



# Big City Planning and Digital Tools

Improving Urban and  
Transport Planning

A Sustainable Built Environment  
National Research Centre (SBEnc)

## Final Industry Report

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Sustainable  
**Built Environment**  
National Research Centre

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## Preface

The Sustainable Built Environment National Research Centre (SBEnc), the successor to Australia's Cooperative Research Centre (CRC) for Construction Innovation, is committed to making a leading contribution to innovation across the Australian built environment industry. We are dedicated to working collaboratively with industry and government to develop and apply practical research outcomes that improve industry practice and enhance our nation's competitiveness.

We encourage you to draw on the results of this applied research to deliver tangible outcomes for your operations. By working together, we can transform our industry through enhanced and sustainable business processes, environmental performance and productivity.

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## Synopsis

Australian cities, especially the four big ones, are growing rapidly. Their growth enables many agglomeration benefits and creates many social and environmental impacts. This report examines new approaches to resolving how we can grow to create new opportunities for our children and grandchildren but at the same time manage the social and environmental issues associated with such growth. The use of digital tools in planning is shown to be on the cusp of providing new ways to resolve the growth vers impacts debate, but will require some new directions if they are to be mainstreamed. (See [Project Website](#))

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# Big City Planning and Digital Tools

## Key Findings

The resolution of growth versus impact in the future planning of Australia's fast growing cities requires a new approach to scenario building that can be based on rapid identification of optimal outcomes for public agencies, industry and communities. This is not likely to be possible given the complexity of the issues and the scale of development unless digital planning tools can be mainstreamed.

Whilst the tools are emerging, they are not yet created in a way that can enable mainstream planning to adopt them. Thus, a new approach to digital planning tools is required. The recommended approach below has been shaped to enable such a tool or set of tools to be created.

Planning needs a digital revolution to enable major projects to be digitally represented to allow for sophisticated modelling and assessment of development options. It also needs to be publicly available so that concerns from the community can be accessible in the planning system and their physical and financial impact can be seen.

This may seem excessive for an already burdened planning system, but in reality it will free up communities to rapidly overcome their anxieties as they examine the extent to which they can actually be anticipated. It can also enable such approaches as 'value capture' for infrastructure financing that need public-private partnerships to include communities in their deliberations.

These partnerships, based on discussion of scenarios and their implications, are likely to be more easily accepted as the resolution of growth versus impact. However, there remains uncertainty as to how to provide the digital tools necessary for this digital planning system. A range of scenario planning tools such as Envison, Urban Footprint, What If? and UrbanSim, are available but are not developed in a way that can be publicly accessible or have universal application.

Based on this research, the following approach is recommended for a digital planning system that could become a Digital City Toolkit (expanded in the section on 'Recommendations'):

1. Select a base digital platform, such as Cesium.
2. Configure data sources with standard format, such as GeoJSON.
3. Access application types compatible with the digital platform and data format, such as Python, R and JavaScript.
4. Use Open City Dashboards, such as the Sydney City and City of London dashboards.

The above combination would enable an open source toolkit to be created for use in city planning by government assessment processes, developer proposals and community engagement. Such a Digital City Platform can be used to create timely scenarios and evidence to shape robust strategic planning outcomes for Australia's rapidly growing cities.



## Context

The cities of Australia, particularly the four major cities of Sydney, Melbourne, Brisbane and Perth, are growing at an unprecedented rate and many fear such growth while others welcome it. There are obvious economic benefits from agglomeration, but also many anxieties about what this can mean for environmental and social impacts. Can this growth be used to make better cities? Can anxieties about impacts be adequately answered?

We want to resolve the growth versus impacts issues, but our planning systems are largely based on antiquated models and tools that are not able to deal with the complexities of most growth and impact issues. Metropolitan governance and infrastructure investments are straining and there is an urgent need for tools to understand, model and manage this unprecedented growth in order to ensure the high quality of life Australians are accustomed to, while minimising the social and environmental impacts.<sup>1</sup>

The rapid development and increasing integration between digital tool platforms increases the opportunities for digital tools to provide a timely evidence base which can provide more accurate analysis and modelling. This in turn, can assist policy makers deliver better city planning outcomes.

### Population Growth

Australia's population is around 25 million people with a net population growth in 2015 of 1.4%.<sup>2</sup>

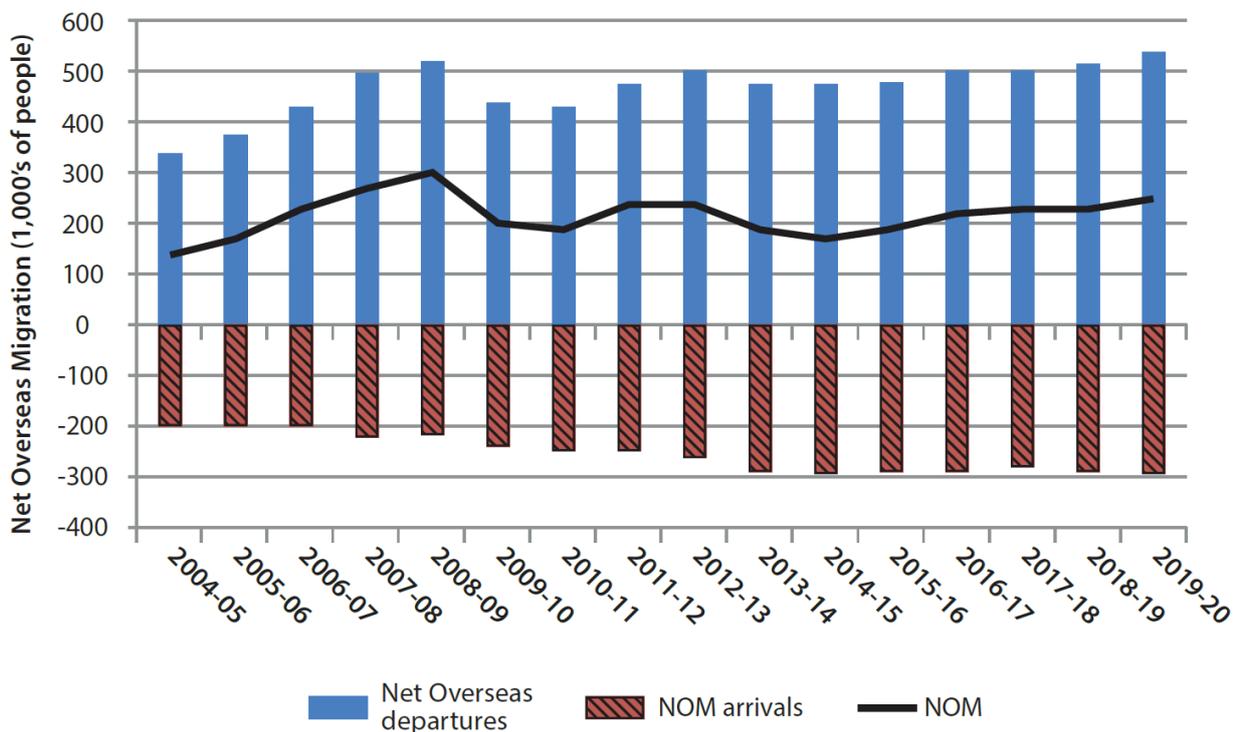
The 2015 population increase saw the nation grow by 316,000 people, which is roughly the equivalent to the combined population of Hobart and Darwin. Around 89% of the Australian populace live in cities, particularly our four biggest cities.<sup>3</sup>

Based upon current projections, population growth from migration and natural increase will see the urban population of Australia grow to around 30 million by 2050, requiring our four major cities to absorb almost 10 million new residents. City planning is struggling to keep pace with this growth.

