and distribution of people and jobs on the use of transport networks.

For appraisal purposes, it is necessary to compare model outcomes where the model and demand and supply models are in equilibrium.[246] This is achieved through iterative uses of the model with varying inputs, allowing feedback on its sensitivities to understood and tested, until a satisfactory level of convergence is reached.[247]

These measures are helpful for network planning and project business cases, but do not always provide insights into the customer experience of using transport or to the detailed performance of individual projects or infrastructure assets.

For instance, the level of service experienced by travellers during rush hours is often not accurately reflected in model outputs due to the fact that many strategic transport models (including Zenith) do not simulate queues, such as waiting in front of traffic lights, in heavy congestion on motorways, or when boarding public transport. Typically, this type of behaviour is produced as an output from project (meso) or link (micro) models and is then fed into the strategic model as a fixed (static) input.

Other relevant level of service outputs may also be missing. For example, the reliability of arrival times often ranks as the most important attribute of travel from the user's perspective,[248] but is not considered in most strategic models because they generally model a normal weekday, with no unplanned disruptions. The importance of travel time reliability is increasingly being considered a key attribute of assessing transport networks[249] and various researchers and transport agencies have an interest in how reliability can be incorporated into models.[250] Although forecasting travel time reliability is challenging,[251] this is an opportunity area for future modelling, and could allow decision makers to develop new kinds of solutions to meet demand, in addition to increasing infrastructure capacity.

Another opportunity is to better model customer behaviour, and in particular peak spreading and activity scheduling. Strategic models are able to allocate demand within a time period by mode, however unless specific time of day choice models are included, models do not account for how people may change their time of travel in response to policy (such as differential fares), infrastructure constraints (such as crowded services or incidents), or if they decide not to travel (for instance working from home on a rainy day).[252]

Focus on work trips and weekdays

Most strategic models have a focus on work trips given these comprise a large portion of total travel in most metropolitan areas.

Non-work trips generally focus on travel which is relatively predictable, and based on observed patterns and available spatial data e.g. education and shopping. Remaining trips are often classified into a residual category of 'other'. As the way that people live, work and move evolves in our cities, there is an opportunity to expand strategic models to consider other periods and a greater diversity of activities.

The application of strategic models is generally focused on weekday peak hour journeys as they were historically the times of greatest congestion on the network. This approach also allows the complexity of models to be reduced, typically to focus on a small period of time, traditionally AM peak, such as 7–9am. This approach provides little opportunity to consider peak-spreading and other forms of journey avoidance during congested periods.

Hence transport planners have generally assumed that new infrastructure and services provided for the peak will be sufficient for meeting long term demand across the full period of the day and across the week.

However, growth in weekend travel has led to increasing congestion on Saturdays and Sundays, especially key holidays. In Sydney, weekend transport demand increased by 68% between 2013 and 2016.[253] Furthermore, in 2016, weekend travel time delays across Australia and New Zealand accounted for between 15% and 25% of total weekly travel time, with the slowest and most delayed period around midday.[254] Customers in major capital cities are increasingly frustrated with congestion on weekends and expect policy makers to take action to address it.

Modelling weekends and holidays can be more complex than weekdays, as a result they are also more difficult to predict. A lack of data compounds these issues, with sample sizes of weekend travel activity from Household Travel Surveys are usually low compared to samples of weekday/peak period travel. Household travel surveys have historically focused on trips made 'on an average weekday', rather than on weekends.[255]

The focus of models on weekdays and commuting has obvious consequences for transport planning requiring the use of tailored project models to assess the impacts of projects designed to cater for weekend or holiday impacts. This can be particularly relevant for major event impacts on transport networks.

More dynamic forms of modelling could allow for greater consideration of the performance of the network throughout the day and across weekends and weekends. This approach, while more complex, could provide the opportunity for the performance of the network under a broader range of circumstances to be understood, including the compounding impacts of congestion across the day.

