



Understanding the disruptive technology ecosystem in Australian urban and housing contexts: a roadmap

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AUTHORED BY

Christopher Pettit

University of New South Wales

Edgar Liu

University of New South Wales

Ellie Rennie

RMIT University

Jake Goldenfein

Swinburne University of Technology

Stephen Glackin

Swinburne University of Technology

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Authors	Christopher Pettit	University of New South Wales			
	Edgar Liu	University of New South Wales			
	Ellie Rennie	RMIT University			
	Jake Goldenfein	Swinburne University of Technology			
	Stephen Glackin	Swinburne University of Technology			
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Michael Comminos	Astrolabe Group Pty Ltd
Brendan Fitzgerald	Infoxchange
Sam Headberry	Infoxchange
Paul McBride	Department of Social Services (Commonwealth)
Alison McClelland	Independent Consultant
Sidesh Naikar	Department of Social Services (Commonwealth)
Emma Ogilvie	Department of Housing and Public Works (QLD)
Lynden Pennicott	Department of Health and Human Services (TAS)
Sandi Phalen	Department of Housing and Public Works (QLD)

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Acronyms and abbreviations used in this report

ABS	Australian Bureau of Statistics
AHURI	Australian Housing and Urban Research Institute Limited
AI	Artificial intelligence
AIHW	Australian Institute of Health and Welfare
API	Application program interface
APM	Australian Property Monitors
ARA	Accredited release authorities
ASIC	Australian Securities and Investment Commission
AURIN	Australian Urban Research Infrastructure Network
CBD	Central business district
CEFC	Clean Energy Financing Corporation
CHP	Community housing provider
CRCSI	Cooperative Research Centre for Spatial Information
CSIRO	Commonwealth Scientific and Industrial Research Organisation
ESP	Envision Scenario Planner
FACS	Family and Community Services
GDPR	General Data Protection Regulation
GFA	Gross floor area
GIS	Geographical information systems
ICT	Information communication and technology
IoT	Internet of things
IT	Information technology
MLS	Multiple listing service
NCRIS	National Collaborative Research Infrastructure Strategy
NDIS	National Disability Insurance Scheme
NID	National Interest Datasets
NRSCH	National Regulatory System for Community Housing
NSW	New South Wales
OGC	Open Geospatial Consortium

OSM	Open Street Map
PEXA	Property Exchange Australia (Australia's online property exchange network)
PIPS	Parallel Infrastructure Provision System
PMC	Department of the Prime Minister and Cabinet
PSS	Planning Support Systems
QGIS	QuantumGIS
RAISE	Rapid Analytics Interactive Scenario Explorer
REIT	Real Estate Investment Trust
SA	South Australia
UK	United Kingdom
US	United States
VCAT	Victorian Civil and Administrative Tribunal
VIC	Victoria
WA	Western Australia

Glossary

Not-for-profit sector	Community organisations providing a broad range of social services, including in relation to homelessness, housing, education, health, conservation and recreation.
Social housing	Rental housing that is provided and/or managed by government or non-government organisations, including public and community housing.

A list of definitions for terms commonly used by AHURI is available on the AHURI website www.ahuri.edu.au/research/glossary.

Executive summary

Key points

- The sharing or ‘gig’ economy, with the likes of Airbnb, is already disrupting the housing sector.
 - Digital planning tools are on the cusp of systematic adoption by councils and metropolitan planning agencies to support data-driven city planning.
 - Whilst much work has been done in opening up property data assets across governments, significant work is required on data standards, interoperability and data sharing across government, industry and the non-profit sectors.
 - Blockchain is considered a new and emerging technology with numerous potential benefits across the housing sector.
 - The Smart Cities movement offers opportunities to undertake pilots and consider new and disruptive technologies.
-

This project maps the ‘disruptive technology ecosystem’ to show how new digital technologies might reshape housing provision and assistance. It is part of a wider evidence-based Policy Inquiry into the impacts of disruptive technologies on different housing markets across Australia, and how policy makers, providers and consumers can engage productively with emerging digital and disruptive technologies. This report specifically provides a critical review of how different emerging digital and disruptive technologies are being incorporated into the housing and planning systems and how they might facilitate greater efficiencies and new opportunities broadly across the housing sector. Through a qualitative approach, the outcomes of a detailed literature review of such innovations are complemented by two technology workshops with stakeholders (social housing providers, local councils, advocacy groups, peak bodies, and technologists) to collaboratively explore implementation options. The literature review and workshop discussions inform the project’s research question:

Which emerging digital and disruptive technologies present the greatest opportunities and threats for more efficient, effective and equitable housing provision and assistance, and what are the likely risks and rewards associated with these technologies?

Key findings

Two competing trends are emerging in relation to Australia’s housing and urban planning processes: one that involves the centralising of data, another that seeks to use distributed technologies that enact processes across a network without the need for central intermediaries. Both arise from attempts to solve critical coordination problems, yet may produce vastly different outcomes in relation to privacy, the accessibility of publicly and privately held information, and the subsequent possibilities for innovation. In this report, we consider how these trends are unfolding across industries and within individual organisations, and the policy and regulatory frameworks that are emerging in response.

The move towards centralised data is most critical in urban planning and social services. A significant portion of government and market processes related to housing are now conducted

via digital technologies. Large quantities of data are collected and stored in the process, creating reservoirs of information that may be used for automated decision making, reputation tracking, and auditing across varied domains: advanced urban planning, utility provision, market signals, welfare eligibility, tenancy applications and more. Digital technologies may, therefore, dramatically transform the built environment and the social and private housing markets over the coming decades. However, these data stores are not necessarily complete or connected, potentially leading to uneven social outcomes. The platforms and applications that utilise data are not always transparent in their design, leaving citizens unaware of how or on what basis decisions are made.

On the government front, national plans and recommendations are developing in the context of smart cities, data ecosystems and state-based regulation, but not necessarily in keeping with the pace of technological advancements and disruptions. Open data access is often promoted by policy makers, as well as the development of digital 'marketplaces' or data swap-shops. For instance, data.gov, data.vic and data.nsw (among others) are clearinghouses for a wide range of government data. Though they currently contain a limited range of information, these systems, and their predecessors, were designed to act as repositories for all government data, which, in companion with data workflow systems, would mitigate duplication and provide access to those who need the information.

The use and protection of personal data is of crucial concern. In the context of social housing allocation, workshop participants expressed a desire for a common waitlist-type vacancy listing—already in place in the private rental sector—so that potential social tenants may be better matched with available properties not managed by the provider (or their immediate professional network) through which they applied. To facilitate this, state level policies and client and property management databases would need to be updated to allow for the creation and sharing of such real-time vacancy listings. Protocols would also need to be developed to ensure data security—potentially with the assistance of blockchain technologies—of both the applicants and the providers. Currently, state agencies and private entities are limited in terms of how they deal with data through national and state data protection legislation, some of which have yet to catch up with the evolving nature of emerging technologies and the data that they create, access, manipulate etc. Additionally many datasets are kept in organisational silos under cloaks of commercial-in-confidence. While the possibilities for better housing services should be explored, automation and machine learning technologies that rely on government data stores also raise ethical and legal questions, particularly if applied to services for vulnerable groups such as social housing tenants.

In the private sector, the growth of digital transactions, combined with the capability to generate and access data markets based on consumer behaviour, creates market advantages for companies that develop digital capabilities. This has led to an increase in the need for specialist data firms, many of whom have generated privately owned and highly commercialisable datasets. In many cases, these commercial enterprises are able to offer better quality and more complete data than public clearinghouses. There are, however, significant reasons to hold back the sale of government datasets and data stores (which is already occurring with land title registries), as technological change may produce alternatives to privatisation of public assets, including new forms of public-private partnerships, that yield greater long term public benefit.

Further, the use of personal data by public or private entities needs to take account of existing legal structures governing the collection, retention, disclosure and analysis of personal information, as well as emerging open data and data sharing frameworks intended to capture public benefit from large existing datasets. The introduction of automated decision making systems operating on personal data can affect the rights of persons. It also raises new legal risks and difficulties, as well as potential efficiencies. Other forms of automation like contract automation also have potentially dramatic legal consequences. These issues require assessing

the adequacy of Australia's data protection offices and infrastructures to ensure certain goals are achievable but with minimum harm to persons.

At the level of individual entities, the amount of data and ability to analyse digital information (such as through Geographic Information Systems (GIS)) hold significant possibilities for better planning of our cities. Technologies for data visualisation and spatial analysis are continually advancing, such as through the development of bespoke tools like ENVISION, ESP, RAISE and What if? and in 2D and 3D modelling to facilitate more detailed and specific analytical functions and forecasting. There are, however, limitations in the internal capacity of organisations to afford regular upgrades and maintain a workforce with a relevant (and constantly changing) skill set to operate these systems. This can create an uneven market so that only entities with the financial means (e.g. larger companies in the private sector or better resourced local councils) to invest in upgrades can benefit, while others (e.g. small to medium-sized specialist housing providers) lag behind, potentially compromising the quality of decision making and client outcomes.

Developments in blockchain and other automation represent a shift away from centralised data and coordination. The blockchain protocol—a ledger of transactions that operates and updates simultaneously across a multitude of participating 'nodes' using peer-to-peer communication protocol—enables the transfer of value without the need for intermediaries. The distributed nature of the technology enhances data security as it cannot be attacked at a central point. While still at an early stage, it can be applied to housing functions such as title registration, co-ownership options (including in reverse mortgages), tenancy management and utilities maintenance, to ensure data integrity. These may reduce the risks and costs of manual entry and expand the capacity of current record-keeping by linking up relevant datasets.

The promise of some of these emerging technologies is that they have the potential to simplify the processes involved in siting, constructing, tenancing, selling and maintaining of properties in cases where that might not necessarily entail substantial regulatory change. There are, however, institutional and structural blockages—in terms of policy, infrastructure, finance, data quality and other legal considerations—that may prevent broader adoption and housing market transformation.

Some of the technologies described in this report and with our workshop participants—blockchain, digital planning tools, automation—are at an early stage of development. While these are already showing promise in influencing the provision of housing products and in urban planning decisions, their real impacts may only be realised after key financial and legal issues are resolved, and when upskilling the relevant workforce has been addressed. Policy makers also need to consider the impacts of emerging technologies not directly related to housing services such as Uber and Deliveroo, which have the effects of destabilising vulnerable groups' financial positions through the casualisation of work and short term, 'gig'-based engagements. While offering flexibility, these can have lasting impacts on individuals' ability to sustain tenancies, access housing loans, and keep up with living costs, the outcomes of which may be far broader than any technological and policy interventions can anticipate.

Policy development options

Paramount for the realisation of many disruptive technologies is the ability to access fine scale data, whether it be property information or personal information. Digital platforms pertaining to the housing sector such as AskIzzy, Wattblock and Powerledger provide good examples of what is possible when data is made accessible. However, a key consideration with open data is the risk of compromising personal data that could result in negative outcomes including identity theft, inequitable treatment and the violations of citizen's civil rights and freedoms.

The key findings from this research highlight a number of areas requiring further consideration. First, there is an identified skills gap in agencies' ability to work with new emerging technologies. In relation to urban planning, GIS-based digital planning tools hold much promise for adoption into the strategic planning workflow. Relating to this is the paucity in policy and statutory regulations to enforce the use of digital planning tools to support the formulation of housing and city plan policies.

In the context of data, we are seeing increased momentum in industry to acquire and value-add to existing government data assets. These commercial data assets offer potentially significant benefits for the non-profit sector including Community Housing Providers, yet as it can be costly to purchase such commercial data, is often not fully utilised. Also, in the area of data, there are opportunities for policy to support better two-way flows between contributors and collators. For example, a housing provider might provide data to government agencies yet not receive access back in the forms of aggregated or value-added data products that might have been contributed by multiple providers and agencies.

This research has found there are barriers to technology uptake in certain sectors due to software licensing costs. Also, in a number of organisations there can be limitations on what software is supported which is another barrier to adoption. Policies and procedures that enable open source software are recommended. Open source software does not come with licensing costs and can support startups, non-profit organisations and government agencies to have access to a wider array of new and emerging technologies. As technology is increasingly made available through cloud services and hosted externally, policies and procedures need to be developed to support the utilisation of such digital platforms.

In an era of 'smart cities', there should be policies to support innovation, pilots and testbeds in exploring the potentials of new disruptive technologies. Blockchain has been identified as one such emerging technology. There are other new and emerging technologies including augmented and virtual reality, Internet of Things (IoT) and artificial intelligence (AI) that also hold potential promise and ability to disrupt the housing sector. Given the increasing digitisation of services and products and the wave of digital disruption which is impacting our cities, there is a need for more agile policy setting and review to ensure we mitigate negative impacts early and realise the positive potential of such technologies for the housing sector and society at large. As our study shows, there is potential for vulnerable communities to experience further isolation and disengagement if the emerging technologies are introduced without careful consideration.

The study

This research incorporates a review of academic and grey literature on emerging technologies with workshop discussions involving participants across the housing, technology, government, non-profit and academic sectors. The findings of these reviews provided important research and policy contexts to inform the research team in designing three case studies discussed at technology workshops held in Melbourne and Sydney in September 2017. The case studies involved real and hypothesised scenarios where emerging technologies may impact on the siting, development and managing of housing products and services, and the research team sought expert opinions from participants on the barriers to implementation and potential impacts. A rapporteur from each table summarised the discussions and reported back to the rest of the workshop for consideration. Recorded audios and rapporteur notes were used as the basis of analysis for this report.

1 Introduction

- We live in an era of smart cities and technological disruptions. There are opportunities for the housing sector to take advantage of these reforms.
 - New and disruptive technologies need to be fully understood by the housing sector in order to capture their full potential as well as mitigate risks.
 - National plans and recommendations are developing in the context of smart cities, technical disruption, data ecosystem and state-based regulation, but not necessarily matching the pace of technological advances and disruptions.
-

This project maps the ‘disruption technology ecosystem’ to provide a conceptual framework for understanding how new digital technologies might reshape housing provision and assistance in Australia. It is part of a wider evidence-based Policy Inquiry into the impacts of disruptive technologies on different housing markets across Australia, and how policy makers, providers and consumers can engage productively with emerging digital and disruptive technologies. This report specifically provides a critical review of how different emerging digital and disruptive technologies can be incorporated into current housing and planning policies and regulations, as well as how they can be used to realise technology enabled efficiencies and new opportunities broadly across the housing sector. The risks associated to these potential changes—such as in regard to data security and privacy protection—are also discussed. The outcomes of a detailed literature review of such innovations are complemented by findings from two technology workshops with stakeholders (social housing providers, local councils, advocacy groups, peak bodies, and technologists) to collaboratively explore implementation options. The literature review and workshop discussions inform the project’s research question:

Which emerging digital and disruptive technologies present the greatest opportunities and threats for more efficient, effective and equitable housing provision and assistance, and what are the likely risks and rewards associated with these technologies?

1.1 Why this research was conducted

We live in an era of smart cities, big data and disruptive technology (Pettit, Bakelmun et al. 2018). There is a need to critically understand what this means to Australia’s housing sector and how we plan our cities. In this context this research has been conducted to identify new emerging disruptive technologies with the greatest potential to enhance or otherwise impact housing provision and assistance in Australia. This research aims to provide a digestible overview of recent innovations as well as a stocktake of current and emerging technologies. We examined their key features, limitations to practical use and consequential risks to housing providers, policy makers, and housing markets.

Given the interest from governments at all levels in the transformative potential of disruptive technologies, as well as from many in both the private and non-profit housing sectors, this is timely. At the same time, there remains significant uncertainty and confusion about what disruptive technologies are, their possible implications for housing provision and assistance, and what their potential benefits, limitations and adverse effects might be.

1.2 Policy context

There are a number of national level policies and programs relevant to new and disruptive technologies. The key documents include:

- 1 Smart Cities Plan, Department of Prime Minister and Cabinet (2016)
- 2 Productivity Commission's report on Digital Disruption (2016), and
- 3 Productivity Commission's report on Data and Availability and Use (2017).

In 2016, the Australian Government released its Smart Cities Plan (PMC 2016). This was the first Smart Cities Plan for Australia and it acknowledged the critical importance of the country's growth through a knowledge-based economy, which goes hand in hand with the growth of its cities and supporting regions. The plan outlines the importance of smart investment through new partnership models across the government and the private sectors such as the proposed 'City Deals' model first implemented in Manchester in the UK.

The Smart Cities Plan takes note of the unprecedented rate of technological progress and how government and communities need to take advantage of real-time data and smart technology to better plan and monitor city performance. Specifically, the plan outlines three key pillars:

- 1 Smart Investment
- 2 Smart Policy
- 3 Smart Technology.

In the context of housing, the Smart Cities Plan outlines a number of opportunities and challenges. With respect to Smart Investment, the plan recognises that increasing housing supply needs to be near job opportunities and transport connections. Consequently, the connectivity between housing and job centres needs improvement and there are a number of policy, planning and regulatory levers available to the Australian and state and territory governments to achieve this. A priority is given in the plan to infrastructure projects that can improve housing affordability and sustainability. A value capture mechanism is seen as a key means for delivering projects sooner and to accelerate urban renewal and housing supply.

The Plan also acknowledges that funding alone cannot resolve congestion, housing affordability and accessibility, and outlines the need for smart policy to deliver 'city deals', lead regulatory reform and measure success. 'City deals' aim to address housing supply and planning changes by encouraging higher density development and affordable housing and activating value capture. The Plan recommends the investigation into innovative models for financing affordable housing through leveraging investment, building on outcomes from the Affordable Housing Working Group.

Smart technology is the third pillar of the Smart Cities Plan, and there are three key opportunities outlined: (i) think of technology solutions first, (ii) leverage open and real-time data, and (iii) drive the use of energy efficient technologies. The Plan notes the potential of the sharing economy for delivering better customer experience. Whilst this might be true for transportation, the shared economy provides some challenges for the housing sector, particularly with the rise of Airbnb. This is addressed more specifically in another project associated with this AHURI Inquiry.

In leveraging of open data, there is significant housing related open data made available through the Australian Bureau of Statistics (ABS) and by some states and territories and councils. Such open data can ultimately be used to support new innovations across the housing sector, more customised (and customisable) services, and make governments more citizen-focused.