Three main factors influence national population growth; natural increase, mortality and migration. In Australia, migration is the largest (and most variable) single driver of growth. Net overseas migration has resulted in an increase of around 200,000 residents per year over the past decade (see Figure 1).

In 2012, 66% of Australia's population lived in capital cities. This proportion is growing and by 2061 is expected to be 74% of the population, with a large majority of new migrants settling in the four major cities, exacerbating natural increase.

Infrastructure and urban planning will need to be well co-ordinated to ensure ordered city expansion that optimises the economic benefits of agglomeration whilst minimising the social and environmental impacts. This report will demonstrate how digital tools need to adapt to help with this challenge.



**Figure 1:** Net overseas migration (NOM) actual and forecast for year ending June in 1,000's of people (Note that NOM departures is under X-axis and NOM arrivals is above) (Source: Australian Government 2016<sup>4</sup>)

## Current State of City Planning

In Australia, responsibility for urban planning is delegated from the Australian Government to the states. State-based legislation outlines a hierarchy of acts, policies and strategies that shape planning decisions. A summary of the key policy directions influencing planning and infrastructure decisions within Australia's four major cities is provided below.

### Sydney

In 2014, the New South Wales government released *A Plan for Growing Sydney*,<sup>5</sup> to guide land use and planning decisions for 20 years. The plan is rooted in a vision '*...a strong global city, a great place to live*' and a series of four goals intended to help achieve the vision.

1. A competitive economy with world-class services and transport.
2. A city of housing choice with homes that meet our needs and lifestyles.
3. A great place to live with communities that are strong, healthy and well connected.
4. A sustainable and resilient city that protects the natural environment and has a balanced approach to the use of land and resources.

The plan presents a 'strategy' for accommodating population growth for 20 years. The plan outlines the means of moving between home and work, developing a variety of housing options and infrastructure that will accommodate projected population growth and protect the natural environment.



There is a set of actions to help deliver the goals:

- Accelerate urban renewal at train stations
- Grow an internationally competitive CBD
- Grow Parramatta as a second CBD
- Invest in and grow Western Sydney
- Enhance capacity at the city's gateways: Port Botany, the airport and the proposed Badgerys Creek airport
- Deliver needed infrastructure
- Protect the natural environment
- Manage long-term growth

*A Plan for Growing Sydney* is intended to be interpreted within the context of the *2012 NSW Long Term Transport Master Plan*<sup>6</sup> and the *NSW State Infrastructure Strategy Update 2014*<sup>7</sup>. As mentioned in *A Plan for Growing Sydney*, the land use strategies presented in that document are integrated with the transportation and infrastructure initiatives in the coordinated plans.

*The NSW Long Term Transport Master Plan* is New South Wales' first integrated transportation strategy. Much of the focus of the document is on cutting congestion and improving public transportation. The document both identifies the challenges in NSW transportation through to 2031 and provides a set of actions to address those challenges.

Benefits put forward by the plan include a fully integrated transportation system, a modernised rail system, an expanded light rail network, a modern bus system, a connected motorway network in greater Sydney, reduced congestion in the Sydney CBD, supporting new economic growth, developing regional connectivity, improving freight

transport, improving access to Port Botany and the Sydney airport, improving walking and cycling including their integration with public transport and providing for future transportation corridors. Specific improvements include widened and expanded motorways, additional ferry services and electronic ticketing (Opal). The plan provides both general and mode-specific recommendations for making public transportation more attractive.

*The NSW Long Term Transport Master Plan* suggests a number of transportation scenario evaluation criteria including infrastructure costs, environmental impacts, social impacts and commercial feasibility, as well as additional demand focused market criteria.

The plan presents a 'do nothing' scenario as a point of comparison with 2011 data, such as travel time, and metrics for 2031. There is also an initial plan and map for high speed rail between Melbourne and Brisbane that includes Sydney and Canberra. The plan culminates with actions and a corresponding timetable by transport mode, along with a discussion of funding sources.

*The NSW 2014 State Infrastructure Strategy Update* is a plan to invest \$20 billion in productive infrastructure. As put forward in the plan, the implementation will create more than 100,000 jobs and increase the NSW economy by \$300 billion over 20 years.

The plan indicates a number of funding targets including WestConnex extensions, a second harbour rail crossing, increasing sports and cultural funding, regional transportation, schools, hospitals, water, regional tourism and environment.

## Melbourne

In March 2017, the Government of Victoria's *Plan Melbourne 2017-2050* was released as a 'refresh' of an earlier 2014 metropolitan plan.<sup>8</sup> *Plan Melbourne 2017-2050* is intended to guide the growth of the city as it swells from 4.5 million to a projected population of almost 8 million in 2050. It includes a new outer ring road, the Mernda rail extension and various motorway upgrades, including new east-west connections and significant extensions to the CBD train network to ease the bottle-neck.

The plan also identifies six national employment and innovation clusters (NEICs) that effectively distribute major activity centres throughout the metropolitan area to reinforce the polycentric nature of the city. These areas include employment hubs but will also become focus areas for absorbing part of the aspirational 70% infill development.

In addition to the 70/30 infill/greenfield development goal, the plan calls for better integration between infrastructure and land release. Value capture from rezoning is suggested as a tool for funding policy priorities such as affordable housing. Other major features include a 25% renewable energy target by 2030 and climate change provision for future infrastructure planning, with a focus on precinct-scale energy production. As opposed to the 2014 version of *Plan Melbourne*, the 2017 edition places far more emphasis on community engagement and has also included greyfield precincts as a potential model for both infill and sustainability in Melbourne.

In December 2016, Infrastructure Victoria released *Victoria's 30-Year Infrastructure Strategy*; the

first of its kind for the state.<sup>9</sup> The plan outlines the short, medium and long-term infrastructure initiatives for the state, and was prepared with the intention to protect long term infrastructure decision making from political changes. It provides 137 recommendations for infrastructure delivery over the next three decades for Victoria.

The plan includes a pipeline of projects and priorities to provide guidance to government and the community and allow the private sector to plan and make investment decisions. The first of these priorities is to increase densities in established areas and around employment centres to make better use of existing infrastructure.

The Infrastructure Strategy suggests that improved digital connectivity is critical to Victoria's future success and encourages State Government to take a proactive, coordinated approach to addressing digital connectivity, including its use in planning.

## Brisbane

The overarching legislation that directs the Queensland State Government and the various Local Government Authorities (LGAs) including Brisbane City Council is the Queensland Local Government Act (2009)<sup>10</sup> which manages the responsibilities and powers of LGAs. State legislation also includes an act specific to Brisbane City Council; the City of Brisbane Act 2010.<sup>11</sup>

With regard to planning and development, the *Sustainable Planning Act* (SPA) 2009<sup>12</sup> is the overarching legislation under which LGAs operate. The SPA (and the 2009 Sustainable planning regulation. The plan is at the peak of a hierarchical body of legislation which includes (in descending



order of priority), the State Planning Regulatory Provisions, the State Planning Policy, Regional Plans such as the South East Queensland Regional Plan 2009 – 2031, and the standard planning scheme provisions.