11.4 New mobility and the implications of new technology

Most strategic models assume that in the future, people will behave in similar ways to today. This is common practice in forecasting and reflects the lack of information modellers have about how society will change. However, with technology increasingly changing the way that people travel, assumptions about future customer behaviour and services are becoming more important.

Mode choice in most major strategic models is usually limited to traditional modes of transport rather than newer ones.[256] However, advances in technology are changing the way that people travel and have enabled new kinds of transport services. Car sharing, ridesharing, and on-demand transport services are changing the way Australians move around our cities today, the cost to travel and could potentially alter long held ideas of car ownership. These new modes have the potential to reduce congestion and improve accessibility however they may also lead to an increase in the use of cars as rideshare and car share reduce their per journey cost. Technology also enables working from home[257] and shopping online,[258] which directly affects travel demand.

There is an opportunity to consider the role that new transport services, as well as travel replacements, can play when planning major projects and services, either through new models, or through enhancements to existing models.

Changes in transport services

Transport service and network providers such as Uber are changing Australian cities by offering new forms of ridesharing, or more appropriately ride-hailing, services. While in February 2015, these services accounted for 10% of taxis, hire cars and rideshare services, by February 2017 this had increased to 37%.[259] It is estimated that Uber now delivers approximately 14.5 million trips per year across Australia in its low-cost ridesharing option UberX.[260]

Car share schemes have become increasingly popular in densely populated parts of Australian cities, made attractive as a result of increasing congestion and limited parking availability. It has been estimated that the global market for car sharing grew 27% per annum between 2014 and 2019.[261] Technology is presenting opportunities for the expansion of the car sharing market by allowing schemes to be better integrated into our cities. For example, in 2012 Brisbane became the first Australian city to integrate car sharing services with public transport, providing car-share members with much greater convenience.

Technology has also enabled trials of 'on-demand' public transport services, offering more flexible alternatives of improving accessibility within low density urban areas and services which bridge the gap between mass transport and point to point services. From October 2017, the NSW Government has conducted trials of on-demand bus services across Sydney. Patronage has grown from an initial level of less than 200 trips in the first month with the introduction of the first pilot service in Bankstown, to over 27,000 trips in November 2018 across nine service providers in NSW.[262] In Brisbane, Demand Responsive Transport trials are currently being carried out across selected suburbs of the Logan City area while in regional South Australia, Dial-A-Ride, on-demand services have been established for more than a decade.

While rapidly growing, it is crucial to consider the overall role of these services in the context of total transport movements. The 14.5 million trips made nationally using UberX each year pale in comparison to use of mass public transport which in Greater Sydney alone supported more than 750 million trips in 2017–18.[263] Car share membership levels in the City of Sydney are now substantial in absolute terms but still a relatively modest percentage of the 233,000 people living in that area.[264] The 27,000 trips made using on-demand bus services in November 2018 compares to over 26 million bus trips across the greater metropolitan area for the same period. However, as these services grow in importance it will be important to understand how they impact on the number and type of trips undertaken.

In the medium to long term, connected and automated vehicles are also likely to change the way we move around and within cities and regions.

Major trials of automated vehicles are being progressed by mobility service providers, car manufacturers and other technology providers in cities across the world. All Australian mainland states and territories now have trialled connected and automated vehicles at level 4 operations. It is estimated that the global autonomous driving market will grow significantly over the next few decades, leading to global revenue of USD $173 billion by 2030.[265] While the long-term implications of automated vehicles are being debated, change is certain. There is an opportunity for modellers to develop and enhance the way automated vehicles are modelled, and the impact they could have on our transport networks.

For most strategic models, 'model estimation' – the process of determining model parameters and coefficients based on survey and other input data – occurs on an irregular basis and usually involves updating existing variables rather than making fundamental changes to incorporate new ones. As a starting point, regular re-estimation of model parameters and updates to variables in response to observed changes in travel behaviour, can allow transport models to evolve and the impact of technological change to be better understood. Given that revealed preference data (observations in the current transport system) are not yet available with respect to new transport modes, understanding preferences towards future transport will require the use of stated preference techniques that analyse responses to hypothetical scenarios.[266]

11.5 Improved data consistency

Land-use data – practical challenges

Developing and maintaining strategic models is complicated and involves combining data from many different sources. Strategic transport models rely heavily on population and employment forecasts (generally referred to as land-use data) as input data. Strategic transport models are sensitive to land-use data and changes in assumptions can have a significant impact on model outputs.[267] Changes in population and employment projections resulted in notable changes in outputs from modelling conducted for the 2015 and 2019 Audits.