In driving the use of energy efficient technology, the plan makes reference to the Clean Energy Financing Corporation (CEFC). The CEFC includes a \$250 million energy efficiency housing fund targeted at reducing energy costs, which are noted as a substantial burden on low income tenants. This includes a community housing program, where the CEFC acts as a broker to leverage necessary funds for community housing providers (CHPs) to construct highly energy efficient housing stock.

In 2016, the Productivity Commission published a report on digital disruption. The Commission anticipates digital technologies will continue and likely accelerate changes in Australia's economy (Productivity Commission 2016). However, the report notes that multi-factor productivity has not recorded the kind of growth that would be expected from a period of change described as 'disruptive'. The report speculates that there might be a delayed response before the onset of significant social and economic changes which may be triggered by digital disruption.

The report does not discuss in detail the likely impacts on the housing sector. It does, however, show that digital platforms are enabling greater utilisation of assets, which include household assets. Specifically, Finding 2.4 outlines the opportunity of digital platforms to allow households to more fully engage in the market economy by 'sharing access to their under-utilised assets' and this poses structural adjustment to industries such as short-term letting. Interestingly the report omits documenting any adverse impacts of disruption on society, most notably the rise of the 'gig economy' in relation to housing access (see Section 1.3.3 for a more detailed discussion on the impacts of the 'gig economy' on housing access), as well as the potential for large platforms to own a majority of household goods, with tenants only having 'access' rights. The report also highlights the opportunity of digital technologies to improve government service delivery and increase government accountability.

In 2017, the Productivity Commission published a report on data availability and use. In the context of this AHURI report this is relevant as data can be considered to be the fuel to many new and disruptive technologies. The Commission's report highlights the extraordinary growth in data generation, and like many other countries, Australia's data framework needs sweeping reform. Key findings from the report include: (i) improving data access, (ii) making more data available to support new products and services and better decision making, and (iii) making more data open and accessible. Any benefits from increasing data availability, however, need to be achieved under conditions of adequate privacy and data protection. Accordingly, existing data protection structures and frameworks, and their clear limitations in Australia, remain highly relevant to the technologies and systems analysed here.

The report recommends the creation of a data sharing and release structure which includes National Interest Datasets (NIDs) which should be resourced by the Australian Government as national assets. In relation to housing, data on housing commencement, housing activity and affordability and social housing should be included in the NIDs. The NSW Government (in the NSW Government's Submission to the Productivity Commission's inquiry into data availability and use) has pointed to a range of data that could be useful for various government agencies, including real estate data to guide the provision of public housing.

The report highlights the need to reduce barriers to data sharing between governments in order to improve the experience of individuals receiving assistance. An example provided by the Australian Institute of Health and Welfare highlights situations where individuals receiving support from multiple agencies (for example, people who access housing support and may also have alcohol and drug addiction support needs) were often required to provide the same information more than ten times (AIHW 2006). Recommendation 5.1 'Implementing the Comprehensive Right' (to the extent that it enables data portability) endeavours to address this issue, by giving consumers the power to authorise community service providers to transfer personal information provided to them to third parties, which will greatly reduce the burden on

individuals. For example, when a person applies for social housing, they will be able to authorise the social housing provider to pass on their information to other support programs that are available from different agencies (such as community support programs provided by other not-for-profit organisations or local governments).

1.3 Existing research

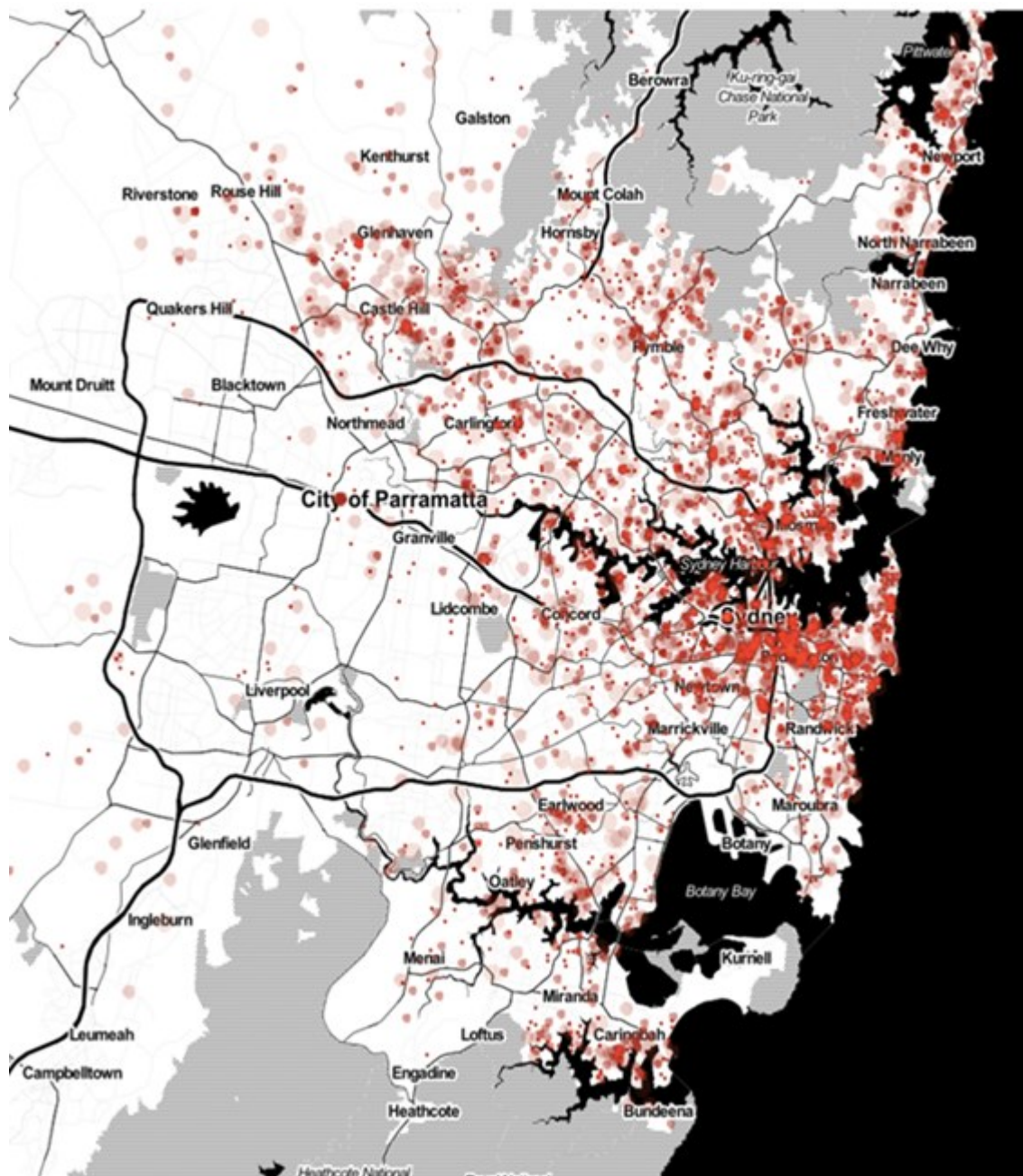
This section provides a precis of current literature on the adoption and impacts of emerging technologies on Australia, focussing specifically on city planning, housing access and impacts on vulnerable communities. A more comprehensive discussion on the potential of relevant technologies is included in the ensuing chapters.

1.3.1 Move towards data-driven smart cities

Smart cities have the potential to apply information and communication technologies (ICTs) to solve urban issues and work towards more sustainable and equitable cities with more informed citizens living better quality lives (Batty, Axhausen et al. 2012; Staffans and Horelli 2014; Batty 2014; Yu, Mao et al. 2017). Definitions of smart cities vary, but most typically focus on entrepreneurship, innovation, improved urban analysis and interconnectedness, with automation—both in terms of data collection as well as traditional processes such as transportation and communication—aided by the emergence of the internet of things (IoT) often a strong feature (Ngai, Dressler et al. 2017). Most literature focuses on smart cities as innovation in ICT (for example, automated vehicles guided by satellite navigation and/or with environment-sensing technology), but Nam and Pardo (2011) stress the importance of moving beyond this to include management of and policy about ICT applications. As discussed with our workshop participants, data security and data sharing are of increasing concern, and appropriate governance and management mechanisms must be developed and adopted to ensure the quality and reliability of data being collected and analysed. This is increasingly the case in the context of open and big data.

By definition, big data are ‘large datasets, mined in bulk from modern electronic devices, that can be analysed to extract patterns of behaviour at both the macro and micro level’ (Carrera 2016: 474) and typically ‘pertains to any and every aspect of the city measured with respect to its population, buildings, transport, and so on’ (Batty 2016: 321). Batty (2016) states that the techniques and methods to analyse big data often differ from conventional methods because of the unstructured format in which it is typically received. Since data streams are often not collected with a specific end-use in mind, these new methods (‘urban analytics’) are needed to define its boundaries and link it with other datasets. As discussed by Goodspeed, Pelzer et al. (2018) visualisation is often involved in communicating big data, since it is often easier for professionals to interpret patterns such as traffic movements or changes in house sales volume over time in cities—see, for example, CityViz housing indicator (Figure 1).

Figure 1: CityViz Housing Indicator—change in million-dollar property sales in Sydney between 2009–2015 (produced by Laurence Troy)



Source: <https://cityfutures.be.unsw.edu.au/cityviz/>

Pettit, Widjaja et al. (2012) outline a number of techniques for methods for visualising urban data including: graphs and charts, heatmaps, choropleth maps, flow maps, brushing and space time cube representation. Wang, Abdelzaher et al. (2015: 194) highlight several other methods and techniques, including dashboards that are used to collect sensed, real-time, heterogeneous information and especially stress that the challenge of ‘collective wisdom of common individuals’ must be addressed before we can take fuller advantage of these datasets. CityDash is one such example of a city dashboard put together for Sydney which provides a visualisation of a number of real-time open data (Figure 2).

Figure 2: City dashboard for Sydney <http://citydashboard.be.unsw.edu.au/>



Source: Pettit, Lieske et al. (2017)

Outside of data analysis and enhancing professional decision making processes, smart cities and IoT technologies have also facilitated the development of socially-conscious platforms to improve service connectivity. Askizzy (<https://askizzy.org.au/>), for example, is an Australian web- and application-based platform that links homeless persons or at-risk populations with a location-based directory. Launched in 2016 with support from the community (Infoxchange), property (REA Group), private (News Corp) and ICT sector (Google), it more than doubled its first year target of 100,000 site visits, significantly improving the service connection capability to the homeless and at-risk communities. Similarly, the Sydney-based startup Wattblock uses data analytics technologies to assist owner-occupiers and tenants of multi-owned units to perform energy wastage assessments and to devise appropriate strategies—including linking to locally available assistance programs—to improve the energy performance of their building.

1.3.2 Emerging technologies' impacts on housing

There is a growing body of literature on the impacts of emerging technologies on housing. The focus of these works often lie in peer-to-peer markets, such as the popularising of sharing platforms like Airbnb. In general, initial research in peer-to-peer markets has investigated their more unique features such as customisation (Levin 2011), scalability and ability to test scenarios at low cost (Varian 2010). Specific platforms, especially Airbnb, are increasingly being researched, and their impacts on city operations, housing affordability, and housing and planning regulations are becoming clearer. These often involve international comparisons (e.g. Coyle and Yeung 2017) so that the impacts of these emerging technologies in different local and regional contexts are also revealed.

Broadly, research on facilitated home-sharing such as Airbnb often focuses on its impacts on supply (New York City Rent Guidelines Board 2016), affordability (Lee 2016), and safety of owner-operators and short term renters (McNamara 2015). Airbnb-specific research further focuses on the negative externalities associated with the influx of tourists into established residential neighbourhoods, and tax and regulations of informal rentals as compared to the hotel industry (Sheppard and Udell 2016). Recent major studies on cities including Sydney (Gurran and Phibbs 2017), Berlin (Braun and Schäfer 2015; Schäfer and Braun 2016), Toronto (Horton 2016) and Vancouver (Sawatzky 2016) have focused on how facilitated home-sharing like

Airbnb has impacted on rental affordability and on access to rental properties at the city scale. Sheppard and Udell (2016), for example, note that the presence of Airbnb listings in a neighbourhood can result in increases in home values to the scale of 6–11 per cent. In terms of impacts on supply, there is evidence to counter claims that facilitated home-sharing removes long term housing supply from the market, with Lewyn (2016) noting that the correlation between short term rental and housing supply is not yet clear.

There is, however, emerging evidence to show that facilitated home-sharing fundamentally changes local neighbourhoods. There are, for example, spatial disparities in where such home-sharing listings are located (often in popular inner city areas with easy access to public transport and facilities). Low income populations in these areas are often priced out. This is especially so with the professionalisation of such facilitated home-sharing, with Quattrone, Proserpio et al. (2016) highlighting that, at least in the context of London, hosts often do not live in the same neighbourhood, region or in the UK. This is despite a Deloitte (2017) review noting that financial returns on facilitated home-sharing to hosts are generally modest (less than \$5,000 per annum in 2015–16).

Many cities around the world like Barcelona and Berlin have in response introduced legislation limiting home-sharing, with NSW currently considering introducing similar legislations (Biber, Light et al. 2017; Knaus 2017). For a more detailed discussion of the impacts of Airbnb on the Australian housing system, please see related Inquiry research project Technological disruption in private housing markets: the case of Airbnb (Crommelin, Troy et. al 2018 forthcoming).

Outside of Airbnb, other emerging technologies and applications are noted to benefit households in accessing appropriate housing and related services. Applications and websites such as 1Form (<https://1form.com/>) facilitate the rental application process for potential renters, streamlining the application process and making the process less daunting. There is, however, emerging evidence to suggest that similar apps like Rentberry are used to pit renters against each other to inflate rental returns for the vendors (Small 2017).

1.3.3 Emerging technologies' impacts on vulnerable communities

The emergence of applications such as Airbnb has happened concurrent to increasing casualisation of the labour force and the creation of what is known as the 'gig' economy, where large numbers of individuals now work on short term engagements ('gigs') such as on a per-transaction basis (Allen 2015). Airtasker, Uber and Deliveroo are notable examples that have impacted trades, transport and food industries. These short term engagements have been particularly popular with relatively low-skilled workers; Chen, Chevalier et al. (2017), for example, highlight that the flexibility arrangements of Uber drivers can potentially lead to drivers earning twice as much as similar transport workers like taxi drivers, especially in the absence of upfront and ongoing costs such as licenses.

Tamvakologos and Cavanough (2016) and Warren (2016), however, argue that this continued move towards the gig economy creates an unstable workforce that has particularly detrimental impacts on vulnerable workers. Specifically, gig workers are not protected by traditional labour regulations as their employment status is often not clear within regulation: whether they are franchisee to these platforms, individual (sub)contractors, or employees. While the gig economy provides greater flexibility to these workers, there are significant drawbacks like uncertainty and insecurity (Aloisi 2016). Further, these workers also typically work without protection mechanisms such as paid leave, superannuation and compensation schemes. The instability of work can also impact vulnerable workers' ability to keep up with housing and living costs and can potentially be prohibitive to accessing financial mechanisms such as home loans. As such, while the per-transaction engagements may be beneficial to a flexible workforce in the short term, there are potentially longer term impacts that are yet to be realised.

Calls for regulators to introduce mechanisms to protect gig economy workers are now emerging, and some gig economy platforms now have provisions to offer worker protection in several aspects. For example, TaskRabbit—an online freelance labour matching service similar to AirTasker—provides access to discounted health insurance to independent contractors. Likewise, Lyft—an on-demand transportation service like Uber—has entered into partnership with Freelancers Union—a US labour organisation that provides group social insurance—to provide a group health plan (Friedman 2014). In her review of regulations surrounding the sharing economy in the US and the responses of the Federal Trade Commission, McNamara (2015) suggests that, in addition to specialised organisations and mechanisms such as the Freelancers Union noted above, many current laws can be adapted to new industries as long as regulatory bodies are prepared for speedy implementation, and have ongoing adaptation strategies in place.

Adapting regulations to a sharing economy might be assisted with co-production, a method of collaboration between companies and consumers to yield value (Humphreys and Grayson 2008). Several platforms are already working with regulatory bodies to respond to issues such as housing affordability (Kopytoff 2013) and data privacy (Cheung 2013; Berthold and Wacks 2003) to increase protection of both consumers, workers and neighbourhoods affected by these platforms. When co-production principles are applied to public services, services can be developed with the involvement of citizens, community organisations and other affected stakeholders (Alford 1998). ICT advances have made it easier to receive stakeholder input (Humphreys and Grayson 2008) and, as the sharing economy is very much a bottom-up, user-centred process, co-production techniques may help build a dialogue that genuinely represents the concerns of citizens, whose motivations for housing and transport choices will provide valuable information for city planners. It can be used to create new data streams that provide decision makers with more useful, potentially real-time feedback in addition to improving citizen attitudes (Needham 2007). Needham (2007) recommends workshops as one way to facilitate co-production; she also cautions that they may not necessarily work if there is a lack of trust between citizens and decision makers. Co-design approaches may be especially beneficial in this regard, such as in co-developing user feedback techniques and mechanisms (Pettit, Glackin et al. 2014).

1.4 Research methods

Two main methods were used to capture the recent developments of emerging technologies and their impacts on city planning and housing internationally: a review of literature and primary sources (including documentation created by technology start-ups) and two co-design technology studios.

1.4.1 Literature and primary sources

A review of academic and grey literature on emerging technologies and their influence on housing provision and assistance was conducted. In reviewing the literature, we focused on five broad fields—data science, internet studies, computer systems, legal dimensions, and planning and housing systems—encompassing 19 main topics and eight further sub-topics (Table 1). Literature was selected to reflect different system specifications and proposed end use, current practice nationally and internationally, and critique of technologies in terms of their benefits and risks across the spectrum of individual users, corporate users, housing organisations and housing markets. The findings of these reviews provided important research and policy contexts to inform the research team in designing the case studies discussed during the co-design technology studios.