## Perth

The Government of Western Australia's *Directions 2031* (2010)<sup>13</sup> is the most recent high level spatial framework and strategic plan to outline a vision for metropolitan Perth (the Perth and Peel region). It was prepared in response to the requirements of the *State Planning Strategy*. *Directions 2031* is a framework to guide the strategic direction of major planning elements including housing, infrastructure and services. The following description is provided by the Department of Planning.

*Directions 2031 recognises the benefits of a more consolidated city while working from historic patterns of urban growth.*

*Importantly, the framework sets achievable goals that will promote housing affordability over the longer term. Directions 2031 addresses urban growth needs and also takes into consideration the need to protect our natural ecosystems.*

*The framework provides for different lifestyle choices, vibrant nodes for economic and social activity and a more sustainable urban transport network. The framework will also encourage a long-term approach to the provision of infrastructure in an economically sustainable way.*

*Directions 2031* is supported by sub-regional strategies and these in turn are interpreted by local governments through local planning controls. In May 2015, a draft *Perth and Peel@3.5 million* suite of documents was released.<sup>14</sup> The purpose of these is to prepare strategic land use planning for co-ordinated growth as Perth moves towards a projected 2050 population of 3.5 million.



[Visit the SBEnrc YouTube channel for a short film on this project](#)

The Western Australian Planning Commission intends these plans to guide where future homes and jobs should be located and which environmental assets to protect, and to optimise the use of existing infrastructure and identify appropriate areas for greater infill development and residential density.

Perhaps the most significant study, however, was a joint Federal and WA State Government initiative called the Green Growth Plan which has only been completed in draft form but was the first Strategic Environmental Assessment of a whole

metropolitan area in Australia. It essentially enables a sustainability perspective to be applied to a spatial plan of a major city.<sup>15</sup>

The finalisation of this plan is likely to be progressed by the new State Government and enable a much broader application of environmental issues to be included in the planning system. However, the scenarios involved still need to be adequately conveyed to the public and their implications understood before a serious resolution of the growth versus impact debate can be resolved.

## Key Lessons Learned from Review of City Plans

While each state is responsible for developing policies to guide the future direction of their capital city, the challenges and indeed many of the recommendations are similar. Cities in Australia are growing faster than administrations can manage. This is most evident in the four largest capital cities discussed above. These cities are currently facing challenges related to their size and inadequate infrastructure provision; they are also expected to absorb the majority of future population growth.

Better co-ordination between city, state and Federal planning and infrastructure investment would undoubtedly help catalyse change in key activity areas identified in the various city planning documents. However, complex long-term, big-city planning decisions cannot rely upon traditional paper-based planning systems. As new developments are announced, communities greet them with little trust that the issues about growth and impact have been dealt with.

There is clearly a need for generic tools to support strategic planning of urban growth occurring

in the major cities and regional centres across Australia. Such generic tools are often referred to as planning support systems (PSS), and can be used to inform strategic planners on the impact of population growth and other socio-economic factors on the future of Australian cities.

These tools are increasingly discussed as being part of the smart/digital city lexicon. The Federal Government have a new draft plan for Smart Cities<sup>16</sup> that describes the need for such tools to be developed and used if Australian cities are to remain competitive.

There will be an increasing need for digital tools to mine data, analyse, model and help shape scenarios to enable proactive, evidence-based, future-oriented planning policies capable of maintaining quality of life while accommodating future population growth within increasingly complex and constrained urban environments. These tools need to be inclusive of urban communities to enable the true resolution of growth versus impact debates.

## Digital Planning Support for Cities

A range of digital planning support systems (PSSs) are currently being used by government and industry to help with decision-making processes. There are a number of PSSs in common usage within government agencies and research institutions; most have been designed with a particular application in mind.

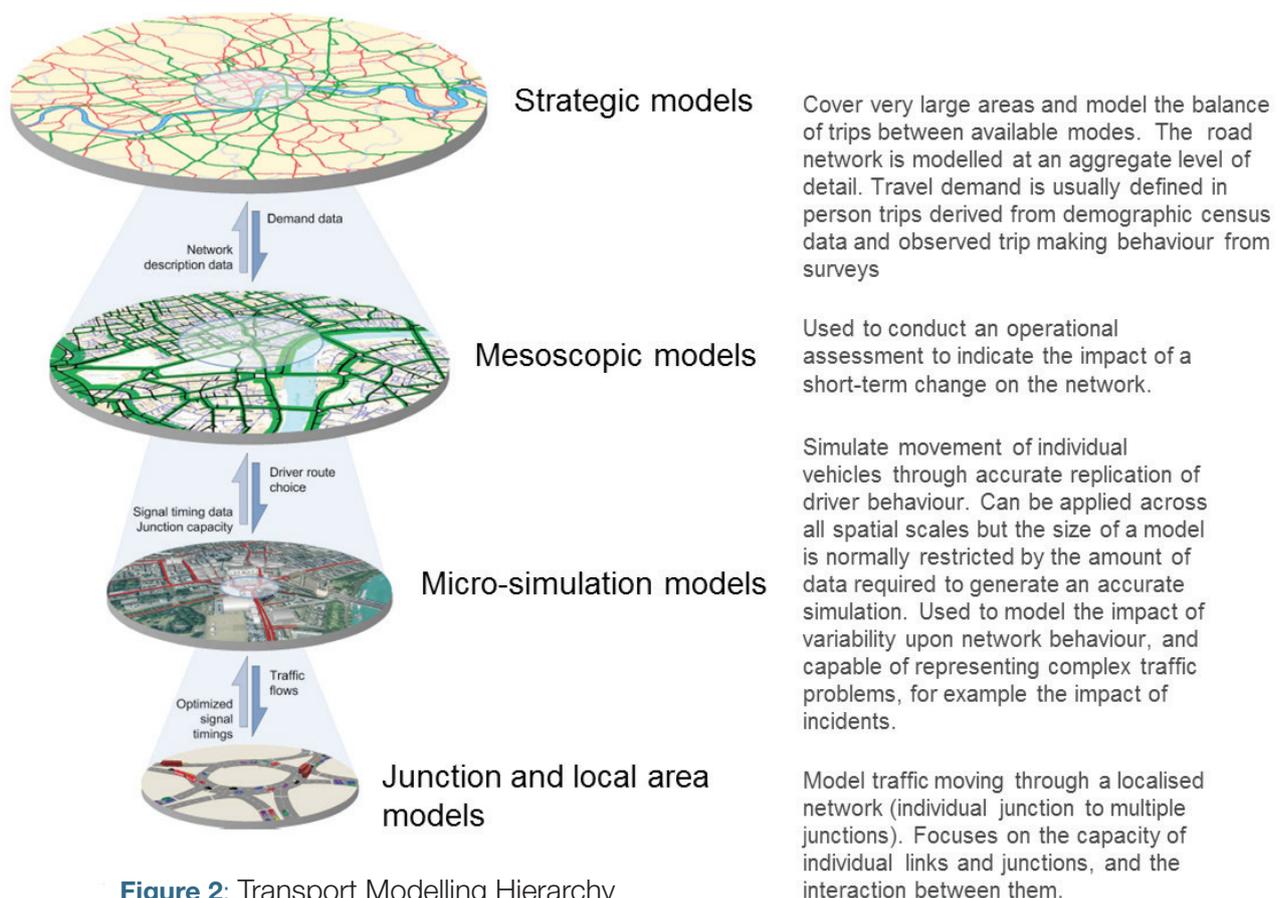
Transport professionals have access to a variety of modelling tools which can be applied at a number of levels depending on the application and modelling need. The different levels of hierarchy are illustrated in Figure 2.