Preparing land-use data is a time-consuming process and usually requires breaking down population and employment projections for large spatial zones into smaller units to allow models to provide a more comprehensive picture of transport movements. The number of zones used in strategic transport models across Australia varies according to the size of the metropolitan area and scope of the model, ranging from several hundred to several thousand.[268]

The process and timing for updating models is heavily influenced by when land-use data is prepared and released by other agencies including the Australian Bureau of Statistics (ABS) and demography units within planning agencies. Agencies that generate land-use data projections may not need to break data into smaller units meaning that the responsibility for developing land-use models may fall to transport and infrastructure planning agencies. With some exceptions, most agencies do not publish underlying land-use data sets.[269] The frequency of updates to land-use data can also be a challenge. In modelling undertaken for the 2019 *Australian Infrastructure Audit,* some underlying land-use data sets had been updated to reflect the 2016 Census while other data sets pre-dated this.

Current practice generally involves land-use data sets being prepared by government agencies. While consistency of use is important, external providers present an opportunity to provide strategic models with more regularly updated data, similar to the way in which there are multiple groups which provide GDP and other economic forecasts. Provided agencies adopt a common case which is used consistently in government planning, data from external providers could provide an opportunity for achieving greater accuracy when forecasting demand through allowing the definition of a range of scenarios. The Council of Australian Governments (COAG), through the Inaugural Treasurers Forum on Population has identified the need for improved data accuracy and consistency, subsequently forming the Data and Forecasting Working Group.[270]

Making assumptions more transparent

Given the complexity of this process and the involvement of multiple agencies, ensuring consistency of land-use data and key assumptions in modelling can be a major challenge. A key issue is what, if any, assumptions are made in relation to future policies and projects and whether predictions are forecasts (predicting the future based on an expectation of what will happen) or projections (future values if existing patterns and trends continue).

As an example, population forecasts may assume future changes in the distribution and rate of growth as a result of land-use policy (e.g. encouraging development around a particular corridor), whereas projections will assume patterns based on past trends without consideration of policy.

Within the context of this report, the variation between the Queensland Statisticians projections and ShapingSEQ's forecasts are discussed on page 84.

Projections and forecasts may be produced separately by different government agencies for valid reasons and used concurrently for planning purposes. For example, projections may be used within an intergenerational report produced by a treasury department for the purpose of considering the long-term sustainability of current projects and policies. A regional land-use plan, on the other hand, may assume the implementation of current policies and projects to increase future population and employment growth within specific areas.

These data sets will obviously have vastly different implications for travel demand. A data set which assumes future transit-oriented development around a particular road corridor or train line may produce lower estimates of future congestion compared to data sets that assume fewer people live near public transport services. Similarly, if population is assumed to increase in a particular area, transport services in that area are likely to need to be upgraded (and these upgrades may have been assumed when the population forecasts were being developed). This highlights the importance of ensuring that the key assumptions used to develop population forecasts are publicly available.

The essential requirement is to ensure clarity about which type of data is used in a model informing a business case or policy and that preferably a consistent, common projection is used as one scenario to allow different approaches, projects or reforms to be compared. The distinctions between similar data sets can quickly become lost during the process of developing policy and planning projects if documentation is limited and project managers are under pressure to use data sets which are most readily available at the time of planning.

Related to this issue, project development teams often identify issues with land-use projections which do not incorporate future effects of projects that they are developing. Ignoring these effects could result in underestimating the benefits of a project, meaning planners often revise land-use projections to incorporate these impacts. Effective governance and documentation are needed to prevent inconsistencies and ensure that modifications and assumptions are formally adopted within future land-use data sets at an appropriate time.