Technology start-ups were identified through industry networks, as well as through monitoring of web platforms and forums. Once significant emerging applications had been identified, we

analysed publicly available documentation, including white papers (defined as a working outline of a company's technology and business model, intended for investors), company blog posts and social media feeds.

Findings from this literature and primary resources review are incorporated throughout this report along with findings of our workshop discussions.

Table 1: Literature review matrix

Fields	Main topics	Sub-topics
Data science	Big data Online platforms Smart cities Visualisation	Internet of things Open data
Internet studies	Blockchain Internet studies Social media	Applications
Computer systems	AURIN ENVISION ESP RAISE What if?	Support systems
Legal dimensions	Automated contracts Legal dimensions of disruptions Online ledgers Privacy and data protection	Data security
Planning and housing systems	City planning Governance Housing system	Casualisation of labour Co-production Share/gig/informal economy

Source: Authors.

1.4.2 Co-design technology studios

Two co-design technology studios were used to showcase and discuss emerging technologies that can have disruptive impacts on housing markets in terms of supply, demand and management. The two studios were held in Melbourne and Sydney in September 2017, each to reflect different local market conditions and policy settings. Both workshops were held in rooms which support group work and discussion (Figure 3).

Figure 3: Co-design technology workshop held at RMIT in September 2017.



Source: Authors.

Representatives from government (national, state and local), industry and non-profit sectors were invited to contribute to the studios. An initial shortlist of 30 participants were invited to each studio. These invitees included experienced technologists and senior management and technical staff in government and non-profit organisations. These organisations were selected based on their likely influences in the adoption of technology across the three scenarios discussed. A small number of these invitees declined due to scheduling conflicts, with a few senior managers deferring to other staff who had more background in the technical operations of their organisations, or had frontline experience in dealing directly with clients. A further few dropped out in the days leading up to the studios. Each studio lasted between three and four hours and involved 34 participants in total, including a mix of experienced and novice users of technology, and five researchers. A list of organisations that participated in the workshop is included as Table A1 in the appendices. All discussions were digitally recorded, with the recordings used by the research team to write up summary notes for thematic analysis.

The format of the studios consisted of three main parts:

- 1** Welcome and overview. This included brief introductions of the three different emerging technologies workshopped in the second part.
- 2** Scenario workshops. Participants each chose a particular scenario and joined the group discussions on the potential applications of different emerging technologies in the housing markets. These discussion case studies incorporated early learnings from the literature review and were designed with three specific housing perspectives in mind:
 - Infrastructure planning (including planning for affordable housing),
 - Social housing allocation and pathways, and

- Private real estate market.

Each case study contained multiple parts, some of which included case specific questions (see Appendix 1 for details).

Participants were asked to consider the case studies in reference to the following question prompts:

- What is the current process?
- What could be automated? What are the risks of automating processes?
- What bottlenecks or regulatory requirements are likely to thwart technology uptake? What might stop technologies from being used to their full potential?
- What are the current/future privacy issues?
- Who would implement such technology (public sector, community, private)? Is there a business case for this?
- What issues do you foresee in terms of data access and management?
- What's your own vision for how this scenario should be resolved?
- What would make technological innovation viable (funding, getting developers involved etc.)?

A rapporteur from each table summarised the discussions and reported back to the rest of the workshop for consideration prior to commencing part 3.

- 3** Free-form discussion. All participants were invited to comment on the rapporteurs' discussion summaries as well as add to any other considerations regarding the intersection of emerging technology, housing and urban planning not covered in the three case studies. These discussions were also digitally recorded and included in the summary notes written up for analysis.

The technology studios were conducted with ethics approval from the UNSW Human Research Ethics Committee (approval number HC17612).

1.5 Report structure

Chapter 2 provides an overview of some of the emerging technological advancements that have impacted on the siting, provisioning, sharing and governance of housing products, including construction, management, and title registrations as well as some of the infrastructure currently in place to manage and govern its uses. This is followed by a discussion of the current uses of technology in the Australian housing systems (Chapter 3). The same themes discussed in Chapter 2—title registrations, planning and provisioning, and impacts on the private and social housing sectors—are repeated here, incorporating findings of our literature and primary resources reviews and the workshop discussions. The challenges to broader technological adaptation in these housing systems are then discussed in detail in Chapter 4, specifically the relevance of automation in some sectors, concerns over data governance and security, including the push for open access data and the reality of datasets having generally been created for very specific purposes, as well as capacity limitations in the adapting of digital advanced and online tools. This Final Report concludes with a broader level discussion of these challenges, especially in reference to institutional and structural barriers that need to be overcome in order for the various housing systems to more fully embrace the advantages of emerging technologies (Chapter 5).

2 Emerging technologies

- Digital transformations are already occurring in urban planning and commercial housing markets.
 - Regulatory frameworks could be made legible to software applications, enabling automation of otherwise cumbersome processes.
 - Some of the technologies described in this report, such as blockchain, are at an early stage of development. Regulatory and legal issues may need to be addressed before the full possibilities of blockchain technology can be realised.
 - Data governance and availability is a pressing concern, particularly for urban planning and for the provision of welfare services including social housing.
 - Platforms are being built on the expectation that they will eventually alter consumption and production patterns. The sharing economy's impacts on short-term rentals is one example of where this has already occurred.
-

Before considering the societal dimensions of digital transformation, it is useful to understand the basic limitations of data-reliant systems. In this chapter, we discuss why data matters and provide an overview of emerging technologies that are likely to impact on Australia's housing system.

2.1 Data and data infrastructure

Without data there can be no functional system, and without a system of collection (software or otherwise) there can be no data. Data is constructed based on a unique identifier, such as address, phone number or a derived string of characters, which is then populated with information relevant to that collection. These records are typically of a particular type, such as an integer, floating point (decimal place), character, or a string of characters. If users do not adhere to the types that the database is programmed to receive, it will make the data entry redundant, which is indicative of how error-prone data capture can be.

In terms of collecting data, there are two ways to input it into a system: manual entry or automated entry. Manual entry is generally (though not always) captured through a form or, if spatial, can be digitised or scanned. If well programmed, these forms limit the state and type of data records to ensure that the system only accepts valid entries. Automated systems vary in design but are typically recorded through software systems that capture specific events. Manual systems are open to user error, for example 'fat finger' errors, while automated systems are open to machine and software error. Simply put, data entry is error prone. Furthermore, while data has traditionally been stored simplistically (two-dimensional rows and columns), the increasing demand for digital data creation and sharing has led to the development of more complex systems—increased investments in comprehensive management systems by CHPs is a case in point (Milligan, Hulse et al. 2015)—which further complicates an already error-prone field.

The other consideration is the output, or how data is used. As with the input, this largely comes down to institutional or departmental business models, but it is also a function of the quality of the data, including its timeliness, which in turn can depend on various institutional capacities. A common expression is 'rubbish in, rubbish out', which indicates that if erroneous data, or data

that is not fit for purpose, is inside the system, then the outputs will also be erroneous. There are multiple ways in which data can be poorly handled. Old data is typically not useful (unless used for historical purposes or for finding patterns that enable machine-learning), and requiring data capture be ongoing can be an expensive exercise. Not all organisations have the financial capacity to fund consistent data capture exercises and ensure that they are backwards compatible with older data collections. Issues can arise out of how it is stored, what access individuals have to it, and how best to manage changes to the dataset. The choice of data collected and mechanisms for processing it may lead to discriminatory outcomes (Barocas and Selbst 2016).

Adequate training in data extraction techniques and data is also relevant, rather than just focusing on its capture, and introduces another set of issues which need to be mitigated. Data needs to be error checked, cleaned for effective use, stored and versioned correctly if it is to be compatible with other systems.

Furthermore, an effective system for analysing data may require training, integration into existing or emerging business processes, flows and maintenance, which can be expensive and out of reach of some organisations. Data collection is, therefore, largely determined by those who pay for it, and it will not necessarily connect to other systems or provide information to organisations outside of the institution or department from where it originated. This lack of interoperability has led to the creation of data silos; data that is locked down to a specific institution for a specific function, making it unusable by others, potentially leading to duplication and incompatibility across institutions. As reported by the Productivity Commission (2016) there is a need to reduce such barriers to data sharing between government agencies in order to improve both the efficiency and the experience of individuals receiving assistance, such as in the case of social housing provision.

Simply put, the rhetorical call for 'open data' is not a panacea, but the beginning of an incredibly complex body of work that will need to tackle all of the above to provide useful information. A critical aspect of this transformation is the relatively new data marketplaces and the revolutionary 'data workflow systems'. Another critical aspect is the data protection and privacy laws relating to citizens and residents for their personal data. Ensuring a minimum level of adequacy in Australia's data protection regime is crucial for these systems to be adopted without inappropriate privacy interference, and reform may be required. Recently the European Union introduced the General Data Protection Regulation (GDPR) (EU) 2016/679. Such legislation is critical and timely in the consideration of open data and will be discussed later in the report (see Sections 4.2 and 4.3 on data governance and open data respectively).

2.1.1 Developments with data: workflow systems and data marketplaces

Another novel, but incredibly powerful development, particularly in the areas of law, policy and other disciplines where the discourse is the data, is development of semantic analysis. This method of data extraction is based on machine learning algorithms, which are arguably at the point where reading and interpreting statutory land use regulations is becoming redundant (Psyllidis, Bozzon et al. 2015). Capacity now exists for digital planning systems to do initial assessments of planning proposals, particularly for smaller endeavours, which would vastly improve the efficiencies of the planning process. These automated systems do require oversight however, and should never be used without capacity for affected individuals to contest their decisions or legislative interpretations.

While the commercialisation of data is not new, the increase in digital transactions, combined with the richness in how this data can be used to inform consumer behaviour, means that operating a business without this information puts it at significant disadvantage. This has led to an increase in the need for specialist data firms, many of whom have generated privately owned and highly commercialisable datasets. Examples include the Australian Property Monitor (APM)

housing dataset, which includes historical and contextual data of all property sales in Australia; the Experian Mosaic dataset, which has real and modelled consumption data for each household in Australia; and Google store data on personal consumption practices and location among others. As our workshop participants explained, the data industry is developing too quickly for government regulations and policies to catch up, and private industry is far more flexible in adapting to these changes. In many cases, these commercial enterprises are able to offer better quality and more complete data, as was expressed by a workshop attendee:

'Google and other organisations have pulled out huge data on almost everything... They were working with us, but then they pulled their data because we were using it for free. They are going to be monetising their data to make decisions support freely available. They are collecting traffic data, where the bathrooms are, the congestion spots. They can already probably provide better info than governments ... Data aggregation is the new anti-trust. Things are moving too fast for governments to respond to. Google has aggregated their data, that's why they are powerful.'

The amount of data and ability to visualise this information hold significant possibilities for better planning our cities (Figure 4). In fact, many firms are collecting big data captured through smart phones and web transaction histories. This includes data from the telecommunication companies, such as Optus, which has set up DataSpark, and Telstra, which has set up LocationInsight. Credit card companies are also now in the business of data with Mastercard releasing its Retail Insights data platform. As these firms make their income from the sale and analysis of these datasets, acquiring them for research or governance is largely not viable due to the prohibitive cost; though occasionally special licences are granted for research such as the case in Davison, Legacy et al. (2013). There is increasing concern of people's privacy with such commercial data exchanges as has been highlighted by the Facebook Cambridge Analytica debacle where it has been reported that more than 87 million people have had their personal information exposed through data scraping (ABC 2018). Those scandals demonstrate the need for strong and effective privacy and data protection laws and enforcement, while still maintaining a workable open data system. To that end, the EU GDPR may also require a ratcheting up of global data protection standards, and Australia should look to that Regulation to guide the augmentation of local data protection laws.

Figure 4: 3D Google Earth representation of the City of Melbourne

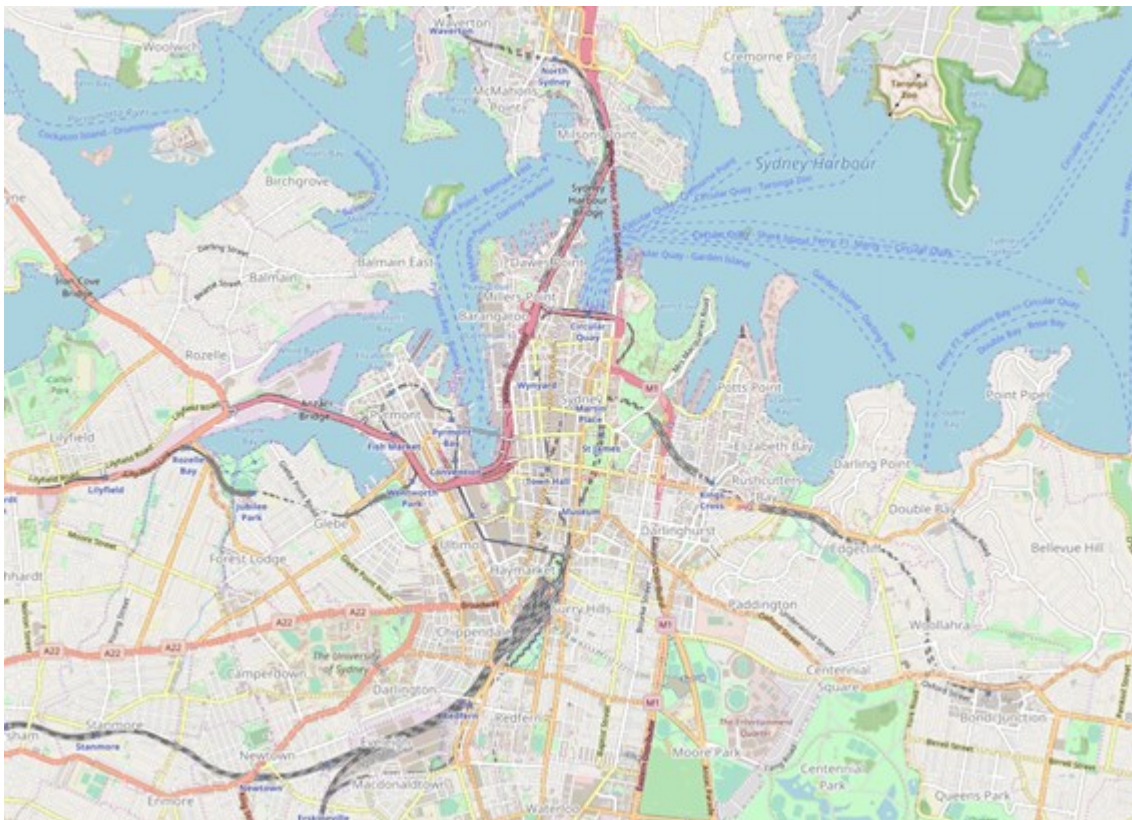


Source: <https://earth.google.com/web/>, accessed 22 April 2018

Whilst there is the proliferation of commercial data offerings being developed, there is also the parallel growth of open access data created through crowdsourcing initiatives. The most notable of these is Wikipedia which has been created through the collective wisdom of individuals

wishing to contribute their knowledge freely. With respect to geospatial data, the most comprehensive open data initiative is Open Street Map (OSM). OSM began in 2004 and is a collaborative mapping project with the goal of creating a free and editable map of the world. OSM is licensed under an open database license as developed by the open data commons. It provides fairly comprehensive data for a number of cities and regions across Australia (Figure 5). OSM is useful for many urban applications including street network analysis, yet, it does not currently include as rich a source of urban data as a number of commercial offerings, where for example the attribution of building footprints and height is incomplete across much of the built environment in Australia. Commercial offerings such as PSMA's Geoscape product include detailed urban data for every address across Australia.

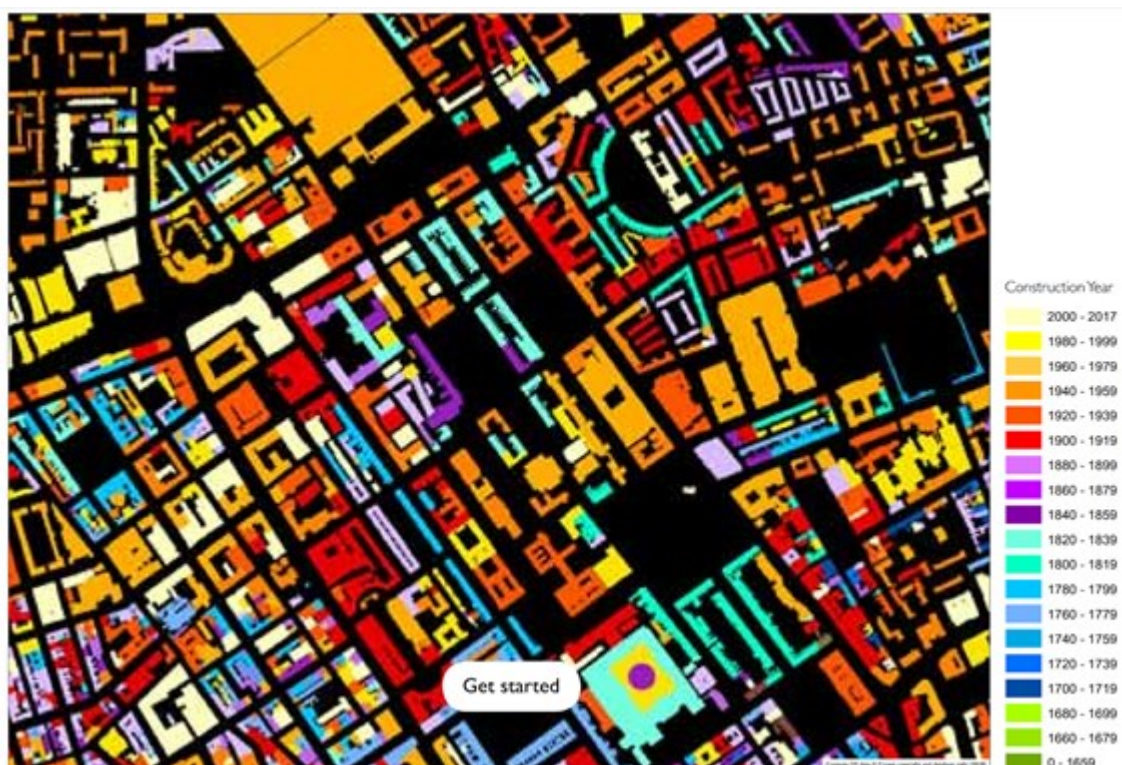
Figure 5: Open Street Map data available for Sydney



Source: <https://www.openstreetmap.org>, accessed 22 April 2018

Another significant crowd-sourced initiative is Colouring London (<https://beta.colouring.london/about.html>), which has been established to capture fine scale information on building characteristics including building age, size, and construction material (Figure 6).