Big City planning will require the application of all levels within the transport modelling hierarchy. The need for land use and transport integration has been identified in a large number of previous

studies.<sup>17</sup> The purpose of Land Use Transport Interaction (LUTI) models is to help decision makers evaluate how cities develop, manage and operate sustainable transport systems, through the interaction of three key factors: population, land use and transport services.

LUTI models can therefore be thought of as tools to identify the optimal distribution of services and facilities in order to maximise access to jobs, activities, services and economic opportunities while minimising the adverse environmental impacts associated with mobility.

The main appeal of these models is their ability to evaluate the interplay and feedback of information from the land use system to the transport system, and vice versa.



This way, the influence of land use patterns are reflected on the development of transport infrastructure and mobility patterns. Similarly, the models can also be used to evaluate how transport interventions impact urban form and how people engage in various land use activities.

For example, the models can be used to estimate the impacts resulting from a change in transport infrastructure (e.g. building a new railway line) or new residential, commercial or industrial developments.

The models produce evaluations that include economic impacts (local, city-wide or regional), often disaggregated by sector, and predictions of impacts on households, population, jobs etc., for each of the modelled areas.

The most fundamental benefit of these models is the ability to predict the effects on land valuation, employment patterns and transport mode choices. These models therefore act as an important bridge between theory and experiment by predicting the impacts of proposed intervention measures before they are implemented in real-world situations.

While the need for LUTI models has long been established, the practice today generally separates the land-use plans from the transport modelling. On the one hand, transport planners utilise transport modelling tools to evaluate the impacts of transport infrastructure interventions with minimal input about land development and social impacts.

On the other hand, land use planners tend to apply qualitative analyses in development of forecasts without a thorough investigation of the transport impacts.

There have been numerous attempts over the past two decades to develop land-use modelling tools that can be integrated into transport models. These include ITLUP (also known as DRAM/EMPAL), MEPLAN, TRANUS and DELTA. However, these tools have met with limited success, due to: rigid data structures and requirements; time-consuming calibration and validation methodologies; lack of GIS capabilities; difficulty of integration with established transport modelling tools; or lack of commercial support.

### Cube Voyager

Strategic transport and land use models within Australia are dominated by the use of software called 'Cube Voyager'. This tool allows users to build macroscopic regional models to understand large-scale personal travel demands. The transport model essentially provides the congestion and accessibility values to the land-use model. The land-use model then determines where households and firms will locate, based on accessibility and other conditions of the zone. The location of households and firms also influences traffic demand and therefore congestion levels.

Cube Voyager is used to understand large-scale personal travel demand. It provides capabilities to create detailed representations of roadway and public transport networks and can be used to create a comprehensive infrastructure database for use in estimating point-to-point paths and associated travel times, costs and distances. It also provides functionality for studying the effectiveness and efficiency of public transport systems.

The software has automated processes for creating walk, cycle and transfer links between

multi-modal services. The software also provides methods to represent highly complex fare structures and for modelling public transport capacity constraints. Cube Voyager includes a well-established four-step travel demand modelling methodology (see Figure 3). The outputs generated include matrices of times, costs and distances by mode and component.

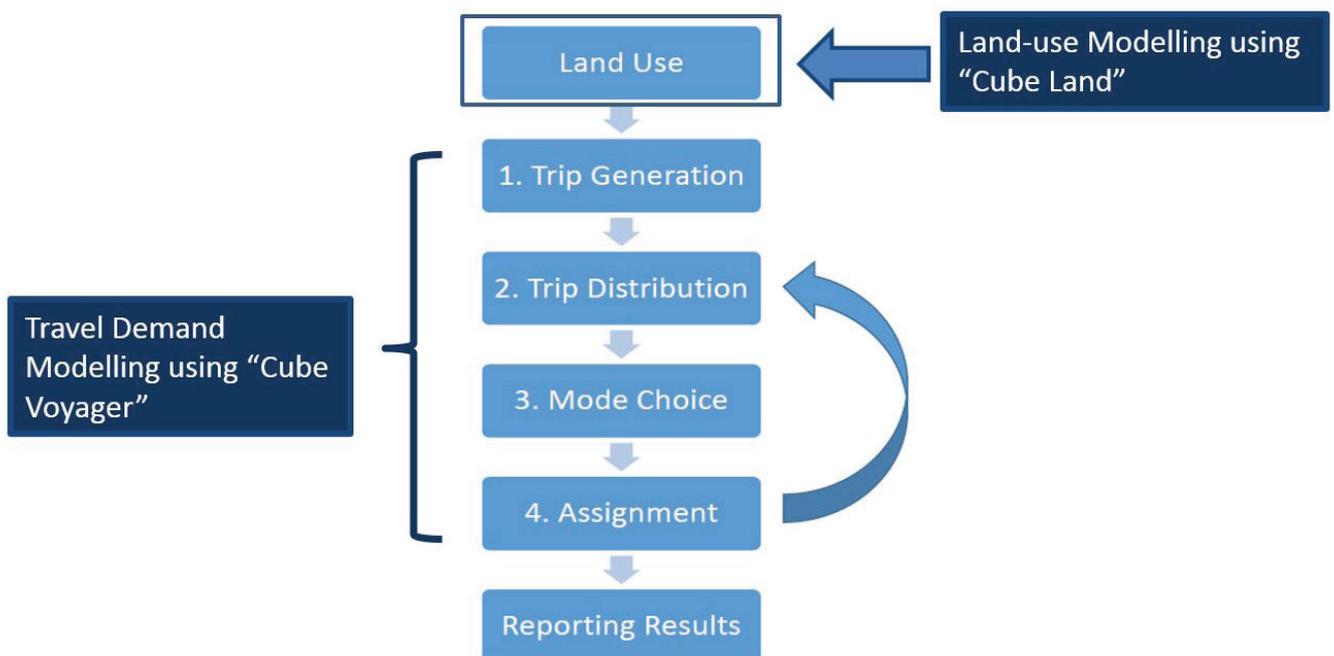
The two LUTI tools that have attracted the attention of researchers and practitioners in recent times include UrbanSim and Cube Land. Cube Land is an economic land-use forecasting software, which allows the user to model the interaction between real estate markets and transport systems. The software can be used to improve transport modelling in terms of providing better forecasts for mobility, while incorporating land use changes in transport demand modelling. The tool can also simulate the interactive loop between the transport system and the activity system, incorporating the concept of

'accessibility'. The tool has features which allow the user to analyse the sociological, environmental and economic impacts of land-use policy measures and transport planning interventions.

