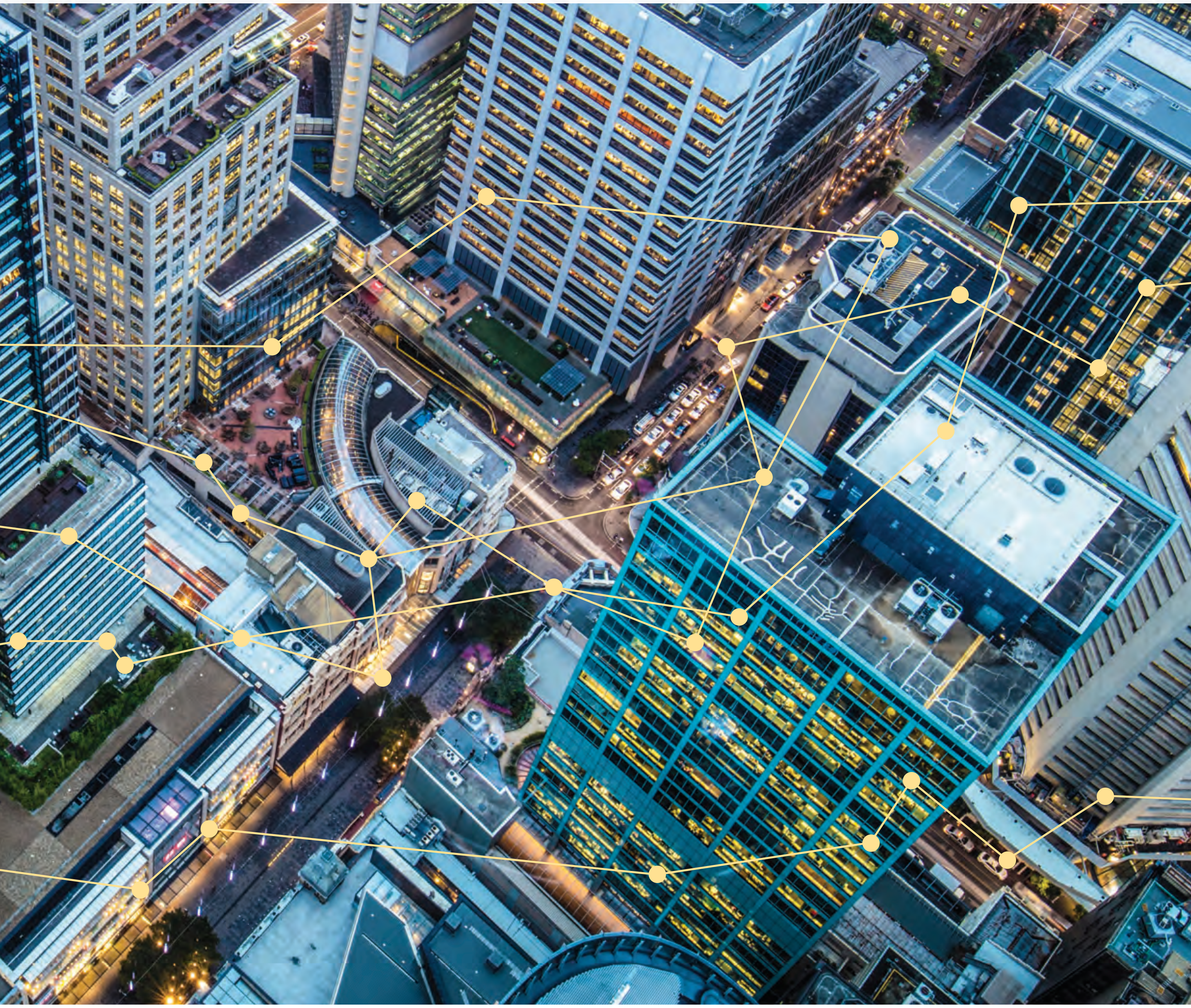
Economic Value of Spatial Information in NSW

Estimated for 2017 and 2022



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ACRONYMS

ABARES	Australian Bureau of Agricultural and Resource Economics and Sciences
ABS	Australian Bureau of Statistics
AMCA	Air Conditioning and Mechanical Contractors’ Association
AMS	Asset Management System
ANZLIC	Australian and New Zealand Land Information Council
ATMS	Advanced Train Management System
Augmented GNSS	Satellite positioning with greater accuracy then raw GNSS usually through provision correction signals from space based or land based signals
BBAM	Bio Banking assessment methodology
BCI	Building, construction and infrastructure
BIM	Building information and modelling
COAG	Council of Australian Governments
CORS	Continuously Operating Reference Stations (a means of improving the accuracy of GNSS to as much as 2 cm)
CAGR	Compound annual growth rate
Corporation	NSW Housing and Land Corporation
CRCSI	Cooperative Research Centre for Spatial Information
DCDB	Digital Cadastral Data Base
FSDF	Foundation Spatial Data Framework
FTE	Full Time Equivalent
GDA	Geocentric datum
GIS	Geographical Information System
GNSS	Global Navigational Satellite System
GPS	Global Positioning System (refers to the US Navstar GNSS)
GRDC	Grains Research and Development Corporation

GSP	Gross State Product
GVAP	Gross value of agricultural production
IAP	Intelligent Access Program
ICSM	Intergovernmental Committee on Surveying and Mapping
ICT	Information and communication technology
ITC	Information technology and computing
ITS	Intelligent transport systems
LIDAR	Light Detection and Ranging
MLS	Mobile Laser Scanning
NICTA	National ICT Australia
NVA	Native Vegetation Act 2003
NVMP	Native Vegetation Monitoring Program
OEH	Office of Environment and Heritage
OH&S	Occupational Health and Safety
PSAT	Pollution Source Risk Assessment Tool
RMS	Roads and Maritime Services
RPAS	Remotely Piloted Aircraft Systems (drones)
RRR	Rights, Responsibilities and Restrictions
RSA	Rapid Spatial Analytics
RTK	Real Time Kinematics (technology for augmentation of GNSS)
SCATS	Sydney Coordinated Traffic System
SDI	Spatial data infrastructure
SEEA	System of Environmental – Economic Accounting
SES	State Emergency Services
UAV	Unmanned Aerial Vehicles
VRT	Variable rate technologies
2D	Two dimensional
3D	Three dimensional

EXECUTIVE SUMMARY

This report has been prepared for the CRC for Spatial Information and the Spatial Services Division of the Department of Finance, Services and Innovation. It assesses the value of spatial information to the NSW economy in 2017 and the expected value by 2022. It also estimates the present value of benefits expected to accrue after 2022 from developments in a single digital cadastre and building information modelling (BIM) federated registries.

This report draws on case studies and desktop research to estimate productivity impacts of spatial information. These estimates were combined with estimates of the adoption rates of spatial technologies across specific industry sectors to estimate the state wide impacts. It also examines the impact of lives saved in the case of ambulance services.

The findings of the report are based on direct benefits of selected case studies and are an indication of first round effects of the use of spatial information and services. The findings do not take into account knock on effects elsewhere in the economy and therefore represent a conservative estimate of the impacts for the economy as a whole.

Foundation spatial data, which is the authoritative geographic information that underpins the use of spatial information, provide the core data sets that support evidence based decision making across government, industry and the community. NSW in concert with the Australian and New Zealand Land Information Council (ANZLIC) has adopted 10 themes under a national Foundation Spatial Data Framework (FSDI) which is the beginning of a national spatial data infrastructure (SDI). The SDI includes both spatial data and positioning infrastructure.

While this report does not specifically estimate the total benefits that might be attributed to foundation spatial data in NSW, the benefits identified are associated with applications and systems that depend on the authoritative foundation spatial data provided by the NSW Spatial Services Division.

Ten areas of activity were examined. These are discussed below.

Land and property administration

The value of spatial information services (including cadastre, topographic mapping, and imagery) is estimated to have delivered around $4 million in net savings to the office of the Valuer General. Greater savings are anticipated by 2022 through data analytics and further automation of the valuation process.

The value of the Cadastre NSW project was estimated to be around $8.5 million per year from 2022 in savings to registered surveyors or $67 million in present value terms (over 15 years). This is based on 10 per cent savings in professional and technical time that would be achievable with the full implementation of a single digital cadastre.

With the completion of the full Spatial Services Road Map for Spatial Data Infrastructure, these benefits could increase to as high as $240 million per year through improved delivery of permit approvals in the property development supply chain. Efficient planning approvals processes are important to overall costs in the land and property development supply chain.

Implementation of the Road Map for Spatial Data Infrastructure will also have important implications for other areas of government activity. Stamp duty, land tax and parking space levies comprise around 46 per cent of total NSW state revenue. These taxes are location based taxes. Full implementation of the NSW Spatial Services Road Map will create the capacity for location based information on taxes to be stored in 3D registries. This will ultimately support improved location based analysis of ownership and land tax payments. Broader development of rapid spatial analytical capabilities will be facilitated by these developments.

The Spatial Services Road Map will create a whole of government validated address file that will provide one source of authoritative geocoded address data. This will be of benefit to government agencies, such as emergency services and the ambulance service, but will also be of value to the insurance industry and other industries dependent on accurate address data. The benefits across government services, including emergency management, are likely to be significant.

Building and construction

The use and application of spatial information in engineering surveying and construction process is estimated to have delivered significant operational efficiencies. This has resulted in greater accuracy and fewer errors, 60 per cent reduction in double handling of materials, improved utilisation of graders and excavators, less machine wear and tear, fuel savings, increased safety and reduced hours required from automatic machine guidance.

The net impact of spatial information services on engineering surveys was estimated to lie between $13 million and $19 million in 2017. These numbers could rise to between $41 million and $50 million by 2022 with a higher adoption rate of spatial technologies in this sector.

Smart buildings and infrastructure

Smart spatial referenced operating systems have significant potential to deliver improved infrastructure services. They have potential applications in smarter delivery of infrastructure, Advanced Train Management Systems (ATMS) and in traffic management. Many of these applications are still in the early stage of adoption in Australia but their potential is significant. One example that has been implemented is the Sydney Coordinated Traffic System that has delivered estimated savings of $3.6 billion per annum. Spatial information systems would represent a component of the system. If this were 10 per cent, for example, the value of spatial information to the system would be around $360 million per year.

The use and application of federated 3D models, such as BIM, has the potential to deliver significant savings in costs associated with engineering construction in the longer term. ACIL Allen estimated that the present value of benefits for NSW could range from $266 million to $1,330 million over 15 years based on productivity benefits ranging from 1 per cent to 5 per cent. ACIL Allen believes a productivity benefit of 3 per cent is a reasonable estimate resulting in savings with a net present value over 15 years of $798 million.

Realisation of these benefits is based on the assumption that the adoption rate for federated 3D models commences at 10 per cent of building projects in NSW in 2026 rising gradually to 70 per cent by 2034. Completion of the proposed Cadastre NSW project will be important to realising these benefits.

Asset management

The use and application of spatial information in asset management in the Department of Education, the Land and Housing Corporation and local government was conservatively estimated to have delivered net benefits of $43 million by 2017. This is expected to increase to $59 million by 2022.

Longer term benefits from the use of BIM and 3D modelling in asset management for non-residential buildings was estimated to deliver additional benefits in the longer term. These were estimated to be between $236 million and $471 million in present value terms assessed over a 20 year period. Benefits are assumed to commence in 2026 and increase gradually from 10 per cent adoption levels in 2026 to 70 per cent of adoption levels in 2034.

Utilities

Spatial information technologies have become integral to the management of water, electricity and gas utilities. They are also critical to the overall management of water resources in the state.

The use of spatial information technologies in these sectors is estimated to have delivered net benefits of around $57 million in 2017 based on net productivity impacts of 3 per cent of labour costs. This figure is expected to rise to $85 million by 2022 based on productivity impacts increasing to 5 per cent of labour costs.

Smart cities and local government

The use of spatial information in support of smarter management of cities and, in particular, local government services has been an important source of cost savings and productivity improvement.

The impact of spatial information and Smart Cities techniques on local government was estimated to have delivered accumulated benefits for local government of $7 million in 2017. This is expected to increase to $11 million by 2022.

These figures do not include the use of spatial information for asset management by local government that are included in the asset management category.

Emergency services, insurance and ambulance services

The socio-economic cost of disasters such as fires and floods has been steadily rising in Australia. The costs of natural disasters is a function of mitigation actions, response measures and recovery action. The Productivity Commission concluded in a 2014 report that governments can do better in terms of policies that enable people to understand natural disaster risks and also to give them the incentive to manage the risks effectively.

Spatial information can be used in many ways to reduce the impact of natural disasters and emergencies. In many cases, it is mission critical. This can be in the mitigation of, response to, or recovery from, fires and flooding and other natural disasters. It is being used by the insurance industry for risk assessment, peril modelling and better customer engagement.

The benefits were assessed as $18 million in savings to the insurance industry and State Emergency Services in 2017. These benefits are expected to increase to $23 million in 2022 with increased adoption of spatial technologies by the insurance industry and improved applications in State Emergency Services.

The report also explored the value of lives saved through the use of spatial information to reduce response times for the NSW Ambulance Service. It estimated that the use of spatial information had contributed to increasing survival rates by around 10 per cent for cardiac arrest patients through faster response times. The report estimated that the value of lives saved was of the order of $322 million in 2017 and could rise to $386 million by 2022.

Agriculture

The use of spatial information in agriculture, including precise positioning using CORS and other augmentation systems, has been growing steadily over the past 10 to 15 years with applications in yield monitoring, variable rate fertiliser application and controlled traffic farming (autonomous farm machinery and vehicles). These applications are often referred to by the term precision agriculture. It is also finding applications in improving weather forecasting and decisions on the timing of planting of crops.

For this report, we examined the use of spatial information in precision agriculture in broad acre cropping in NSW. Assuming a 10 per cent cost saving and a 30 per cent adoption rate over the 7 million hectares cropped in NSW, ACIL Allen estimated a cost saving of $21 million in 2017 by using precision agriculture in cropping. With an increase in the adoption rate to 80 per cent, the benefit is estimated to be $84 million by 2022.

Forestry

Spatial information is used by the forestry industry for a number of purposes including remote sensing, production monitoring, fire management, habitat modelling and fire management.

The benefit to forestry of spatial information is estimated to be around $5.5 million in 2017 based on an adoption rate of 30 per cent and cost savings of 20 per cent. By 2022 this is expected to increase to $9.3 million with an increase in the adoption rate to 80 per cent and cost savings rising to 30 per cent.

Planning and environment

Spatial information services have delivered net savings in vegetation mapping undertaken by the Office of Environment and Heritage (OEH) of around $5 million in 2017. This estimate is considered to be conservative as it does not capture the full extent of the use of spatial information by the OEH. The contribution is likely to increase by around 20 per cent to $6 million by 2022 as pressures on land development grow.

The Biobanking program administered by the OEH has established a market in traded biodiversity certificates worth around $16 million in the 2016 financial year. Increasing the spatial capabilities of the program could be expected to increase the value of this mechanism by around $1 million by 2022.

Location analytics is expected to play an increasingly important role moving forward in managing the balance between economic activities and maintaining a sustainable environment. The OEH is developing tools for better environmental accounting to provide better data for evidence based decision making. Development of rapid data analytical capabilities will further enable this endeavour.

Logistics

The logistics industry uses positioning, GIS and tracking devices to maintain competitiveness in what is a very competitive industry. Levels of adoption are around 20 to 30 per cent and are expected to rise to around 40 per cent by 2022. The industry is characterised by large and small players. Major players such as Toll, Linfox and K&S Corporation are the leaders in adoption of these technologies. Productivity gains are believed to be around 5 per cent.

ACIL Allen estimates that the benefits of spatial technologies to the logistics sector are $71 million in 2017. They are expected to rise to $106 million in 2022 with increased adoption of spatial technologies across the industry.

Summary of benefits

The benefits as estimated for 2017 and 2022 are summarised in Table ES 1. The table shows total net benefits of $923 million in 2017 and $1,395 million possible by 2022. These benefits are primarily productivity improvements through improvements in works flows or asset and systems management. They also include an estimate of the value of lives saved by the ambulance service.

TABLE ES 1 SUMMARY OF BENEFITS IN 2017 AND 2022

Case study	Assumptions	Value	
		2017 $ million	2022 $ million
Land and property information	Savings from the use of spatial information (cadastral information, topographic mapping and imagery) in valuation processes by the Valuer General. Savings estimated to be 15 per cent of operating costs less cost of spatial information services including imagery and graphics. Greater savings expected in the future from increased use of data analytics and automation, but these have not been quantified for this report.	4.4	4.4
	Improving the land permit approvals process through implementation of the Road Map for Spatial Data Infrastructure		240.0
Building and construction	Savings from integration of spatial information data and systems in data acquisition, planning and route selection, and machine guidance.	13.5	40.5
Smart buildings and infrastructure	Savings from the Sydney Coordinated Traffic System spatial information. Longer term benefits from coordinated application of BIM models in federated registries (discussed below).	360.0	360.0
Asset management	Benefits of the use of GIS and positioning technologies in asset management in selected applications in the Department of Education, the Land and Housing Corporation, and in Local Government.	43.2	58.7
Utilities	Net benefits of the use of GIS and positioning technologies in the management of water, gas and electricity assets.	57.1	84.5
Smart cities and local government	Benefits to local government and local authorities in the use of spatial information systems in planning, development approval, crime management, and services to rate payers. Does not include the value of asset management in local government, which is included above.	7.0	11.0
Emergency services, insurance and ambulance services	Based on assessments of savings in the insurance industry, state emergency services, and the ambulance service.	17.9	23.4
	Value of increase in survival rates as a result of improved ambulance response times	322.0	368.0
Agriculture	Net benefit of $75 per hectare in the cropping industry from use of precise positioning and GIS in the grains industry, with an increase in adoption rates and production from 2017 to 2022.	21.0	84.0
Forestry	Use and application in inventory management and operations.	5.5	9.3
Planning and environment	Savings in vegetation mapping costs, with additional savings in the Biobanking program in 2022. Future savings in location based analysis in prospect but not quantified for this report. Future potential for spatial data analytics by the OEH.	5.0	6.0
Logistics	Application of positioning, GIS and vehicle tracking.	70.5	105.8
Total		927.1	1395.5

SOURCE: ACIL ALLEN

Longer term benefits post 2022

A summary of the net present value of benefits that are expected to accrue between 2026 and 2036 is provided in Table ES 2. The table shows additional benefits of $918 million in present value terms, over 15 years, which are estimated to accrue from developments in the single digital cadastre, and from the integration of the digital cadastre and federated 3D models. If this analysis is extended for 20 years, the present value of the net benefits increases to around $3 billion.

These longer term benefits assume that a single digital cadastre is implemented in NSW by 2026 and federation of 3D models of the built environment (including BIM) is achieved. Adoption is assumed to start at 10 per cent in 2026 and reach 70 per cent by 2033.

TABLE ES 2 LONGER TERM BENEFITS FROM DIGITAL CADASTRE AND FEDERATED 3D MODELS

Case study	Assumptions	Present value over 15 years	Present value over 20 years
		$ million	$ million
Smart buildings and infrastructure	Savings from integration of digital cadastre and BIM in federated registries of 3 D models of the built environment. Productivity improvement in the building and construction sector of 3 %. Benefits from 2026 to 2036.	798	2,622
Asset management	Application of BIM and 3D models in asset management for non-residential buildings. Benefits from 2026 to 2036.	120	471
Total		918	3,093

SOURCE: ACIL ALLEN

1

INTRODUCTION

The Cooperative Research Centre for Spatial Information (CRCSI), in conjunction with the NSW Spatial Services Division of the Department of Finance, Services and Innovation, commissioned ACIL Allen Consulting (ACIL Allen) to conduct an assessment of the economic value of the Spatial Services delivered in the state of NSW. For the purposes of this report, the economic value is the 'direct economic impact of spatial services on the NSW economy'.

This study focuses on estimating the value of spatial information in 2017, and the expected value of spatial information in 2022. The report also assesses longer term value for benefits that are expected to accrue beyond 2022.

The last study conducted by the CRCSI on the value of spatial information was conducted in 2008, at a macro level and covered all of Australia.

1.1 Modern spatial information

Spatial information has been around for many centuries. Surveys, maps and charts have been integral in the development of human settlements and navigation.

Spatial information took on new meaning with the development of computer assisted drafting (CAD), geographic information systems (GIS), Global Navigational Satellite Systems (GNSS), information technology and computing (ITC), and web based applications. These developments emerged slowly, initially in the 1980s. However, their potential to deliver significant productivity improvements emerged around 2000, and beyond, as their uses and applications converged.