Figure 6: Colouring London—Crowdsource building information project



Source: Polly Hudson, CASA UCL

All of the above are creating the foundation upon which open data can become universally functional, both inside and outside of the organisation collecting it, providing smaller organisations, such as municipalities, the tools they need to construct their own systems and capture their own data.

2.2 Geographical Information Systems for urban planning

The broad acceptance of applications such as Google Maps is indicative of the accessibility, cultural normalisation and power of map-based tools. The growth in use of spatial information has also grown within organisations, with the vast majority of large businesses having a unit, or at least an individual, compiling and managing spatial data along with traditional business data. This growth in the use of geo-coded information has also spread to government, with all state and municipal authorities now reliant on geographic information systems (GIS) to hold, sort and view almost all of their datasets. And even in the event where the data is not geo-coded, it will inevitably have a link to a mapped object, such as a cadastral parcel, point of interest, road centre line, suburb or other significant land subdivision. It is, therefore, safe to say that GIS and geospatial data provide the majority of organisations' evidential data and form the core of government digital intelligence.

In terms of foundational GIS, there are three main systems, all of which perform similarly regarding functionality. Presented in terms of adaptability, QuantumGIS (QGIS) is an open source system allowing for the storage and manipulation of spatial data (QGIS 2017). Due to being open source in nature, and openly promoting the development of plugin applications and tools by its users, QGIS is the standard for small scale operations that may not be able to afford the licencing of the larger products, though it is beginning to be used by many municipalities and larger organisations also. MapInfo (Pitney Bowes 2017) is the second industry standard and is adaptable through its mapbasic language. This package is second only to ESRI's ArcGIS

(ESRI 2017a), which is the most prolific system in terms of global use. All systems, as well as other unmentioned products, allow for data storage, geocoding, manipulating, overlaying and querying geospatial data, and are the most fundamental spatial tools. As discussed in Section 2.1.1 above, the data used in these systems is typically a mixture of open and closed data.

The next level of spatial analysis lies in the development of bespoke tools, typically used for scenario modelling. These have to be constructed, in part by a software developer and in part using existing technology. Without being overly technical, each of these systems requires an interface to view and manipulate the data (web page or application window), a database (e.g. MongoDB, SQL) to hold the data and some middleware to serve the data to the interface (e.g. postGIS). The combination of these software components, with the operational logic provided by a programmer, is capable of producing digital planning tools such as ENVISION, ESP, RAISE and What if? (discussed in Appendix 2).

A final level of complexity is introduced when the visualisation moves from 2D (maps) to 2.5D (extrusions on a map) and 3D (three-dimensional mesh models on a map). As with the above, this incorporates utilising an existing technology, such as CityGML (OGC 2017), Cesium (2017) or City Engine (ESRI 2017b), which are, respectively, a set of libraries enabling visualisation of urban objects, a full online architecture for visualisation and inspection of 3D objects and an ESRI product for urban modelling. By introducing these technologies users are then able to traverse the virtual landscape and the objects (which will be loaded with data) within the map as illustrated using Google Earth in Figure 4.

In Australia, the costs of installing and maintaining many of these platforms are quite prohibitive for government and commercial purposes. As a result, this provides barriers for community groups, start-ups and small to medium enterprises to access and use these systems, unless they are using open source software such as QGIS.

A number of councils and state jurisdictions have set up ePlanning portals to move from a paper-based system to online support for businesses and community to access and transact with planning services, as in the case with the NSW Planning Portal (<https://www.planningportal.nsw.gov.au>; Huxley, Williams et al. 2014). This ePlanning system has been modelled on the Danish Plansystem DK ePlanning portal which, as of 2014, included more than 40,000 active plans, and supports about 500,000 downloads of plans annually from the portal (Larsen, Hudson et al. 2014). Of notable difference in Denmark is the role of the National Government which has a Planning Act, for which the Minister for the Environment retains a general supervisory role over the planning system as a whole (Larsen, Hudson et al. 2014). Hence, the Plansystem DK resides as a national ePlanning digital infrastructure (<https://eng.naturstyrelsen.dk/planning/plansystemdk>). It is important to note that the use of the NSW Planning portal has been legislated through the NSW Environment Planning and Assessment Amendment Bill 2014.

As mentioned, all state and municipal departments are moving towards the geocoding of their data, which enables lay users to quickly explore various data layers instantaneously. This is being supported by demands on developers to submit digital planning documents through ePlanning portals, as for example, in the City of Moreland. The next step in the maturing of the ePlanning portals is to enable the submission of 3D models of development proposals, which, when approved, can easily be added to 3D massing models of the municipality, which will, over time, generate a full 3D municipal model. However, barriers of adoption for the realisation of full 3D city models include the capacity and capability within government to work with Building Information Models, and the 3D database infrastructures to support these 3D models.

2.3 Blockchain platforms and applications

The Australian housing system relies on information stored within public sector infrastructures. Property rights are recorded in carefully maintained ledgers of dealings (including the Torrens system of land registration), which create agreement in matters of ownership and enable the enforcement of rights. This ‘stack’ of data, physical servers, and regulation (Bratton 2016) reduces uncertainty in housing markets and enables credit systems to operate. Commercial intermediaries including real estate agents and banks interact with these records and contribute additional layers of information, brokerage and financial instruments.

While the internet has enabled greater efficiency in some housing related processes—such as online real estate and mortgage advertising and online transactions, e.g. Property Exchange Australia (PEXA), whose staff attended our Melbourne workshop—it has not fundamentally changed the ledger of transactions or its management. Internet protocol is not equipped to transfer value in a trusted fashion. As a result, bureaucracies, banks, lawyers and estate agents are still required to perform the institutional arrangements that make property ownership possible, including the enforcement of transactions, the granting of exclusive use, as well as transferability and inheritability. Data is managed in central repositories and protected against security breaches at significant public expense.

The blockchain protocol, unlike internet protocol, enables the transfer of value without the need for intermediaries (Swan 2015; Monegro 2016; Tapscott and Tapscott 2016). A blockchain is a ledger of transactions that operates and updates simultaneously across a multitude of participating computers (‘nodes’, using peer-to-peer communication protocol). The distributed nature of the technology enhances data security as it cannot be attacked at a central point. Blockchain transactions are linked, verified and updated using cryptography. As a blockchain updates only when there is computational agreement from the network that a transaction has occurred, a value cannot be spent twice.

The blockchain economy—or ‘cryptoeconomy’—is therefore fundamentally different from the digital economy we have known to date. While the web 2.0 economy has been characterised by centralising forces, resulting in large companies that handle transactions on our behalf, the cryptoeconomy theoretically does not require the same market or government mechanisms for trusted transactions to be achieved, potentially doing away with current processes of licensing, self-regulation and branding. Instead, peer-to-peer transactions, as well as direct, transparent incentives for participation, are the foundations of the cryptoeconomy. In the short term, for Australia’s housing system, blockchain technology could create significant efficiencies, including land title processes. This would involve the use of blockchain technologies in the service of traditional governance functions like data registration and management. In the longer term it may also bring about significant transformations in the housing sector by automating reference checking, access to property, and property or tenancy escrow. Blockchain startups are also beginning to address the collection and sharing of geospatial information, such as the recently launched platform FOAM (<https://www.foam.space>). As discussed in Section 4.1, these transformations provoke questions around the new institutional dynamics that these technologies introduce, as well as their relationships with existing structures of law and governance (Reijers, O’Brolcháin et al. 2016; Yeung 2017).

A key attribute of blockchain is that those developing and using blockchain platforms and applications are incentivised to participate. Blockchain platforms reward participants who perform the computational processes that produce consensus on a blockchain and resolve glitches (known as ‘miners’). Blockchain applications can also be created with in-built protocol tokens, typically designed so that only a finite number can exist to ensure scarcity and price. Tokens monetise products and services; they are used to access a particular service and can be earned or traded on secondary markets. For instance, a blockchain application that

facilitates electric cars to charge at privately-owned charging stations will require that a car purchase the power by transferring an amount of the app's native tokens to a charging station (such as Share&Charge: <https://shareandcharge.com>). The owner of the car might initially purchase the tokens using fiat currency (or other tokens and cryptocurrencies), or by earning them through their own charging station.

Power Ledger is another example of blockchain where homeowners can trade homegrown units of electricity known as Sparkz directly to their neighbours in what is referred to as peer-to-peer energy trading. These Sparkz are backed up by a blockchain platform known as power tokens. Power Ledger has been developed in Western Australia (WA) and has been successfully trialled with homeowners in Busselton, demonstrating those with solar panels could get a better return (<https://powerledger.io>).

A significant question is the extent to which blockchain can reduce market friction and regulatory burden to achieve public policy goals. Disruptions in the housing system may occur due to reductions in transaction costs from the automation of bureaucratic and banking processes. In economic theory, complex evolving systems typically move from centralised to decentralised systems (Coase 1960); centralisation enables enforcement and creates knowledge system rules but can also come with costs (corruption, inflation, security costs). Decentralisation occurs when the costs of centralisation rise and the costs of decentralisation fall, often due to technological progress (Davidson, de Filippi et al. 2018). In the case of blockchain, efficiencies that are achieved in land registries, for instance, might also enable complex title arrangements for co-ownership to evolve, possibilities that are currently not pursued due to onerous administrative requirements.

If integrated with IoT technologies, smart contracts can also be deployed to manage access rights to properties. The German company Slok.it, for example, is developing blockchain-based IoT systems, including web-enabled locks, that can provide access to properties according to coded smart contract conditions. The company also intends to extend these systems to include numerous web-enabled objects (not just locks). These objects can have their own 'identities' that interact with a blockchain, meaning secure machine-to-machine transactions may soon extend and transform what we currently think of as the sharing economy. Other examples of blockchain applications are described in Chapter 4.

2.4 Automation

There are multiple forms of automation that may influence the provision of housing services in various forms. In the US, there are already examples of automated systems that coordinate between users and suppliers of housing services (Eubanks 2018). For instance, 'Coordinated Entry' and 'Homeless Management Information Systems' are projects that automate needs-based identification, assessment, referral and assistance for homeless persons. There are also many automated decision making systems in Australian administrative governance, and the number is likely to increase. Data61 at the Commonwealth Scientific and Industrial Research Organisation (CSIRO) runs the 'Regulation as a Platform' project in Australia, wherein government entities partner to have legislation or policy documents translated into automated decision making digital systems. The use of such systems by government generally requires enabling legislation. Such legislation has, to date, facilitated the use of automated decision making in:

- taxation (including systems that describe whether an individual is an employee or subcontractor);
- determinations for eligibility for social security, including compensation in Military and Veterans Affairs (that system uses a digital reference library of up to 260 injuries and diseases);

- determinations for child support and defining familial relationships between parties;
- media content classification;
- health records management;
- mining royalty administration;
- migration and visa decisions; and
- customs duties and importation permissions.

Existing decision making systems used by government are typically of limited sophistication. They generally fall into the category of 'expert system', whereby legislation or policy documents are translated into algorithmic decision trees (or flow charts). Their potentially damaging limitations were demonstrated by the Centrelink 'RoboDebt' scandal (Terzis 2018).

Nevertheless, these systems are increasing in scope, sophistication, and use. Their use in determining the provision of housing services and assistance seems highly feasible. As these systems adopt more machine learning functionality, they also become more complex and difficult to regulate (see Section 4.2). Nevertheless, it is likely that automated systems will be further deployed in various social welfare programs, including systems that establish eligibility and priority for social housing and other housing related services.

Automation is also a feature of blockchain technologies. Some blockchain technologies enable the use of Turing-complete programming languages to write programs that can be uploaded on a blockchain. These are sometimes called 'smart contracts', although the name is somewhat problematic as the connection to traditional legal contracts is relatively tenuous (Werbach and Cornell 2017). Nevertheless, these software agents can perform transactions between parties on the triggering of certain conditions without intermediaries. Parties pay crypto-tokens into the contract, which holds them until an event or condition triggers their distribution. This is why blockchain protocol is sometimes discussed in the context of 'the internet of agreements' (Gupta 2017), as the underlying code can be used to automate processes, not just financial exchange. Therefore, while the internet was transformative at the communications layer, blockchain can potentially disrupt governance systems and markets far more directly. Transaction and process automation using smart contracts may similarly have applications in housing services in a manner different to rule-based automation. Possibilities for smart contract applications are discussed in Chapter 3.

3 Implications for the Australian housing system

- Blockchain offers significant benefits to those jurisdictions that do not have in place a Torrens system for land registry, but its benefits for the titles registry system in Australia remain unclear.
 - Co-ownership of property could be facilitated more easily through blockchain, although this will only occur once significant work has been done to address legal entitlements related to smart contracts, and when compliance with securities and financial product regulation has been determined.
 - Digital planning tools are in the early stages of adoption and hold promise in providing more rigorous data-driven support to urban planners and policy makers in exploring sustainable housing futures.
 - Policies and databases that activate a real-time property vacancy listing may improve efficiencies for Community Housing Providers in checking for stock availability and suitability for clients.
-

This chapter maps out a number of ways in which emerging technologies may influence the current Australian housing systems. These include applications in title registrations, private housing sales, planning and the built environment, and social housing provision and allocation.

3.1 Implications for titles registration

For land registries and property transactions, there are multiple jurisdictions exploring the possibility of blockchain-based solutions for both registering and transacting in land ownership (van Erp 2017). A number of nation states—for example, Ghana, India, The Netherlands, Brazil, Ukraine, Japan, Russia—and US states have experimented with putting land titles onto blockchain platforms. The State of Illinois in the US is keeping a tracker of blockchain in government initiatives, which lists a dozen current land registry projects, including two which are in production or live (the Republic of Georgia and Ghana, <https://airtable.com/shrelXQjzluCxm37/tbl7qVDFKkiEcFFrc>).

Aside from reducing the costs of maintaining legacy land registry records, these initiatives are the foundation for other so-called ‘proptech’ (property technology) innovations, e.g. establishing a global market for peer-to-peer property sales and leasing requires trusted records of when a purchase has occurred. Ukraine has entered into a partnership with blockchain start-up Propy, initially transferring land titles to the blockchain, with the ultimate goal of attracting foreign investors through greater certainty and efficiency in the sales process.

The most promising applications in this context appear to be those that either address a lack of trust in governing institutions, or address the possibility of fraud. The former application is, therefore, most relevant in the development context, whereas the latter application would apply in deed-based property systems, where there is no central register verifying property ownership. Since the introduction of the Torrens System in Australia (implemented in Victoria in the *Transfer of Land Act 1958*), Australian state governments have maintained a register of property ownership. Each parcel of land has a volume and folio reference, through which any relevant rights holders can be identified. The legal significance of the register is that title vests through the act of registration. In other words, the Torrens system is not a system for registering

title but rather a system of title by registration. Registration generates an 'indefeasible' title—i.e. a registered proprietor is taken to be the owner unless fraud can be proven. This means parties that transact or create interests in land need only look at the register to identify any relevant interests in land. There is no need to examine the chain of title for errors, discrepancies, or underlying interests, and any non-registered interests (except certain paramount interests like a tenant in possession) are destroyed when a party without notice of those interests registers as owner. Title documents under this system are already digital. The Torrens system also includes an insurance scheme for compensating those that suffer damage as a result of the indefeasibility of the register.

The Torrens system, when used in Australia, offers a secure, trusted and relatively efficient mechanism for managing ownership of real property. According to participants in the workshop involved with property transacting, it is therefore difficult to see applications for a blockchain based real register, despite whatever additional efficiencies it may bring. The transaction volume for real property is unlikely high enough to really benefit from automation, and the Land Titles Office is a trusted and secure institution. There was some discussion at workshops about the feasibility of using blockchain as a centralised database technology for title registration in the form of a 'private blockchain'. However, participants also questioned the utility of blockchain for title registration if there were no decentralised incentive mechanism. There may be scope for using a blockchain for interests that cannot be registered under the *Transfer of Land Act*.

These interests may include, for instance: short leases, equitable leases, other equitable interests like trusts, or rights associated with adverse possession. However, it is unclear whether registration of those interests on a blockchain could constructively fix third parties with notice such as to make the elimination of those interests through Torrens registration (and taking possession) a species of fraud. Similarly, there may be value in creating a registration system for the remaining parcels of Common Law Land (i.e. land that has not been brought under the Torrens system) to reduce the possibility of fraud, and to reduce the expense of searching the chain of title to identify any existing interests. But this would also require a legal mechanism to fix parties with notice to be effective, and it involves a relatively insignificant amount of land in Australia.

Ultimately, workshop participants seemed to think that rather than replacing the existing land title registration system, blockchain platforms would be better suited to the recording of new categories of information (not otherwise recorded on titles). This might be information relevant to limitations on land use, for instance, types of restrictive covenants or limitations on selling land for profit as have been implemented in some new private housing options (i.e. Nightingale Housing). It could also be information relevant for leasing such as maintenance records. Participants expressed an ideal situation where this type of land use and title information were linked directly to cadastral systems. In these far broader systems, workshop participants (like REXmls) discussed the utility of blockchain platforms for incentivising the contribution of information through token systems, while at the same time noting that full transparency on a blockchain may not always be desirable.

In a Torrens jurisdiction, it is accordingly unclear what a blockchain-based register could afford in terms of legal rights that would constitute an improvement over existing mechanisms. Beyond Australia, most Commonwealth countries (as well as some others) use Torrens-like land registration systems, including Canada, Dominican Republic, Ireland, Israel, Malaysia, New Zealand, Philippines, Russia, Singapore, Thailand, and some states of the US. There are also equivalent concepts (i.e. registration systems) in some civil law jurisdictions. Jurisdictions without effective land registration laws and institutions may accordingly pursue new database technologies in this area, but it is unlikely that those with Torrens and Torrens-like systems will. It is unclear how the increasing privatisation of land registries across Australia might change the techniques and technologies of registration and transaction. It is possible those entities may

explore blockchain based systems in an effort to improve efficiency and automation in providing their functions under the Torrens system. However, there are numerous alternative database systems capable of automation that would also be useful (Ammous 2016). Further, title registration will remain a monopoly activity, limiting the types of transactions that could legally potentially be performed by smart contracts.