### UrbanSim

*UrbanSim is a tool for use by urban planners, policymakers, and other community stakeholders to help formulate and evaluate combinations of land-use, transportation and environmental policies. It is intended to support deliberation and debate on such issues as building new transit systems or freeways, or adopting alternative growth management regulations and incentives, as well as on broader issues such as sustainable, liveable cities, economic vitality, social equity, and environmental preservation.*<sup>19</sup>

UrbanSim is primarily designed to be used to support urban land-use, environmental and transportation planning, including modelling future scenarios.



**Figure 3:** Land-use Transport Integration Models using Cube Suite of Software

It aims, by using a simulation framework, to model how the market works and changes over time.

*Although UrbanSim is designed to model real estate markets, the raison d'être of UrbanSim is as a scenario planning tool. Regional or city planners want to understand how their cities will develop in the presence or absence of different policies or in the context of different assumptions that they have little or no control over, like economic growth or migration of households.*

The underlying basis of UrbanSim is an agent-based modelling framework that uses random utility theory (discrete choice) and urban economics of location behaviour to predict real estate price movements. It is not a single model, rather it is a software architecture comprising a number (family) of models based on relational database architecture, incorporating geographical, demographic and economic information. Sub-models are used to describe actors or processes. Other models, such as transport models (travel demand models) or macro-economic models are available, but are external to UrbanSim.

UrbanSim has a number of advantages that would make it suitable for use in scenario planning, as it is extremely powerful, specifically designed for such use and can incorporate transport modelling. It is also open source software and (currently) free to use. On the other hand, it has a number of disadvantages, including the highly specialised knowledge required to make the most effective use of its powerful modelling ability, and the time necessary to prepare the datasets for even a simple model.

UrbanSim has been used in more than 70 cities worldwide, but the majority of implementations of

the tool have been for research purposes, and in the USA (where it was developed). UrbanSim is not commonly used in Australia and there is very little research on its use in the Australian context.

## CommunityViz

CommunityViz comprises two integrated extensions to ArcGIS, the world's leading GIS platform. The tool has been applied at the subdivision, precinct and city level. For example, at the precinct level, the New Jersey Transportation Planning Authority (NJTPA) used CommunityViz as a software foundation for developing a small area land use impact tool (SALUIT).<sup>20</sup> The tool provides a scenario-based analysis of the transportation, economic, environmental and infrastructure impacts of land-use changes.

The tool is intended to help NJTPA staff work with county planners on projects such as transit-oriented development, corridor redevelopment and neighbourhood revitalisation. It is easy to use; after users define a study area it downloads all data relevant to the area and automatically calibrates models. Results are presented as a series of maps and linked charts. These have been used in a number of North American communities for scenario comparisons and to develop preferred growth scenarios.<sup>21</sup>

## AURIN

The Australian Urban Infrastructure Network (AURIN) has a website with data and tools that can assist in building an evidence base around existing localities at various scales. Funding for AURIN has been provided by the Australian Government under the National Collaborative Research Infrastructure Strategy (NCRIS). Regarding big city planning, AURIN's greatest

contribution would be in the provision of strong evidence-based inquiries to inform future plans. It is not a tool for creating future city plans, rather it can help with the analysis of current urban performance.

The AURIN portal's strength is that the researcher can combine many different datasets, thus offering researchers great scope and creativity to seek out interesting patterns that future strategic plans may wish to retain, strengthen or rectify. The AURIN platform also includes extended workbench tools such as, What-if?, Envision and Envision Scenario Planner. Brief descriptions of these tools follow.

## What If?

What If? is an on-line GIS-based Planning Support System (PSS) designed to support the land planning process. It does so by conducting land suitability analysis, projecting future land use demand, and allocating the projected demand to suitable locations based on a range of planning criteria. Developed initially as a desktop application in the 1990s, What If? has been updated and re-engineered as an online application.<sup>22</sup> The original desktop What If? 2.0 planning support system has been used by over 150 users in 22 countries (see example in Figure 4).

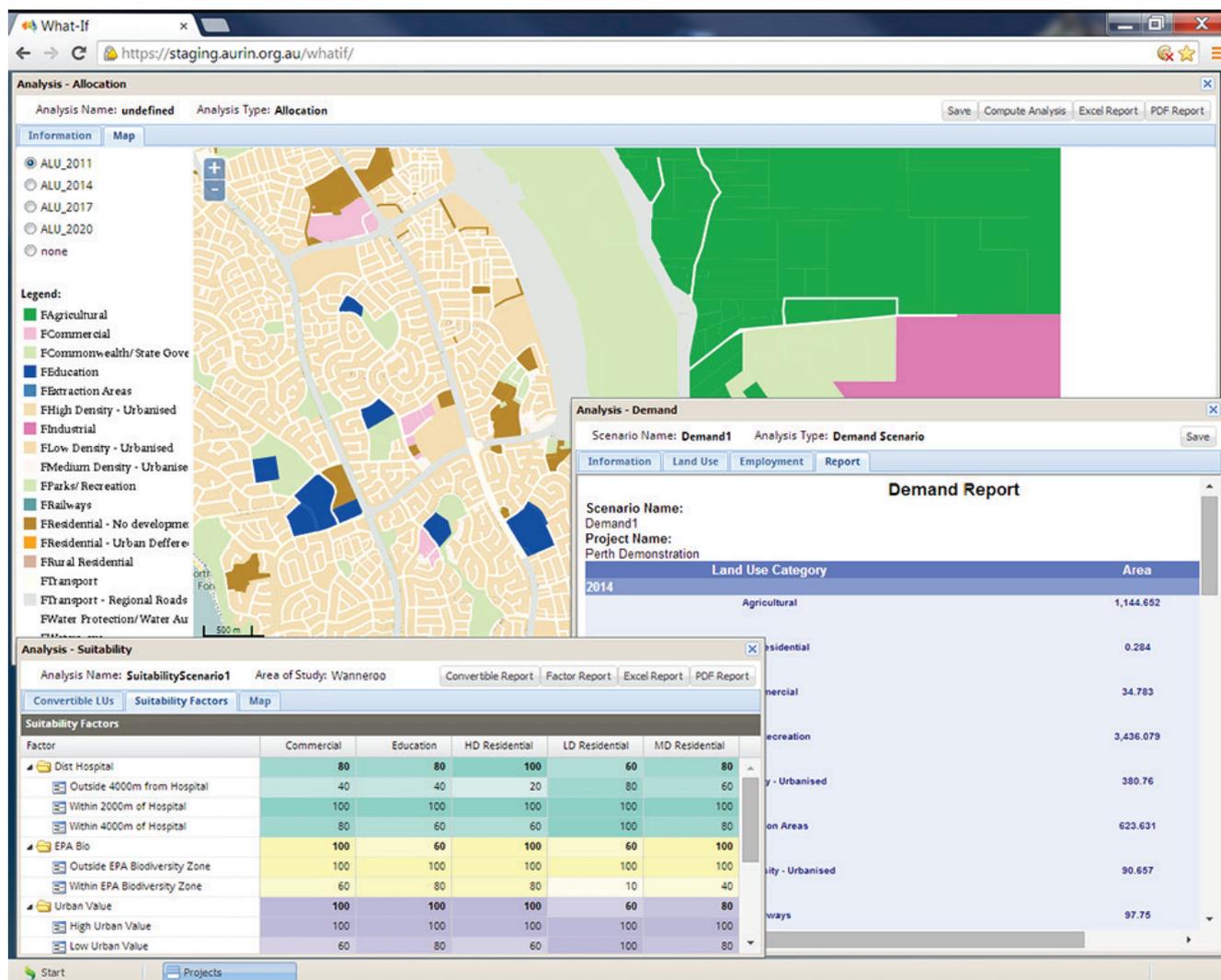


Figure 4: Online What If? Scenario Planning Tool comprising land suitability mapping and land demand reporting. (Source: Pettit *et al*, 2015)