Convergence in technologies and data infrastructure is currently evolving as governments develop open data policies for core foundation data, and as communications, sensors and robotics connect with spatial information to provide new and more productive ways in which many areas of human endeavour are conducted.

Modern spatial information can help businesses make better decisions, and thereby enhance productivity, across many industries. In addition, modern spatial information and the technologies by which it is created, used and disseminated, can be enabling as it allows for some totally new business applications.

It is rare that spatial information is an end in itself. Rather, it is typically used to create useful information products that help organisations improve their productivity. This is most obviously so in industries where location and questions of 'where' are important, and hence where spatial intelligence is advantageous, but it's suspected that the value of spatial information now extends to many industries other than the traditional high intensity users.

1.2 Foundation spatial data

Foundation spatial data is the authoritative geographic information that underpins the use of spatial information, or can add significant value to, any other information (ANZLIC, 2014). It is the core datasets which support evidence-based decision making across government, industry and the community and provides the basic data infrastructure within which richer applications can be developed.

The Australian and New Zealand Land Information Council (ANZLIC) is driving an initiative to define a national Foundation Spatial Data Framework (FSDF). This framework marks the beginning of a spatial data infrastructure (SDI). It has been developed to deliver a national coverage of the best available, most current, authoritative source of foundation spatial data, which is standardised, quality controlled and categorised into the 10 themes of:

1. geocoded addressing
2. administrative boundaries
3. positioning
4. place names
5. land parcel and property
6. imagery
7. transport
8. water
9. elevation and depth
10. land cover and land use.

The spatial datasets that make up these themes are considered foundational because they are:

— geospatial
— essential for public safety and wellbeing
— critical for a national or government function
— contribute significantly to economic, social and environmental sustainability.

In the same way the internet has enabled increased business and social interaction, the FSDF is a state and national approach to enable increased access to, and the continual evolution of, national foundation spatial data (Box P et al, 2015). As spatial data and associated applications become common place in activities across all sectors of both the Australian and New Zealand economies, the FSDF provides a standardised and trusted repository of foundation level spatial data in order to serve the increasing number of users across government, industry and the community.

Positioning services and infrastructure are also considered a fundamental part of an SDI, delivering accurate positions reliably, conveniently and ubiquitously in the same way that telecommunication, electricity, and water are delivered (Hale, 2015). Infrastructure such as Global Navigation Satellite Systems (GNSS) and Continuously Operating Reference Stations (CORS) underpin the accuracy, quality and authority of many of the foundation spatial datasets, and support the realisation of the economic, environmental and social benefits under an SDI.

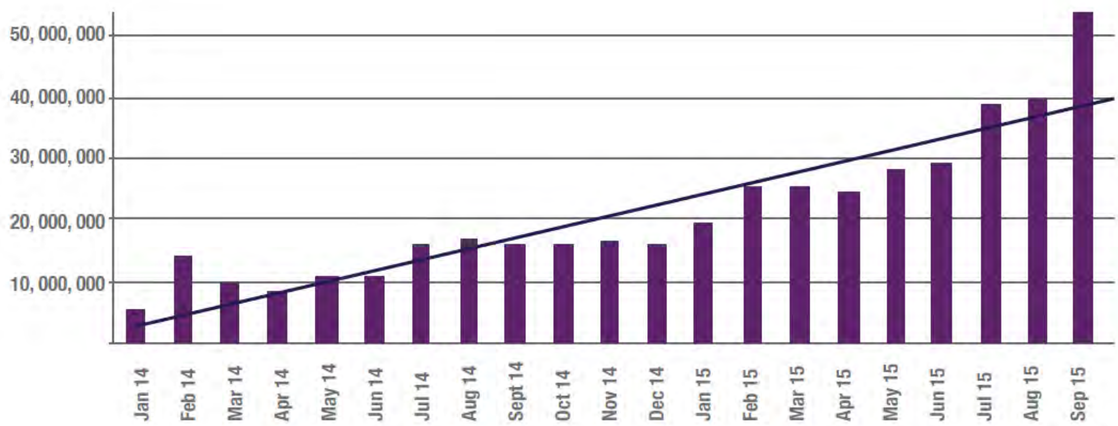
For example, a geospatial reference frame is an integral component of an SDI for both NSW and Australia. It is the reference system and fundamental layer for all survey, mapping, spatial datasets and activities as it supports geospatial information through accurate horizontal and vertical positioning of datasets. Infrastructure and services such as GNSS and CORS now provide the basic framework to enable downstream centimetre level accuracy, navigation and positioning applications. As a result, with minimal training, users are now able to position themselves to an unprecedented level of accuracy with the simple push of a button on a smart device such as a hand held tablet or phone.

1.3 A rapidly evolving operating environment

Over the past ten years the focus of spatial policy and programs by governments in Australia has been on progressing an open data agenda and establishing national foundation spatial data. Australian governments have been progressing these goals individually, and through cooperation via ANZLIC.

Open foundation spatial data has been established in NSW since 2014. An example of the growth in the use of open spatial data can be seen from the number of hits on the NSW Globe website following its launch in 2015, as shown in Figure 1.1. Such trends are a dramatic illustration of the interest in, and the use of, open data and open foundation spatial data, in particular.

FIGURE 1.1 NUMBER OF HITS ON NSW GLOBE



SOURCE: (CRCSI, 2016)

To date an SDI has been of more interest to governments and academics than to the private sector (CRCSI, 2016). However, this situation is changing as the emerging use of Building Information Models (BIM), transport logistics, intelligent transport systems and environmental monitoring systems by the private sector create new opportunities.

The next generation of SDIs is likely to involve:

— seamless supply chain integration
— greater involvement by consumers in defining SDI needs
— merging of private and public data into federated models (including BIM)
— automatic query driven architecture
— improved and more user friendly data access for end users
— open spatial analytics.

In addition, continued development and improvements in foundation spatial data, positioning data and integration with ITC and devices is creating new applications and uses for spatial data. This is increasing the access to, and use of, spatial data by business. In particular, the ability to combine spatial information with demographic, financial and operational information is creating significant opportunities for users that are likely to rapidly emerge over the next 5 to 10 years. Analytics is one of these opportunities.

Rapid spatial analytics

The CRCSI in Australia has developed a research program for Rapid Spatial Analytics (RSA). This development aims to rapidly create and value add spatial information products, manually or through automation, from devised and cloud-based infrastructure (Coppa, 2016). The RSA program has five themes:

— spatial work flows
— real-time spatial analytics
— big spatial analytics
— foundation spatial analytics
— visualisation and decision-making analytics.

The term “rapid” has several meanings depending on application. Its meanings include near real time provision of outputs, efficient processing or fast access and integration of data. Such innovations will be necessary to meet future demand for analytical capabilities for use by other disciplines in developing more efficient and faster solutions to design, construction, operation and management of complex systems such as federated BIM registries, intelligent transport systems, management of health care services and a range of other endeavours central to the Australian economy.

1.4 Structure of this report

This report focuses on modern spatial information – that is, spatial information technologies and data that have evolved since 2000. It examines case studies of the use and application of spatial information in NSW to provide evidence and information of its direct economic impact on the NSW economy in 2017 and the estimated impact in 2022.

The methodology is based on assessing the difference between the impact with modern spatial information technologies and data, and what could be expected to have arisen under a counterfactual. The counterfactual represents the hypothetical situation without modern spatial information and technologies. For 2022 it has been necessary to estimate likely levels of adoption of existing and new technologies and applications that can be expected with increased access to spatial data and analytical tools to use them.

The methodology is described in more detail in Appendix A.

The value of spatial information from the perspective of land and property administration is discussed in Chapter 2. While this chapter focusses on the land and property supply chain supported by the Spatial Services Division of the Department of Finance, Services and Innovation, and the productivity improvements that have been and are expected to be realised in this process, it also draws on findings from subsequent chapters on the downstream uses of data and services delivered by the Spatial Services Division.

Subsequent chapters then discuss the value of spatial information to the following sectors of the NSW economy:

— Engineering surveying and construction (Chapter 3)
— Smart buildings and infrastructure (Chapter 4)
— Smart asset management (Chapter 5)
— Smart utilities (Chapter 6)
— Local Government and smart cities (Chapter 7)
— Emergency services and insurance (Chapter 8)
— Agriculture and forestry (Chapter 9)
— Planning and environment (Chapter 10)
— Logistics (Chapter 11).

The value of spatial information to the NSW economy, and the key findings from the case studies, are summarised in Chapter 12.

2

LAND AND PROPERTY ADMINISTRATION

The property sector is a vital part of the Australian economy. Indeed, the industries within the property sector are significant contributors to the national economy in terms of output and employment. Land administration services play a significant ongoing role supporting the property sector.

There are currently around $1.6 trillion of mortgages secured against land titles in Australia, of which an estimated $581 billion are in NSW.[1] The total value of all the residential property held in NSW was $2,325 billion and $5.9 trillion Australia-wide.[2]

As noted in ICSM (2014)[3], land administration systems allow people, businesses and governments to leverage and manage these huge national and state asset bases. Indeed, given that the size of the NSW and Australian economies was $581 billion and $1.6 trillion respectively[4], the value of the land administration systems to the property sector and the economy in general is substantial.

NSW's Spatial Services Reform Program is described in section 2.1 and provides the context for valuing spatial information to the land and property administration sector.

2.1 Spatial Services Reform Program

An SDI provided by governments is the foundation on which land and property activities are based. An SDI provides a framework for community and organisational information systems to facilitate and coordinate access, exchange and use of spatial data effectively and as efficiently as possible (GDSI, 2012). Where required, the SDI provides a source of authoritative spatial information for use by governments and industry in their business activities. It is fundamental to the land and property sector.

The Spatial Services Division of the Department of Finance, Services and Innovation provides this and spatial related services in NSW. The Division is developing a road map to improve the delivery of spatial services in NSW by increasing the value of the data and information assets that it provides, and encouraging innovation and industry development consistent with the emerging digital economy.

The initiatives included in the Spatial Services Reform Program are:

— a single authoritative digital cadastre
— a single authoritative spatial data indexing framework
— a single data and services discovery platform

1 Australian data sourced from Australian Bureau of Statistics (ABS) (2016), *Housing Finance, Australia*, Catalogue number 5609, June. NSW figures were estimated by ACIL Allen.
2 ABS 2016, *Residential Dwellings: Values, Mean Price and Number by State and Territories Dataset*, http://stat.abs.gov.au/Index.aspx?DataSetCode=RES_DWEL_ST, accessed August 2016.
3 Intergovernmental Committee on Surveying and Mapping (ICSM) 2014, *Cadastre 2034: Powering Land and Real Property, Cadastral Reform and Innovation for Australia – National Strategy*, Consultation document, April.
4 ABS 2015, *Australian National Accounts: State Accounts, 2014-15,* Catalogue number 5220.0, November.

— a federated, high performance delivery network to support the discovery service.

These developments will enhance many areas of government and industry endeavour, some of which are discussed in this report. They will also provide much improved access to spatial data and spatial data analytics by the community, as well as business and government, helping to transform workflows, improve delivery of public services and capitalise on the emerging digital economy.

These measures will deliver:

— digital end to end work flow implementation
— role based security of data
— a business intelligence layer over the top of the data.

Spatial services have already delivered improved work flows for the Valuer General's office. Future improvements will improve work flows and spatial data analytical capabilities for many areas of the NSW economy. Significant benefits are expected to be realised in many areas of land and property activities for both government and the private sector. These benefits could include:

— streamlined land and property development
— savings in surveying and land management
— improved revenue collection by government
— whole of government address validation.

The existing and potential beneficial impacts of spatial information systems for the Valuer General are discussed in section 2.2, and for land and property development are discussed in section 2.3. Other potential benefits of spatial information to the land and property administration sector are discussed in section 2.4.

The economic value of spatial information to the land and property administration sector is summarised in section 2.5.

2.2 Valuer General

The Valuer General is an independent statutory officer appointed by the Governor of New South Wales to oversee the valuation system. The Valuer General provides independent and impartial land valuations used by councils for rating and the state government for taxing purposes. The Valuer General is also responsible for the independent determination of compensation when land is compulsorily acquired and ensuring the process is fair and transparent. Property NSW, a Division of the Department of Finance, Services and Innovation, manages the valuation system on behalf of the Valuer General.

There were 2,529,278 valuations on the Register of Land Values as at 30 June 2016. The Valuer General issued 1,820,393 valuations in the 2016 financial year and issued 880,841 notices. The valuation base is increasing as the economy and population of NSW grows. There is an ongoing challenge to improve the performance of the valuation system, which is subject to formal Parliamentary Oversight by the Joint Standing Committee of the Office of the Valuer General.

Mapping and property data, including property sales information, is also available through NSW Globe.

The cadastre data base, topographic mapping and imagery are important tools for valuers and a substantial source of efficiency, particularly for valuations in remote areas. Spatial information is reported to be a powerful tool for efficiency as well as for customer services and maintaining public confidence in the valuation system. The Valuer General estimated that spatial information services delivered between 10 per cent and 20 per cent savings in operating costs.

Looking to the future, there is understood to be significant potential for further development of spatial information services as an enabler of greater efficiency in the valuation process. Spatial analytics could potentially lead to streamlining and some automation of valuation processes. Higher quality imagery, for example, can provide greater granularity of detail for capital improvements at assessments of site value. Many of these improvements will be in place by 2022.

There are also significant opportunities in the real estate and property sector to improve services and lower costs. These opportunities have not been quantified for this report.

Economic impacts – Valuer General

The base level budget for the Valuer General was $44 million in financial year 2016, with costs of around $1.6 million for spatial services. The office employed around 100 staff plus around 300 contract valuers.

The Valuer General estimates that spatial information services delivered around 10 to 20 per cent in cost savings as a conservative estimate. Assuming that the cost savings are 15 per cent (the mid point of the estimated range of savings), ACIL Allen estimates the value of spatial information to be in the order of $4.4 million in 2017. Further details on this calculation are included at Appendix C.

ACIL Allen has not made an assessment of the additional benefits that might be realised through automation and improvements in the use of imagery and other data sources over time. However, it is likely that the value of spatial information services in 2022 will be higher than in 2017.

KEY FINDING 1 ECONOMIC IMPACTS – VALUER GENERAL

Spatial information has extensive application in valuation processes for the Valuer General's office. The cadastre, topographic mapping and imagery are important tools used in the valuation process. Property value information is also provided through the NSW Globe based on Google maps.

The use of spatial information by the Valuer General's office is estimated to have delivered savings of around $4 million in 2017.

Further increases in productive value are anticipated by 2022 including use of higher resolution imagery, greater use of location analytics and further automation of the valuation process. These developments are expected to deliver greater benefits by 2022, but have not been quantified for this report.

2.3 Land and property development

Land management encompasses a broad range of activities including measurement, recording and setting out of land development. The surveying and land management industry is a broad based, multi-disciplinary industry that is technologically advanced in its use of geospatial information systems.

Cadastral surveying underpins the legal right to land title through the determination of the position of the boundaries of public or private land, including national and international boundaries and the registration of those lands with the appropriate authorities. Engineering and building surveying, on the other hand, supports planning and construction, setting out of roads, infrastructure and buildings. Engineering surveying also plays a role in the creation and formatting of spatially accurate and reliable 'as constructed' and asset management records.

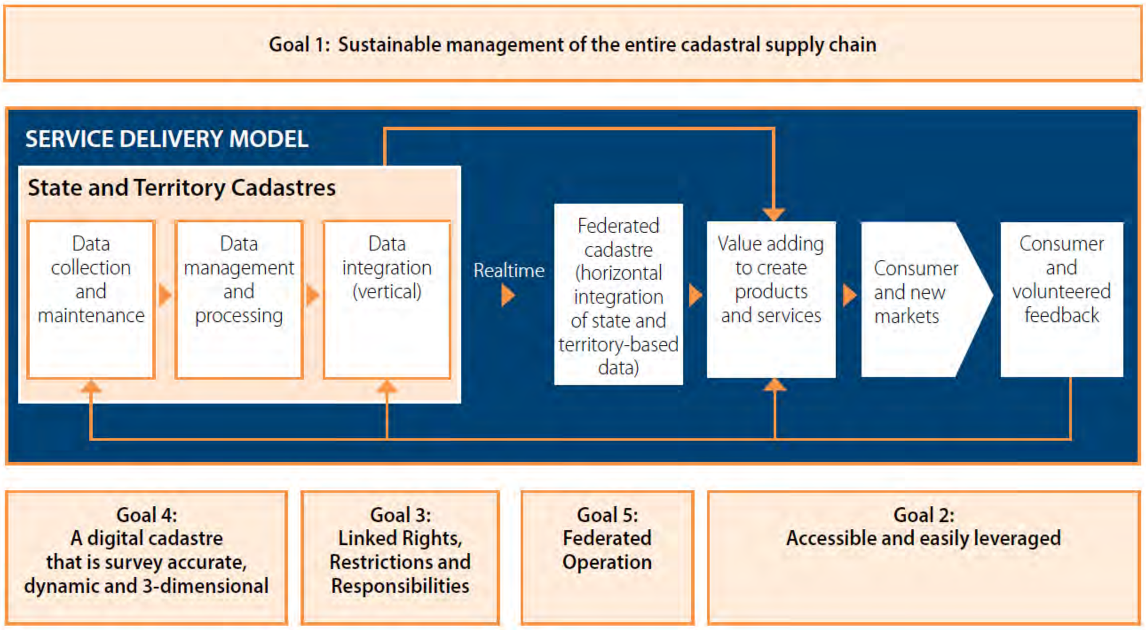
2.3.1 Improvements in cadastre

The advent of precise surveying technologies has not removed the requirement for the application of land law and administration. However surveying processes have been evolving rapidly with the development of electronic and spatial systems to acquire and represent land data. Cadastral surveyors have adopted electronic technologies for recording position and elevation as illustrated, for example, through the use of total stations to capture and record position and elevation. While such developments have resulted in some productivity improvement, the legal processes for recording and publishing the cadastre are still on paper based two dimensional (2D) cadastres.

There are a number of initiatives developed under the guidance of the Intergovernmental Committee on Surveying and Mapping (ICSM) that offer significant potential benefits from improvements in cadastres in Australia.

The first of these is the vision for a future cadastral system in Australia that will enable people to easily and confidently identify the location and extent of all rights, restrictions and responsibilities related to land and real property (ICSM, 2015). This is referred to as Cadastre 2034, the aim of which is to establish a shared vision and aspirational goals for the cadastral surveying and spatial sector, and a unified approach to the management of cadastral information (see Figure 2.1).

FIGURE 2.1 GOALS AND SERVICE DELIVERY FOR CADASTRE 2034



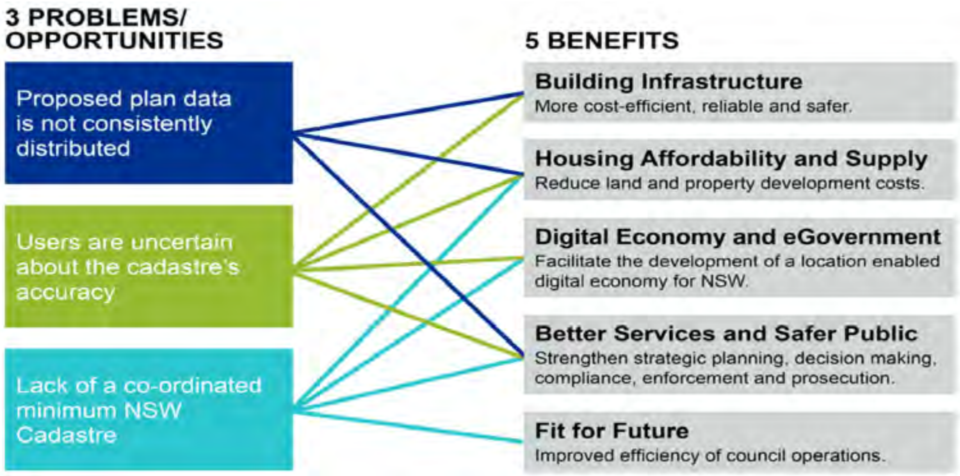
SOURCE: (ICSM, 2015)

The second initiative is to modernise the current national geocentric datum (GDA) so that by 2020 the GDA will be current, and updated every year. Over time this will be carried through to the cadastre.