Common planning assumptions

In NSW, a set of common planning assumptions have been prepared to collect and document the fundamental assumptions that underpin the development of key government strategies. This cross-agency initiative is aimed at ensuring the alignment and consistency of assumptions in strategies and plans prepared by different NSW government agencies and departments. It was established to minimise the risk of some agencies using different assumptions and projections for service and infrastructure planning – a situation which could contribute to suboptimal decision making.[271]

Source: Bureau of Infrastructure, Transport and Regional Economics (2018)[272]

11.6 Using scenarios to look beyond averages

Making scenario and sensitivity testing easier

Scenario modelling is the process of investigating and evaluating different possible events in the future. Scenario modelling is an effective way to consider the potential effects that social and economic changes could have on the way that people live and work. This can help us understand the possible impact that new technology and transport services can have on the movement of people and the need for future infrastructure, how changes to housing and jobs can improve cities, and possible outcomes of future changes in the economy and key sectors such as health, education and the environment.

The use of models to demonstrate network performance under a range of scenarios can support better decision making. Better consideration of planned and unplanned events, ranging from the impacts of major periods of construction on network performance to the impacts of varying rates of population growth, changing consumer preferences and the impacts of technology.

While strategic models have the capacity to evaluate scenarios, there are practical limitations to the extent to which this can be achieved. Models were not necessarily designed with this purpose in mind. Major changes in behaviour and technology may be approximated by changing certain underlying assumptions and model parameters. For example, testing the possible impacts of connected and automated vehicles by reducing average headways between vehicles and/or increasing road capacities as a proxy for how such vehicles may operate.

Other changes in transport, such as the growth of on-demand services and Mobility-as-a-Service, may be much more difficult to consider within existing models. Crude scenario testing within existing models has value, but new types of models or separate modules may enable scenarios to be evaluated and reassessed on a regular basis.

Similar issues apply for sensitivity analysis which consider changes in factors which influence project design and investment decisions. With the pace of technological and geo-political change increasing, amending models to give better regard for uncertainty should be considered. Making simple variations in key assumptions, such as the population in each travel zone, the value of time and elasticities can provide significant insights for planning but is often an expensive and time-consuming process as it requires repeated re-runs of models.

11.7 New and emerging data sets

New data sources can address gaps and supplement survey data

Most strategic travel models have been designed around household travel survey data. These surveys have played an important role in transport planning for a number of decades, providing detailed information on travel by households across metropolitan areas. These surveys are conducted at regular intervals for most major metropolitan areas. Survey samples usually align with spatial units and other key attributes of strategic models. Data is often combined across multiple years for the purpose of transport modelling.

While household travel survey data is essential for transport modelling and planning, surveys are very expensive, particularly for face-to-face data collection. Response rates for traditional interview-based surveys are declining in most countries, meaning that the cost per completed survey is increasing. A 2018 Australasian Transport Research Forum study of travel survey responses across 24 countries concluded that non-response was a significant issue.[273] Over 50% of study participants indicated an unwillingness to complete a survey regardless of delivery method.[274] The high cost of surveys inhibits annual data collection for many agencies and requires modellers to decide which aspects of travel are most important for the purpose of modelling. Data may provide a statistically representative picture of overall travel by households within a metropolitan area, but become less representative at finer spatial levels, or when looking at specific variables. Survey costs usually preclude the collection of statistically representative data on regional travel, which is one of the key reasons why most transport agencies do not have regional passenger transport models.

Advances in technology provide unprecedented insights into travel behaviour and opportunities to improve transport planning. Data from electronic ticketing systems represented a large initial step forward for most government agencies, providing vastly improved information on public transport use.[275] GPS/smartphone and other transactional and mobility data from telecommunications companies, app vendors, financial institutions and other sources can provide insights into aspects of passenger travel - such as the use of active transport and regional travel - which have been largely invisible to planners in the absence of time consuming and costly data collection. In the short term, these data sets can help to address gaps in survey data and/or reduce sample sizes needed for modelling applications. In the long term, these data sources could replace survey data altogether.