3.2 Implications for private housing markets

Blockchain platforms are being used to develop a range of different property-related applications. Automated property transaction platforms require that those rights are encoded on a blockchain (Fairfield 2015), as well as systems capable of automating contract obligations under arrangements such as leases, licenses and short-term rentals. For example, so called 'smart tenancy products' are being developed that can hold bonds in escrow, automate rental payments, and manage maintenance workflows (Egbertsen, Hardeman et al. 2016). There is interest in using the technology for listing services that include incentive mechanisms for supplying information about listed properties. Currently nascent models of fragmentation of property assets may also become commonplace as blockchain technology evolves, creating greater liquidity in property.

A number of blockchain companies are creating tokens that represent fractions of a property (including Propy, Atlant, Pangea and LAToken). The owner of a property can sell tokens that represent shares in that property, thereby creating greater liquidity of real estate assets. Some platforms are building in smart contracts whereby any rental dividends are automatically paid to token holders (investors). For example, Blockchain start-up Meridio claims to be tokenising \$100 million worth of real estate assets in the US, as well as similar amounts in Germany and Dubai. The first offering was for tokens representing shares in an apartment block in Brooklyn, which can be traded to others on the platform.

As blockchains can store or reference records, and a significant development in proptech is the ability to verify records in real-time or see a property's entire rental and maintenance history. Property development may also be transformed by transparency in supply chains during the contracting and building process. Companies working on this, such as Bitrent, are promoting blockchain as a means to crowdfunding development and attracting smaller investors (potentially from across the world), whilst providing investors with real-time information on the construction process to help them make investment decisions.

Technology participants at our workshops suggested that blockchain applications could be developed that provide private property owners with incentives to list properties on public housing registers. For instance, tokens could be issued in a voucher-style system, and possibly even shift in value according to supply and demand.

Most of the blockchain use cases outlined above seek to reduce transactions costs—for instance eliminating the fees associated with purchasing property—through smart contracts. At least for now, they do not signify a major change in how property is bought and sold. For instance, start-up seeking to tokenise shares in property, or to crowdsource funding for construction projects, will need to comply with Australian corporate legislation. Systems of property products or interests represented by tokens might constitute managed investment schemes or share issuances, which require significant compliance with securities regulations. To legitimately sell tokens representing equity in a property, an owner would need to establish a Real Estate Investment Trust (REIT) and keep a register of token owners. Australian company BrickX already offers investors with the ability to buy a fraction of a property that it owns, and which it has turned into 10,000 'bricks' whose value is proportionate to the original sale price of the property (see also Bricklane in the UK). International experiments also seem to be

conforming to these requirements: Meridio is working with a REIT to offer tokens in the Brooklyn project and similar projects.

Moreover, as discussed during the co-design technology workshops, home reversion schemes already provide some level of liquidity, by offering homeowners in Melbourne and Sydney the option of selling part of their equity and forgoing future profits on that share of the property. It is noteworthy that home reversion products are only available in Melbourne and Sydney where real estate prices are most likely to increase (Kollmorgen 2016). Co-ownership of property is also possible without blockchain via Tenants in Common legal agreements. Timeshare arrangements are also a financial product that has enabled shared property ownership along with rights to occupy that property under agreed terms. Equity release (including reverse mortgages) and timeshare products have attracted scrutiny from consumer organisations such as Choice, as well as regulatory agencies (ASIC 2005; de Silva, Sinclair et al. 2016). Blockchain securities are already being scrutinised and regulated in many countries, including Australia.

However, the promise of blockchain is that by simplifying the processes involved in selling property, or portions of property, significant shifts might occur even without substantial regulatory change. Some blockchain proptech companies are basing their business model on social equity arguments. For instance, Meridio claims the platform may one day provide an entry point into the property market for those who cannot afford an entire property (although currently the platform is restricted to accredited investors as per US securities regulation). In addition, it might provide tenants with a means to own a share in the property they live in—a seemingly mutual benefit that would incentivise good behaviour among tenants and owners as the tenants would receive some return if the property is sold.

The main difference between existing REITs and blockchain property tokenisation (other than fees) is that it gives the buyer complete control over what they purchase, as opposed to relying on the decisions of a portfolio manager, which can come with high fees. Those holding property would be able to do so using the same ‘wallet’ technologies that are used for other crypto assets. Tokenisation of property, therefore, accords with a blockchain economy in which users of platforms have control over the assets they own, as well as easily accessible and secure data. However, it is likely that greater liquidity and speed in property markets will benefit some socioeconomic groups over others, as argued in works on intergenerational transfers and equity (Barrett, Cigdem et al. 2015). Furthermore, as tokenised property securities facilitate speed in property transfers, it is possible that these technologies will enable investors to manipulate real estate markets for the purposes of margin trading, as is purportedly being done in cryptocurrency markets, leaving home owners financially vulnerable.

Workshop participants (such as CHOICE) also expressed interest in blockchain platforms for addressing what was described as a ‘broken’ market for residential tenancies, by providing more transparency and information symmetry between owners, agents, and tenants, as well as potentially disintermediating leasing (removing the role of real estate agents) and directly connecting owners and tenants. This was connected to the discussion of blockchain platforms for property listing services. Participants also expressed interest in the idea of using smart contracts as an escrow system for private rental bonds (despite that being contrary to law in most Australian jurisdictions).

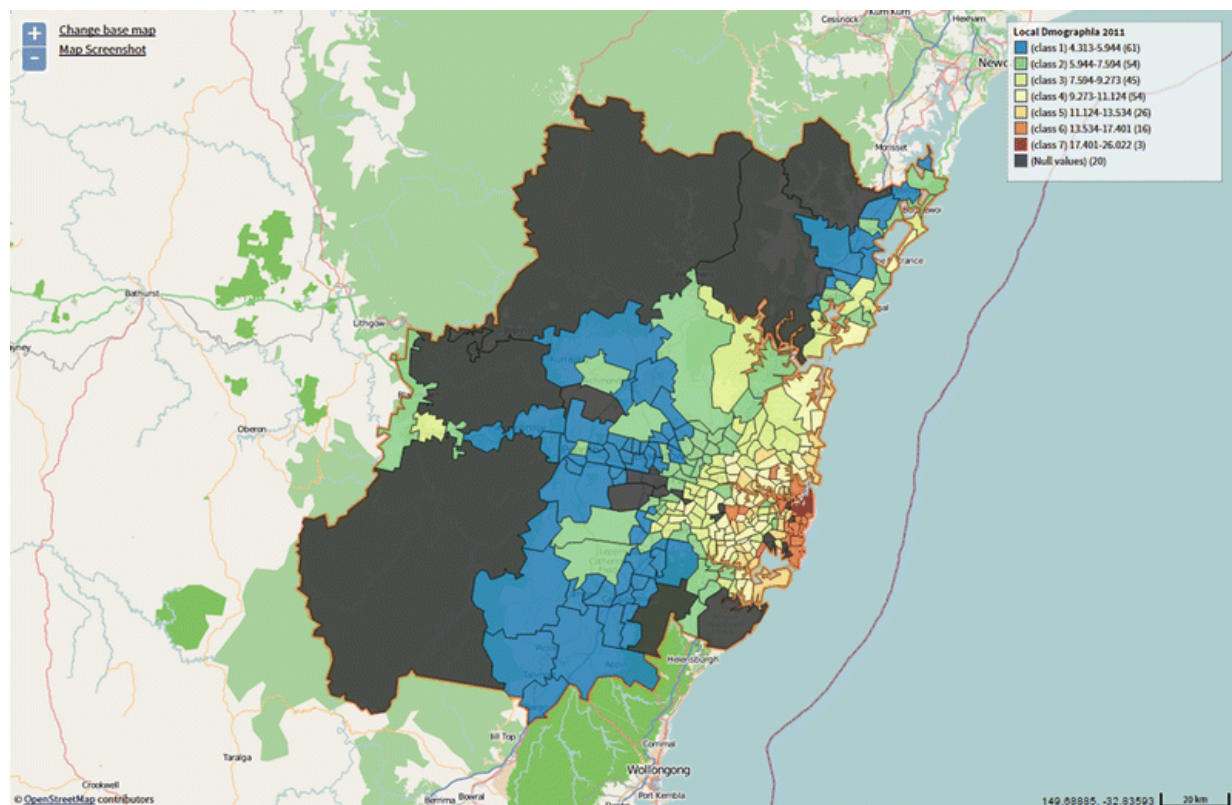
3.3 Implications for planning and the built environment

Technology is changing where and how housing is provided, as well as assisting in planning more compact cities and sustainable precincts. ePlanning systems, which require digital applications, combined with a mass migration of data from all spheres of government to some form of geocoding, and growing access to spatial tools, are resulting in systems that can be used by non-experts to access almost all data holdings in an organisation simultaneously. This

near immediate access to an evidence base allows officers to be far more informed of the broad policy implications within their portfolio, enabling them to consider the ramifications of decisions made across multiple sectors. While urban planners have long used GIS to support planning decisions, advancements in GIS means more complex modelling is now performed to more accurately predict final outcomes (e.g. Lotteau, Yepez-Salmon et al. 2015). We are also seeing the emergence of monitoring and tracking technology, such as that used by Wattblock in Australia, is helping strata-titled buildings achieve and exceed renewable energy and carbon reduction targets (Aliento 2016). However, access to these systems, and ensuring that organisations have both the data to engage with them and the capacity to utilise them, is resulting in poor uptake by government, due to a number challenges discussed in detail in the next chapter.

Attempts to reconcile the need for accessible urban and housing data have resulted in university-led portals, such as the Australian Urban Research and Infrastructure Network (AURIN). AURIN has been funded through the National Collaborative Research Infrastructure Strategy (NCRIS) and provides access to over 3,500 datasets and 100 spatial statistical tools for undertaking urban analytics across Australia's cities and regions (Sinnott, Bayliss et al. 2014; Pettit, Barton et al. 2015; Pettit, Tanton et al. 2017). The AURIN portal provides aggregate access to public and private sector datasets including property data from the APM that has been used by academics in undertaking housing studies related to affordability (Figure 7; Pettit, Barton et al. 2015). AURIN also comprises an application program interface (API) where industry, government and academics can programmatically access datasets and ingest these into their own GIS and software packages to conduct urban analysis.

Figure 7: Median Income to median sales prices in Sydney 2011



Source: Pettit, Tice et al. (2017)

A suite of university developed GIS Planning Support Systems (PSS) now exist for a variety of bespoke operations and are gradually gaining traction in their application across Australia

(Pettit, Bakelmun et al. 2017). ENVISION and Envision Scenario Planner (ESP) allow planners in state and local government to identify areas that will undergo transformative change and assess the future outcomes of these sites. These systems provide experts with a greater understanding of change in urban fabric at a lot-by-lot level across the entire metropolitan area (Glackin 2013; Trubka and Glackin 2016; Trubka, Glackin et al. 2016). Another university-led system, Rapid Analytics Interactive Scenario Explorer (RAISE), allows planners to assess the value uplift of housing based on the addition of new infrastructure. This allows planners to have a fuller understanding of the incentives and potential revenues that can come from infrastructure investment and assists with the development of 'City Plans' (Figure 8; Lieske, van den Nouwelant et al. forthcoming).

The GIS based What if? PSS was developed to run future city scenarios driven by population and employment projection. What if? has been applied in a number of jurisdictions across Australia, including Queensland, Victoria and Western Australia (Pettit, Keyzers et al. 2008; Pettit, Klosterman et al. 2013; Pettit, Klosterman et al. 2015). What if? enables future housing growth to be forecast based on a number of planning and policy considerations. The What if? tool is open source and can be used by government, academics and industry to model future land use scenarios anywhere in the world where the required data is available (<https://aurin.org.au/projects/portal-and-infrastructure/what-if>). Additional software systems exist to calculate the Urban Heat Island effect (Santamouris and Kolokotsa 2016), stormwater flow in urban environments (Löwe, Urich et al. 2017), walkability (Badland, White et al. 2013; Boulange, Pettit et al. 2017; Boulange, Pettit et al. 2018; Giles-Corti, Macaulay et al. 2014) and many others (<https://docs.aurin.org.au/projects/planning-support-systems>).

Figure 8: RAISE tool being applied in Western Sydney for exploring residential value uplift scenarios as driven through new transport infrastructure.



Source: Lieske, van den Nouwelant et al. forthcoming

3.4 Implications for social housing

In comparing Australian CHPs to those in the UK and the Netherlands, Milligan, Hulse et al. (2015) reveal investment in ICT as a significant internal driver for improving operational efficiencies and tenant services for CHPs in Australia. Most had already invested heavily in, or were in the process of investing in, new integrated systems that would 'provide more strategic

and management information for boards and executive' (Milligan, Hulse et al. 2015: 32), especially in view of expanded operations through anticipated transfers of public housing stock. Increased ICT investment would also facilitate improvements in tenant services and has already seen expansion in providing additional channels of communication (such as via Facebook and Twitter) as well as new means to provide services, such as app-based rent payment or lodgement of maintenance and repair requests.

All Australian jurisdictions now also operate common social housing waitlists for their respective jurisdictions. In assessing the potential of common waitlisting prior to its introduction to Australia in the early 2000s, Burke and Hulse (2003) highlight the advantages (e.g. cost savings, in terms of both financial and human resources) and disadvantages (e.g. loss of autonomy). While it is still voluntary for CHPs to join, this move towards common waitlisting has nonetheless standardised the assessment procedures, expanded the number of entry points where applications can be made, and generally facilitated better tenant–housing matching. This shows that common social housing waitlisting is important as the functions of public and community housing sectors increasingly converge, especially in the context of estate renewals and tenancy transfers, where standardised tenant and property information is easier to transfer from one provider to another.

A recent Australian study by Blunden, Liu et al. (2017), however, reveals in their evaluation of a South Australian transfer program that Australian state housing agencies sometimes still use outdated systems that have limited functionality and are inefficient to operate. In that case, important information about the tenants, such as support service requirements, detailed ledger of credits and arrears for rent and utilities and condition reports of each property to be transferred, may not be provided to CHPs taking on the tenancies. In these instances, tenant service officers could spend months to assess the transferred tenants' support needs; and the planning of property upgrades, a key performance indicator of many transfer programs, may also be delayed significantly and over budget.

CHPs operating in other jurisdictions, including those that attended our workshops, have reported similar experiences regarding the unavailability of tenant information during tenancy transfers. This could become more problematic, with more transfers and estate renewals scheduled to take place across Australia in the coming years, such as through NSW's Communities Plus, Victoria's Public Housing Renewal Program, and SA's Renewing Our Streets and Suburbs initiative. This demonstrates the importance of system compatibility, especially when the more onerous task of setting up standardised procedures has already been conducted.

The move towards common waitlisting for social housing allocation has greatly improved the efficiency of the system by standardising the application and assessment processes. At our co-design technology workshops, representatives noted the community sectors' appetite for a similar real-time listing of stock vacancies, such as those already available for private rental listings online. Such a real-time listing could allow for better tenant–housing matching, especially with policies such as No Wrong Door adopted by NSW's Housing Pathways (NSW FACS n.d.), where potential tenants now enter the common system via a number of entry points. Under No Wrong Door, housing applications may be received at any 'service delivery' door of participating CHPs. In the case where suitable housing is not available at these entry points, applicants are assisted in finding alternatives. At present, this process relies heavily on established contacts and pre-existing relationships between tenancy managers across regions and providers, and by manually checking for stock available such as by calling up a different provider. A real-time property vacancy listing may better facilitate this process, allowing staff at entry points to check for stock availability before directly contacting the CHP with suitable housing, potentially cutting down search time. This may also allow tenancy managers to search

for properties available at CHPs they do not already have a working relationship with, expanding the possibility of matching an applicant to suitable housing.

Additionally, a dynamic, real-time vacancy listing may allow for better outcomes of transfer and mutual exchange applications. As Wiesel, Easthope et al. (2012: 68) note, while there are formal applications for tenant-initiated transfers, tenants would typically (depending on jurisdiction) need to advertise and arrange mutual exchanges through their own means. Further, such transfers and exchanges are typically restricted within rather than between providers. The creation of real-time vacancy listings may facilitate this, allowing tenants to move to better suited properties and/or locations that are currently not part of their provider's portfolio.

State level policies and client management databases would need to be updated to allow for the creation and sharing of real-time vacancy listings. Cross-jurisdictional policies, especially if inter-provider and cross-jurisdiction transfers and exchanges are to be permitted, would also be needed to ensure that the ultimate control of placement lies with the receiving CHP. Potentially this may be an additional function of the National Regulatory System for Community Housing (NRSCH), though at present two jurisdictions have opted not to join this national system by maintaining their own separate registries.

4 Challenges to implementation

- There are numerous aspects in the housing sector that could potentially be automated to improve efficiency. These include physical access to social housing and rental payment. However, such automation requires serious consideration as to its suitability, especially for vulnerable groups, before implementation.
 - The use and protection of personal data is another critical challenge. While data is the fuel for many new and disruptive technologies, data governance is of primary consideration to ensure personal information is not compromised in the quest for automation and data-driven decision making. This is especially in view of governments' push for open data.
 - Data sharing between agencies and with housing service providers is absolutely critical to ensure performance metrics can be accurately and efficiently reported in relation to social housing and housing affordability targets.
 - Modelling using accurate share data can also facilitate the planning of housing provision (siting, service connectivity and coordination) through advancing technologies in the digital planning space.
-

New technologies challenge existing systems of governance. This Final Report thus far has described how technical disruptions may affect housing systems in Australia in various ways. There are, however, several areas where institutional and structural barriers exist. Legal innovations or reforms associated with these technologies are required in order for these technologies to play a significant role in achieving greater efficiencies. New or amended legislation may be required to ensure people's personal information is protected and their vulnerability is not exploited. This chapter explores some of these challenges facing the different housing systems in Australia.