In NSW there is currently no common digital representation of the cadastre across governments and industry, with over 100 cadastre datasets being maintained on a daily basis. This results in significant duplication of resources, a higher regulatory burden on industry, constraints on decision making, and unnecessary barriers to digital government services.

The NSW Government is developing a single cadastral system following consultations with local government and industry, referred to as Cadastre NSW. The problem with the current arrangement, and the benefits that stakeholders expect from implementation of a single cadastre under the Cadastre NSW program, are illustrated in Figure 2.2.

FIGURE 2.2 CADASTRE NSW – PROBLEMS, PROSPECTS AND EXPECTED BENEFITS



SOURCE: (JACOBS, 2016)

2.3.2 Economic impacts – surveying and land management

There are no reports or analysis available of potential savings that might be realised from implementation of Cadastre NSW. This report analyses some of the benefits that could be expected to be realised. For the purposes of this report, we have focussed only on the savings that might be realised by the surveying profession as a result of surveyors using digitised models, avoiding the need for transcription to and from a 2D paper based format.

ACIL Allen estimates that a reduction in professional and technical time of 10 per cent would be possible with the full implementation of the Cadastre NSW initiative from 2012. On this basis we estimate that the single digital cadastre in NSW would save the NSW surveying profession around $8.5 million per annum by 2022[5].

The benefits flow only from sharing pre-existing private imagery/models, data, and Rights, Responsibilities and Restrictions (RRR), federated with existing public data (including RRR). The benefits do not take into account savings flowing from the original creation of the data or from the use of scanned models to facilitate asset management.

KEY FINDING 2 VALUE TO SURVEYING OF A SINGLE DIGITAL CADASTRE

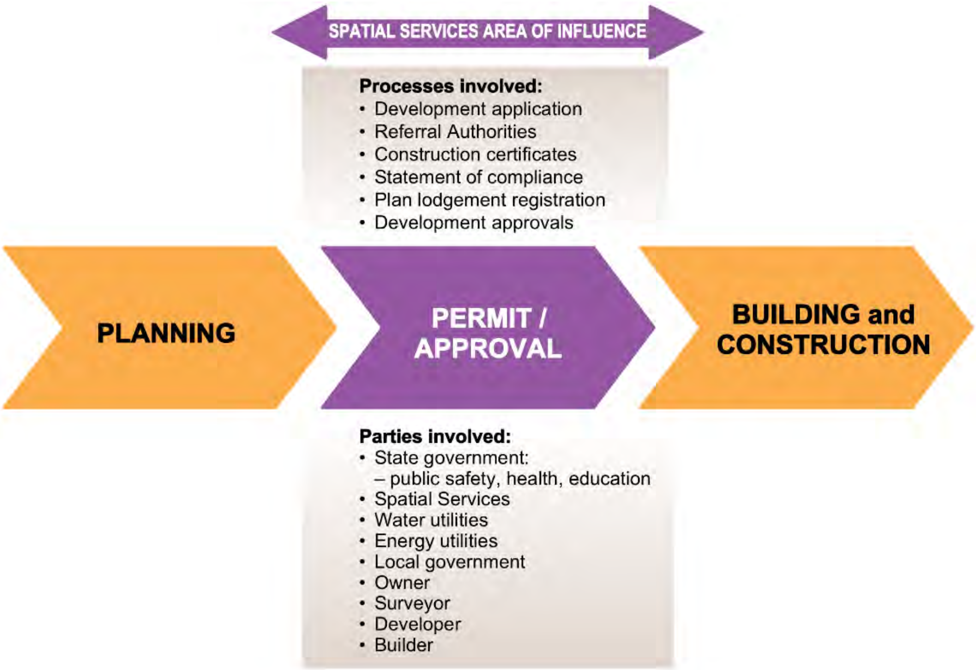
> The value of the Cadastre NSW project is estimated to be around $8.5 million in savings to registered surveyors in 2022. This is based on a reduction in professional and technical time of 10 per cent that would become possible with the full implementation of the Cadastre NSW project.

2.3.3 Permit and approvals processes for land development

Spatial Services products are relevant to all aspects of the property supply pipeline. However, as shown in Figure 2.3, they are critical to the permit and approval process for land development.

[5] Based on a 7 per cent discount rate, around 940 registered surveyors working in NSW and an average annual wages cost of $90,000 per year.

FIGURE 2.3 PROPERTY DEVELOPMENT PIPELINE



SOURCE: (SPATIAL SERVICES, 2016)

Permit approval commences at the conclusion of the planning stage and extends through to the commencement of the building and construction phase. It includes activities such as development application and approval, statements of compliance, plan lodgement and registration, and clearance through referral authorities.

Referral Authorities include State Government agencies for health, public safety and education, water and energy utilities, and local government. Parties involved include surveyors, engineers, architects, developments and builders.

The Spatial Services Division estimates that delays and reworking of data is leading to around $200 million per month in extra costs.

Implementation of the measures to improve the delivery of spatial services will reduce delays and the need for reworking. It has been conservatively estimated that the productivity improvements from these activities could improve efficiency by between 5 and 10 per cent (NSW Spatial Services, 2016).

This could conceivably reduce the costs for permit approval process by between $120 million and $240 million per year by around 2022.

KEY FINDING 3 VALUE OF SPATIAL SERVICES TO THE PERMIT AND APPROVAL PROCESS FOR LAND DEVELOPMENT

Improvements to the permit and approval process for land development through the full implementation of the spatial services improvement road map may result in benefits of up to $240 million per year by 2022. These benefits include the savings to registered surveyors, which were discussed in section 2.3.2.

2.4 Other potential benefits of spatial information

2.4.1 Office of State Revenue

The Office of State Revenue is responsible for the collection of taxation and other revenues for the NSW Government. Location based taxes – stamp duties, land tax and the parking space levy – make up around 46 per cent of total NSW State revenue, as set out in Table 2.1.

TABLE 2.1 EXTRACT FROM NSW STATE REVENUE

	2016-17	2017-18	2018-19	2019-20	CAGR
	$ million	$ million	$ million	$ million	
Stamp duties	10,587	10,947	11,366	11,817	4%
Land tax	3,136	3,444	3,626	3,761	6%
Parking space levy	107	109	111	114	2%
Sub total	13,830	14,500	15,103	15,692	4%
Total State revenue	29,759	31,240	32,503	34,021	5%
Location based taxes as a proportion of State revenue	46%	46%	46%	46%	

Note: CAGR is the compound annual growth rate

SOURCE: (NSW TREASURER, 2016-17)

Full implementation of the NSW spatial services road map will create the capacity for location based information on location based taxes to be easily recorded in 3D registries with information on ownership, payments and location easily analysed. Such systems are being developed in the Netherlands and Denmark to improve the management of property taxes by governments.

This has the potential to improve government revenue collection. We have not estimated the value of this to the efficiency of revenue collection but it can be seen from the size of the revenue items that a small improvement in revenue collection could lead to material increases in NSW State revenue.

2.4.2 Whole of government address validation

Address data is currently held in more than one data base and in more than one location. Address files can be held in several locations including Spatial Services data bases, Australia Post and Local Government. These data bases are not always consistent, creating problems for emergency services, government agencies and the private sector when seeking to locate a precise address. For example, in rural areas the postal address may be some distance from the physical address.

Addresses and strata title may also not be fully matched, which can be a problem for emergency services and other agencies that need to link actual location with address.

The Spatial Services Road Map will create a whole of government validated address file that will provide one source of authoritative geocoded address data. This will be of benefit to government agencies such as emergency services and ambulance but will also be of value to the insurance industry and other industries dependent on accurate address data.

The benefits across government services, including emergency management, are likely to be significant, but have not been quantified for this report.

KEY FINDING 4 OTHER POTENTIAL BENEFITS OF SPATIAL INFORMATION TO THE LAND AND PROPERTY ADMINISTRATION SECTOR

> The Spatial Systems Reform Program can be expected to deliver benefits to government services across the board through an improved spatial data and services delivery program. In particular, the Office of State Revenue should be able to improve its administration of stamp duties, land tax and parking fee revenues through more comprehensive and accurate geocoded property data.

2.5 Summary of economic impacts – land and property administration

There are current and future benefits from the use of spatial information for the land and property administration sector. ACIL Allen selected a small number of case studies to illustrate the current and potential value.

2.5.1 Office of the Valuer General

The use and value of spatial information for the Office of the Valuer General was estimated to be of the order of $4 million per year in 2017. It is expected that this value will increase by 2022 with developments foreshadowed in the Spatial Services Road Map. These have not been estimated for this report.

2.5.2 Land and property development

It was estimated that the benefits of a single digital cadastre to registered surveyors could be around $8.5 million per year by 2022.

With the completion of the full Spatial Services Road Map for Spatial Data Infrastructure, these benefits could increase as high as $240 million per year by 2022 through an improved permit and approval process for property development.

2.5.3 Other areas of potential benefit

The Office of State Revenue would benefit from the provision of more accurate and easily accessible spatial data in areas such as the administration of land tax and parking levies in NSW. The ability to analyse transactions and relate location to other data can be expected to improve the efficiency and effectiveness of revenue administration.

The ability to provide better government services through wider and easier access to spatial data can be expected to lead to a general improvement in the delivery of government services. In particular, access to whole of government addressing will be of benefit to health and emergency services in urban and rural areas.

The ability to undertake rapid data analytics that will be enabled by a single authoritative data and service delivery platform with real time access to large spatial data sets is certain to lead to overall productivity in the delivery of government services across portfolios.

3 BUILDING CONSTRUCTION AND INFRASTRUCTURE

While the benefits of spatial information systems for cadastral surveyors are likely to be realised more in the future, the benefits for planning, construction and maintenance of civil engineering projects are being realised now, with the potential for significant future benefits.

The building, construction and infrastructure (BCI) sector requires survey mapping, and vertical and horizontal control needs to be integrated into the cadastral system. Survey mapping and survey set out for the BCI sector can be defined as:

— picking up the land form, service and building data
— setting out locations for construction.

Scanners and augmented GNSS for positioning are increasingly employed to pick up the land form, service and building data, and there is the potential to use new technologies, such as machine guidance, in setting out processes.

A recent report released by the House of Representatives Standing Committee on Infrastructure Transport and Cities adopted the term Smart Infrastructure to capture the concept of the use of smart information and communication technologies (ICT) systems in the planning, development and management of infrastructure in Australia. The use of spatial information systems is increasingly being seen as part of the Smart Infrastructure revolution (Standing Committee on Infrastructure, Transport and Cities, 2016).

Australia has seen quantum changes in the spatial market for surveying, mapping, planning design, construction and maintenance of infrastructure. The market is characterised by innovation in spatial, control and ICT technologies. The convergence of these technologies enables products and services that increase the efficiency, accuracy and safety of planning and construction processes.

The use of spatial information in the BCI sector is discussed in more detail in section 3.1, and the economic value of spatial information to the BCI sector is discussed in section 3.2.

3.1 Surveying and mapping

Surveying depends on accurately positioned benchmarks for reference controls. The availability of control marks varies from jurisdiction to jurisdiction and from region to region. In some regions the availability of control benchmarks is limited and this can create problems for mapping and surveying.

New techniques for acquiring data and for machine guidance have seen significant productivity gains in civil engineering design, construction and maintenance, through improvements in engineering and building surveying.

3.1.1 Survey control

Topographic mapping and all surveying data relies on survey control marks that form the basis of Australia's geodetic framework. This framework provides the underlying control of position and elevation on which all surveying reference points are based. Fundamental geodetic data is required at the millimetre level and is determined from astronomical data, laser ranging stations and GNSS systems.

GNSS have become widely used in surveying practice. From a gradual take up during the 1990s, mainly amongst larger firms undertaking project control network surveys, most surveying firms now have GNSS capability. Further improvements in positioning technology is possible through increasing the use and adoption of GNSS technologies for these purposes.

Evidence in Australia has found that the use of CORS networks and Real Time Kinematics (RTK) systems has reduced the costs of establishing reference controls for projects in remote regional areas. Photogrammetric surveys and use of augmented GNSS delivers significantly lower costs than conventional terrestrial survey techniques. It has been estimated that these techniques reduce the time required in the field for survey teams by around 75 per cent (Lorimer, 2007).

3.1.2 Engineering surveys

Engineering surveys are a key component in the delivery of infrastructure projects. This includes route selection, detailed surveys, setting out, and as constructed surveys.

Detailed surveys of route corridors for infrastructure, such as pipelines and power lines, require two centimetre accuracy. In the past this required a survey team to traverse the route, often in remote locations where the survey data are limited. Most traditional survey teams require at least two surveying personnel which involves travel and accommodation costs as well as the time to traverse the survey route. With growing demands for infrastructure and rising costs, new techniques are needed to undertake engineering surveys more efficiently and at lower costs.

Spatial technologies have significantly improved the productivity of engineering surveys in many ways. Examples include:

— Route selection – with improved remote sensing techniques, such as aerial and satellite imagery, and the increased use of Light Detection and Ranging (LIDAR) technologies, far less ground survey work is required for route selection for large infrastructure projects.

— Detailed route survey – availability of CORS networks has reduced the need to create primary control networks.

— Set out – machine control is increasingly being applied to set out roads projects, for example. With the expansion of the CORS network, machine control is feasible and reduces the costs of staking out designs by up to 90 per cent.

— As constructed surveys – GNSS and laser guided machines now record the position of roads and trenches as they are constructed. This data can be provided to surveyors to input into as constructed plans, which greatly reduces the need for surveyors on site.

Research undertaken in 2013 indicated that the use and application of spatial technologies, including precise positioning, LIDAR and machine control, is likely to have resulted in productivity improvements in infrastructure by the following orders of magnitude:

— route selection – 20 per cent

— detail control – 40 per cent

— detail survey – 40 per cent

— set out – 20 per cent

— as constructed surveys – 20 per cent.

The same report estimated that further improvement in Australia is likely to increase this improvement by a further 10 per cent, as a minimum (ACIL Allen Consulting, 2013).

3.1.3 Mobile laser scanning

Mobile laser scanning (MLS) is a vehicle mounted system that combines high resolution photography with highly accurate laser and GNSS systems. MLS provides fast, accurate and comprehensive data capture for roads and other infrastructure. It has significant potential to undertake rapid surveys that would otherwise take thousands of hours of work.

It can be combined with “structure in motion” software that uses algorithms to determine traceable points in video frames. These points can them be triangulated between frames to produce a model of the road or infrastructure in an arbitrary pixel space coordinate system. The model can then be fixed to real world locations using alignment with simultaneously collected GNSS data.

The use and application of MLS is dependent on access to accurate augmented GNSS, such as CORS or other systems, to be effective. It has significant potential productivity benefits in intelligent transport systems and BIM modelling generally. For example, BCE Surveying has stated that:

The development of MLS has resulted in a number of tangible productivity benefits to the surveying industry, clients and the community. Economically the resources required for completing surveys using MLS are far less than traditionally required using conventional survey methods. Using traditional methods to survey a one square kilometre site would have taken up to 16 hours while the MLS can complete the equivalent area in just 2 hours. The savings in time, money and man power has substantial productivity benefits to all parties involved.

(BCE Surveying Pty Ltd, 2015)

3.1.4 Machine guidance

Machine guidance systems are increasingly being introduced to large scale construction projects. Surveyors are responsible for the manipulation, upkeep, troubleshooting and quality control of the machine data and software. Without such expertise, the construction industry could not capitalise on the advances in technology that are having a significant effect on project cost control and design compliance.

Machine guidance systems operate in a wide range of sectors including, land development, civil and mining engineering, property development and agriculture. Its activities also extend to hydrographic and geophysical surveys for the petroleum and mining sectors.

The provision of 3D spatial data services by surveyors is used by developers, architects and engineers and forms the base data for conceptual and detail design for major infrastructure projects.

The benefits of machine guidance are:

- Improved accuracy improvements – tasks are done correctly the first time around, resulting in reduced operational inefficiencies, and fewer errors and greater specification conformance, even with rookie operators at the wheel
- reduced double handling of materials by around 60 per cent
- improved timing of job given less passes required for graders and excavators by around 70 per cent
- less machine wear and tear
- fuel savings of around 25 per cent
- improved machine utilisation and reduced downtime
- reduced capital
- increased safety.

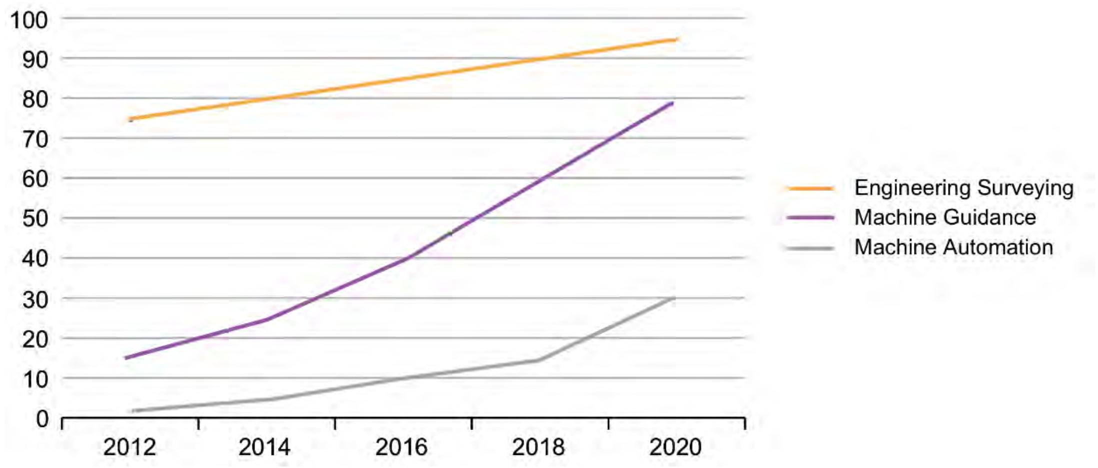
Machine guidance removes the need for on-the-ground survey set out and construction crew string lining; there are fewer opportunities for potentially dangerous machine / ground-worker interactions (Machine Guidance, 2016). This has the direct benefit of reducing labour costs and improving health and safety records.

Through a combination of these benefits, it is estimated that savings of between 10 per cent and 20 per cent are being achieved through the use of machine guidance systems.

3.1.5 Adoption rates

The rate of adoption of engineering surveying, machine automation and machine guidance were estimated in a report published by ACIL Allen in conjunction with the then SKM and Lester Franks on the use and application of precise GNSS in Australia (ACIL Allen Consulting, 2013). Figure 3.1 illustrates the increase in adoption of the above technologies in the construction sector that was considered to be likely at that time. Consultation with stakeholders suggests that these adoption rates still apply today.

FIGURE 3.1 ADOPTION RATES



SOURCE: (ACIL ALLEN CONSULTING, 2013)

3.2 Economic impacts – engineering surveying

Based on estimates from case studies undertaken by ACIL Allen over the past ten years, the productivity improvements in the engineering survey sector from the use of spatial information technologies are likely to be at least 30 per cent in 2017, increasing to 50 per cent by 2022.

ACIL Allen estimated the economic value of spatial information to the engineering survey sector on the basis of the following assumptions:

— productivity improvements increasing from 30 per cent in 2017 to 50 per cent in 2022

— adoption rates increasing from between 25 per cent and 35 per cent in 2017 to between 45 per cent and 55 per cent in 2022

— the engineering surveying sector represents slightly under 1 per cent of the value added in the professional services sector.[6]

The results of the analysis are provided in Table 3.1. Further detail is provided in Appendix D.

[6] Based on earlier work undertaken by ACIL Allen (ACIL Allen Consulting, 2013)

TABLE 3.1 IMPACT OF SPATIAL INFORMATION SYSTEMS ON ENGINEERING SURVEYING

		Low scenario		High scenario	
Year	Assumptions	Productivity impact	Net benefit	Productivity impact	Net benefit
2017	Cost savings 30% Adoption rate 25% - 35%	8%	$13 million	11%	$19 million
2022	Cost savings 50% Adoption rate 45% - 55%	23%	$41 million	28%	$50 million

SOURCE: ACIL ALLEN

The table shows that the net impact of spatial information services on engineering surveys could rise from between $13 million and $19 million in 2017 to between $41 million and $50 million by 2022. The principal cause of the increase is the increased levels of adoption that are expected in this sector.

KEY FINDING 5 VALUE OF SPATIAL INFORMATION TO THE ENGINEERING SURVEY SECTOR

The net impact of spatial information services on engineering surveys could be between $13 million and $19 million in 2017, rising to between $41 million and $50 million by 2022.