A barrier for using this type of data in forecasting is the level of manipulation required for it to be useable. Data is collected for a purpose other than transport modelling (e.g. billing a customer) meaning it offers insights into a highly specific part of transport use.

Many major government transport and planning agencies are now trialling the use of third-party transactional data sets. Commercialisation of these data sets is now advancing rapidly. Consideration will need to be given to regulators longer term regarding the ownership of this data and its potential for use. Innovative data sharing platforms and service providers are well established, allowing agencies to gain insights from multiple sources of linked data without compromising privacy requirements.

These data sets provide opportunities to improve existing strategic transport models and allow the development of new more customer-centric models.

11.8 Enhancing model capability

Providing a customer-centric view of transport needs

Since the 1950s, trip-based models have primarily been used to model demand.[276] However, new technology and better data provide the opportunity to move beyond these conventional models to focus on the travel purpose and pattern (daily travel plan) of specific types of people. This new approach is often referred to as an activity-based model.

While trip-based models use origin and destination-based trips as the unit of analysis, activity-based models provide further insight, with trips being undertaken as part of a more comprehensive linked travel plan. Due to the additional detail, activity-based models typically use a day or week as the unit of analysis.[277] This approach theoretically allows the generation of more realistic outputs, however the quality of the outputs is highly reliant on the stability and performance of the model.

Activity models involve the generation of synthetic populations (households) which are then given activity-travel schedules, these are often known as daily travel plans.[278] These schedules provide linkages between trips, nature of the journey and duration of stay. By linking these features, the fixed and variable characteristics of a journey can be better understood and accommodated.[279] For instance, a journey to school may have a fixed time to ensure arrival for 9am, however the model of travel could vary based on whether a parent can accommodate the drop-off as part of their own time-critical journey to work.

The addition of these schedules gives activity-based models a more complex structure than traditional four-step models. These models therefore require significant longer run times and require additional microsimulations. As a result they may not converge to an equilibrium in practical applications.[280] Therefore, it is important to balance model realism with model stability.

While activity-based models are challenging and expensive to build, they hold the potential to more accurately discern how households and individuals make choices that drive activity and travel patterns than conventional trip-based models. Activity-based models are therefore generally considered to have a greater capacity to assess how travel behaviour might be affected by new transport projects or policies.

The use of models developed by private organisations varies by jurisdiction. Their use is often limited to strategic studies,[281] with in-house models sometimes favoured for project planning.[282] While having independent and consistent in-house models will continue to be important, in-house models should be viewed as just one of many decision-making tools that can be used to plan infrastructure and services. Greater contestability in modelling and advice, particularly during early stages of policy and project planning may improve the development of solutions and outcomes for customers. Economic appraisal guidelines can support this.[283] New types of partnerships and alternate models (e.g. open sourcing) may help government agencies maximise value for money and innovation while ensuring that they do not become dependent on single external model or vendors.

Recent examples of activity-based models

KPMG Melbourne Activity and Agent Based Model

The primary purpose of strategic models is to assess how travel behaviour and traffic flows might change in response to changes like new transport projects or policies. Traditionally, strategic transport models in Victoria use a trip-based approach, which considers the characteristics of individual trips.

The Melbourne Activity and Agent Based Model is a customer centric model that considers the characteristics and behaviours of individuals, rather than trips. The model represents each person in Melbourne and their daily travel plans, including when, where and how they will access their various activities. It also includes their demographic characteristics such as age, income and household composition. This means that the model is well suited to understanding user profiles and therefore equity impacts of transport interventions. It was recently used by Infrastructure Victoria to examine the future impacts of automated and zero emission vehicles.

Unlike traditional models, Melbourne Activity and Agent Based Model uses a continuous timescale. As congestion grows people tend to change the times that they travel to avoid congestion (known as 'peak spreading'). It can also model behavioural responses to connected and automated vehicles, zero emission vehicles, car sharing services, ride-hailing services and demand responsive transport and Mobility-as-a-Service.