4.1 To automate or not automate

With increased automation, questions arise as to the new locations of institutional agency, whereby bureaucratic officials are marginalised in favour of software and system engineers with expertise in areas such as digital platforms, data science, cryptocurrency, robotics and machine learning (Eubanks 2017). These new institutional arrangements include highly hybridised technical and legal mechanisms, the potential consequences of which require close examination.

Representatives of housing providers, advocacy groups and support services at our workshops highlighted that automation may not necessarily always be the preferred client service interface. This is especially the case for clientele with increasing and complex needs, such as social housing tenants and other vulnerable groups, where frontline staff are trained to identify these complexities that the clients may or may not disclose, as well as to combat their clients' social isolation. These undisclosed needs may include mental health support needs or maintenance needs not reported by individuals who did not want to be seen as a 'trouble tenant'.

For vulnerable groups, individuals may also have limited capacity or appetite to engage with new technology. Liu and Judd (2016) report that disadvantaged individuals struggled to access information on welfare support such as energy rebates because they did not know how, or could

not afford home internet, where such information is increasingly made available. Many of their participants also spoke of their distrust of technology such as smart meters, fearing 'big brother' style monitoring by agencies and companies. However, artificial intelligence can also overcome digital inequalities by providing accessibility when it comes to the user interface (voice commands, for instance), or enabling faster information processing for those liaising with clients, thereby reducing wait times. As AskIzzy is demonstrating, artificial intelligence may provide tailored services that are more responsive to a client's needs.

Emerging technologies are raising new ethical questions relevant to housing inclusion and services. For instance, reputation-based automated systems also pose a threat to social inclusion. New technologies are emerging that provide services and advantages to those who meet reputational criteria. While processes such as applying for tenancy have always relied on references, these may become automated through accessing personal data (Malo 2018). For example, Australian company Trustbond replaces traditional bond systems by providing applicants with a score based on social media data. If the applicant meets Trustbond's standards as a 'good online citizen', the company will cover the cost of the bond for a fee (providing a surety bond).

Many of the systems discussed in this report include some degree of automation in an effort to improve decisions or increase efficiency. Automated decision making systems raise several unique legal and governance concerns. In Europe, the use of automated decision making that affects legal or other significant rights is regulated under European data protection law. Similar provisions give individuals whose personal information has been collected and processed the right to object to certain types of processing; some crude right or logic or explanation as to how such automated decisions are made may be replicated in Australia.

Beyond data protection, other jurisdictions are experimenting with mechanisms for 'algorithmic accountability' and transparency. In fact, algorithmic accountability has emerged as a significant field in law and technology research. In the US, the first legislative requirement for transparency in automated decision making systems used in the provision of government services, including public housing allocations (Powle 2018), requires the provision of the system's source code to a new task force to ensure there is no inappropriate bias or discrimination. There are also calls for the introduction of 'Algorithmic Impact Assessments' (Reisman, Schultz et al. 2018) in a similar vein to how 'Privacy Impact Assessments' have operated. It is important to keep abreast of legal mechanisms geared towards algorithmic accountability as they evolve, as their introduction in Australia seems highly likely.

Beyond automation of decisions around provision of housing services, certain automated technologies in combination with IoT technologies, like automated locks, also raise novel legal questions. These systems may afford useful mechanisms for remote access control over property, meaning users of housing services could have technologically assisted access to properties without having to collect keys. However, automating access and prohibition to properties in both the public and private housing markets can be problematic (Kerr 2010). While service providers and landlords may be within their strict legal rights to exclude parties from property once their right to possession is expired, dispute resolution in the property system has typically afforded a degree of discretion and lenience. Similarly, automated rental payment systems challenge the practice of withholding rents or paying rents into escrow, while disputes over property condition maintenance are determined.

There are similar concerns with respect to the relationship between dispute resolution and smart contracts more generally. There has been ongoing debate over the legal status of smart contracts, and whether they represent the entirety of a contract governing the relationship between parties. Despite claims that smart contracts might usurp the need for legal enforcement mechanisms and traditional agreements (Wright and de Filippi 2015), the better understanding is that smart contracts do not represent contractual agreements. Rather, they

should be understood as enforcement mechanisms for agreements (Werbach and Cornell 2017). Where payments or access are defined by smart contracts between parties, these automated systems risk undermining existing dispute resolution mechanisms such as provided by the Victorian Civil and Administrative Tribunal (VCAT). The discretion of a tribunal decision maker cannot be replicated in automated systems that determine access, nor in automated systems that make decisions about legal rights (Karavas and Teubner 2008).

A further difficulty is that, at this stage, once a smart contract is operational on a blockchain platform, there is no way that it can be directed to operate in a manner contrary to how it has been coded. In other words, no injunction or judicial direction can effectively change how a smart contract operates or allocates tokens. Accordingly, these automated systems risk decreasing the effectiveness of legal outcomes. More sophisticated systems that can apportion access (i.e. interact with IoT systems), and manage payments, will only develop once adequate dispute resolution mechanisms are either built into (i.e. equivalents to online dispute resolution) or are enabled by blockchain and smart contract architectures (i.e. smart contracts that can be amended by judicial orders). The former system would also require sophisticated identity mechanisms on blockchain platforms in order that users could be made accountable in the case of disputes. Accordingly, blockchain platforms and smart contracts are unlikely to exclude the need for traditional legal mechanisms and enforcement (Werbach forthcoming). Indeed, a great deal of effort is now being expended on building smart contracting modules capable of completing transactions (like exchanging property rights), however with in-built mechanisms for dispute resolution (Mattereum 2018).

If technologies include automated decision making or profiling systems, for instance in the allocation of services, there may be other regulatory considerations. There are already numerous automated decision making systems operational in the provision of Australian government services, including social welfare services, however these are not governed by Australian data protection law. European data protection law, on the other hand, does include limitations on automated decision making and profiling (EU General Data Protection Regulation 2016), although the effectiveness of these limitations is questionable. The European General Data Protection Regulation that came into force in May 2018 has increased compliance and enforcement with greater penalties. That regulation includes a right not to be subject to a purely automated decision that produces legal effects (Art 22), and a right to meaningful information about the logic involved in an automated decision (Art 15(1)(h)). It is unclear how these provisions will affect the use of automated decision making systems (Goodman and Flaxman 2017; Wachter, Mittelstadt et al. 2017), although it is likely that some general limitation on automated decision making and profiling will be legislated in Australia in the medium term. Any such limitations or requirements will increase the compliance burden for the use of data-driven systems in housing.

4.2 Governance and data security

Compliance with data governance rules is always a challenge for emerging technologies. New technologies and platforms enable new systems of data organisation for behavioural and economic coordination. However, state agencies and larger private entities are limited in terms of how they deal with data through national and state data protection legislation (e.g. the *Privacy Act 1999* (Cth) and the *Privacy and Data Protection Act 2014* (VIC)). These statutory regimes impose rules on the collection, processing and distribution of data when that data is 'personal information'. Although the definition is contentious, 'personal information' can be understood as data that identifies or can be used to identify a person, and that is 'about' a person (*Privacy Commissioner v Telstra*). The Australian definition is considerably narrower than the definition used in Europe, which for instance, takes into account that anonymous data may still identify a person when linked with other datasets (*Patrick Breyer v Bundesrepublik*

Deutschland). In any case, it is likely that the majority of data collected and shared by housing and associated services concerning clients would be personal information and governed by data protection law. It is less clear that general data about use of services that did not necessarily include identifying information, or had been de-identified, would be considered personal information. If housing information were de-identified for the sake of participating in an open data system, it is unclear whether de-identification would diminish or even eliminate its value, or whether certain levels of specificity could be included that might still take the material outside the definition of 'personal information'.

Privacy and data protection obligations apply to national and state level government departments, public sector agencies, bodies established by an Act or Minister appointed for a public purpose, contracted service providers under a state contract, as well as private entities that turn over more than \$3,000,000 annually.

The primary obligations for relevant entities with respect to data collection, use and distribution are set out in the Information Privacy Principles. Of highest relevance to the development and deployment of new databases and data sharing arrangements in the housing sector, are 'use' and 'disclosure' requirements. These are known as purpose specification rules and prohibit entities using or disclosing personal information for a purpose other than the primary purpose for which the data was collected.

The relevant exceptions to this rule are that the use or disclosure for a secondary purpose is both related to the primary purpose and the identified individual would reasonably expect the organisation to use or disclose the information for that secondary purpose. Other exceptions include if the individual has consented to the use or disclosure; if the use or disclosure is necessary for research or the compilation or analysis of statistics, in the public interest, and is not published in a form that identifies an individual; or in a situation where it is impracticable to seek consent, and the entity reasonably believes that the organisation that receives the information will not subsequently disclose the information. Public 'open' housing data systems may satisfy this latter exception. However, this will depend on the particular applications, entities, and purposes for using the data. Further requirements also exist around data quality, data security, affording rights of access and correction, although canvassing these is beyond the scope of this report.

In short, workshop attendees saw data regulation, the ability to access it, and having it in a form to allow its integration into pan-institutional systems, as some of the most significant barriers to the utilisation of technology.

'Having data in a consistent format between organisations is really difficult. The format, classification, etc. is going to be different'

'We don't even know about contamination, so when you buy a [social housing] place you have to spend 600,000 on cleaning it up'

'If we had the data we could plan for change, and we can also see where infrastructural needs are. Then we could see it all. We can't now'

'Most issues in the municipal planning come from the private rental sector and having to get lots of housing in. Then Transport tell us to go do a \$200,000 transport analysis, but if we had that data we could make our jobs easier.'

Dealing with this problem still requires sensible laws and trusted institutions. At present, Australia's privacy, information and data protection bureaucracies and institutional structures are woefully underfunded and inadequate. Powerful and independent Information Commissioners and Privacy Commissioners would be a useful first step to ensuring that existing legislation were properly enforced.

At the time of writing, there is no Australian Privacy Commissioner, no constitutional or common law right to privacy, and no right to data protection. Mechanisms for enforcing rights granted to individuals under the *Privacy Act 1988* (Cth) are weak and limited, and there are very broad exceptions. Australian data protection laws also typically do not apply to individuals or small businesses (that turn over less than \$3 million annually). And the definition of ‘personal information’ is presently not considered to cover browsing histories, geolocation data, or IP addresses. The definition also likely excludes data collected, disclosed, processed and operationalised through IoT systems.

Ultimately, the introduction of successful open data systems should include the introduction of a robust infrastructure capable of considering how particular datasets should be treated, what type of processing should be permissible, and for what purposes that processing should be used. While some of this might be dealt with by the new entities proposed in Australia’s inchoate data availability framework (described below), our suggestion is the introduction of entities similar to European Data Protection Authorities (or the upgrading of existing entities accordingly). These bureaucracies have become necessary to ensure that there is adequate knowledge and skills in dealing with these issues, and mechanisms for certification, auditing and compliance of open data programs and automated decision making systems.

4.3 Open data versus data silos

Open data is part of the Department of Prime Minister and Cabinet’s *Open Government National Action Plan 2016–2018*. Legal reforms are accordingly being rolled out to make data more available for use in open data systems. One example is the Australian Productivity Commission’s proposed Data Sharing and Release Act (Productivity Commission 2017), that suggests new institutional structures for data sharing and release, and new centralised permissioning systems. Under this regime, a National Data Custodian would be created in order to accredit and audit a suite of Accredited Release Authorities (ARA), being ‘sectoral hubs of experience’ that develop, integrate, and anonymise datasets; and approve trusted users of sensitive data. The ARAs then accredit trusted users for access to data governed by the ARA.

This system is intended to address the reality that, due to the division of interest, governance and business models, useful data stores are distributed, discrete, in some cases privately-owned, and largely non-interoperable. This has led to canonical datasets that, while not being global in their data capture, are accepted as the best attempt—in terms of geographical coverage, backwards compatibility, reliability and data richness—to capture a specific field. According to our workshop participants and as noted in Chapter 3, there is generally a lack of standardisation across actors and institutions that results in different actors and institutions operating different systems. This could be due to siloes, both internal and external, that create non-standardised data. As our participants explained, various functions within an organisation—or the same functions across different organisations—may record and code data differently. Such differences may be due to the specific needs of each organisation and their respective internal functions (e.g. asset management of a CHP would require different information than accounting, though the rent received from and expenses incurred by a particular property would ultimately impact on longer term financial planning), as this participant explained:

‘The big organisations have different sections for strategic, funding and data. In education, for example, they collect on cost of maintenance, but not about capacity—which they could have done. So there are siloes within organisations. So the guy looking at pipes won’t care about how it could benefit VicRoads.’

These siloed effects may also be the outcome of the funding they each receive to perform that data collection (e.g. different grants requiring different reporting periods and variables, and the

collection and use of specific databases are supported by dedicated business cases). Participants noted that no government organisations would have a funding base across all departments that would facilitate integrating and standardising data collection and maintenance, let alone across agencies. Human resources, sometimes tied to funding, may also be limited:

'A repository of all works is required, but it's not viable as we don't have the staff, the coordination or the resources or the relationships.'

As an outcome, data collection is fragmented, and data quality may vary, resulting in incompatibility and data gaps:

'The big central agencies are not great at it. Councils also own infrastructure, like pipes and water. So planning for infrastructure is hard. Councils are fragmented, as they do things differently, then each infrastructure team does it separately. We are trying to join up the organisations. Most of this is reactive, as we have a huge backlog. But just getting the list of projects to be built and have them in a way that's not year to year is an issue.'

Much stronger government direction and facilitation is suggested as the solution, as this workshop participant highlights:

'The government needs a ministry of data to speak to all the siloes. Or maybe it's less government, as people already do this, maybe we could facilitate instead.'

In addition to incompatibility, there are often restricted uses on high quality government data—valuations data, tenant welfare benefit and service needs data, dwelling level energy use—information that could enable research and empower better governance—through privacy covenants on the release and use of data (such as through data supply agreements) or, increasingly so, through commercialisation (such as sale to private companies). The effect of this, for the housing and urban research sector, is to generate data that is partial, at times unreliable, and locked away from those who most need it.

Two of our workshop participants from the academic and social housing sectors, for example, encountered these restrictions, in one case significantly delaying the process, and in the other adding additional costs to the provision of housing for the disabled:

'I was working with the [state planning authority] and I needed the Valuer General's data to do their job for them. The department asked the VG for the data and they said no. It took another two years to get something from them'

'There was one instance where I was bidding, and the developer says that they got a better offer, so I got more cash. This went on for a bit. The bidding war pushed the price of the house up \$75,000, and it turns out I was bidding against another housing organisation who also provide affordable housing...People come to me and ask where to build houses for disabled, because it pays well, but no one can tell me. They won't release [the information], for privacy reasons. The government wants this sector grow quickly, but no one is putting their hand up because they can't find the customers.'

For participants in data markets, the capacity for compliance with rules around open data remains a critical question. Regardless of legislative framework, capacity will remain a critical issue, particularly for understaffed municipalities and NFPs who will struggle not only to achieve Open Geospatial Consortium (OGC) data interoperability compliance, allowing their data to become open, but also to maintain this level of compliance for the history of the data, which is equally critical. Similar issues will also arise for open source analysis systems; making them unviable without institutional and inter-departmental cooperation and funding.

On the other hand, ongoing data breaches globally and in Australia have indicated the highly problematic claims of data security in open data infrastructures. Promises that data in open data systems will remain anonymous have become dubious as data re-identification has become a sophisticated sub-discipline of computer science. The creation and sharing of large data sets, along with the possibility of re-identification, also shows the potential for such data to be repurposed for social service allocation, taxation, or policing purposes.

Such systems sometimes challenge data protection regimes for violating the purpose specification principle. Specifically, the data collected for one purpose should not be used for a secondary purpose without explicit consent. Further, even if data remains anonymous (i.e. is not connected to an individual), it still has the potential to be harmful.

The definition of personal information, as indicated above, will likely exclude a great deal of information with the potential to affect people's lives from the ambit of Australia's data protection systems. Rather than biographic or service use data about individuals (i.e. the data in identity systems), open data systems typically focus on more abstract data categories about system use and function. This data is then made available, sometimes through data markets (as discussed above), to third parties for the sake of application development and research. Ordinarily, a centralised entity coordinates the collection, processing (often washing, de-identifying, and packaging) of data, as well as its release by relevant government institutions.

Legal reforms are being rolled out to facilitate the Department of Prime Minister and Cabinet's '*Open Government National Action Plan 2016-2018*'. One example is the Australian Productivity Commission's proposed Data Sharing and Release Act (Productivity Commission 2017), that suggests new institutional structures for data sharing and release, and new centralised permissioning systems. Under this regime, a 'National Data Custodian' would be created in order to accredit and audit a suite of Accredited Release Authorities (ARA), being 'sectoral hubs of experience' that develop, integrate, and anonymise datasets; and approve trusted users of sensitive data. The ARAs then accredit trusted users for access to data governed by the ARA.

On the consumer side, the new 'comprehensive consumer right' is presently being debated in Parliament. While the comprehensive consumer right will increase data portability, which may be useful in the context of 'open banking', it does not introduce any privacy protection when data is collected and disclosed beyond the user's control. In fact, the Productivity Commission has been relatively dismissive of the risks of data linkage, claiming they are manageable through correct policies and processes (Productivity Commission 2017). In fact, in this context, the Productivity Commission described 'privacy' as merely an 'incumbent value'.

Improper use of personal data may ordinarily be caused by a data breach (for instance, hacking) rather than release of de-anonymised data, but regulatory frameworks need to adapt to higher risk environments. However, the surveillance possibilities of any highly connected, data intensive environment are confronting, and any system of data openness will require measures to ensure the protection of individuals. The introduction of offences for the re-identification of data was tabled in a 2016 Bill (*Privacy Amendment (re-identification offence) Bill 2016*), which is currently before the senate. However, this Bill has been criticised as unlikely to deter nefarious actors, and for taking attention away from the difficulty and necessity of properly de-identified datasets.

The movement towards open data therefore requires significant improvements to the existing data protection regime beyond the implementation of new entities within the data availability framework.