The drivers behind these numbers derive from increased operational efficiency resulting in greater accuracy and fewer errors, 60 per cent reduction in double handling of materials, improved utilisation of graders and excavators, less machine wear and tear, fuel savings, increased safety, and reduced hours required from automatic machine guidance.

4

SMART BUILDINGS AND INFRASTRUCTURE

Engineering and construction represents around 5 per cent of the NSW economy with a gross value add of $25.4 million in 2014 (ABS, 2013-14). It is important as an employer as well as a developer of buildings and infrastructure on which the NSW economy depends.

As discussed in Chapter 3, there has been a quantum change in the application of spatial technologies in conjunction with other technologies for surveying, mapping, planning, construction and maintenance of infrastructure. A House of Representatives Standing Committee report noted in its opening remarks that smart information and communications technologies have the potential to transform the way in which we plan and manage infrastructure. The report examined the ICT hardware, software and new applications that are changing the face of the infrastructure sector and society more generally, driving greater efficiency, increasing productivity and greatly simplifying construction processes and life of asset maintenance (Standing Committee on Infrastructure, Transport and Cities, 2016).

Smart information and communications technologies apply to buildings, energy infrastructure, rail, road and water, and include:

- Geographic Information Systems (GIS)
- augmented GNSS
- airborne LIDAR
- airborne oblique camera systems
- Mobile Laser Scanning (MLS)
- machine guidance
- Remotely Piloted Aircraft Systems (RPAS)
- structure in motion surveys
- machine learning
- sensors
- augmented reality
- the internet of things.

These technologies are facilitating a move to 3D mapping and models in the development of new infrastructure. These models provide platforms for design and construction but offer more than just basic surveying. Their use extends to ongoing management, maintenance and modifications. They have significant implications for buildings but also for utilities, roads, pipelines, ports, water and energy infrastructure. Ultimately these technologies, when integrated into 3D spatial models, can facilitate better decision making prior to construction as well as management of developments throughout their lives.

The application of smart technologies in buildings and infrastructure is discussed in section 4.1, and the economic impact of spatial information for smart buildings and infrastructure are discussed in section 4.2.

4.1 Building Information and Modelling (BIM) and smart technologies

BIM is a powerful ICT tool that is transforming the planning of construction and subsequent maintenance.

At its simplest level, BIM is a digital representation of the physical characteristics of the built environment. BIM can provide a shared knowledge resource for single point of truth for all parties involved in a construction project. It can also provide highly valuable information to support the subsequent use, maintenance and modification of the build environment.

BIM is already being adopted in many projects in NSW including:

— Moorebank Intermodal Terminal Project
— Barangaroo development, including Wynyard Walk
— the North West Rail Link
— the Southern Freight Link
— Auburn Stabling Yard
— Sydney CBD light rail early works.

According to the House of Representatives Standing Committee report and consultations with stakeholders undertaken during 2016, the major private infrastructure construction firms have all implemented some form of BIM System.

At the present time, there is no process for coordinating privately developed 3D models in in Australia. Significant savings would be realised if utilities, road authorities, and local councils held authoritative 3D models. The Sydney Light Rail Project provides an example of the problems encountered in trying to establish existing conditions for a major project in the absence of authoritative 3D models.[7] These problems are described in Box 4.1.

BOX 4.1 PROBLEMS ENCOUNTERED WITH THE SYDNEY LIGHT RAIL PROJECT IN THE ABSENCE OF AUTHORITATIVE 3D MODELS

The Sydney Light Rail Project is a $2.1 billion project to deliver approximately 12 km of light rail from Circular Quay to Sydney's south eastern suburbs by 2019.

Prior to commencing award of the main public-private partnership contract, the Department of Transport for NSW undertook approximately 12 months of night works to map around 5,000 subsurface utilities along the route.

Approximately 500 existing subsurface utilities had been identified for relocation to make way for the new infrastructure (e.g. light rail track slab). During the course of construction, an additional 400 unknown services were identified.

Each service had to be treated as live, and requests for information had to be sent to all providers to identify the owner and status of the conduit. This process typically takes about a month for responses to be returned and the issue closed-out.

Of the 400 new services found, only a handful were claimed. The remaining services were managed, and often found to be redundant and no longer in service.

Unnecessary costs to the program were incurred as a result of this issue, with relocation works delayed by approximately 5 months, although these activities were not the critical path for the project.

As-built information from utility providers also proved to be problematic and frequently unreliable (e.g. services out of location, marked as incorrect material etc.). This also caused disruption and delays with construction.

[7] Matt O'Sullivan, Delay to construction of $2.1b light rail line in Sydney CBD, The Sydney Morning Herald, Aug 2016 http://www.smh.com.au/nsw/delay-to-construction-of-21b-light-rail-line-in-sydney-cbd-20160809-gqod41.html

While the project remains 'on time and on budget', this is only because these sort of delays and costs are included in the pricing and schedule; though with a high degree of risk. If all the data now being gathered had been available at project planning stage, the project could have been completed at least one and a half years sooner, at less cost with a much lower level of risk (ACIL Allen, 2017).

4.1.1 Road transport

BIM and related smart technologies have the potential to deliver significant improvements to the future development and management of urban transport networks, public transport and freight transport networks in NSW.

Intelligent transport systems (ITS) have been around for over 20 years. ITS are gaining increased application as spatial systems, combined with sensors, augmented GNSS and ITC developments, in the transport sector. Such technologies have the potential for productivity improvements in transport systems, including time saved and more sustainable environmental outcomes. Benefits are already being delivered.

Transurban has noted that the implementation of ITS on road networks optimises traffic flow, enhances the management of road space and creates extra capacity within the existing footprint with little impact on the surrounding environment and minimal disruption to the public (Transurban, 4 February 2016).

In its submission to the Standing Committee on Infrastructure, Transport and Cities, National ICT Australia (NICTA)[8] estimated that the use of ramp metering and traffic data analytics resulted in:

— travel time reductions during congestion periods of 40 per cent
— capacity improvements delivering additional 100 cars per hour
— economic impacts in one year of 400,000 commuter hours equating to about **$22 million per year** excluding social and environmental costs (NICTA, July 2015).

The Sydney Coordinated Traffic System (SCATS), developed by Roads and Maritime Services (RMS), coordinates traffic signals in response to traffic conditions and relies, in part, on spatial information systems for its operations. Systems similar to SCATS are used in all Australian cities and are finding applications overseas.

A recent study indicates that SCATS has delivered substantial economic benefits of around **$3.6 billion per annum** compared to conventional methods of traffic management, by reducing Sydney travel times (Transport for NSW, 2016).

An important application of spatially enabled telematics is the Intelligent Access Program (IAP) operated by the National Heavy Vehicle Regulator.[9] This is a voluntary program that uses GNSS to monitor heavy vehicle road use. Road agencies can provide transport operators using IAP with greater access to road networks while the data so generated provides them with the assurance that heavy vehicles are complying with agreed access conditions. Over 3,000 vehicles are enrolled in IAP related programs.

4.1.2 Rail

GNSS and GIS in the rail sector currently have applications in surveying track, locating infrastructure, managing train movements (mainly in long distance applications) and in managing rail operations at ports.

The Advanced Train Management System (ATMS) is an important application of augmented GNSS services[10] as well as GIS and communications technologies. ATMS is a communications-based train management system that replaces traditional line-side signalling, enhancing safety and allowing rail operators to increase the capacity of existing rail infrastructure through running trains closer together. (DIRD, 2015). In 2016, the Australian Rail Track Corporation trialled ATMS in South Australia and was understood to be including it in its planning for the proposed Melbourne to Brisbane inland rail project.[11]

[8] Now Data 61, a Division of CSIRO
[9] See https://www.nhvr.gov.au/road-access/access-management/intelligent-access-program
[10] Augmented GNSS includes technologies that provide higher levels of integrity and accuracy than raw GNSS. Accuracies of up to 2 cm are possible with some systems. However high levels of integrity and reliability provided by augmented GNSS create more opportunities for their use in safety critical areas of operation.
[11] Personal communication

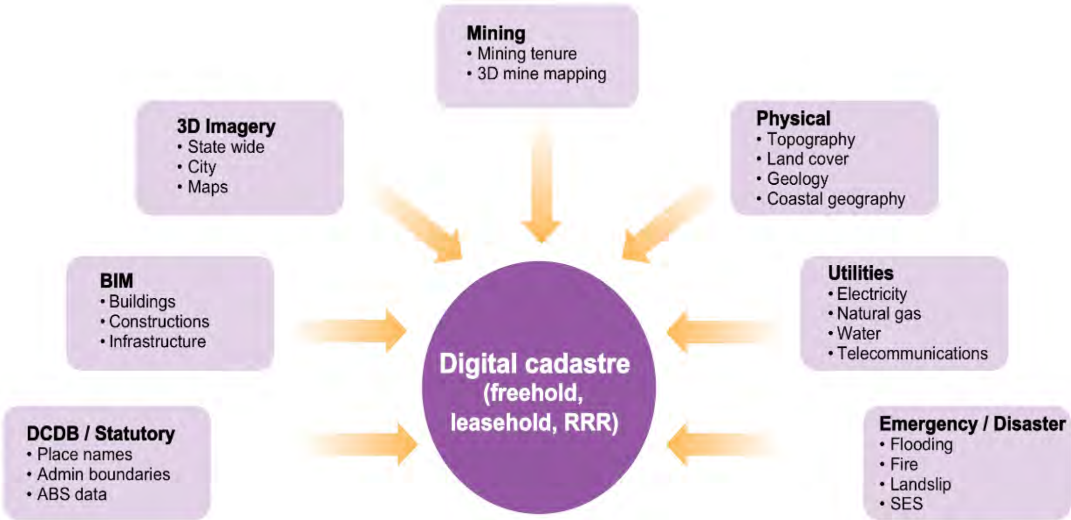
When combined with improved communications systems, these systems will enable the next generation of train control systems for both passenger services in metropolitan areas as well as long distance and interstate freight services. While the improved communications services will benefit mainly passenger services, the development of common ATMS platforms will provide further opportunities in the future to realise the benefits of these new systems.

4.1.3 Longer term potential for BIM and other 3D models

The longer term vision for BIM and the 3D models is for integrated and secure 3D data sets of the built environment. The benefits would flow from sharing pre-existing private imagery/models, data, and RRR, federated with existing public data (including RRR). This would avoid the cost of acquiring data, searching many different data sets, and collating them into a single data base for planning, design and construction purposes.

An illustration of how different data bases (many in 3D) could be federated in the longer term is provided in Figure 4.1. This would require significant collaboration between government and industry, and thus would be challenging.

FIGURE 4.1 INTEGRATION BETWEEN SPATIAL DATA BASES AND A DIGITAL CADASTRE



Note: RRR stands for rights, responsibilities and restrictions.

SOURCE: (ACIL ALLEN, 2017)

According to industry stakeholders consulted, the benefits of a federated 3D model would be significant, with potential savings of the order of 20 per cent in the cost of planning, design and construction possible with an integrated model (ACIL Allen, 2017). There are further potential savings associated with managing these assets, which are discussed in Chapter 5.

Such a vision will take a long time to realise, although steps are already underway in some countries to develop such federated models. For example, in the Netherlands and Denmark authenticated registries of 3D building data, linked to core foundation data sets, are being established.

While there is a growing number of 3D models of the built environment in NSW used for planning and design purposes, the potential development of a single digital cadastre in NSW, through the Cadastre NSW project, would be an important pre condition of developing a system of federated 3D models. If government and industry were to reach agreement on development of such a model, it is unlikely that a reasonable degree of integration could be achieved before 2026. Progress from then on would take many years, but as the level of integration increased each year so would the benefits of doing so.

4.2 Economic impacts – smart buildings and infrastructure

A number of important applications of ICT for smart buildings and infrastructure have been discussed in section 4.1 to illustrate the significance of the benefits from 3D models for the built environment. These include:

- Sydney light rail project – potential savings in cost and 18 months in time for construction if 2D data, as envisaged in a BIM model, had been available
- use of ramp monitoring could deliver annual savings of around $22 million per year
- SCATS system developed by RMS is delivering $3.6 billion per year of benefits through coordination of traffic control systems – if spatial information systems supported 10 per cent of these savings, the value of spatial information systems to the NSW economy would be in the order of $360 million per year
- the potential for automated train management systems to increase capacity of existing rail infrastructure.

All of these systems are enabled by spatial information systems in BIM models which in conjunction with ICT and a range of other smart technologies have the potential to revolutionise the way in which cities are planned and managed.

The full realisation of the benefits from these technologies will take many years. The potential of BIM and related smart 3D data approaches will require the coordination of registries of 3D as built models in different sectors. This will require considerable reform in the way in which the private and the public sectors cooperate in the maintenance of, and access to, 3D models of the built environment. As discussed previously, this is a long term prospect that depends on significant collaboration and is unlikely to begin delivering benefits prior to 2017. However the potential benefits are significant.

Recent consultations with stakeholders in the construction and infrastructure sectors, including practitioners and researchers, suggest that savings in the order of 10 per cent to 20 per cent in construction costs could be realised if fully integrated BIM models were available.[12]

To estimate the likely value of such savings, ACIL Allen made a number of assumptions which include:

- the NSW Government proceeded with the proposed investment in a single digital cadastre starting in 2018
- adoption of BIM models in planning and construction of buildings and infrastructure begins at 10 per cent in 2026 culminating in a maximum adoption rate of 70 per cent by 2034
- net savings from the application of these models ranged from a low of 1 per cent to a high of 5 per cent.[13]

The results of applying these calculations to projections of expenditure on engineering and construction in NSW are provided in Table 4.1. The details of the calculation and assumptions are provided in Attachment E.

TABLE 4.1 ESTIMATED NET BENEFITS OF FEDERATED 3D AND BIM MODELS TO NSW'S ENGINEERING AND CONSTRUCTION SECTOR

	Evaluation period		
Percentage savings	24 years	20 years	15 years
	$ million	$ million	$ million
1%	1,406	874	266
3%	4,218	2,622	798
5%	7,030	4,370	1,330

Note: Cash flows discounted at 7 per cent.

SOURCE: ACIL ALLEN BASED ON DATA PROVIDED FROM CONSULTATIONS AND RESEARCH

[12] Based on consultations with industry stakeholders and researchers undertaken during 2016.
[13] This is a conservative assumption but allows for costs associated with implementing the models.

The table shows that, on the basis of conservative assumptions, the benefits of implementing federated, secure registries of 3D models of the built environment would deliver benefits to the building and construction industry of between $874 million and $4,370 million in present value terms if evaluated over a 20 year period.

However, for evaluation purposes, ACIL Allen has assumed annual savings of 3 per cent and an assessment period of 15 and 20 years, respectively. On this basis, the value of federated 3D models to the NSW economy is estimated to be in the order of $798 million and $2,622 million, respectively, in present value terms.

KEY FINDING 6 POTENTIAL BENEFITS OF FEDERATED 3D MODELS

Smart spatial referenced operating systems have significant potential in the delivery of improved infrastructure services. They have potential applications in smarter delivery of infrastructure, Advanced Train Management Systems (ATMS) and traffic management. Many of these applications are still in the early stage of adoption in Australia but their potential is significant. One example that has been implemented is the Sydney Coordinated Traffic System that has delivered estimated savings of $3.6 billion per annum. Assuming that spatial information systems represent 10 per cent of these systems, for example, the value of spatial information to the system would be around $360 million per year.

The use and application of federated 3D models such as BIM has the potential to deliver significant cost savings in engineering construction in the longer term. ACIL Allen estimated that the present value of benefits to be of the order of $798 million in present value terms over 15 years from 2017 and $2,622 million over 20 years in present value terms.

Realisation of these benefits is based on an assumption that adoption commences at 10 per cent of building projects in NSW in 2026 rising gradually to 70 per cent by 2034. Completion of the proposed Spatial Services Reform Program is required to realise these benefits.

5 ASSET MANAGEMENT

Asset management is an important area of activity. It has been estimated that operating costs represent around 63 per cent of the whole of life cost of a building (Dewar, 2004).

Spatial information systems have found major application in asset management by both government and industry. They are being used to manage assets in areas such as ports, railroads and logistics, and are actively applied in areas of government such as the Department of Education, and the Land and Housing Corporation.

Stakeholder consultations also highlighted the growing importance of spatial information in the effective management of local government assets in NSW. Local Government officers consulted advised that they could not do the work they do without the benefit of GIS Systems.

The use of spatial information in asset management by the Department of Education is discussed in section 5.1, by the Land and Housing Corporation in section 5.2, and by local government in section 5.3. Section 5.4 considers future potential savings with further development of 3D data bases, and section 5.5 summarises the economic value of spatial information to asset management.

5.1 Department of Education

The NSW Department of Education is the largest "landholder" within NSW with nearly 3,000 sites consisting of all school and TAFE campuses with a total asset value of around $26 billion. The Department's property group manages 23,000 buildings and 400,000 rooms at these sites. Recurrent costs are around $800 million per annum, which comprises around 50 per cent of total asset costs, and includes cleaning costs of around $140 million per annum. Management of these assets, including an asset revaluation down to room level every five years, is a major undertaking.

An Asset Management System (AMS) was first developed in 1993 for all schools. A spatial view of assets has always been seen as core to the system and has continued to be integrated to all business functions within the system. This is achieved using GIS integrated with a sophisticated relational database.

The initial system provided three basic modules based upon the migration of legacy systems that mainly dealt with assets from a purely financial and inventory basis. Three more modules that focused on specific business units within the Department (planning, maintenance and demountable) were added as a second stage.

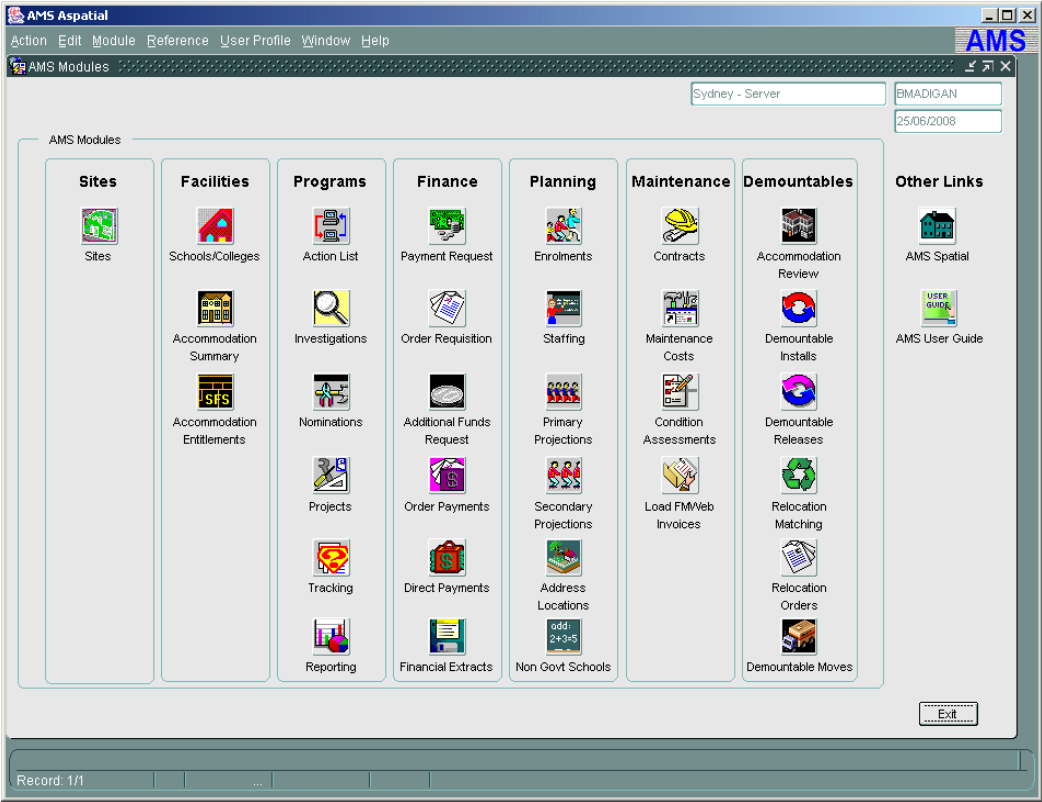
The data base now comprises eight modules:

- sites
- facilities
- programs
- finance
- spatial

— planning
— maintenance
— demountables.

These modules are shown in Figure 5.1.