Traditional models seek to optimise the travel choice (mode or route) for each individual trip. As a result, these models do not consider how trip choices made across the entire day are interrelated. The Melbourne Activity and Agent Based Model considers all journeys and activities taken by an individual in a day. This means that it is able to more realistically represent traveller behaviour. For example, if you need to pick your child up from school after work, you might bring your car even if public transport would have been faster.

Source: KPMG (2018).[284]

PwC Customer Transport Simulator

PwC Australia has developed a multi-modal transport simulation model that provides a more customer-centric view of public transport services and helps understand the impact of incidents on networks. The model was initially developed for a rail operator and has been expanded to include buses, ferries and light rail.

Input data for the model was obtained from various sources, including the transport company, government, and publicly available sources. The main metric collected was Lost Customer Minutes (LCM), calculated as sum of delay minutes for all individual journeys within a particular mode or on multiple modes across a broader network. The model allows the users to obtain a passenger-centric LCM calculation, which is more precise than traditional vehicle-centric methods that were considered to over- or underestimate LCM.

Using an agent-based approach, the different components of the network (e.g. vehicles, network topography, stations, stops) are added into the simulation. Behavioural rules are assigned to each agent (e.g. trains will follow a specific timetable, they need to stay a minimum distance from the train in front). Customers are added as a specific layer of agents in the simulation. Using anonymised public transport ticketing data or assumed customer journey information, the model can simulate an individual's journey through the network including use of interchanges.

The model includes a reporting layer which provides a view of the historical performance of the transport network against a variety of performance measures. The dashboard provides a snapshot view of the overall network and each individual mode's performance on a day. Measures such as customer punctuality, vehicle crowding, average journey time and lost customer minutes, provide insights to support decisions from the customers' perspective. Measures such as vehicle punctuality and patronage give the more traditional insight used to make more operationally focused decisions. The simulation engine provides the ability to ask what-if scenario questions of complex networks and understand customer and operational impacts.

Source: Anylogic (2019).[285]

Better accounting for the impacts of asset performance

Since the 1950s, commonly used strategic transport models have taken a prescriptive approach to route choice within the model. As a result they have limitations in their capacity to accommodate delays from intersection queueing and other aspects of asset design.

Typically strategic transport models use assumptions regarding the capacity of infrastructure derived from the high level characteristics of the asset, e.g. lane numbers, speed and historical usage levels, or derive inputs from mesoscopic or microsimulation models. While these inputs provide a view of network performance, these mostly static supply models do not account for time-varying conditions and can understate queuing delays, for instance at intersections or due to planned impacts, such as road works or construction. Subsequently, they are most accurate in study areas with light congestion.[286]

Given that queues can have a significant impact on network flows and travel times,[287] there is an opportunity to better account for network capacity through the incorporation of asset performance into strategic models, such as through the use of dynamic capacity constrained traffic assignment and simulation models.

The transfer of outputs created within strategic city-wide models to project (mesoscopic) or link (microsimulation) models, or vice versa, is traditionally used to allow refinement of the understanding network performance and improvements to accuracy. In addition to the incorporation of dynamic asset performance, there is scope to strengthen to improve information flow between established models in many jurisdictions.

The United States Transportation Research Board published a primer on dynamic traffic assignment[288] to facilitate informed decision making by practitioners regarding these more sophisticated models. The KPMG Melbourne agent-based model described above for example, adopts the MATSim, an open-source multi-agent dynamic transport simulator.[289] Dynamic models require more computation time and an equilibrium solution may no longer be unique,[290] hence just like activity-based models it is important to balance model realism with model stability.

Most strategic models consider trips by either private transport or public transport and perform traffic assignment more or less separately for private and public transport. However, due to the presence of ride-hailing and shared bicycle schemes as well as automated vehicles in the future, the lines between public and private transport are blurring. As such, intermodal trips that use a mix of private and public transport modes may need to be considered. TRANSIMS[291] is an example of an open-source intermodal traffic simulator to conduct transportation system analyses for a region. Like MATSim, it models individual travellers based on a synthetic population.