The first application of the Online What If? PSS has been developed and tested in the context of the Perth to Peel Region in Western Australia.<sup>23</sup>

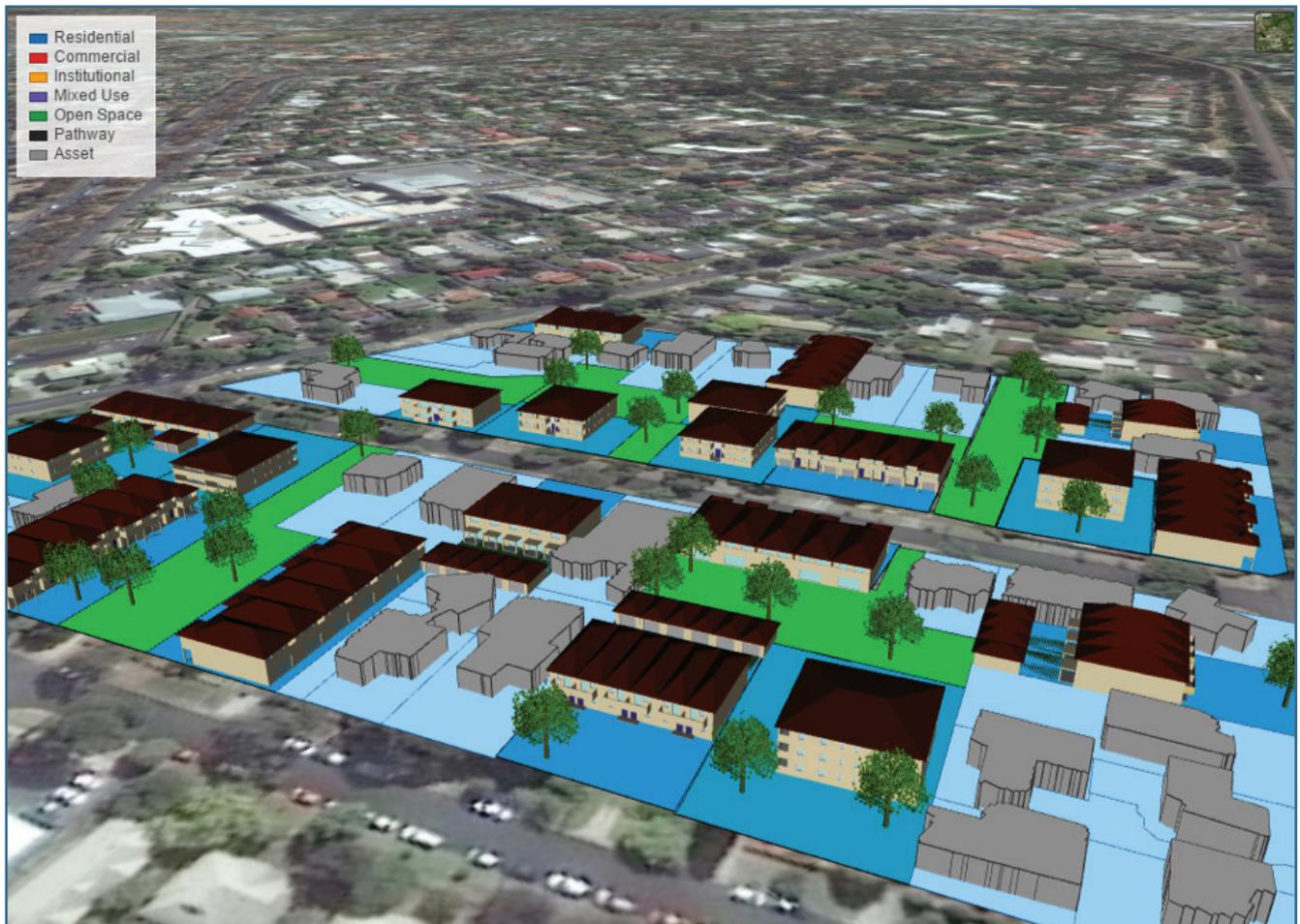
The AURIN team at the University of Melbourne worked with the Department of Planning in Western Australia in data preparation and in the formulation of a series of planning scenarios which align with the Directions 2031 Metropolitan Plan.

The Online What If? PSS tool has been designed to assist other cities and regions across Australia in understanding land use supply, demand and likely future land use change scenarios including in Melbourne<sup>24</sup> and Hervey Bay.<sup>25</sup>

## Envision

Envision and the related Envision Scenario Planner (ESP) were developed as research tools through the Cooperative Research Centre for Spatial Information (CRC SI). Both Envision and ESP are online tools but user access requires CRC SI approval.

Envision is designed for use at the subdivision and precinct level (See Figure 5) Currently it has road and limited transport data used to locate land use. It also has the capacity to add new transport and land use layers, but the outputs would be limited to finding precincts close to specific forms of transport or in high (low) transport areas.



**Figure 5:** Envision Scenario Planner Tool  
(Source: AURIN)



The potential for further data provision is endless (if they exist), but this would also only be used in locating properties and precincts. ESP is based on land use typologies and has the capacity to alter roads and paths, but only at a precinct scale. There is also no capacity to join precincts to link transport data (which would be ideal).

ESP runs on various ‘typologies’ which are placed into a precinct. Each typology takes significant time to prepare and assess. New climate areas (NSW, QLD, SA) would need to have each typology assessed to accommodate the climate factors for that area. Housing typologies are owned by CRC SI, however, any new typologies are owned by the individual responsible for creating them.

## UrbanFootprint

UrbanFootprint is a modelling framework designed by Calthorpe Associates, based in Berkeley, California, for data development and organisation, and land use planning, modelling, and analysis. It is fully built on open-source platforms and tools.

UrbanFootprint aims to increase the technical capability of national, state, regional and local users to analyse the impacts from fiscal, environmental, transport and public health plans and policies.

It functions as a data and scenario planning exercise. The scenario-based planning normally involves four stages: data development and organisation, existing plan transformation, scenario development, and scenario analysis. The developed scenarios run through land use,

transportation, fiscal impacts, public health, energy and water, household cost, and emissions engines to develop the metrics required for urban planning.

- Land consumption analysis: land consumption analysis for each future scenario is developed to evaluate the existing land consumed to accommodate new growth. The analysis can include agricultural lands, habitat lands, aquifers, or other land types. Cost and carbon implications for new land consumption are another two outputs of this function.
- Fiscal impact analysis: capital infrastructure costs, operations and maintenance (O&M) costs, and revenues are three major metrics used to evaluate the fiscal impacts of new residential growth and commercial development variations. Capital infrastructure costs include: local streets and transportation, water supply, sewage and wastewater, and local parks. O&M costs include: public works functions, general government services, public safety (police and fire) and community services, and revenues include property taxes, property transfer taxes and vehicle license fees.
- Building energy analysis: this function assesses both residential and commercial building energy and greenhouse gas (GHG) emissions, for both future new and existing buildings. Scenarios change due to the variation of building assumptions, the location of new growth and assumption of policy and technological improvements in energy efficiency.