FIGURE 5.1 ASSET MANAGEMENT SYSTEM MODULES



SOURCE: (OMNILINK, 2014)

The Department's AMS is now one of the largest spatially integrated systems within the NSW Government. The AMS is estimated to deliver total savings in the order of $20 million. Table 5.1 provides a broad breakdown of these savings.

TABLE 5.1 BROAD ESTIMATE OF ANNUAL SAVINGS FROM THE DEPARTMENT OF EDUCATION'S AMS

Item	Savings
	$ '000
Asset management	8,925
Building code compliance	1,964
Maintenance	1,785
Demountable transport and siting	456
Administration and productivity	405
Planning, review and queries	116
Cleaning contracts	140
Transport claims	69
Briefings	46

Item	Savings
	$ ‘000
Data reporting	39
System operating costs	30
Valuations	10,000
Total	**23,975**

Note: Estimates based original business case adjusted for inflation plus other adjustments provided by the Department of Education

SOURCE: ACIL ALLEN, 2016

The AMS has supported other departments and organisations including:

- the NSW Emergency Information Coordination Unit to manage a buildings database within the Sydney CBD
- a bush fire remediation program, which used the Rural Fire Services bush fire layers to rank the assets in terms of bush fire risk.

Productivity impacts

2017

The AMS is spatially enabled. While there are several components of the system including data bases, ICT systems etc., the spatial component underpins the location analytics that deliver cost savings as set out in Table 5.1.

At the margin, ACIL Allen considers that it would be reasonable to assume that the AM’s functionality would be reduced by 75 per cent without the spatial component. This translates into around $18 million in savings per year that are attributable to spatial information, which represents a productivity improvement of 2.25 per cent for the asset management function and 0.15 per cent for the Department as a whole.

Further details on this calculation are provided in Appendix F.

2022

The Department expects that enrolment numbers in public schools in NSW will increase from around 150,000 today to 200,000 students by 2030 – a 33 per cent increase. If this growth is linear it would imply growth in enrolments of 12 per cent by 2022.

Schools are currently at capacity and one strategy to address the growth challenge is to utilise demountables to manage overloaded facilities while permanent facilities are developed. This requires management of free space as well as asset mobilisation. GIS is likely to be one of the key enablers of the management of these challenges.

GIS will also support planning and analysis of catchment boundaries to assist in the location of school facilities and assets. It is difficult to extrapolate these effects, but a conservative estimate suggests that the contribution of spatial information services will increase by 10 per cent as pressure on resources increases. This would lead to savings of around $20 million in 2022.

5.2 Land and Housing Corporation

The Land and Housing Corporation (the Corporation) is a Public Trading Enterprise within the Family and Community Services Portfolio. The Corporation’s role is threefold: planning and building social housing, managing the housing portfolio to maintain properties at an acceptable level and prolong their useful life, and funding and managing tenancy management services delivered by Housing NSW.

The Corporation is responsible for managing around 129,000 government social and community service housing assets valued at around $45 billion in 2013-14 with an annual budget of around $1.5 billion.

Virtually all of the Corporation’s asset and tenancy management issues are underpinned by a GIS. Activities that are GIS enabled include:

- Identifying and developing opportunities to restructure the property portfolio to maximise the availability of social housing while at the same time maximising returns from redevelopment opportunities.
- Improving work flows to maximise the efficiency of their workforce by:
  - optimising office space requirements
  - optimising routes travelled by workforce
  - route planning to different sites
  - tracking routes taken by the workforce to reduce OH&S risks and costs.
- Managing data from different sources including:
  - ABS data for demographics
  - planning information and zoning from Local Government
  - education and health information.
- Better targeting of tenant servicing – GIS has delivered a 30 per cent productivity improvement for the delivery of the Community plus project.
- Maximising productivity of the workforce through:
  - route planning and optimisation
  - better management of Occupational Health and Safety policies.
- Identifying savings in maintenance contracts, for example, $300,000 savings (or a 1 per cent efficiency improvement) in lawns and grounds maintenance have been achieved by using the GIS
- Managing address locations:
  - the Corporation uses post codes for contacting tenants, but uses administrative boundaries for health and safety management
  - the discrepancies are managed with GIS, which is estimated to deliver a 20 per cent productivity improvement for this function.
- Improving policy and compliance through better measurement and reporting of outcomes.
- Improving evidence based decision making.

The Corporation has reduced its staffing levels from 508 in 2013 to 430 in 2016, a reduction of 15 per cent, which is attributed to the use and application of spatial information systems and services. It has also been able to reduce the number of office locations from 30 to 17 as a result of better work flow management and route optimisation based on the use of spatial information systems.

Productivity impacts

2017

Corporation staff estimate that GIS has delivered a 15 per cent labour productivity improvement in the housing stream, which amounts to savings of around $7.9 million per annum by 2017. The costs of the GIS service software and supporting team are around $0.6 million so the net savings are around $7 million in 2017, which implies a net productivity impact of 0.6 per cent of the Corporation's budget.

As this estimate does not quantify any other productivity improvements that have been identified, it is considered to be conservative.

2022

From 2017 to 2022, the Corporation sees potential for drawing on airborne LIDAR data to build imagery of building footprints to increase the efficiency of the maintenance program and map underground service lines.

The Corporation pays $3 million per year in premiums to cover catastrophic incidents to its asset base, which has a replacement cost of over $30 billion. The use of LIDAR mapping would assist in making more informed risk assessments for insuring against catastrophes, and would potentially deliver a 50 per cent reduction in insurance premiums. This translates into savings in the order of $1.5 million per annum. As the cost of supporting the services is estimated to be around $700,000 per annum. The net saving is around $800,000 per annum.

It is estimated that, with such developments and further savings from improved processes, the savings from the use of geospatial systems could reasonably be expected to rise by around 17 per cent to around $8.4 million per annum by 2022. This represents around 0.7 per cent of the Corporation's annual budget.

5.3 Local government

Most of the larger councils use GIS and spatial devices to undertake condition assessments, record and log assets for inventory and depreciation purposes, for recording site conditions and planning work flows. Stakeholder consultations confirmed that the task of asset management could now not be done without spatial information.

There was a general consensus that GIS and spatial information delivered at least 5 per cent in productivity improvements for asset management in local government.

An Audit of Infrastructure in Local Government published in 2013 provided a comprehensive survey of the state of asset management in local government in NSW. The Audit found that around 75 per cent of Councils in NSW fully met the requirements of having asset management plans in place. However only 25 per cent of Councils had fully implemented data systems which included GIS systems linked into their AMS (Department of Premier and Cabinet, 2013).

Productivity impacts

2017

The total value of infrastructure assets in Local Government in NSW was estimated to be $81,000 million in 2013. Assuming operating costs of around 3 per cent of capital costs and that 25 per cent of local governments have fully integrated GIS systems into their asset management data systems, the operating costs associated with assets managed using spatial data is in the order of $607 million per year (see Appendix F for details).

Assuming a productivity improvement attributable to spatial information of 5 per cent, and an annual cost for operating the GIS system of 0.5 per cent, the value of spatial information to the management of local government assets is estimated to be in the order of $18 million in 2017.

2022

The NSW Government is encouraging local governments to improve their performance and efficiency. The 2013 Audit of Infrastructure in Local Government provided a clear picture of the areas where improvements were needed.

The NSW Government has established a program for Strengthening Local Government including a Local Government Infrastructure Renewal Scheme as well as promoting better practice in local government in NSW. It would be reasonable to assume that these programs would lead to a higher level of adoption of fully integrated GIS systems in asset management information systems – perhaps rising to around 40 per cent by 2022.

If this were to be realised, the value of spatial information systems to asset management in local government in NSW would rise to $29 million by 2022.

5.4 Future potential for BIM for asset management in NSW

On-going use of 3D models, integrated with the building management system for asset and facility management, are estimated to generate savings of 1-2 per cent of operating costs over the life of any building or piece of infrastructure.

They savings are based on industry and research comparisons of current paper-based management practices, with the use of 3D BIM.[14] However, they are less certain than estimates for the other sectors due to the limited number of examples of 3D models currently being used for asset and facility management.

[14] (Badinloo, 2015) provides a useful overview of the applications.

In Australia, the Air Conditioning and Mechanical Contractors' Association (AMCA) is leading the use of BIM within the construction industry and for facilities management. According to AMCA, the software, services and standards that encompass BIM for facilities management has the capacity to cut facilities management costs by 30 per cent. Discussion at a Facilities Management Association briefing in May 2016 confirmed that savings are likely to be substantial.[15]

The potential for application of federated 3D models, such as envisaged with the wider application of BIM systems, is significant in the longer term. According to consultations with government and industry, particularly the engineering and construction industry, it is unlikely that such developments could commence before 2016. However it is anticipated that their use and application could begin to arrive from around 2016 with fuller development after 2030. The process is long term but the potential benefits are very high if levels of adoption of, say 70 per cent, could be achieved across the facilities management process for assets in NSW, both in the public and the private sectors.

Estimating the value of such benefits is challenging given the uncertainties. However, during 2016, ACIL Allen consulted with the engineering and construction sector concerned with non-residential building. On the basis of these consultations, it is expected that the use and application of BIM models could begin to take effect after 2025 with adoption starting at a low level, rising gradually to adoption of around 70 per cent by 2033 (ACIL Allen, 2017).

Productivity impacts

To estimate the future productivity impacts of BIM for asset management in NSW, it is assumed that all buildings from 2017 are using BIM models for design and construction, and that the use of BIM models for asset management is not implemented until after 2025 following the development of more coordinated registries of buildings. It is assumed that the asset management systems are then applied to these buildings.

The adoption is assumed to commence in 2016 at 10 per cent, rising gradually to 70 per cent by 2032, after which time adoption levels off. We have used estimates of the value of adopting BIM models in asset management to deliver net savings of between 1 and 2 per cent. This is considered to be conservative as many building managers felt the figure could be as high as 4.5 per cent as it was reported above for local government.

On the basis of these assumptions, ACIL Allen has estimated that the net present value of the benefits of this application, evaluated over a 15 and 20 year period, and assuming a 2 per cent cost saving would be:

— $120 million in present value terms over 15 years
— $471 million in present value terms over 20 years.

These longer term benefits are additional to those quoted above.

5.5 Economic impacts – asset management

The consultations and research undertaken for this report provide convincing evidence that spatial information systems have become essential tools in asset management for larger organisations in industry, state government and local government. They have already delivered significant productivity savings of the order of 1 per cent to 5 per cent of total expenditures and savings of around 15 per cent to 20 per cent in staff costs for organisations such as the Department of Education and the Land and Housing Corporation. The use and application of spatial information for asset management in utilities is also significant as discussed in Chapter 6.

The findings from the case studies discussed in this chapter are summarised in Table 5.2. The table represents only a snapshot of the impacts of spatial information systems in asset management in government. However, the consultations and case studies confirmed that GIS and spatial information systems were fundamental requirements to efficient asset management.

The case studies considered in this chapter are estimated to have saved around $43 million in asset management costs in 2017 through the use of spatial information. These savings are expected to increase to $59 million in 2022 on the basis of some conservative assumptions.

[15] Expert Panel, BIM and the Impact on Future Facilities Management, Breakfast Briefing, Facilities Management Association, NSW, May 2016.

TABLE 5.2 SUMMARY OF PRODUCTIVITY IMPACTS FROM USE OF SPATIAL INFORMATION FOR ASSET MANAGEMENT

Case study	2017			2022		
	Impacts	Impact as a proportion of division's costs	Impact as a proportion of organisation costs	Impacts	Impact as a proportion of division's costs	Impact as a proportion of organisation costs
	$ million			$ million		
Department of Education	18	2.50%	0.15%	20	2.59%	0.18%
Land and Housing Corporation	7		0.60%	10		0.70%
Local Government	18		0.25%	29		0.39%
Total	43			59		

Note: Savings expressed as a percentage of operating costs for each organisation.
SOURCE: ACIL ALLEN

There are potentially additional longer term benefits that are estimated to accrue after 2022 as a result of the application of BIM and 3D models to facilities management in non-residential buildings. These range from $236 million to $471 million in present value terms over 20 years.

KEY FINDING 7 VALUE OF SPATIAL INFORMATION TO ASSET MANAGEMENT

The use and application of spatial information in asset management in the Department of Education, the Land and Housing Corporation and local government was estimated to have delivered net benefits of $43 million by 2017. This is expected to increase to $59 million by 2022.

There are potentially additional longer term benefits from the use of BIM and 3D modelling in asset management for non-residential buildings. These are estimated to be between $236 million and $471 million in present value terms assessed over a 20 year period. Benefits are assumed to commence in 2026 and increase gradually from 10 per cent adoption levels in 2026 to 70 per cent of adoption levels in 2034.

6

UTILITIES

The utilities sector includes electricity, gas and water. These industry sectors manage key infrastructure and provide energy and water services to residential, commercial and industrial consumers as well as managing wastewater and environmental services across the state.

In 2014-15 the sector contributed around $10 billion in gross value added to the NSW economy.[16] This represented around 2 per cent of gross state product (GSP).

The value of spatial information to the water sector is discussed in section 6.1, the electricity sector in section 6.2, and the gas sector in section 6.3. Section 6.4 summarises the economic value of spatial information to the utilities in NSW.

6.1 Water

The water sector comprises water supply and waste water services to both urban and rural regions, and includes providers of bulk water, such as that undertaken by Water NSW and catchment management authorities. Water supply and sewerage services are provided by a range of organisations including large and small water supply and waste water treatment authorities including Sydney Water and Hunter Water.

Spatial information technologies are used extensively to model surface water and groundwater to inform ecological outcomes and policy formulation, particularly with respect to water use by large industry users. They are also used to model security of supply and predictive states of water supply.

Water NSW reported that spatial information services and analytics support modelling of groundwater and surface water for both supply planning, better ecological outcomes and policy support. They are also used in modelling security of supply, optimising of water markets and managing environmental flows.[17]

Water resources modelling is also undertaken in a number of areas including:

— CSIRO water resources assessments and the Murray Darling Basin Sustainable Yields project
— Bureau of Meteorology with its Australian Hydrological Geospatial Fabric which is used by water resource planners and the insurance industry
— irrigation release planning by water authorities and catchment management authorities.

The use of spatial information by Water NSW is discussed in section 6.1.1, and by Sydney Water and Hunter Water in section 6.1.2.

16 Excludes electricity generation and gas production.
17 Personal communication

6.1.1 Water NSW

Water NSW is responsible for developing infrastructure solutions for improved water supply and reliability, protecting water quality in its designated catchments, asset management, and flood operations and mitigation. The Spatial Science work unit provides support for Water NSW's functions.

Satellite imagery and spatial data analysis are used to monitor the condition of Sydney's drinking water catchments. They are used to examine vegetation conditions, disturbance (e.g. bushfires) and pasture conditions, monitor land use changes, and identify potential sources of pollution.

These techniques are also used to inform the development of a healthy catchment strategy, which is in turn used to inform a wide range of users (government departments, local governments, graziers, regulators, etc.). Information such as fire fuel loads, severity of bush fires, etc. is also provided to other EOS groups on request. EOS data enable a reduction in the risk of water quality issues emerging through better planning and targeted actions.

Staff at Water NSW also believe that decision making would be much more risky without the use of satellite data. For example, the Pollution Source Risk Assessment Tool (PSAT) provides a decision making tool for $4.7 million of catchment intervention works as part of the Targeting High Risk Pollution Sources program in Water NSW's 2014-2015 Healthy Catchments Program. EOS provides critical input datasets into PSAT.

In addition, satellite data enables Water NSW to meet its legislative, regulatory and service standard requirements at lower cost. It estimates that such costs would increase from $100,000 to $500,000 per annum in the absence of EOS.

ACIL Allen estimated that the annual net benefit of the use of remote sensing data from satellites, combined with spatial analytics, delivered net savings to Water NSW of around $390,000 per annum based on a productivity estimate of 20 per cent.[18] This represents around 0.14 per cent of its annual budget.

6.1.2 Sydney Water and Hunter Water

Sydney Water and Hunter Water supply the Sydney and Newcastle greater metropolitan regions.

Consultations with both organisations indicated that spatial information had delivered between 10 per cent to 20 per cent in savings in managing assets and servicing the community. These savings derived from:

— improved modelling capacity for servicing plans
— improved interaction with planners and property developers
— outage management
— emergency response
— managing work requests
— reducing staff requirements in asset monitoring and mapping.

There is little information available on the overall value of these savings. The majority of the benefits were considered to have been in better management of water resources, water assets and service delivery to water customers and landholders in the regions serviced by the organisation[19].

It was estimated that the savings in spatially related services by Sydney Water represented a reduction in drafting and related staffing of around 180 full time equivalent (FTE) staff. Recent savings in staffing for spatially related services have been in the order of 10 per cent to 20 per cent. This would represent overall savings of around $16 million prior to the widespread use of spatial information and related systems and around $500,000 in recent years for Sydney Water.

6.2 Electricity

The electricity sector includes electricity generation, transmission, distribution and retail. In this section we focus on the transmission and distribution components of the supply chain.

[18] Personal communication with Water NSW staff.
[19] Information from follow up to Workshop

Spatial information is used extensively in the management of electricity transmission and distribution networks. Applications include mapping of assets and easements, supporting field officers in consultations with property owners and the community, environmental management in relation to their networks, bushfire and emergency services management.

6.2.1 Transmission

Transmission systems deliver electricity from power stations to distribution networks using high voltage wires. Transgrid supplies transmission services in NSW.

According to Transgrid, spatial information systems are fundamental to their operations. Transgrid use a GIS system designed specifically for the electricity industry. The system links with field officer devices and draws on incremental updates from the digital cadastral data base (DCDB). The DCDB is the base layer of their system for their GIS system.

The GIS system maps the transmission and distribution assets and the physical features of the easements on which they are located. It is a web based system using a networked viewer. In addition to details of the assets, it also includes information on property owners, environmental and heritage data, native title, and hazard and bushfire data. Data are linked to emergency services, the OEH data bases, and to data from the ACT electricity authority.

Field officers have access to the data via devices. This enables the field officers to source information relevant to property owners and the community in support of their liaison on site with property owners. It would be impossible to provide this support without the benefit of the GIS system. Prior to the use of such systems, the data was held on paper plans or microfilms. Updating and distribution of the data to field officers was difficult and costly. The GIS system provides this information on devices automatically.

The systems have been synchronised with the central GIS system but this has proved problematic and Transgrid is now looking at other methods of updating the data on field officers' devices. Incremental updates into the GIS are also provided from the DCDB and from OEH. Property holdings are based on the DCDB.

The GIS system is also used to map renewable energy production to assist with planning and grid operations.

Productivity impact

Transgrid officers estimated that the productivity achieved through the use of the GIS system for their operations were of the order of 3 per cent to 5 per cent of the company's operating costs.

6.2.2 Distribution

Distribution networks distribute electricity from transmission systems to households and businesses using low voltage wires. Distribution networks include poles and wires in cities and suburbs, local transformers and electricity meters. There are three distribution network operators in NSW – Ausgrid, Endeavour Energy and Essential Energy.

Unfortunately it was not possible to fully consult with the distribution companies during the research for this project due to the asset sale processes. However, ACIL Allen's research suggests that it would be reasonable to assume that the levels of productivity improvement reported by Transgrid would be of the same order, or possibly greater, for the distribution networks as their operations involve, to some extent, more complex physical locations and operations than transmission systems.

ACIL Allen concludes that it would be reasonable to assume similar levels of productivity impacts as found for Transgrid.

Productivity impact

In line with the suggested productivity impacts cited by Transgrid, ACIL Allen considers that a productivity improvement of between 3 per cent and 5 per cent of labour costs would be reasonable to assume as the benefit to both electricity transmission and distribution from the use of spatial information.

This would represent an economic benefit of between $38 million (based on a 3 per cent reduction in labour costs) and $64 million (based on a 5 per cent reduction in labour costs). Further details are provided in Appendix H.

ACIL Allen has assumed that the $38 million would reasonably apply in 2017. ACIL Allen has also assumed that the benefit would reasonably be expected to grow to the higher $64 million by 2022 with further development of systems as was evident from the discussion with Transgrid.

6.3 Gas

The gas sector includes gas production, transmission, distribution and retail. Gas production and gas retail activities draw on spatial information systems but for the purpose of this report we focus on transmission and distribution activities.

Gas distribution pipelines are operated by Jemena in and around Sydney, Australian Gas Networks in Wagga Wagga and APA in the Central Ranges. Jemena operates the largest network.