4.4 Digital planning tools

Though all of the aforementioned digital planning tools represent a significant breakthrough in terms of data accessibility and urban modelling, these are limited in their widespread adoption by a number of factors as reported by Russo, Lanzilotti et al. (2018a; 2018b). While there have been attempts to make these tools more user-friendly, e.g. with the AURIN portal (Barton, Goldie et al. 2015), the key factors for their lack of adoption to date are discussed in this section.

The funding behind new planning and modelling tools tends to come from research organisations, meaning that the tools are usually novel and future looking; also, they are rarely, if ever, designed by the staff who will eventually use them to advance urban design (arguably the governance sector). This creates a significant issue, namely that systems rarely have a formal business case. They may perform their duties well, such as being able to predict specific behaviour, but they are not developed by the institutions where they will be used, meaning that they will probably not be mapped to existing institutional business logic. The effect of this is that many systems will not actually be of benefit to organisations, as they do not fit into established workflows, may contain data that is not appropriate for the end user, or illustrate issues that the organisation cannot control or feasibly address. This was expressed by a workshop attendee:

'coders don't understand the policies in place. They might develop the tool, but it won't get used in the field'

and another said

'we actually have heaps of data [on tree populations] but we have no way of using it. The last thing we need is another system that doesn't give us what we want'.

A second, and related, issue is the capacity of organisational staff. Modelling systems are not created by government, largely because this is not the business of government officers, who are more concerned with policy and reasonable simplistic spreadsheet tools for analysis. As such there is a shortfall of individuals who have the technical skills to utilise these systems, which, combined with the budgetary restrictions on excessive hiring for non-critical issues, means that either there are no staff hours left to learn and use new systems, or a lack of technical capacity to engage with new technology. Again, this was commented on by workshop attendees:

'Infrastructural data and systems exist, but most planners don't know how to use the software'

'It [an optimisation system] is not feasible. We don't have the staff, the coordination, the resources or the relationships.'

A third and final issue relates to data and the siloing of data, which is covered above, but given that systems need data to run, and that most data is institutionalised, partial, or lacking in timeliness or quality, collating a large system that can provide outcomes to under sourced, geographically isolated and technically unskilled workers is largely impossible.

In short, workshop attendees were open to the use of new planning tools, but given that they are already at capacity, and following existing established workflows, all of which relate directly to personal and institutional indicators, means that there is little or no capacity for additional work (such as learning new systems), particularly if this work lies outside of their current work commitments.

5 Policy development options

- Strengthening Australia's privacy and data protection infrastructure by introducing adequately funded agencies (or upgrading existing agencies) capable of certification, compliance, auditing and standard-setting for data sharing applications and automated decision making systems.
 - Policies should be developed to make considered decisions around the degree of openness of data products and the introduction of a framework to facilitate those decisions.
 - Policies should consider supporting better two-way flows of data between contributors and collators, such as in the form of a framework.
 - Implementing a data management framework that supports innovation and transparency in decision making.
 - Policies and statutory regulations should be established for the use of digital planning tools as a requirement in strategic planning. Workforce upskilling is also required to address skill gaps in capitalising on opportunities in the application of digital technologies and data.
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This report has critically examined both the opportunities and challenges that go hand in hand with new and disruptive technologies. Paramount for the realisation of many disruptive technologies is the ability to access fine scale data, whether it be property information or personal information. In an era of open and real-time data, we are starting to utilise new data-driven technologies that could change the operation of Australia's housing system in many ways. However, a key consideration is the risk of compromising the security of personal data that could result in negative outcomes including identity theft, inequitable treatment and the violations of citizen's civil rights and freedoms.

Concerted efforts in identity-based blockchain technology offer promise in terms of privacy and data-sharing. Done well, these technologies could unlock new digital platforms and smart city applications to function in ways which could result in better housing outcomes both from the perspective of service provision and efficiencies (Potts, Rennie et al. 2017). The undertaking of technology pilot projects could, if successful, result in more liveable, productive, sustainable and resilient cities.

The tech start-up community has a mantra of failing often and failing fast, which is not appropriate when our rights to shelter or privacy are at stake. In a time where housing affordability and accessibility is paramount for planning 'just' and 'equitable' cities, there may be a need to trial new approaches and activate much needed innovation, agility and collaboration in and across the housing sector. Future developments may include the consideration of smart city housing pilots using Australian cities as living laboratories and exploring opportunities to break down data silos between agencies and across the sector. Data governance, ethics, quality, openness and interoperability are all areas warranting research and require careful policy consideration.

As demonstrated throughout Chapters 2, 3 and 4, however, a number of institutional and structural barriers exist to the adoption of emerging technologies to drive greater efficiencies in the provisioning and managing of housing products across the different sectors. These barriers

exist at a broader level, and implications that relate specifically to the housing sector are drawn out in this concluding chapter in the context of our four research questions.

5.1 Potential road blocks ahead

The research reflected in this Final Report focussed on four main areas:

The potential use of the technology in their current role

In their current role, there is a suite of digital technologies that hold significant opportunities to disrupt the housing sector both positively and negatively. With respect to digital planning tools such as ENVISION, ESP, RAISE and What if?, these are only being sporadically used by local councils for planning purposes. The smart cities agenda offers potential for such digital planning tools to be more widely adopted across municipalities and to improve council's ability to use data-driven approaches to land use planning. This is, however, obstructed by a range of institutional, structural, political, and financial reasons, as discussed in this report.

Under the support of the current government, the open data movement has been gaining momentum. This is seeing a number of national, state/territory and local government digital assets being made publicly available through data.gov portals and dashboards. In the context of housing data, we have seen the release of open digital datasets across NSW, Victoria and other jurisdictions that include current land use zoning overlays and bulk land valuation data. The release of such valuable data is a significant step in providing housing related data to support smart city startups like Wattblock, and councils, CHPs, researchers, policy makers and the general public. However, there is a long way to go in realising the full potential of open data for the housing sector as much of the data released is not real-time and is not in a machine-readable form.

At the time of writing this Final Report, blockchain is still in its infancy but may impact on the housing sector in a number of ways. We are seeing the emergence of the first wave of blockchain startups, for example, Powerledger which has been trialled in Western Australia for peer-to-peer, household-to-household solar power distribution. There could be risks associated with early adoption, especially before technologies reach a mature enough level, and where policies and other considerations regarding arbitration and appeals are yet to be in place.

Barriers to uptake including ethical issues, training, data access, and institutional issues associated with collaboration

As it currently stands, and irrespective of national and state calls for open data, there are still significant blockages to open data being implemented.

First, data is difficult to get. Though many base layers are available, the relevant information required to populate these base layers with is—for political, ethical and financial reasons—heavily guarded by data custodians, many of whom are either unaware of, or unwilling to enter into, data sharing agreements.

Second, the limited human capacity to operate emerging systems to their full potential. Though many base layers and some open datasets exist, the vast majority of non-experts in digital data are largely unaware of these and lack the capability to make use of them. In reality, very few individuals have the skill sets to utilise the current available data, let alone make advances into new data sources. This is largely a result of funding and prioritisation, as many smaller organisations either do not have the capacity (financial and human resources among others) to ensure that their internal data are compatible with external data (except in cases where this is mandated such as part of a reporting structure of funding) or consider rigorous data collection a low priority and outside of core business processes.

Third, the lack of data integration across agencies and catchments. For the reasons covered above and more (such as the lack of an overarching data agency), data stores continue to be silo based and rarely usable outside of their organisations' geographical coverage or service portfolio. One of our workshop participants highlighted this seemingly perpetual dilemma where they supply data and report on their organisation but get nothing in return:

'We send all of our data to the governance organisation, but they don't give it back to us. Not in a useable fashion anyway, because it's confidential'.

Fourth, the data age is reasonably new, meaning that governance processes are still adjusting to the digital transformation. This is an expensive process, especially when the speed at which change in the technological space is occurring and the cost to continually upgrade large, cumbersome hardware and software systems is taken into account. Upgrading hardware and software for a large government department can cost the same as a major infrastructure investment, meaning that it is often left until systems reach absolute obsolescence before upgrades are done. As a result, many sectors have ICT and data management systems that are well passed optimum, such as being heavily reliant on manual data entry and having duplicate (or missing) records, as this workshop participant explained:

'We are transforming systems and processes that were put in place for Y2K. We still have paper in many instances.'

In combination, these four factors have significant implications for the future provisioning of much needed housing, its successful management (in terms of private sales, tenancy management and transfer, and ongoing property and neighbourhood maintenance), and the provisioning and maintenance of related services and infrastructure. It is critical that data is provided and shared with relevant agencies, and that agencies that are resourced with appropriate skills to operate the increasing advance planning, design and maintenance systems, to avoid unnecessary delays and duplications.

Implications on tenant–landlord legal frameworks

As discussed in Section 3.4, the move towards automation may not necessarily benefit vulnerable groups such as social housing tenants. In many cases, a human interface is preferred, as staff are trained to recognise signs of distress and other support needs not necessarily identified by the tenants themselves. In the context of increasing likelihood of public estate renewals and transfer of tenancies from public to community housing providers, however, standardisation and automation may ease the transfer of critical information about the tenants such as support needs to minimise the level of disruption and distress. For this to happen, notable investments must be made in compatible systems (for public and community housing providers as well as the support service providers they work with) and in upskilling the workforce to manage and maintain these complex systems.

As noted in Milligan, Hulse et al. (2015), to date only larger CHPs with sizeable portfolio and income streams have the capacity to finance these upgrades. Without funding support, this can potentially create an uneven sector where some of the smaller providers, many of which provide more specialised services to individuals with additional service needs such as those with a physical and/or mental disability, persons escaping domestic violence, people exiting prison, indigenous communities, persons of non-English speaking backgrounds, refugees and those who are drug and alcohol-dependent. As one of our workshop participants emphasised,

'To make simple things simple, you need to put in a lot of work and that needs to be funded.'

Coupled with funding support, legislative changes may also be required in order to facilitate the transfer of data. At present, like many other organisations, CHPs are regulated by privacy and

data protection legislations and as such the use of tenants' personal information is restricted. While it is important to protect tenants' privacy and identity, provisions must be made to include clauses where, with tenants' permission, such information can be shared in the context of tenancy transfer and linking up with necessary services. Likewise, for the common vacancy listing as proposed by our workshop participants to come to fruition, legislative changes may be needed to facilitate the necessary infrastructure in the same way as each state has created their own common wait-lists, or in the way the NRSCH now provides a national (except in Victoria and WA) standardised platform for CHP registration and accounting. This infrastructure, however, needs significant development to take on the additional functionality.

Aside from impacts on the social housing sector, and beyond the scope of our workshop discussions, emerging technologies can also facilitate better tenant–landlord relationships in the private rental sector. The increasing use of standardised application forms like 1Form was discussed in Section 1.3.2. Its potential can be considerably expanded when paired with blockchain technologies. In that case, there could be a full ledger of the applicant's rental records, their correspondence with the agents and landlords, if they had been in arrears, their bond lodgements, etc. Such clear ledgering can potentially replace the need for references as the applicants' full rental history is available for view. Conversely, however, this may also potentially disadvantage vulnerable individuals in private rentals, particularly if they had trouble keeping up with rental payments due to unstable employment, or if they have special needs (such as grab rails and level access that may require some modification to the dwelling) that some landlords may discriminate against.

Likewise, a full record could also be available of the landlord, for example, if they responded to maintenance and repairs promptly, if they raised rents excessively, if they had been taken to VCAT (or other states/territories' equivalent) and whether and how the matters were resolved. The transparency of such ledgers can potentially improve the functioning of the private rental sector, by forcing landlords to keep their investment properties to decent standards; in the case where minimal standards are applied to rental properties such as in the UK (Pinsent Masons 2015) and New Zealand (Cabinet Social Policy Committee n.d.), these ledgers can also be used track their implementation.

The future of housing assistance and provisions in the face of these new technologies

Similar to the discussions on improving tenant–landlord relations above, emerging technologies can be used to provide a clearer accounting of housing assistance and other welfare payments tenants receive. This can reduce the onus on tenants to report change in income and circumstances, ensuring that the correct rent is charged (and received by the providers) and available assistance funds are used more equitably. This can also simplify procedures, such as in the case when a private tenant who receives several state-based welfare benefits (such as an energy rebate) relocates from one state to another, their eligibility for these benefits can be easily assessed by their new state's welfare offices, particularly if the eligibility criteria are similar. It may also be easier for support services to assess the needs and requirements of the transferring tenants, including, for example, a full accounting of the accessible features that the tenants had in their previous homes. This can help ensure that the level of service provision and connectivity is maintained.

The provisioning and siting of subsidised housing can also be assisted by emerging technologies. The increasing advances in GIS and digital planning tools discussed in Section 3.3, for example, can greatly assist planners and developers in finding suitable sites, in forecasting budgets (including collaborating with other nearby developments) in service and utility provision and upgrades, as well as in visualising potential impacts at the conclusion of the developments such as traffic flows and impacts on house prices. Davison, Legacy et al. (2013), using a GIS approach, demonstrated the negligible impacts affordable housing developments

had on local house prices. If such negligible impacts can be displayed at the community consultation and engagement phase, there may potentially be lower levels of community opposition to such developments, considering that decreasing neighbourhood property value is often stated as one of the main contributing factors to such opposition (Tighe 2010).

However, for comprehensive adoption of GIS-powered digital planning tools and portals there is a requirement that has been identified by Russo, Lanzilotti et al. (2018a; 2018b) for upskilling and capability building in the use of these platforms and digital technologies. There is also the matter of software licensing and institutional support. Specifically, proprietary GIS and other pertinent software can be prohibitively expensive for municipalities and CHPs to purchase. However, alternative solutions such as open source software like QGIS, externally hosted cloud-based tools, and innovative partnership arrangements (including encouraging larger developers with the resource capability to work with CHPs to develop new housing products) can be encouraged and facilitated to fill this gap.

5.2 Final remarks

Whilst we live in an era of smart cities, big data, sensors and cryptocurrencies, the widespread adoption of digital technologies and data-driven solutions to support the housing sector remains slow at best. As participants from the workshops note:

'We still don't have data that can be joined up'

'it's only 20 years ago that we digitised addresses'

This Final Report provides a comprehensive review of the state of play in current and emerging digital technologies in the context of the housing sector. What this research has clearly shown is there are significant opportunities to improve and modernise parts of the housing system through policies that embrace and support the development, testing and adoption of new and disruptive technologies and data-driven solutions.

However, it is important to note caution should be used with deregulatory approaches that support gig economy applications—Airbnb has shown that new technologies can result in housing exclusion for some. For vulnerable communities, particularly, consideration must also be given to whether technological disruptions will result in more benefits than harm—automation may improve operation efficiencies in some respects but can at the same time lead to further social isolation of disenfranchised individuals. Governments must set up appropriate regulations and policies to ensure that technological interventions will not lead to further social inequality.

Of critical concern is assurance of data accuracy and security—and this requires addressing not just within the housing system but for government, private and non-profit entities more generally. Housing is often the most valuable personal asset of any individual, and data custodians must ensure that related data—house deeds, tenancy agreements, rent receipts—is secure to protect the interests of these individuals. Any misuse can have significant short and long term consequences—with the recent privatisation of land title registries, for example, legal and technical assurances must be given to deal with any potential data hacking and the ramifications, including access to different forms of housing assistance.

Governments also need to ensure that critical information is not just made available to those with the financial means, especially when, in conjunction with advancing technologies such as digital planning and housing tools, this can result in better responses from the housing sector to address increasing gaps in housing affordability, security and service connectivity.

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Appendix 1: Technology studio case studies and participants

Table A1: Organisations that participated in the technology studios

Government	Industry	Non-profit
Department of Health and Human Services (VIC)	PEXA	Bridge Housing
Fairfield City Council (NSW)	Rex	Choice Australia
Greater Sydney Commission (NSW)	WattBlock	Hume Housing
Parramatta City Council (NSW)		RMIT University ¹
		SGCH Ltd
		Swinburne University of Technology ¹
		UNSW Sydney ¹

¹Housing, planning and technology academics not part of the research team.

Source: Authors.

Case study 1: Increasing housing capacity and infrastructure planning using ‘big data’

1A. Infrastructure—capacity and optimisation

Yarra Valley Water, SPE Ausnet (energy provider), Telstra and VicRoads have developed an online system that shows the location of all assets, date of construction, level of use disrepair, capacity and current demand placed on these assets. It also allows proposed maintenance to be entered, which is then flagged to all agencies to promote efficient groundworks. The system is called PIPS (Parallel Infrastructure Provision System).

Use case: Simon works at Yarra Valley Water. A municipal engineer has informed Simon that an area in her municipality can no longer deal with the increasing rates of floodwater and has requested assistance from Yarra Valley Water. Simon acquires a costing for the upgrades and communicates this to the municipal engineer, who tells him that they do not have the budget for the complete works. Regardless, Simon then enters the proposal into the PIPS system, noting its location, details and that it cannot proceed without a budget partner. This information is recorded in the system and relayed to the PIPS system administrators in each partner organisation. Michelle, who is a strategic planner at VicRoads has just been given approval for a series of roadworks. She enters these into the PIPS system; one of the proposals intersects with Simon’s proposal and Simon is notified of this. Simon then contacts Michelle and they negotiate that the flood mitigation can occur simultaneously, significantly reducing the cost of the exercise, which is now affordable for all parties. Telstra and SPE Ausnet are also informed of this project. Telstra has no plans to do any operations in this area, but SPE Ausnet consults its internal database.

1B. Smart mass-retrofitting

All energy companies now have access to smart meters, allowing them to categorise dwellings into efficient and inefficient dwellings. This, combined with third party data based on feedback from household IoT objects (all white goods and household consumables), allows SPE Ausnet to categorise areas that are poorly performing, which they report on to state government. State

government has recently initiated a 'Greyfield Precinct' policy, which aims to amalgamate lots, and in doing so create the economies of scale necessary to supply sustainable infrastructure to new dwellings.