- **Water analysis:** UrbanFootprint can assess both indoor and outdoor residential and commercial building water use, for both future new and existing buildings. The variation of building policies, the location of new growth and assumption of policy improvements in water efficiency are three important factors in water consumption scenarios, as with energy. Lot size and landscaped area assumptions, and subsequent irrigation are considered for outdoor residential water use estimation, while the state-wide average is applied directly for indoor water consumption.
- **Transportation analysis:** transportation analysis is based on intensive studies on the relationship between built environment and travel generation. Eight key mechanisms ('8Ds') are considered to build the relationship and include: density, diversity, design, destination,

distance to transit, development scale, demographics and demand management. The outputs from this transport model are: vehicle miles travelled (VMT or VKT in Australia), mode choice and congestion estimates for land use and transportation scenarios, as well as transportation-related costs, GHG emissions and other pollutant emissions.

- **Public health analysis:** this function evaluates the health-related impact from land use patterns and urban form. The outputs of health-related indicators include: physical activity-related weight and disease incidences, pedestrian safety measures, and respiratory impacts. Potential cost from these health impacts is another output from this function.

UrbanFootprint is being calibrated for use in Australia and will be available for public use.

## Key Lessons Learned from Review of Digital Tools

The modelling tools outlined are beginning to provide the solutions and the opportunities to support a new digital scenario planning approach to resolving the growth issues of cities. However, they have not yet been enabled to be suitable for mainstream planning, especially at a local level where most of the issues are found.

The tools are taken up by consultants and are made available to developers and sometimes to planners if they can afford the cost, but their use in day-to-day planning has not yet been achieved. How to make a more publicly available set of tools for planners remains a major challenge.

In much the same way that siloed agencies tend to deliver urban outcomes that focus on only one aspect of urban development to the detriment of other aspects, many digital tools have been designed with a limited focus, while those that have a more integrated approach are still too complex for most planners to use.

The need for an integrated tool that can invite easy, cheap and collaborative scenario building has not yet been met.



It is increasingly possible to use passive data sourced via Bluetooth from phones, automated number plate recognition and credit card transaction data and the like, to provide origin-destination data to improve urban modelling and simulation endeavours.

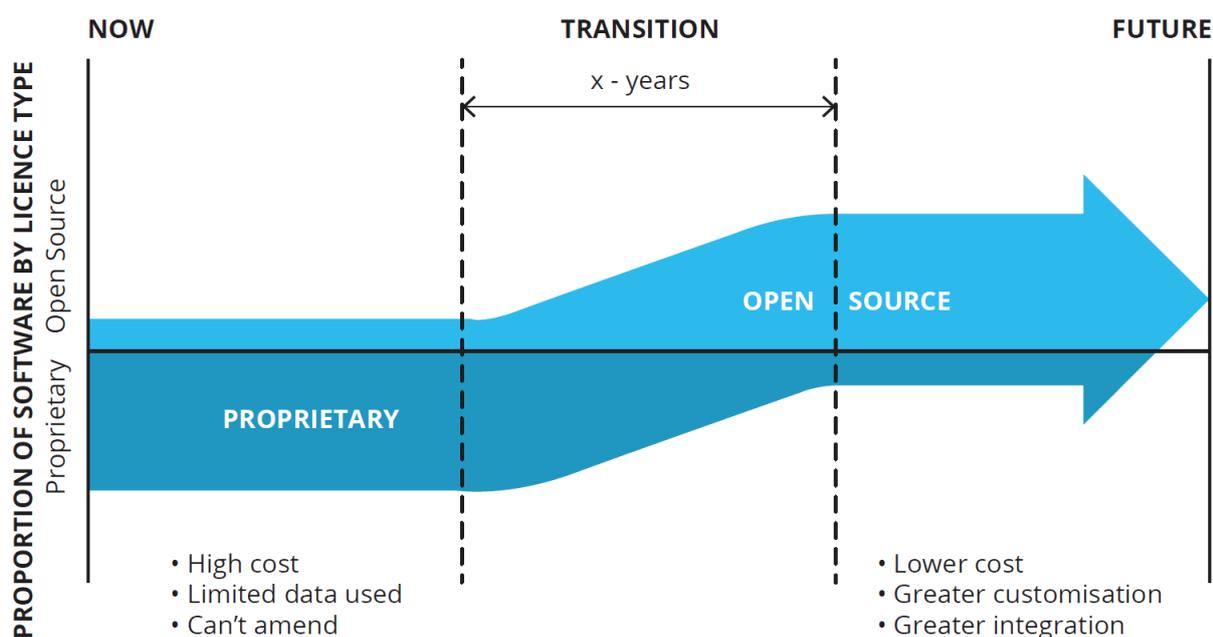
Current levels of data are patchy and much is held as proprietary or closed. Typical reasons for not making data publicly available are commercial, i.e. to monetise information, or confidentiality, i.e. perceived commercial-in-confidence or data requiring privacy. However, limiting data availability is against the public interest and privacy issues may be overcome through data aggregation or de-identification. Without good data it is difficult to undertake good scenario planning consistently across cities.

This limitation could be overcome with open data that makes more data freely available (see previous Figure 6). The Australian Bureau

of Statistics is opening up census data which provides a valuable resource to support scenario planning endeavours. However, there is a need for other government agencies and the private sector to contribute towards open data initiatives to support better evidenced-based city planning and decision-making.

Data standards (including privacy and security) are not uniformly applied, making analytics challenging. Because governments tend to lock into standards, it is important that we have the right standards in place to ensure that only the most accurate, appropriate and comparable data is made available.

International data standards as supported by bodies such as the open geospatial consortium (OGC), which have championed the Web Mapping Service (WMS) and Web Features Service (WFS) standards, need to be embraced to assist in making data more readily accessible to the urban modelling community and city planners alike.



**Figure 7:** Digital democratisation through increased access to open source software



Vendors of private digital planning tools are capitalising upon the commercialisation of proprietary software and data products. This is leading to the ad hoc and the siloed use of proprietary tools at high cost and control. The use of proprietary software usually locks in users to expensive software; open source software offers both reduced licensing costs, greater software access and greater opportunity for customisation and sharing of software.

These aspects, in turn, increase the possibility for more widespread and integrated scenario modelling efforts. The increased use of open source software has the potential to foster communities of practice around scenario planning tool developers and increase scenario quality and transparency while reducing costs (Figure 7). However, it is important that those who use and extend the functionality of open source software contribute these improvements back to the open source community, so all can benefit from advancements which have occurred when using a particular open source software platform.

There is a need for a clear and consistent approach to allow data to be harnessed. This is also recognised by government. For example, in December 2016, the Council of Australian Governments (COAG) communiqué called for greater data transparency:

*Leaders agreed the need for better and timelier public transparency around government expenditure, outcomes and performance. Expiring performance benchmarks under inter-governmental agreements will be independently reviewed to ensure governments are holding themselves appropriately to account for outcomes achieved. Leaders agreed to commit to the release of more timely, including real-time, performance data in new national agreements.<sup>26</sup>*

The increased use of open data and data sharing would make available greater and more complete data to allow more robust and transparent decision making, while benefiting users through reduced costs and supporting innovation in digital tool development and application (Figure 8).