Discussion with Jemena revealed that GIS, aerial photography and spatial information systems are used for recording the location of assets, site conditions (including soil types and conditions), contamination, design, and as built changes, and for route optimisation, planning, and improving response times to faults. The use of GIS and related systems depends on capturing the data and at this stage not all the assets are recorded in 3D. However this will change more data is captured.

Engineers estimated that the use of spatial information systems was delivering at least 3 per cent in savings in staff time, which would potentially increase over time to 5 per cent.

Productivity impacts

On the basis of these estimates, and allowing for costs associated with GIS ACIL Allen has estimated that the use and application of spatial information systems in gas distribution delivered savings of around $2.7 million in 2017. This could be expected to rise to $4.5 million by 2022.

Further details are provided in Appendix I.

6.4 Economic impacts – utilities

The economic value of spatial information systems for utilities is summarised in Table 6.1.

TABLE 6.1 SUMMARY OF COST SAVINGS ATTRIBUTABLE TO SPATIAL INFORMATION BY UTILITIES

Type of utility	2017	2022
	$ million	$ million
Water	16.0	16.0
Electricity transmission and distribution	38.4	64.0
Gas distribution	2.7	4.5
Total	57.1	84.5

SOURCE: ACIL ALLEN

KEY FINDING 8 SMART UTILITIES

The use of spatial information technologies in the water, electricity and gas sectors is estimated to have delivered net benefits of around $57 million in 2017 based on net productivity impacts of 3 per cent of labour costs. This figure is expected to rise to $85 million by 2022 based on increased productivity impacts of 5 per cent of labour costs.

7

SMART CITIES AND LOCAL GOVERNMENT

The technologies that are discussed in Chapter 6 have applications in the overall management of infrastructure and assets that support the communities that live in cities.

Around 40 per cent of the NSW population live in the Sydney metropolitan area. The population of the Sydney metropolitan area is expected to increase by 37 per cent by 2036. This will place further pressure on the development of infrastructure. In addition to this, the cost of housing is increasing at a rate where concerns over housing affordability are emerging.

The application of the Smart Cities concept to meeting the needs of a growing population are discussed in section 7.1 and its application to local government is discussed in section 7.2. The economic value of spatial information to local government is summarised in section 7.3.

7.1 Smart Cities

The concept of Smart Cities has evolved in the literature and research into ways in which the needs of the people that live and work in cities can be better met. The approach to smarter cities is being developed to varying degrees in cities such as Singapore, London, Barcelona, San Francisco and Madrid. The cities of Melbourne and Brisbane have also been actively developing programs in this area.

The potential applications of the Smart Cities concept in the Sydney metropolitan area are significant and are being implemented in areas such as in the CBD light rail project, and in planning for transport logistics and the second Sydney Airport.

Smarter cities means more than just better planning of infrastructure. It also means improving the efficiency of delivery systems from high level logistics to garbage collection. It means more geospatial services to citizens in taxi services, public transport and delivery of health and human services.

Dr Michael Dixon of IBM told the Standing Committee on Infrastructure, Transport and Cities

In simple terms, Smarter Cities is about applying the currency of the 21st century data to all manner of challenges historically faced by cities in order to make traditionally dumb things smart and enable everything, from machine to machine communication through to the most sophisticated predictive modelling. In turn, ICT is providing management information and decision support systems which increasingly optimise existing systems, enable the design of new and advanced systems and provide the ability for the interaction of such systems across a city. While the underlying technology is very sophisticated, the effects of its applications are readily identified. The results are obvious in better services, better cost efficiencies and cities that distinguish themselves for their liveability, vitality and economic prosperity.

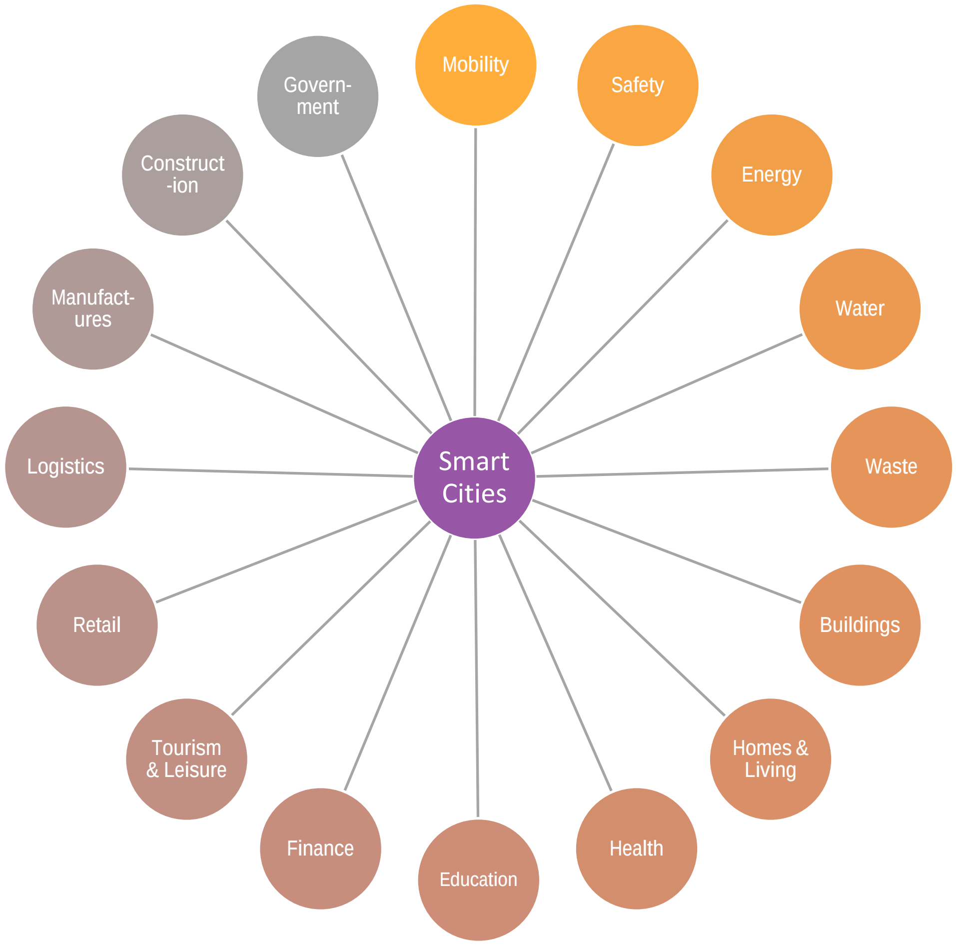
(Standing Committee on Infrastructure, Transport and Cities, 2016)

The Smart Cities Concept builds on the concepts and technologies that enable smart infrastructure. However Smart Cities extends the concepts to the human level involving wider aspects of human engagement with the city environment, and extending to greater engagement with the community on planning and management of city infrastructure and services. Smart Cities concepts are argued to deliver:

— significant reductions in infrastructure planning costs
— reduction in infrastructure planning time
— improved communication and understanding between planners, designers and the community
— improved capability with the delivery of services including primary health care and community services (Urban Circus, 2016).

The socioeconomic gains are in productivity improvements and i better customer experiences. The technologies also provide support for new business models and platforms that facilitate developments such as advanced analytics, smart metering and transport management. Smart Cities approaches have the potential to affect just about every aspect of city and urban living, as illustrated in Figure 7.1.

FIGURE 7.1 IMPACT AREAS FOR SMART CITY APPROACHES



SOURCE: BASED ON (DELOITTE, 2015)

The Commonwealth Government released its policies on Smart Cities in 2016 in the form of the Smart Cities Plan (Department of Prime Minister and Cabinet, 2016). The plan sets out policies to assist in programs of investment, policy reform and technology to provide support for Smart Cities Development in Australia. The programs of financial investment and policy review are in the early stages of development.

Regional Development Australia, Sydney (RDA Sydney), a COAG initiated partnership between the Australian and NSW governments, identified seven priorities in its submission on the Smart Cities Plan. These were:

1. job clusters in cities to deliver economic growth, innovation and better paid jobs
2. delivering affordable housing close to jobs and services

3. improving accessibility and liveability in cities through better infrastructure and transport connections
4. increasing the liveability and sustainability of cities through urban design and green spaces
5. driving smart investment that allows for new ways to fund infrastructure
6. delivering smart policy approaches that allow for coordination of actions and investments across all levels of government
7. encouraging the use of smart technology to drive innovation and change how people live and work (Regional Development Australia, Sydney, 2016).

These priorities illustrate the broad scope of activities and impacts that the Smart Cities concept embraces. Spatial information is one of the enabling technologies that will be necessary to support these aspirations.

Many sectors will be involved in Smart City developments, and the impacts will affect many sectors across the economy and the community, as illustrated in Figure 7.1.While smart infrastructure approaches were discussed in Chapters 4, 5 and 6, discussion in this Chapter focusses on the role and contribution that local government is likely to continue play to this endeavour. The

7.2 Local government

Local government is a key player in the delivery of Smart Cities and draws on spatial information to deliver improved productivity as well as better customer and community outcomes. ACIL Allen consulted with officers at the Blacktown City Council as one example of the use and application of spatial information systems in local government.

7.2.1 Blacktown City Council

Blacktown City Council is one of the larger councils in the greater Sydney metropolitan area and is experiencing growth as the Sydney urban areas extend westward. This is creating significant challenges for the management of planning decisions and for asset management, which was discussed in section 5.3.

A GIS system is fundamental to the Blacktown City Council to inform the planning decision process and the development application process. GIS layered data is used to assess site constraints in zoning decisions, including flooding and bushfire risk, and for decisions on zoning certificates.

File archives in the system assist in assessing changes over time, as well as compliance with zoning determinations.

Asset management is also critically dependent on GIS systems. Council officers suggested that it would not be possible to meet the requirements of asset management without a GIS system in the present climate. Blacktown City Council has over a quarter of a million assets on its register. Not all are captured, such as street trees, although work is underway to address the backlog.

GIS is also used for asset condition assessment. The results of inspections are entered into the GIS system as defects are categorised. Field staff use motion devices to record these data. This allows for pro-active asset maintenance, which is critical to maintaining the condition of the Council’s assets.

The GIS system is also critical to meeting the Council’s statutory obligations with respect to asset valuation, depreciation and maintenance of the asset inventory. This system is the primary source of truth for asset reporting.

7.2.2 Experience in England

ACIL Allen also drew on research it undertook in England and Wales for the UK’s Local Government Association. Many of the examples examined in the UK are relevant to Australia and some are already being implemented. The case studies for the UK project provide insights into the possible applications and impacts in Australia through the Smart Cities initiatives. Examples include:

- Optimisation of waste collection and management from the use of spatially enabled route optimisation technologies
  - mileage reduction of 12 per cent for garbage trucks

  - elimination of the need for overtime
  - reduced need for investment in garbage trucks
- Improved management and coordination of **street works** through a cloud based local government network (ELGIN)
  - utilities self-coordinate street works saving Council staff time
  - reduced time lost for commuters and road users through better coordination of street works (saving 10 per cent of journey time for commuters)
- Improved control of **criminal activity**
  - spatially enabled crime analysis improves preventative measures, reducing the cost of police time
  - georeferenced CTV cameras reduced police time spent per robbery by 75 per cent
  - Intranet based spatial mapping of criminal activities reduced the cost of crime analysis activities such as hot spot mapping and repeat victimisation patterns
- Improved **interface with customers** by Councils through web based applications for consultations and development approvals
  - community reporting of faults and maintenance needs in roads and parks
  - time savings for the community and developers from web based spatially enabled consultation and approvals processes
- Improved highway inventory management
  - savings in reducing the need for reactive response to problems of around 200 per cent
  - reduced repudiation rates
  - reduced need for site visits and back office staff.

ACIL Allen has used these examples as indicators of the potential situation in the Greater Sydney metropolitan area.

7.2.3 Adoption

Smart City approaches have been actively adopted by the Brisbane and Melbourne City councils through support for the application of Smart ICT technologies. The City of Melbourne, for example, is using Smart ICT in asset management, integrated paving design, mapping, modelling, public tools for navigation, and community engagement.

As indicated in report of the Regional Development Association cited above, momentum is likely to pick up in the Sydney Metropolitan area (Regional Development Australia, Sydney, 2016).

The Local Government Infrastructure report suggests many local government organisations in NSW are in the early stage of applying these technologies more widely than development and zoning applications and asset management, and are probably not as advanced, for example, as local government in England (Department of Premier and Cabinet, 2013). However there are many Councils, such as Blacktown City Council that are well advanced in the use and application of spatial information technologies.

For the purpose of this report it has been assumed that the benefits from Smart City approaches in the Sydney Metropolitan area are captured in the benefits identified for Smart Buildings and Infrastructure in Chapter 4. However, given the rapid evolution in technology and devices, and growing awareness of the potential of such approaches, we consider it reasonable to assume that the adoption of Smart City technologies will increase relatively quickly over the next five years. One factor that might motivate this adoption is the further development of a single digital cadastre that will, along with the development of other core foundation spatial data sets, facilitate adoption of these smart technologies increasingly by local government.

7.2.4 Impacts

There is little in the literature assessing the broader socio economic impact of the Smart City approach. Examples of some of the efficiency and customer gains quoted by IBM are provided in Box 7.1 (IBM, 2015). There are individual estimates available in some areas, for example, Professor Hussein Dia of Swinburne University of Technology estimated a benefit cost ratio for the application of smart technologies for infrastructure at around nine to one, which is extremely high.

BOX 7.1 EXAMPLES OF BENEFITS AND OUTCOMES FROM THE SMART CITY MODEL

Benefits identified by IBM in its submission to the House of Representatives Standing Committee on Transport Infrastructure and Cities.

Productivity Gain & Efficiencies	Drive Better Customer Experiences
– Deployment of advances analytics to understand, improve and optimise operations of infrastructure	– Improve retention and customer satisfaction
– Gain predictive insights for ahead of time decision making – e.g. traffic flows linked with weather prediction	– Create new reliability, efficiency, demand response and clean energy options
– Predict outages/failures and maintenance and optimise restoration	– Prioritise a 360-degree view of customer preferences, attitudes and expectations
– Monitor, maintain and optimise the network and assets	– Enabling services for citizens that are highly mobile and diverse
– Predict demand and better forward planning for usage	– Improve interaction via social and mobile
– Better plan for extreme weather conditions, security threats or major event	Support New Business Models & Platforms
	– User pays models e.g. congestion charging, road user charging, smart motorways
	– Smart metering & smart grids
	– Renewable energy management
	– Electric vehicles & battery storage

SOURCE: (IBM, 2015)

Work done by ConsultingWhere and ACIL Allen in 2010 for the UK's Local Government Association estimated that the applications implemented by local government in England and Wales had delivered total factor productivity benefits of around 0.2 per cent in 2009 rising to around 0.3 per cent by 2015. These figures include the impact on crime, which is jointly managed by local government and the metropolitan police forces in England. They also include allowance for improved asset management, which was considered in Chapter 5.

ACIL Allen considers that these productivity benefits are a reasonable indicator for local government and for some aspects of crime prevention in the Sydney metropolitan region[20] allowing for a possible slower rate of adoption of these technologies in NSW compared to England and Wales.

7.3 Economic impacts – local government

2017

Adopting the impacts from the ACIL Allen report for local government in England and Wales, we have estimated the accumulated impact of spatial information and Smart Cities techniques on local government in the Sydney metropolitan region in NSW in 2017 to be around 0.20 per cent of operating costs, which is equivalent to $7 million. This does not include the value of spatial information in asset management, which was separately considered in section 5.5.

[20] For details of the local government areas in the Sydney metropolitan region see Appendix B

2022

Using similar logic, ACIL Allen has estimated the accumulated impact of spatial information and Smart Cities techniques on local government in the Sydney metropolitan region of around 0.3 per cent of operating costs by 2022, which is equivalent to $11 million.

There are also significant opportunities in route optimisation and planning of work flows. Such applications are being applied in local government in England and in other sectors in Australia (ConsultingWhere and ACIL Allen, 2011). However industrial issues are often barriers to implementing some of these initiatives.

In many cases such approaches provide managers with information on the location of maintenance crews that was opposed by some employee representatives. However it was felt that over time the value of such systems to improving work flows, and the increasing acceptance of location sharing in smart phones, would eventually lead to further use of such applications.

The total value of spatial information systems to impact assessment for local government in NSW, including the value to asset management by local government as discussed in section 5.5, is summarised in Table 7.1.

TABLE 7.1 SUMMARY OF USE OF SPATIAL INFORMATION IN LOCAL GOVERNMENT AS PART OF SMART CITIES

Coverage	Activity	2017		2022	
		Impact	Proportion of operating expenses	Impact	Proportion of operating expenses
		$ million		$ million	
All Councils in NSW	Asset management	27	0.57%	44	0.93%
Greater Sydney Councils	Activities other than asset management	7	0.20%	11	0.30%
Total		34		55	

Note: includes net benefits associated with asset management discussed in section 5.3

SOURCE: ACIL ALLEN

KEY FINDING 9 USE AND APPLICATION IN LOCAL GOVERNMENT TOWARDS SMART CITIES MANAGEMENT

The value of spatial information systems and Smart Cities techniques to the Greater Sydney Councils is estimated to be $7 million in 2016, increasing to $11 million in 2022.

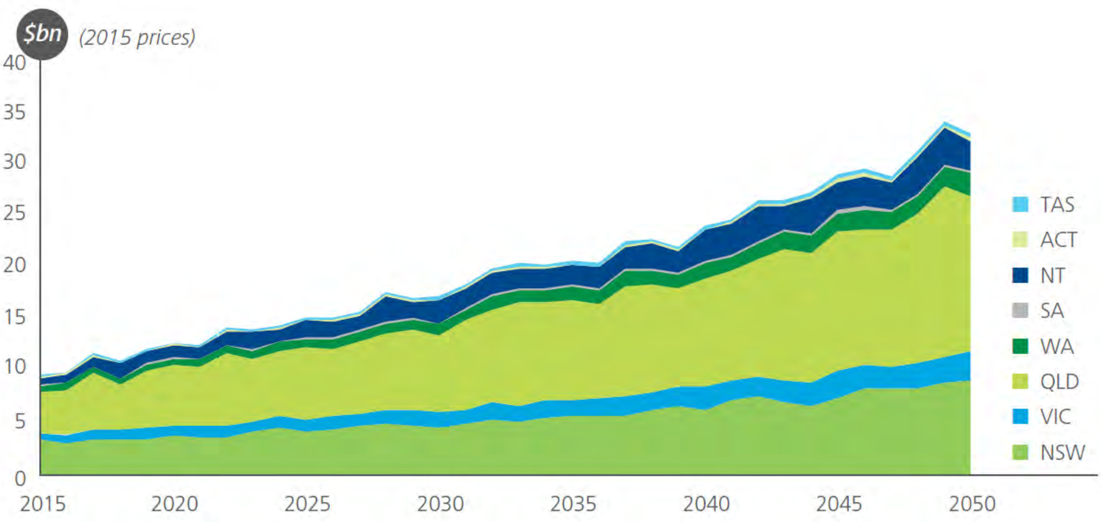
The value of spatial information systems to asset management by local government in NSW is estimated to have delivered benefits of $27 million in 2017, increasing to $44 million in 2022, as discussed in Chapter 5.

8 EMERGENCY SERVICES AND INSURANCE

Recurring natural disasters are a fact of life in Australia creating costs to the economy, governments and society. In reports prepared for the Insurance Council of Australia, the average economic and social cost of natural disasters was estimated to be around $9 billion in 2016 (about 0.6 per cent of Gross Domestic Product) rising to $33 billion by 2050 unless steps are taken to increase resilience (Deloitte Access Economics, 2016).

Figure 8.1 shows that around 40 per cent of this estimate for 2016 falls within the state of NSW.

FIGURE 8.1 SOCIO ECONOMIC COSTS OF NATURAL DISASTERS



SOURCE: (DELOITTE ACCESS ECONOMICS, 2016)

There has been considerable discussion and debate over the past five years on how to best reduce the economic and social costs of natural disasters. Past reports have pointed out that mitigation strategies and greater resilience in the community are an effective way to reduce these costs. In particular, the Insurance Council of Australia recommended better coordination and transparency of disaster risk management information including:

— more efficient and open national platform of foundation data
— transparent and available access to data and research
— more effective decision making through a prioritisation framework (Deloitte Access Economics, 2014).

The Productivity Commission reviewed policies and programs in support of mitigation of the impacts of natural disasters in 2014. Among other things, the Productivity Commission observed:

Governments can do better in terms of policies that enable people to understand natural disaster risks and also to give them the incentive to manage the risks effectively.