Integrating transport and land-use models

For most forms of software, risks and development timeframes often increase in response to product complexity and features. Forecasting models which meet multiple needs can be useful but are more complicated and costly to develop compared to models developed for a single purpose. If the development of apps is anything to go by, the future may involve decision makers using more models rather than less.

With this aside, there is significant scope to better integrate transport and land-use models. Transport models focus on passenger transport with freight considered indirectly through the category of light commercial vehicles (LCVs) or through separate applications which consider LCVs and heavy vehicles.[292] There are currently few applications that allow trade-offs between passengers and freight to be easily tested.[293] This is important within environments which road space is constrained (e.g. major arterials and activity centres), and where planners need to consider options for maximising productivity.

There has traditionally been a large disconnect between transport and land-use models. While transport models usually include significant functionality for testing land-use changes, they can sometimes be developed with little input from planning agencies who may use separate analytical tools.

Integrated transport and land-use (ITLU) planning models can potentially address a city or region's long-term challenges and create a shared vision of what the space aspires to be in the future by coordinating investments and policy decisions to achieve that vision.[294] An example of this is DELTA, a transport model developed by various consultancies and the Institute for Transport Studies (ITS) of the University of Leeds in 1995–96.[295] The land-use model was designed to model a variety of different processes of change in an urban system.[296] By aligning core functions between models through ITLU models, scenarios involving changes in transport and land use may be more easily tested.

In the context of Australia, the University of Wollongong developed TransMob, an agent-based model for South East Sydney that simulates interdependencies between transport and land use[297] where TRANSIMS was adopted as the traffic simulator. MetroScan[298] is a fully operational integrated model developed at the University of Sydney for the Sydney Greater Metropolitan area that describes the interaction between transport and land use, passenger movement with freight movement, and work location choice with firm location.[299]

12

Next steps

12.1 The modelling is an input to the Audit

The strategic transport modelling undertaken for the *Australian Infrastructure Audit 2019* provides an insight into the impacts to cost, access and quality of transport services in our major cities over the coming years in response to changing population, land-use and projects currently planned.

Under this scenario, congestion in our major cities is expected to grow, especially in our large fast growing cities of Sydney and Melbourne, with pressure in Perth and South East Queensland, especially Brisbane. The impacts of congestion on Adelaide and Canberra will be less pronounced, however will be significant in their local context.

While congestion will increase, changes to inputs and the approach to modelling has presented a new perspective on future network pressures when compared to our inaugural *Australian Infrastructure Audit* in 2015. The discrepancies between results show the importance of high quality data and the need to continue to plan, especially within a highly uncertain and rapid changing period in Australia's history. There are also opportunities to improve strategic modelling as a result of access to new data and new approaches to modelling.

The 2019 *Australian Infrastructure Audit* is written in this context and provides a view of the impact of uncertainty on the impacts on infrastructure services for users across our diverse country. The Audit analyses this transport modelling and reflects its findings both in terms of transport network performance and with regard to the second impacts on the accessibility of employment and services, especially social infrastructure like schools and hospitals.

The Audit presents these considerations in a series of *Challenges*, impediments to maintaining Australia's quality of life and productivity, and *Opportunities*, the potential to provide step-change improvements. The future presented by this modelling is one potential view of the future under a do-little approach to further reform and infrastructure investment.

Infrastructure Australia would like to invite submissions on the Urban Congestion and Crowding Report as well as the *Australian Infrastructure Audit 2019*.

12.2 Our targets and priorities

Your feedback will guide our infrastructure decisions

Completing this Audit, and the supporting technical papers, was the first step of Infrastructure Australia's program of work. We will next use the findings to build a package of recommended reform and investment priorities.