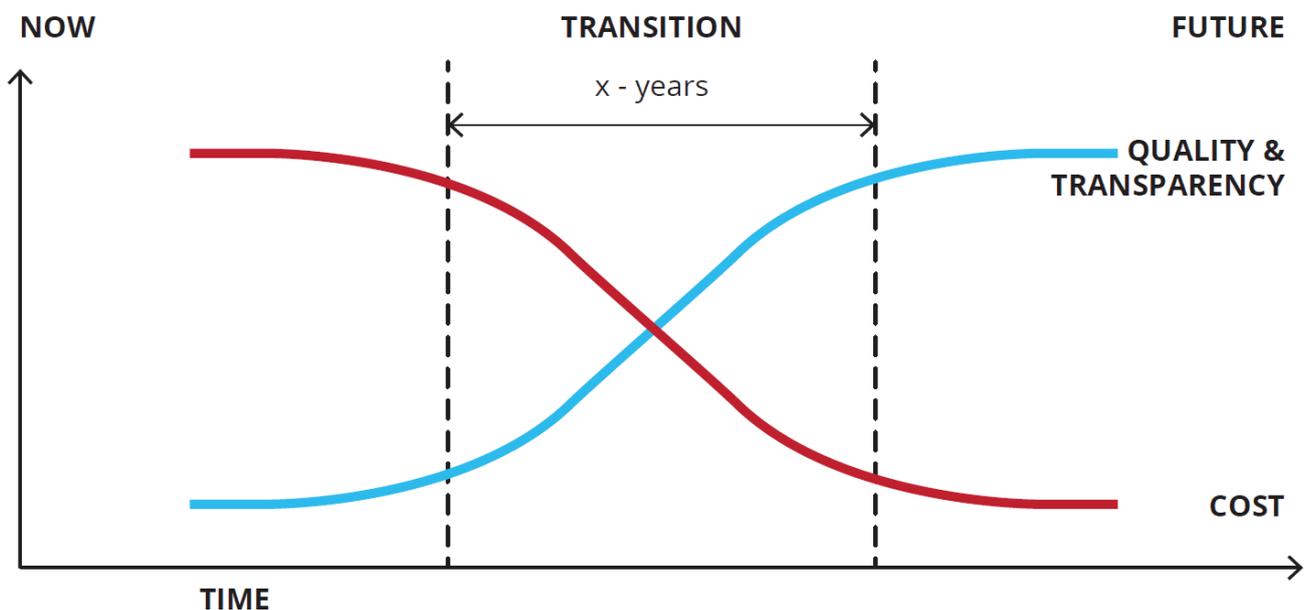


Figure 8: Benefits of open data to users

## Recommendations

Based on this research, the following approach is recommended in developing a digital planning system that could become a 'Digital City Toolkit' as shown in Figure 9. The requirement is to create a platform to build models upon that is open and accessible, and this would involve:

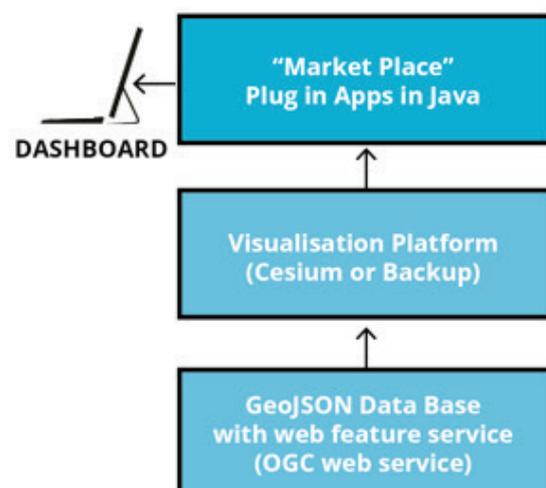
1. **Selecting a base platform:** Selecting an open source enabled visualisation platform is required and the research team has concluded that Cesium or similar open source platforms such as NASA Web WorldWind, would work well. Cesium has had significant uptake across Australia as a base platform. It currently supports 'NationalMap', the 'Queensland Globe' and planning support tools including the Cooperative Research Centre for Spatial Information (CRC SI) 'Envision Scenario Planner' (ESP) and 'Rapid Interactive Scenario Explorer' toolkit (RAISE). It would be necessary to ensure future data compatibility with the system (or have software to amend the data to be compatible).
2. **Configuring databases:** Configuring existing databases and encouraging new data sources needs to be based on internationally recognised data standards, to feed into the selected platform. Some of the key standards to be recommended include: GeoJSON format with OGC (Open Geospatial Consortium) data services including WFS (Web Feature Service), WMS (Web Map Service), WCS (Web Coverage Service).
3. **Accessing applications:** Encouraging the development of new applications and tools to run on this platform would then be needed. It is recommended to use open source software languages including Python, R and

JavaScript, to create a marketplace for third party applications that compete based on functionality. Once this begins, there will be a plethora of new functions created in a similar way to the explosion of apps created for use on mobile phones.

4. **Creating dashboards:** Developing user open city dashboards would then be required to undertake analytics on selected databases, supported by third party applications (apps) through the selected visualisation platform. These would be customised to the user using the apps and could include reporting apps. For example, the Sydney City Dashboard and the City of London Dashboard.

The above combination would enable a toolkit to be created for use in city planning. There is a need for new tools to be created that use the above framework and are based upon open data and software.

Open source software and open data reduce costs, increase transparency and accountability and deliver better planning outcomes. All of these factors are priorities for governments when considering the best use of public funds.



**Figure 9:** Conceptual Digital City Toolkit

## Conclusions

The resolution of growth versus impact, of agglomeration versus anxiety, in the future planning of our four biggest cities urgently requires a new approach to scenario building that can be based on rapid identification of optimal outcomes for public agencies, industry and communities. This is not likely to be possible given the complexity of the issues and the scale of development unless digital planning tools can be mainstreamed. While useful tools are emerging, they are not yet created in a way that can enable mainstream planning to adopt them. Thus, a new approach to digital planning tools is required. The recommended approach has been shaped to enable such a tool or set of tools to be created.

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## SBEnc Overview

The [Sustainable Built Environment National Research Centre](#) (SBEnc) is the successor to Australia's CRC for Construction Innovation. The Centre is a key research broker between industry, government and research organisations for the built environment industry.

The SBEnc is continuing to build an enduring value-adding national research and development centre in sustainable infrastructure and building with significant support from public and private partners around Australia and internationally.

Benefits from SBEnc activities are realised through national, industry and firm-level competitive advantages; market premiums

through engagement in the collaborative research and development process; and early adoption of Centre outputs. The Centre integrates research across the environmental, social and economic sustainability areas.

Among the SBEnc's objectives is to collaborate across organisational, state and national boundaries to develop a strong and enduring network of built environment research stakeholders and to build value-adding collaborative industry research teams.

The research would not have been possible without the ongoing support of our core industry, government and research partners.

## SBEnc Core Partners



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