– *Information on hazards and risk exposure has improved significantly in recent years, but there are opportunities to improve information consistency, sharing and communication.*
– *Regulations affecting the built environment have a significant influence on the exposure and vulnerability of communities to natural hazards. While building regulations have generally been effective, there is a need to transparently incorporate natural disaster risk management into land use planning.*

Insurance is an important risk management option. Insurance markets in Australia for natural disaster risk are generally working well, and pricing is increasingly risk reflective. Insurers can and should do more to inform households on their insurance policies, the natural hazards they face and the indicative costs of rebuilding after a natural disaster.

(Productivity Commission, 2014)

Spatial information has a key role to play in the mitigation of, responses to, and recovery from, the impacts of natural disasters. It is important to provide location relevant information to the community with respect to increasing resilience and in helping the insurance industry to better manage risk and price hazards, and engage with households and the community in general on ways to manage the risks that they face from natural hazards.

The application of spatial information systems to the insurance industry is discussed in section 8.1, the State Emergency Services in section 8.2 and the NSW Ambulance Service in section 8.3. The economic value of spatial information services to the insurance industry, the State Emergency Services and the NSW Ambulance Service are summarised in section 8.4.

8.1 Insurance industry

Foundation spatial data has been identified by the Insurance Council of Australia as one of the key requirements to reduce the social and economic costs of natural disasters in Australia. The inputs required by those concerned with mitigating and managing the impacts of natural disasters include:

— foundation data – data that provides the basic layers of locational information, including information on the characteristics of assets at risk, community demographics, topography and weather
— hazard data – hazard specific information on the risks of different disaster types, providing contextual data about the history of events and the risk profile of hazard prone locations
— impact data – data on the potential and actual impacts associated with natural disasters including information on historic costs and damage, and the current and predicted future value at risk.

The insurance industry uses spatial data in support of risk selection and pricing of risk. Key activities in this regard are:

— managing claims costs
— understanding claims frequency
— assisting households and businesses to mitigate risk.

Most of the larger insurance companies have now developed risk models including flood, weather and peril modelling, all of which are dependent on foundation data, with demographic and mapping data overlays to support location analysis of risk profiles and risk modelling.

8.1.1 Productivity impacts

2017

Consultations with representatives from the insurance industry indicated that spatial information systems are delivering national productivity savings of around $20 million per annum against an annual claims and underwriting expense of around $5 billion. After allowing for annual costs of spatial information systems of around $0.8 million this results in a net saving of $19.2 million nationally in this example.

Consultations suggested that the level of adoption of such spatial technologies was around 80 per cent in 2017. On the basis that around one third of the benefits accrue to NSW and that the industry representatives consulted represent around 34 per cent of the insurance market, it is estimated that the value of spatial information systems to the NSW insurance market is around $14.9 million in 2017.

2022

Industry consultations suggested that the adoption of spatial techniques is likely to increase as the national coverage of 3D mapping of cities and towns in Australia develops. This is likely to see adoption levels increase from around 80 per cent in 2017 to around 95 per cent in 2022, which would result in the value of spatial information systems to the NSW insurance market of around $17.6 million in 2022.

It was not possible to provide more details of the calculation of these cost savings owning to commercial-in-confidence concerns.

8.2 State Emergency Services

The State Emergency Services NSW (SES) uses spatial information in all aspects of their work, including their capacity in a supporting agency role. The adoption of spatial technology has led to considerable efficiency gains for the SES and increased their effectiveness in the provision of crucial services for the people of NSW.

The primary application for spatial information is for decision support for the planning and response to floods, storms and tsunamis. The types of technologies used by the SES include:

- remote sensing
- GIS
- aerial photography
- satellite imagery
- spatial analysis
- geocoded addresses
- LIDAR output (e.g. for levy assignment) (not raw data).

Prior to 2005-06, all SES decision support and the locating of calls from the public was a paper based system. Since then, there have been huge efficiency gains in the ability to use geocoded address systems and other locational data.

The non-market benefits of spatial information are also perceived to be great and include:

- public safety/community safety
- data integrity and accuracy e.g. accurate definitions of flood risk
- community resilience – better understanding through data leads to better communication/education of the community
- operational efficiency
- information management.

Productivity impacts

2017

Consultation with the SES indicates that productivity gains are estimated to be over 80 per cent of total operating costs over the last decade. This is equivalent to a saving in 2017 of around $4 million. The estimated costs associated with the spatial information system are likely to be in the order of $1 million per annum. This includes the costs of setting up spatial systems (hardware and software), staff training and development, and licensing costs.

This results in net savings in 2017 of $2.6 million, which is around 4 per cent of operating costs.

2022

Consultation with the SES suggests that productivity gains over the next 5 years (to 2022) will not be as great as those for the previous 5 years – it is estimated that the productivity gain over the next five years will be 50 per cent. The implication is that the major economic benefits have already been realised. However, there may be scope for increased use of:

— public information products
— open data (financial and non-financial benefits).

Indications are that there will be a reduction in some costs over the next 5 years suggesting that costs will be approximately $200,000 per annum.

This would result in a saving of around $5.2 million by 2022 representing around 3 per cent of operating costs (assuming the same level in real terms as in 2017).

Further details on the calculations are provided in Appendix J.

8.3 Ambulance service

NSW Ambulance is an operational organisation within the Health Administration Corporation. It provides ambulance and related services over all of NSW, employing around 4,000 people of whom around 90 per cent are operational staff.

The service managed 226 ambulance stations across NSW in 2016. In 2015-16 it provided 1.1 million response services of which 86 per cent were emergencies.

A key goal for the service is to rapidly respond to calls on behalf of emergency and urgent patients. Rapid response is critical to the survival and positive health outcomes of many patients. For the 75 per cent of patients who require transport to hospital, the time to transport these patients is also of importance.

In Australia, the 50th percentile response time is a key measure of ambulance service provision, allowing the performance of the NSW Ambulance Service to be compared with ambulance services in other states. In 2015-16 the 50th percentile (median) response time for the state for:

— the highest priority patients with imminently life threatening conditions (1A) was around 7.5 minutes
— patients with potentially life-threatening conditions (priority 1) was 11.0 minutes.

NSW Ambulance's GIS services contain all cadastral, topographic, imagery and addressing data, which is provided by the Spatial Services Division and updated regularly. Address points and points of interest are critical to their operations. This data is used to assist the despatch of ambulances in a timely manner with the objective to arrive within 30 minutes to commence treatment of patients. This timing is a factor in life and death outcomes for patients – the sooner an emergency patient can be reached, the more likely that a life will be saved.

Research indicates that the probability of survival from cardiac arrest is around 80 per cent if remedial action is taken within the first two minutes of a heart attack and decreases by 10 per cent for every minute extra delay.[21] While early response from defibrillation is critical, prompt response from the ambulance service and paramedics is also a key factor for saving lives.

According to Ambulance NSW officials, spatial information is mission critical to their operations and analysis.

8.3.1 Planning and evaluation

Geospatial data is routinely utilised in the operational management and planning of emergency ambulance services.

Ambulance locations are recorded at all critical points in the treatment and transport of patients, including the time that the ambulance departs to travel to the patient, the time it leaves the scene and if the patient is transported, the time it takes to arrive at the transport destination (most commonly a hospital). This data is available as it is

[21] See https://www.stjohnsa.com.au/shop/defibrillators, (Wilde, 2013) and (Lyon et al., 2004)

recorded every minute or 250 metres travelled on the ambulance journey and, most importantly, it is readily accessible to senior managers via the QlikView application that accesses the Ambulance Intelligence System.

Two case studies are provided below to illustrate how geospatial data is used by the NSW Ambulance Service.

Evaluation of the impact of a strategy to reduce traffic congestion on emergency operations

Traffic flow improvements have an impact on emergency ambulance services by reducing delays in response times for paramedics to arrive on scene and transport times to get patients to hospital. Geospatial data that is regularly collected can be retrospectively utilised to evaluate the impact of changes in the operational environment, including the impact of traffic flow strategies.

The impact of a clearway strategy at location x to reduce congestion on ambulance response times is set out below.

— Location x is a key radial route into the city from the west and is currently used by 70,000 vehicles and 8,000 bus passengers on a Saturday.
— A review of location x compared the traffic volume and travel time speeds data for Saturday and Sunday before and after extended clearway times were implemented.
— The traffic volumes throughout the periods 8am until 8pm on Saturday and Sunday (the clearway times) remained relatively consistent before and after implementation of the clearway.
— However, based on data for a sample weekend, travel times at location x have decreased by up to 40 per cent throughout the day on Saturdays and Sundays since the introduction of weekend clearways.
— Travel time city bound between 8arn and 8pm (clearway times) before introduction of the clearway varied from 2 minutes up to 9 minutes 40 seconds. Travel time since the introduction of the clearways varied from 2 minutes up to 6 minutes 30 seconds. This represents an improvement of up to 3 minutes 10 seconds per vehicle.

Based on the information provided within this example, it was estimated that the clearway would have improved ambulance response times for 374 patients, reducing the average travel time and therefore the response time by 1.5 minutes.

This is a significant improvement in a context where the response time target for Priority 1 patients is 10 minutes. Improved response times will have an improvement in health care outcomes for patients including for some patients reduction in risk of mortality.

Planning a new ambulance station

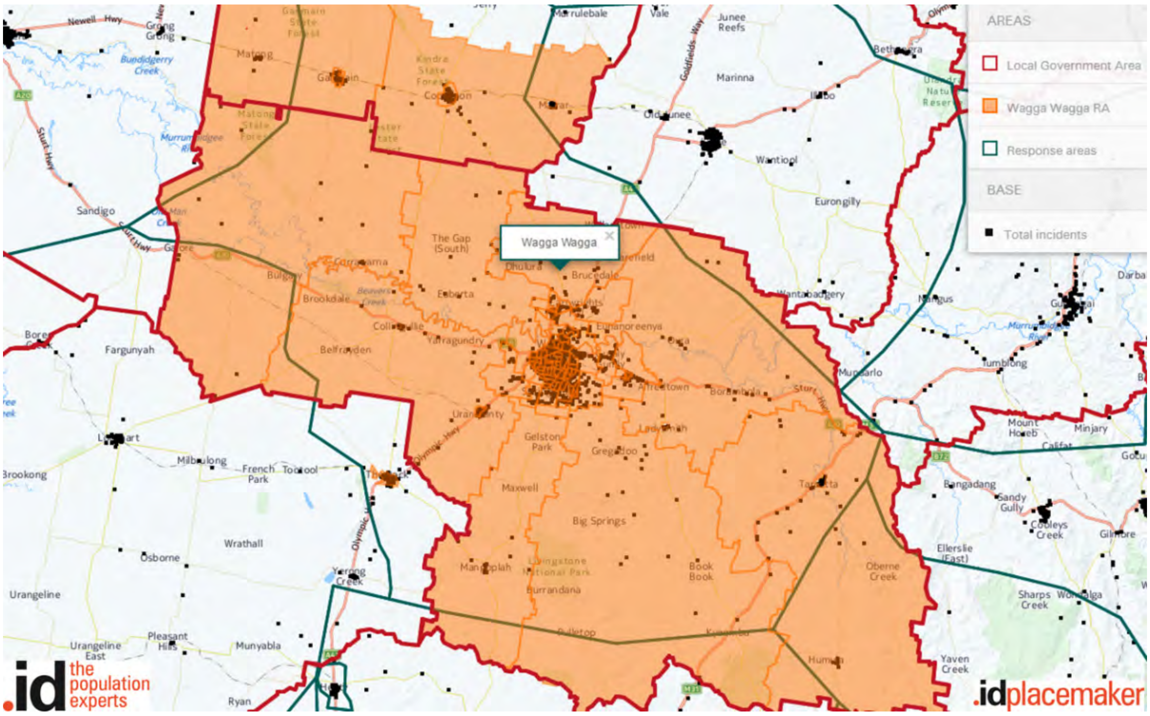
When new ambulance stations are built, or existing ambulance stations need to be rebuilt, the location of the station is the most critical factor that impacts on the capability of paramedics who will respond from it to reach patients most quickly. In planning an ambulance station, geospatial data is used in the following ways:

— The geospatial data that records the location of all patients for a sample period, usually the preceding year, are mapped.
— The travel times from multiple points are tested against their capacity to reach patients using commercially available travel times, adjusted for lights and sirens speeds.
— In some instances, data are utilised from the exact journeys on the previous year.
— The patient location is mapped for its correlation with ambulance response areas, Local Government Area boundaries, Department of Planning and Environment population projections, small area population projections that are commercially purchased, location of hospitals, location of other ambulance stations and the nodes that are utilised in custom built tools that enable comparison of sites and development of optimum locations.

Without access to both the original GIS data and the tools that integrate multiple information sets onto a single map, this planning could not be undertaken based on evidence. It would have to be done solely on the opinion of stakeholders. Availability of GIS data and, more particularly, the ability to express all relevant planning factors on a map, makes a fast, efficient and thorough analysis possible.

An example of the mapping undertaken for an ambulance station is shown in Figure 8.2. In this instance, the mapping enabled NSW Ambulance to simultaneously consider the current demand, future demand and potential locations and in the context of the relevant boundaries. The illustration identifies approximate locations of patient incidents for a recent year, small area boundaries for which indicative current and projected population data is available, Local Government Areas for which definitive population projections are available as well as NSW Ambulance response areas (RAs).

FIGURE 8.2 MAPPING ANALYSIS FOR A NEW AMBULANCE STATION



SOURCE: NSW AMBULANCE

8.3.2 Economic and social impacts

2017

NSW Ambulance noted that geospatial information systems had delivered significant cost savings and increased output that would not have otherwise been possible.

For example, two analysts are now able to deliver the same output formerly provided by eight analysts; a substantial productivity benefit. Data extraction and analysis can also be done faster with time taken for some planning tasks reduced from 10 person days to 30 minutes. This is having a significant impact on the efficient use of resources and to inform the optimal balance of recurrent and capital expenditure.

There will also be service wide benefits from faster and better planning decisions that are beyond the scope of this report.

A significant source of benefit would be in the value of lives saved through faster and more effective response times by ambulance services. As discussed above, the faster the response time, the lower the probability of death from a cardiac arrest. Research data from the USA indicates that for a wide range of patient conditions, including cardiac events, additional lives are saved for every 1 minute earlier that an ambulance arrives. Econometric research on mortality and ambulance arrival times for a sample from Salt Lake City suggested that every additional minute on response times increased mortality rates by between 8 per cent and 17 per cent (Wilde, 2013).

There is no comparable research undertaken in Australia. However data on emergency responses to cardiac arrests occurring outside of hospital in NSW, shows that survival rates have been increasing over the past ten years as shown in Table 8.1. Survival is defined as a return to spontaneous circulation until transfer to care of medical staff at the receiving hospital.

TABLE 8.1 SURVIVAL RATES FOR ADULT CARDIAC ARREST EVENTS TRANSFERRED TO HOSPITAL

	2006-07	2007-08	2008-09	2013-14	2014-15	2015-16
Adult cardiac arrests	2,066	2,684	2,083	2,466	2,193	2,305
Survival incidents	458	476	407	760	707	767
Survival rate	22%	18%	20%	31%	32%	33%

Notes: (1) Data is not available for the years 2010-11 to 2012-13 (2) Cardiac arrest survival; event rate is defined by the percentage of patients, aged 16 years and over, who were in out of hospital cardiac arrest and had a return to spontaneous circulation (that is, the patient having a pulse) until administration and transfer of care to the medical staff at the receiving hospital.

SOURCE: (PRODUCTIVITY COMMISSION, 2017)

It would appear that the survival rate of cardiac arrest transferees has increased by around 2 percentage points since 2013-14 and by 13 percentage points since 2008-09. Most of the impact of the use of contemporary spatial information support systems would have occurred over the last 5 years, therefore a possible figure of around say 2 to 3 percentage points might reflect the increase in survival for cardiac arrest patients transferred to emergency departments by ambulance. This is around a 10 per cent increase for the 2015-16 survival rate and broadly within the 8 per cent to 17 per cent range for a 1 minute decrease in the response time estimated by (Wilde, 2013).

Consultations with Ambulance NSW suggest that attributing a 1 minute improvement in response times over this period to the use of spatial enabled information systems would not be unreasonable. This would mean a saving in lives of around 152 in 2015-16. Using the value of a life recommended by the Commonwealth Department of Transport of $4.2 million this would be valued at around $322 million in 2015-16.[22] Improved response times would have been an important contributor to this outcome. Accordingly a large proportion of this value would have been enabled by spatial information and related systems.

Cardiac arrests form only a small component of total transfers by ambulance to emergency departments in hospitals. A total of 417,897 patients in the resuscitation, emergency or urgent category were admitted to emergency departments in NSW in 2015-16. Of these, around 334,000 (80 per cent) were estimated to have arrived by ambulance (Productivity Commission, 2017). The mortality rate for this group is understood to be around 10 per cent[23]. This implies that around 33,000 of patients in the resuscitation, emergency or urgent category would not have survived.

This is significantly higher than the 3,033 cardiac arrest patients transferred to emergency departments, which suggests that the value of spatial information as an enabler of increased survival from faster response times could be significantly higher than estimated.

Such estimates are subject to considerable uncertainty and the attribution of the benefits to spatial information and services is difficult to assess. However, our consultations suggest that improved response times can be attributed largely to the use of spatially enabled systems. It should also be noted that the benefits are not net as the cost of spatial systems have not been deducted. However the costs are not likely to be significant in comparison to the magnitude of the benefits.

2022

Consultations have suggested that that the use and application of spatial information systems will continue to improve the performance and response times for the ambulance service as planning systems are improved and as location enabled services evolve. Spatial data provided by the Spatial Services Division of the Department of Finance, Services and Innovation are critically important to Ambulance operations in NSW and their further development will create opportunities to refine and improve systems.

[22] Value of a life of $4.2 million adopted from Commonwealth best practice guidelines (OBPR, 2014). This is a lower figure than produced by Transport for NSW in 2013 (Transport for NSW, 2013).
[23] Personal communication. The other forms of transport to admission include air ambulance, helicopter and private transport including taxis.

Continued improvement in the location of ambulance stations using spatially enabled analysis can be expected to occur. ACIL Allen considers that an improvement of 20 per cent in response times would not be unreasonable. This would lead to an increase in the value of lives saved to around $386 million.

8.4 Economic impacts – emergency services and insurance industry

The economic impacts for the use of spatial information in insurance, State Emergency Services and the Ambulance Service are summarised in Table 8.2.

TABLE 8.2 ECONOMIC VALUE OF SPATIAL INFORMATION SERVICES FOR INSURANCE AND EMERGENCY SERVICES

	2017		2022	
	Value $ million	Proportion of operating costs	Value $ million	Proportion of operating costs
	$ million		$ million	
Insurance industry	14.9	0.22%	17.6	0.26%
State Emergency Services	2.6	3%	5.2	7%
Total	17.5		22.8	
Ambulance Service – value of increased lives saved from reduced ambulance response times	322.0		386.0	

SOURCE: ACIL ALLEN

KEY FINDING 10 INSURANCE AND EMERGENCY SERVICES

Spatial information is used in many ways in natural disaster management. This can be in the mitigation of, or recovery from, fires and flooding and other natural disasters. It is also being used by the insurance industry for risk assessment, harm modelling and for customer engagement. The benefits were assessed as $18 million in 2017, based mainly on benefits to the insurance industry. These are expected to increase to $23 million with an increase in adoption of spatial technologies by the insurance industry and improved applications by State Emergency Services.

Spatial information is also critical to the NSW Ambulance Service. Reduced ambulance response times facilitated by the use of spatial information has contributed to higher survival rates of patients transferred to emergency departments. An indicator of the value of the lives saved is estimated to be in the order of $322 million in 2017 and $386 million in 2022.

9 AGRICULTURE AND FORESTRY

The gross value of agricultural production (GVAP) in NSW was $12.125 billion in 2014-15, which is around 23 per cent of total agricultural production in Australia. The most important commodities, contributing a combined 42 per cent of NSW GVAP, were cattle and calves ($2.29 billion), followed by wheat ($1.96 billion) and wool ($0.89 billion) (ABARES, 2016).

Agriculture has been a relatively early adopter of spatial information technologies beginning in the early 2000s with the use of augmented GNSS positioning for precision agriculture and yield management. The application and value of spatial information services to the agriculture sector are discussed in section 9.1.