To set these priorities, we will work intensively for the next three months to engage with governments, community and industry. Your feedback will inform our work in developing two key documents:

- The Australian Infrastructure Plan will respond to each policy challenge and opportunity. It will give recommendations for reform and set a path for measuring progress.
- The Infrastructure Priority List will continue to evolve with new initiatives added to reflect nationally significant problems and opportunities that have been identified by the Audit. Existing Projects and Initiatives will, where relevant, link to the challenges and opportunities identified by the Audit, and Initiatives may be removed where the Audit findings do not support them.

The process does not end there. Once the reform and investment priorities are set, Infrastructure Australia will track and publically report on progress. We will track Australia's progress against meeting the reform targets set by the Plan and progressing the potential investments highlighted in the *Infrastructure Priority List.*

12.3 We want your input

To help us shape the future, we want to know what you think about this Audit. There will likely be differing views, and there may also be gaps in our evidence. We don't have all the answers, so we need your help to get this right.

To give feedback on our Audit, you can:

- **Make a submission** to tell us what we got right, what we missed, and what responses may be needed – such as policy reform or project investment. When you give this feedback, please respond directly to a relevant challenge or opportunity.
- **Provide new evidence**, if it is available and not reflected in the Audit. Please do this in a submission, or over time as evidence becomes available. Your contribution will ensure our evidence base stays as up to date as possible.

12.4 Your feedback

Anyone can make a submission

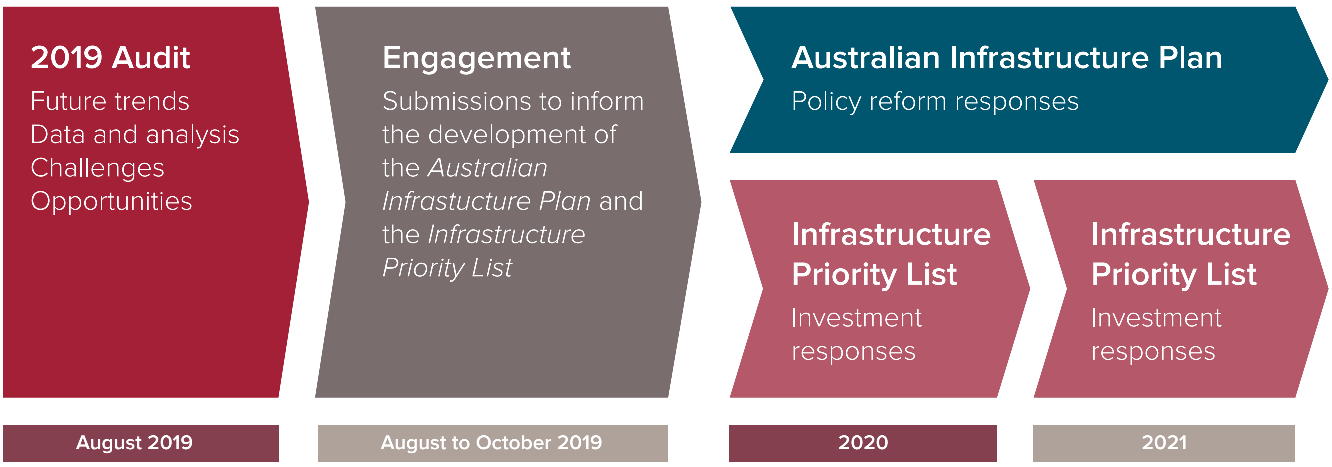
We encourage everyone to get involved, from governments, industry experts and peak bodies, to academics, community groups and individual Australians. This is your chance to have a say on our infrastructure for the next 15 years and beyond.

To comment on individual challenges and opportunities, or download a longer template with room for more supporting evidence, visit the Infrastructure Australia website: www.infrastructureaustralia.gov.au

If your submission includes a specific investment proposal, you should provide supporting documents through the separate *Infrastructure Priority List* submissions process, which closes on 31 August 2019 for this round. If you submit after this date, we will consider your submission in early 2021, along with the next *Australian Infrastructure Plan*. Figure 137 summarises the submission process and identifies indicative dates.

Your submission should identify which challenge or opportunity from the Audit it seeks to address.

Figure 137: We invite submissions to help shape our future advice



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