Use case (followed on): Jason is the strategic data manager at SPE Ausnet. He has received a notice that significant joint work programs are to occur in a specific location (see above). He queries this location on his smart metre system and seems that it is in an area that is drastically underperforming, in terms of energy use. He then goes to the PIPS system and identifies the area as a possible Greyfield Precinct zone. This action triggers planners at local and state government to assess the proposal. State and local planners then use the ENVISION system, which shows the age, value and other aspects of the property and its environs. Seeing that the proposed area has upwards of 80 lots that are (statistically) ripe for development, they then fast-track the greyfield planning zone process. Landowners are immediately notified that, should they choose, they could redevelop their land now significantly cheaper than at other times, due to the ongoing infrastructure work, and also, if done in scale, and as a redevelopment precinct, be able to have net positive emissions on all new dwellings, thus making considerably more than if developed alone.

Due to the significantly increased proposed densities in the area, Telstra now come on board for localised upgrades to nodes.

1C. Optimisation of business districts

Results from the Annual Travel Survey have been combined with ABS job analytics data to produce job density and transport metrics capable of creating a baseline for all urban travel to work journeys. Third party data was acquired from TomTom indicating the destination and origin of all trips based on GPS feedback (to within 100 metres). All of this data was combined with VicRoads congestion data and implemented into an employment and dwelling location modelling system capable of calculating the traffic effect of placing specific numbers and types of jobs in specific areas within the metropolitan area.

Use case: Based on the above system, the state department of planning has seen that current plans for major activity centres are largely unviable, due to the projected densities in proposed areas and that the vast majority of workers currently travel to the CBD to work. The system has indicated that large volumes of 18–24 year olds, who will be living at home and without established careers, will occur closer to the urban fringes than in the proposed areas. The planning authority runs an optimisation query on the system, which concludes that rather than new activity centres occurring in low density middle suburbs, they should be constructed in 15-year-old greenfield development areas, i.e. areas where there will be a significant employee pool to draw from. The system also optimised their location so that they are far enough apart to prevent cross contamination of employee populations, which will aid in creating the poly-centric city that will reduce traffic congestion and ensure financial viability for all investors.

1D. Place making through clustering algorithms

A system has been produced that analyses market behaviour in any area (based on data from the ATO with some data provisions from anonymised commercial accounts in banks). This system also utilises the consumption behaviours of individuals from national consumption databases (Mosaic). The system's functionality allows analysis of comparable densities and the forms and volumes of land use over an area. Based on baseline analysis of comparable densities, in comparable locations, the system generates the optimised number of businesses and social services that should be walkable to in that area and which will activate the area to a contextually appropriate level.

Use case: Planners in Sunshine, a hamlet in Melbourne's west, are struggling with the activation of its CBD. Regardless of their efforts they cannot create an environment that is

inviting and safe for locals (with many shops being left vacant). They enter the specifics of their location into the database, which then calculates the densities, road network and economic data. It then compares the area to other areas that have been successful in activating their CBD. The system suggests that an optimum distribution of commercial premises (for their context) is 20% clothing trade, 15% licenced venues, 25% food retail, 20% blue collar services, and 20% white collar services, all of which needs to be within an 800 metre buffer of the CBD. Based on this information the council then advertises concessions for licenced premises and white collar services in the area, which are significantly lacking. This creates both day time and night time traffic, which begins to activate the area.

Case study 2: Social housing allocation and pathways

2A. Entering the social housing system via emergency allocation

Scenario: Gina requires emergency accommodation for herself and her two young children as a result of domestic abuse. Due to her circumstances, she does not have personal documents on her. She is told by a homelessness service that she can be housed in temporary accommodation for a limited time. There are a number of steps to this process: the client needs to be assessed; the housing resource needs to be identified; the client needs to be provided with the address and keys; payment transfers need to occur.

Questions for participants:

- How can this process work more efficiently for the provider and the client?
- Discuss when the face-to-face service is desirable versus automated allocation/assignment. What information is needed for the allocation process?
- What are the current privacy issues and can these be resolved through new KYC/identity methods?
- What are regulatory requirements (compliance) that technologists need to be mindful of when developing technology applications/infrastructures for social housing?

In terms of emergency accommodation, the client is currently required to visit a homelessness service in person, tell her story and provide documentation such as proof of identity. The service then rings around to find available accommodation. The client needs to go to the agency to collect a voucher and be authorised for assistance before travelling back to the accommodation.

Know Your Customer technologies may be of use here. For instance, a number of start-ups are developing identity systems (including Australia Post), which differ from existing processes as information does not have to be centrally stored, and individuals can maintain ownership over their own data.

Verification and information checking could be automated, and clients could apply through a mobile device rather than needing to travel to the agency and queue for a place. Vouchers could be tokenised. Smart locks could be used to allow people with entry into properties, removing the need to pick up keys.

2B. Transitioning from emergency to permanent housing

Scenario (followed on): Sometime later, Gina is applying for a permanent home through the public housing system. Gina has preferences that she would like to be taken into account. Ideally, she would like to know what housing is available, and she would like to nominate where she and her children end up.

When it comes to assigning permanent public accommodation, Gina's preference is for a home that is near her family (for child care reasons).

Currently, public housing applicants have limited choices in where they live, other than across relatively large allocation zones. If they reject a couple of reasonable housing offers, they go back down the bottom of the waiting list.

Most jurisdictions now have common waitlists (i.e. everyone applies to the same list which housing providers would then 'pick' from depending on what stock they have available, area preference etc.), which means a lot of information about the tenant is automatically transferred to the community housing provider (CHP) that ends up taking the tenant. There is a lot more coordination with other service links that the tenant may come with (commonly Centrelink but could also be Veterans' Affairs, National Disability Insurance Scheme (NDIS), other support services) or that the CHP itself would like to link the new tenant to. However, this information regarding support services is not necessarily always transferred with the tenant.

Further, if Gina, being a high priority applicant, applies for housing through one CHP, but unfortunately that CHP does not have any suitable property, Gina's chance of gaining a tenancy rests on the tenancy officer's ability to ring around tenancy officers of other CHPs who s/he knows in hope of finding suitable accommodation for Gina and her children. If one of the tenancy officer's former contacts leave their organisation, s/he may not know who else can be contacted.

- How can this process be better facilitated? Can a common listing of current vacancies nominated by CHPs be of use here? How can uploaded listings and associated information be stored securely while remaining accessible to participating CHPs?

Recent AHURI report (Milligan, Hulse et al. 2015) shows IT upgrades as being of high importance in the coming years for CHPs in managing tenancies, stock and their back-room operations (finance, development, workforce etc.). A more recent study on transfers (Bullen, Liu et al. 2017) also shows that tenants from mass transfers (rather than individual new tenancies off waitlists) often do not come with enough background information, particularly relating to support and service needs.

- How can Gina's support needs as a tenant be protected in the process of transitioning from one provider to another? Can information about these needs be linked with other administrative records, e.g. via a tenant record number, a Centrelink record ID, or a tax file number?

2C. Transferring within a diversifying social housing system

Scenario (followed on): Two years on, Gina finds that the accommodation is no longer ideal as she has taken work across town. She would like to transfer to a home in a different suburb.

With a diversifying social housing system, where the management of some housing estates is transferred to community housing providers, the opportunity for tenants to exercise is limited as transfers (or mutual exchanges) is currently only possible within rather than across providers.

- How can the transfer process be better facilitated? Can there be a centralised transfer nomination forum that tenants and housing providers can access? Are policy and/or regulation change required to facilitate inter-provider transfers?

Case study 3: Private real estate markets

The relationship between property ownership and information systems is changing. Intellectual property licensing has been the primary mechanism for transacting in property rights online for some time. Very simply, this is because the reproduction of content with perfect fidelity makes informational assets non-rivalrous online. Digital content distribution has focused on monetising intellectual property through licensing access to content, rather than by transacting ownership of that content. Distributed registers have the capacity to change the nature of property rights online by reorienting property into a species of information law. The blockchain protocol enables

the creation and transaction of rivalrous digital tokens capable of representing property ownership. It also facilitates the existence of shared ledgers recording property ownership (or consensus around any particular state of affairs), which updates itself on all participants systems, is not centrally verified, but resists malicious interference.

The application of this technology to the real property system is already in development. This workshop seeks the reactions and inputs from participants in the real estate industry that might seek to adopt or are likely to interact with new blockchain based real property systems and products. It can also be demand-focussed, from the perspectives of developers, planners, conveyancers and real estate market people. What might be desirable outputs from these new technologies?

3A. Land titles offices/property exchanges

Since the introduction of the Torrens System for real property in Australia (and other countries), land title registration has been the domain of state level government agencies. The legal innovation of the Torrens System was to vest property rights upon successful registration rather than provide a forum for registration of title. In other words, the Torrens system provides title by registration, rather than registration of title.

The original Victorian Land Titles office at 283 Queen Street maintained its property registry in a strong room of stone walls and doors, cement floors, and iron shuttered windows, effectively providing a fire and theft proof fortress for the individual property folios residing therein. The current Victorian Land Titles Office on Bourke St does not project the same sense of physical security, but still maintains the register in combined paper (analogue) and digital forms. However, it appears that the technologies of the property register and the land titles office are set to change again. Those changes might affect the format of a land title (certificate of title), the processes by which they are stored and maintained, the processes of registration, as well as the transactions that lead to registration.

Distributed registry systems are demonstrating a capacity to devolve the governance functions of the Land Registrar and the Land Titles Office into automated technical architectures, as well as provide platforms for transacting in real property rights. The stone doors of the registry might be replaced with sophisticated cryptography (a blockchain), and the paper folios with automated agents ('smart contracts'). Similarly, technologies of individual identification (which in property law are necessary for transactions and mortgages) could potentially change to include blockchain identity systems (or other 'RegTech' style systems capable of verifying identity).

Australian Government IT procurement has not been historically successful in the case of housing registries and transaction systems. However, the recent privatisation of the NSW and Victorian Land Titles Offices raises the possibility of new innovations and technological approaches. While some of these efforts have already failed (e.g. in Honduras), Sweden, for example, is quite advanced in its development of both a blockchain based transaction registry, as well as a 'smart contract' based transaction platform. The Swedish system enables users to transact using digital signatures and automated escrow systems.

The consequences of such changes being introduced in Australia could be radical. This is not simply in terms of the elimination of fraud (which has been the impetus for all technological advancements in land registration), or the increased efficiency of the transactions, but also in terms of the technologies of governance.

Questions for participants

- What might titles look like in this kind of property system?
 - Register of ownership
 - Smart contracts for property

— Tokens for property

- What are the values and risks of this type of update in land registries?
- What structures are most appropriate for designating property ownership on a blockchain? Smart contracts, coloured coins, permissioned vs open systems etc?
- Should ownership be attributed to a private key or a person? Risks?
- What would be the relationship of a blockchain register and the use of smart contracts to the enforcement of common law and equitable property rights?
- Do we still need off-line registries that can associate objects and tokens?
- Could this kind of system be useful for new housing ideas (i.e. shared government bonds for first home buyers)?
- What about crowdfunded mortgages?

Chromaway (Swedish transaction system / registry) demo: <https://chromaway.com/landregistry>

Further ideas for tokenisation involve real estate assets being traded with digital currencies. This might involve using the blockchain protocol to designate property ownership (without necessarily being a real property register). These approaches might also be desirable for housing trust schemes (i.e. BRICK) or crowdsourced mortgages, where distributed ownership systems can be transparently coded, with necessary investments and remittances automated on the triggering of certain conditions.

Questions for participants

- Would blockchain be helpful for identity verification (i.e. RegTech applications)? What about financial verification? To what extent are escrows used in transactions? Would you be happy to automate an escrow through a smart contract?
- To what degree do you rely on parties to provide documents relevant to a transaction? Would a verified register of all relevant documents be useful?
- What kinds of frauds and scams occur in the real estate industry?

3B. Multiple listing services (MLSs)

Multiple listing services collate property-level information from the private databases of brokers and agents. Placing multiple listing registries on a blockchain enables the creation of a tokenised economy for data about properties. These technologies have the potential to improve information environments for property leasing and purchasing, as well as provide transaction platforms.

The premise behind multiple listing services is that each particular property will have an entry on an openly available register. Within this register, transaction histories and documentation can be recorded on each entry. This enables the creation of an immutable and dynamic information source for real property. The result would be a digital identity for real property with relevant reports, inspections, maintenance, leases, encumbrances, mortgages, and any other property interests or source of information available in a single place. This could effectively potentially constitute a combined inspection ledger and title registry. Parties would be incentivised to contribute information to the register through tokenisation, where individuals receive tokens in exchange for information about a property. Those tokens can be exchanged for using other services on the platform—such as sponsoring markets, creating a broker profile, or buying information about properties. The idea is to create a digital marketplace/economy for real estate information.

The primary company in this field is REXmls. This company emerged as a response to the expenses associated with collecting real estate data. The idea is to provide an information exchange for vendors and buyers globally (avoiding regionalisation of existing MLSs). This system is presently focused on exchange of data rather than real estate assets themselves. However, the initial data layer is intended to be supplemented into a global property transaction system that includes smart contracts for leasing / escrow with oracle system. They see lawyers and brokers having roles in negotiating transaction and leasing smart contracts.

REX demo: <https://www.youtube.com/watch?v=MfK91P3sfd4&feature=youtu.be>

Questions for participants

- To what degree is information about real estate limited or difficult to obtain?
- What types of data do real estate agencies usually hold but not provide? How protective is real estate of its data?
- Is this level of transparency a threat to existing business models or processes?
- What do you see as particularly useful about the incentive mechanisms?

3C. Smart tenancy products

These technologies provide for automation of typical real estate agent functions. They have the potential to manage payments through smart contracts, manage maintenance workflows, and avoid disputes by automating certain lease conditions. They could also be used as escrow mechanisms that release money to parties on the triggering of certain conditions. However, the relationship of these technologies to existing statutory requirements (for bonds for instance) would need clarification.

There also exists proposals for blockchain based IoT systems with property applications. A primary example is the Slockit lock system which automates access to properties by giving users digital keys to digital locks for certain periods according to rights coded into a blockchain. Using the Slockit system, access rights to properties can be automated, reducing issues associated with short term rentals and overstays. These automated systems do however, raise questions about how disputes will be managed, as the authority of the technical system might challenge the authority of existing administrative tribunals which typically resolve tenancy disputes.

Slockit demo: <https://www.youtube.com/watch?v=-Ht23KXic1k>

<https://www.youtube.com/watch?v=49wHQoJxYPo>

Questions for participants

- What are the primary challenges within real estate management?
- Where are there increased needs for verification or automation?
- Can you think of any other good uses for internet of things in the property system?
- Where do tenancy disputes primarily arise?

All of these approaches might be combined with blockchain based identity verification mechanisms, which can be discussed separately.

Appendix 2: Examples of emerging technology applications

ENVISION (Glackin 2013) was funded by the Cooperative Research Centre for Spatial Information (CRCSI) with the aim of identifying potential redevelopment opportunities for precinct scale housing. This online tool incorporates data from the Valuer General (in Western Australia, Melbourne and Christchurch, New Zealand), ABS data, derived distance calculations (from trains, main roads, shops and so forth) and a range of other geographical and built environment data. Users use a simplistic multicriteria analysis to identify dwellings that are undercapitalised and potentially open for redevelopment, once sold. The aim of the software is to predict where precincts could occur and begin community engagement to encourage more medium density housing in established suburbs (Glackin and Dionisio 2016; Glackin and Newton 2015).

The follow on from ENVISION is Envision Scenario Planner (Glackin, Trubka et al. 2016), which was also funded by the CRCSI. This is a 3D tool for testing the performance of a redeveloped precinct. The tool uses pre-assessed housing and mixed-use building typologies, using CSIRO's AccuRate sustainability tool (CSIRO 2017), which users can place onto a map and then assess for energy performance, carbon performance, water use, stormwater mitigation and additional Vehicle Kilometres Travelled (Trubka and Glackin 2016). The tool is currently being used by municipal governments in Victoria and Christchurch to prove the effectiveness of precinct scale redevelopment for various targets in sustainability, flood mitigation and housing affordability through providing a diversity of housing products.

RAISE, again CRCSI-funded, was written as a tool to indicate the value uplift of infrastructure investment on surrounding housing, so as to provide the national and state governments with the information required to leverage investment against the increased value of land adjacent to new services (CRCSI 2017). The tool rests on its ability to apply hedonic modelling algorithms to its valuation engine, which derives property values from land sales data.

What if? originally developed by Klosterman (1999) was recently reproduced in the AURIN workbench (Pettit, Klosterman et al. 2013). This software allows users to look into the future scenarios of urban growth by providing information of a range of land-uses and the probable necessity of these land-uses for future population increase.

The walkability tool was developed within AURIN and incorporated the work of Billie Giles-Corti (Christian, Bull et al. 2011). This tool allows users to select an object or objects and to see their area of immediate effect based on the walkable network to that feature (Pettit, Barton et al. 2015). As such it can provide clues as to where to situate both housing and infrastructure for the most benefit.

MUtopia was developed by the University of Melbourne to assess the holistic effect of specific amounts of gross floor area (GFA), in terms of energy and water use. MUtopia is a design tool for sustainable cities made up of an integrated visualisation and simulation platform, which displays in 3-D the appearance of an urban development and quantifies the performance of key sustainability metrics at different scales. Urban designers can assess the viability of introducing sustainability measures, as well as ascertaining best practice in areas such as water efficiency, energy efficiency, dwelling and transportation design, construction and maintenance and waste management. MUtopia is also a knowledge platform to evaluate aspects of architectural and urban planning, sociological and community issues, economic modelling of capital and operating costs and benefits, for proposed urban developments (Melbourne University 2012).

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.

UrbanSim is a tool for use by urban planners, policy makers, 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. UrbanSim is primarily designed to be used to support urban land use, environmental and transportation planning, including modelling future scenarios. It aims, by using a simulation framework, to model how the market works and changes over time (Urban Sim 2017).

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. The tool provides a scenario-based analysis of the transportation, economic, environmental and infrastructure impacts of land-use changes. 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 (City Explained Inc. 2016).

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 metrics required by urban planning (Calthorpe Analytics 2017).

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Australian Housing and Urban Research Institute

Level 1

114 Flinders Street

Melbourne Victoria 3000

T +61 3 9660 2300

E information@ahuri.edu.au

ahuri.edu.au

ACN 090 448 918



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