The Forestry Commission of NSW, which is the largest manager of commercial native and plantation forests in NSW, uses spatial information for more than 90 per cent of its work. The application and value of spatial information services to the Forestry Commission of NSW are discussed in section 9.2.

9.1 Precision agriculture

Spatial information has been widely used in agricultural applications for crop and soil monitoring as well as monitoring the fertility of agricultural fields to optimise the application of chemicals and fertilisers. The global market size for precision farming has been estimated to grow by over $6.34 billion by 2022 at an estimated compound annual growth rate of 13.09 per cent from 2015 to 2022 (BIS Research, 2014).

Precision agriculture is about collecting timely geospatial information on soil-plant-animal requirements, and prescribing and applying site-specific treatments to increase agricultural production and protect the environment. Precision agriculture is increasing in popularity largely due to the introduction of high technology tools that are more accurate, cost effective, and user friendly. Many of the new innovations rely on the integration of on-board computers, data collection sensors, time and position reference systems, and control systems.

Examples of spatial information systems in precision agriculture include:

— farm machinery guidance or controlled traffic farming applications, which use positioning to assist drivers to follow the optimal path, thus minimising risks of overlaps, and automatic steering, which completely takes over the steering of farm equipment

— production management applications, which includes the use of spatial data to improve production decisions such as yield mapping, livestock management, soil measurements and the variable rate (VR) application of fertilisers and other chemicals

— Supply chain management applications such as geo-tracking to maintain integrity in the food chain from farm to fork.

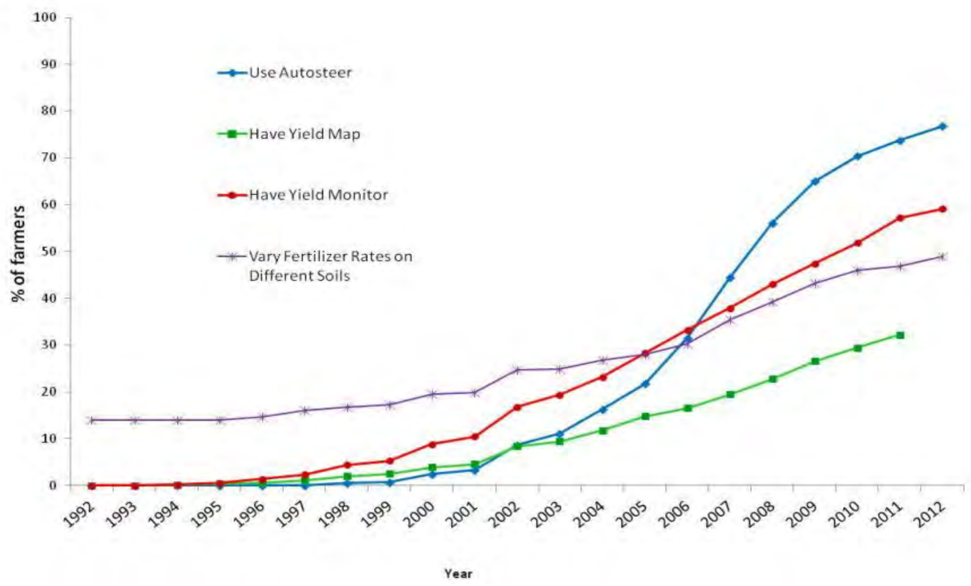
The majority of economic research in NSW on the costs and benefits of precision agriculture has been done on a case study basis for the grains industry. Currently, the cropping sector is the leader in the use of precision agriculture with an estimated adoption rate of 30 per cent. There is a very limited, but growing, use of spatial information for the livestock sector.

The main economic benefits of precision agriculture in grain production are due to:

— reduced use of inputs through improved vehicle navigation through use of positioning systems
— site specific crop management systems identifying and managing yield changes (Whelan, 2013).

Precision agriculture is being increasingly adopted in cropping. Figure 9.1 shows high rates of adoption of auto steer, yield monitors and yield maps.

FIGURE 9.1 ADOPTION OF PRECISION AGRICULTURE TECHNOLOGIES



Note: Variable rate data does not represent automated variable rate

SOURCE: DR R LLEWELLYN CSIRO

There is limited recent information on the economics of the different aspects of precision agriculture in Australia. Land and Water Australia cited studies from 1998 to 2003 which found yield increases for average years of between 10 per cent and 30 per cent, and increases of up to 50 per cent in above average years (Schofield, 2007).

Robertson et al (Robertson, Carberry, & Brennan, 2007) undertook a survey of farmers in 2007 and found that benefits from the use of variable rate technologies (VRT) for fertiliser applications ranged from $1 per hectare to $22 per hectare.

Another study by the Grains Research and Development Corporation (GRDC) in 2007 included yield increases in a survey of the benefits of VRT in crops (GRDC, 2007). This study found that the average benefits ranged from $9 per hectare to $22 per hectare in 2007 ($13 per hectare and $32 per hectare at current average grains prices).

Costs and benefits are farm type and location specific and greatly variable with some studies suggesting that there may indeed be a net cost for some farmers (Robertson M. C., 2009). Costs are generally still higher than the perceived and reported economic benefits and depend on the availability of infrastructure and type of equipment purchased. The costs of positioning related equipment are higher than the equipment needed for site specific crop management (Whelan, 2013).

Other benefits not quantified include (Whelan, 2013):

— environmental benefits such as:
  – the reduction in greenhouse gas emissions
  – reduced use of chemicals and fertilisers
— social benefits such as:
  – reduction in driver fatigue, stress and error
  – reduction in injuries associated with the above.

There is also a suggestion in the literature that there is still a lack of understanding of the benefits of variable rate applications of precision agriculture, meaning that economic benefits are yet to be realised by farmers:

the rate of adoption of VR (Variable rate technology) in 2008–2009 has increased significantly to 20% nationally from the low levels recorded in 2002. We see no reason for the rate not to continue to rise based on a number of factors: (1) the on-going rise in input costs for grain production placing greater emphasis on efficiency of input use; (2) an increasing awareness and appreciation of the agronomic and economic benefits of VR; (3) the active evaluation and perception of potential value by many current non-adopters; (4) many adopters using a stepwise approach to adopting precision agriculture and VR technologies; and (5) the greater availability and affordability of equipment.

(Llewellyn, 2012)

9.1.1 Productivity impacts

2017

An estimate of the cost savings that could be expected from the use of precision agriculture in grains in Australia is 10 per cent. This estimate draws on the examined case studies of the abovementioned reports, plus consultations with agricultural consultants and researchers. The calculation includes the impact of increased yield, at 0.33 tonnes per hectare and the 10 per cent cost savings arising from application of precision agriculture technologies. It takes into account additional costs associated with investment in capital equipment associated with precision agriculture.

2022

The rate of adoption of the use of precision farming is expected to increase over the next five years to 2022. We assume adoption increases to 80 per cent in NSW cropping in line with reports of increased adoption rates of 85 per cent in precision agriculture across Australia by 2025.

We further expect an increase in the adoption of precision agriculture in the livestock industry at an adoption rate of 50 per cent for NSW by 2022. However, there is no information currently available on the costs or benefits of precision agriculture for livestock production.

9.1.2 Economic impacts

ABS reports that the total cropped area in NSW in 2012-13 was approximately 7 million hectares.[24]

Based on previous research by ACIL Allen, we assume an adoption level of precise agriculture technologies of 30 per cent in grain farming. This is considered a conservative estimate given the increasing uptake of controlled traffic farming and precision farming generally. Assuming a 10 per cent cost saving and a 30 per cent adoption rate over the 7 million hectares gives a cost saving of $21 million in 2017 by using precision agriculture in cropping.

Taking the GVAP for wheat at $1,960 million ($1.96 billion) would suggest a maximum productivity gain from precision agriculture of approximately 1 per cent.

With an 80 per cent adoption rate of precision agriculture technologies by 2022 and an assumed reduction in the cost of equipment for precision agriculture, we see a considerable increase in the benefit from precision agriculture over this time.

[24] From: ABS Datacube, Agricultural Commodities, Australia, 2012-13

Assuming that the land area dedicated to the production of crops stays the same over the next five years, a cost saving of 15 per cent and an adoption rate of precision agriculture technologies of 80 per cent gives an estimated cost saving of $84 million in 2022.

With an assumption of a conservative change in the gross value for cropping of -5 per cent over five years,[25] this gives an estimate GVAP for NSW wheat of $1.86 billion. Converting this to productivity using a similar approach to the calculation for the 2017 estimate implies a 4.5 per cent productivity gain from precision agriculture in cropping by 2022.

Research suggests that the economic impacts for agriculture are highly variable as the costs and benefits of precision agriculture are farm type and location specific. Costs are generally still higher than the perceived and reported economic benefits and depend heavily on the availability of infrastructure and type of equipment used.

Further, asymmetry in information means a lack of understanding by farmers of various precision agriculture techniques suggesting that economic benefits are yet to be realised by farmers. This in turn implies a large potential for an increase in adoption rates across the sector which will deliver further productivity gains in the future.

If we factored the potential gains for livestock management and the benefits from better weather forecasting into these estimates it is likely that the net benefits would be significantly higher.

KEY FINDING 11 AGRICULTURE

Assuming a 10 per cent cost saving attributable to precision agriculture and a 30 per cent adoption rate over the 7 million hectares cropped in NSW gives a cost saving of the use of precision agriculture in cropping of $21 million in 2017. With an increase in the adoption rate to 80 per cent, we estimate the benefit to be $84 million by 2022.

9.2 Forestry Corporation of NSW

The Forestry Corporation of NSW is the largest manager of commercial native and plantation forests in NSW with an industry value of $240 million.[26] They manage over two million hectares of NSW State forests which are used for recreation, environmental sustainability and renewable timber production.

Spatial and location information is used in all aspects of forestry work with a particular emphasis on the use of remote sensing. More than 90 per cent of all work done by the Forestry Corporation uses spatial information of one type or another. The types of spatial technologies used include:

- remote sensing
- GIS
- aerial photography
- satellite imagery
- LIDAR
- Unmanned Aerial Vehicles (UAVs)/drones.

LIDAR offers the greatest benefit of all these technologies as it allows users to see through the canopy to the forest floor. This allows for more accurate surveying than field surveys and allows changes to be monitored over time.

Significant non-market benefits of spatial information systems include:

- Timber harvesting of both pine and native forests: spatial technologies allow accurate records of the location of habitat trees and streamside buffers, for example. Ecological surveys can be integrated into forest management.

[25] From http://www.abs.gov.au/ausstats/abs@.nsf/mf/7503.0
[26] See: http://www.forestrycorporation.com.au/about

— **Fire management**: spatial information, including LIDAR, can display and capture information in different ways. This suggests that there are corporate spatial data sets which can be shared with other departments and used for hazard reduction and bush fire suppression.
— **Habitat modelling**: LIDAR allows for modelling of threatened species (previously the forestry community were reliant purely on field surveys).

9.2.1 Productivity impacts

2017

Consultation with the Forestry Corporation of NSW indicates that cost savings are estimated to be over 20 to 30 per cent of operating costs over the last five years.

The estimated costs associated with spatial technologies are likely to be in the order of $375,000 per annum, which is primarily expenditure on LIDAR (e.g., licences, software etc.). Over the last few years there has been a significant increase in the quality of the imagery for the same price, i.e. costs have not declined but quality has significantly improved.

The Forestry Corporation receives all their remote sensing, and aerial and satellite imagery from NSW Land and Property Information (for free) under an MOU.

2022

The Forestry Corporation expects that cost savings over the next 5 years (to 2022), but these will not be as great as over the previous 5 years (to 2017). The estimate is for a further cost saving of between 10 and 20 per cent to 2022. Consultation suggests that most of the benefit has already been realised.

There is an expectation that costs associated with spatial technologies will decline, but not significantly. However, there is still potential for better value for money as the quality of the imagery continues to improve over time.

Further opportunities for an uptake of spatial technologies lie with a whole of government approach and by converging state based (and private) data for use across jurisdictions. The adoption rates across the sector nationally are as follows:

— 10 per cent adoption rate in private native forestry
— 60 per cent adoption rate for native forests (government run) across Australia
— 100 per cent adoption for native forests (government run) in NSW, Tasmania and SA
— 80 per cent adoption rate Australia wide for plantations (all privatised).

Victoria is the only jurisdiction which does not currently use spatial information to inform their operations.

Adoption rates for spatial technologies are dependent on costs, and the availability and accessibility of state wide data sets. If costs decline and state wide data sets are produced, it is expected that adoption rates for spatial technologies will increase by 10 per cent for private native forests, government run native forests (QLD, VIC and WA), and for use in plantation management by 2022.

The uptake of spatial technologies likely in the National Parks sector is likely to increase as they currently rely on satellite imagery rather than LIDAR. LIDAR is able to provide dynamic habitat modelling which will greatly improve operations and management of native species (flora and fauna).

Further benefits will accrue for fire planning and behaviour as data becomes more consistent and standardised and available across multiple jurisdictions.

9.2.2 Economic impacts

The Forestry Corporation of NSW has an annual revenue of $317 million (2015-16.)[27] Total costs for the Forestry Corporation are estimated to be $234 million. The costs of spatial information is reported to be $375,000 per annum which is just 0.2 per cent of total costs.

[27] From the Forestry Corporation of NSW, Annual Report, 2015-2016.

Taking the lower bound of the reported cost savings from spatial information over the last 5 years for the Forestry Corporation of NSW as 20 per cent suggests a benefit of $4.6 million to the Forestry Corporation.

Using Input-Output tables, ACIL Allen has been able to estimate the industry wide revenues and costs as $523 million and $345 million, respectively. The Forestry Corporation of NSW makes up 60 per cent of total revenue for the sector and accounts for 70 per cent of the total costs, implying that they are representative of the sector. If we extrapolate the estimated cost savings of 20 per cent across the total industry operating costs, but assume that the adoption rate of spatial technologies is lower, say at the national rate of 80 per cent, we estimate that the benefit to forestry of spatial information is around $5.5 million.

If the cost savings associated with spatial technologies increase by a further 10 per cent by 2022 (total cost saving of 30 per cent), and assuming no change to industry operating costs but a 10 per cent increase in adoption rate suggests that the benefit could be $9.3 million in 2022.

Spatial information has the potential for increased benefits to NSW if adoption increases across the private forestry sector in NSW and in other states. In addition, there is value in the consistent and standardised data produced across all states.

Further economic value may accrue due to better fire management and to the protection of native species through the use of dynamic habitat modelling, particularly for National Parks & Wildlife.

Gross value add for forestry and logging in NSW was $285 million for 2013-14 suggesting a productivity gain of 1.9 per cent.

KEY FINDING 12 FORESTRY

The benefit to forestry of spatial information is around $5.5 million in 2017 based on an adoption rate of 80 per cent and cost savings of 20 per cent. By 2022 this is expected to have increased to $9.3 million with an increase in the adoption rate to 30 per cent and cost savings rising to 30 per cent.

10

PLANNING AND ENVIRONMENT

The Department of Planning and Environment and its agencies are heavy users of spatial information services. Activities that draw on spatial information include planning and approvals processes, local environmental plans, public consultation, and monitoring. Interviews with officials from representative areas indicate that it would be impossible to contemplate doing their job without spatial information.

Just about every development, planning decision or licence to operate requires spatial information. It provides the ability to relate economic and environmental information in a spatial context. Planning activities are moving into a map based regulatory system. It is critical to licencing and approvals where activities can be related to a cadastral lot. Planned improvements to the NSW Cadastre will be very important to the future efficiency of the planning system.

Managing a sustainable environment is a key responsibility of the Office of Environment and Heritage (OEH). Spatial information is used for many critical activities of the OEH including:

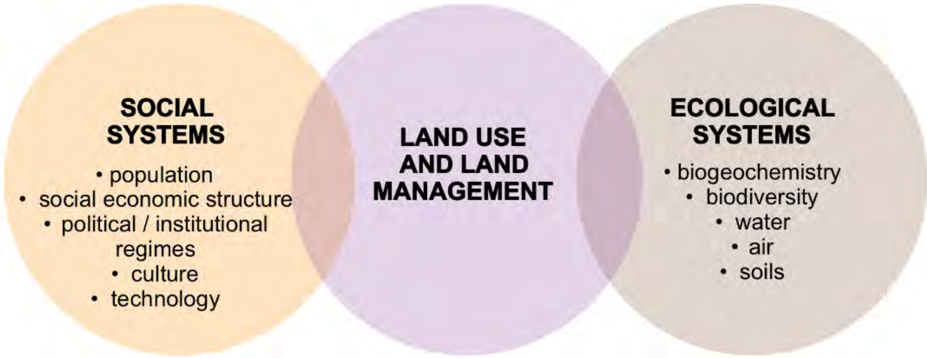
— managing park boundaries
— vegetation mapping and monitoring
— asset management
— fire management
— incident management
— licensing bio certification and bio banking.

Two examples that provide an indication of the application of spatial information are the use of satellite imagery for monitoring ground cover as part of the NSW Native Vegetation Monitoring Program, which is discussed in section 10.1, and its use in supporting the bio-banking program, which is discussed in section 10.2. Location analytics are discussed in section 10.3, and the economic value of spatial information systems to planning and environment are summarised in section 10.4.

10.1 NSW Native Vegetation Monitoring Program (NVMP)

Land use and land management is one of the critical linkages between human social systems and ecological systems. This relationship is illustrated in Figure 10.1. Monitoring vegetation and land use is a critical role in the implementation of land use policies, and in managing the interaction between economic activity and sustainable natural resource management.

FIGURE 10.1 LINKAGE BETWEEN LAND USE, SOCIAL AND ECOLOGICAL SYSTEMS



SOURCE: (LESLIE ET AL., 2011)

In 2007, NSW committed $24 million to enhance its capacity to undertake vegetation change monitoring and compliance using high resolution satellite imagery. As a result, the NVMP was established. The high level goal of this program was to support NSW's commitment to monitoring and reporting state-wide woody vegetation changes with a focus on compliance activities related to the *Native Vegetation Act 2003* (NVA).

The program was instituted to address a number of deficiencies, including the lack of a system to accurately monitor changes to native vegetation and the absence of a formal risk assessment to serve as a basis for prioritising monitoring efforts.

The activities and outputs of the program impacts on the wellbeing of the community by:

— reducing the amount of illegal clearing of native vegetation in NSW which is valued by society due to associated improvements in biodiversity status, reduced erosion and improved water quality
— reducing the costs of achieving zero net loss in native vegetation in NSW
— improving the management of natural resources on private land in NSW
— improving the understanding and management of waterways in NSW.

Other benefits generated include an increased knowledge of natural resources and the potential for future refinement of native vegetation management options under the NVA.

In the absence of the NVMP, the policy and compliance activities would:

— rely on compliance solely based on public reporting
— involve periodic mapping through aerial means
— base education and incentive programs on priorities informed by anecdotal evidence and public reporting.

In addition, there would also be no benefits from the state-wide mapping outputs for natural resource management actions undertaken by the NSW Government.

The operational implementation of the NVMP required the establishment of an in-house capability to map state-wide woody vegetation extent annually and map consequent changes. To establish the desired vegetative mapping capacity, a custom-designed computing facility was established and personnel were recruited. The scientific strategy for the NVMP was to adapt Queensland's State wide Land Cover and Trees Study to NSW

Productivity impact

The CRC for Spatial Information undertook a cost-benefit analysis of NVMP in 2010 (CRCSI, 2010). The benefits of the NVMP that were quantified in the cost-benefit analysis were:

— the avoidance of illegal clearing that would be undertaken in the absence of the NVMP (assessed through a per hectare value placed on areas not cleared, estimated at approximately 9,500 hectares, at $760 per hectare)

  - the annual benefit of the NVA in reducing illegal clearing is estimated at $7.169 million, of which 75 per cent (that is, $5.377 million) is attributable to the NVMP
- the decrease in compliance effort associated with implementation of the NVA (assessed by estimating the additional costs needed to offset the impact of no comprehensive monitoring)
  - the annual benefit from reduced compliance effort as a result of the NVA is estimated at $680,000 per year
- the improved effectiveness and efficiency of interface activities in natural resource management. (assessed by assigning an efficiency factor to current total expenditure on Catchment Management Authorities' activities that relate to landscape management of 2 per cent)
  - this benefit is valued at $1.32 million per annum between 2008 and 2010 and at $1.82 million per annum between 2011 and 2022.

The benefits of the program arising from reduced illegal clearing and cost efficient provision of appropriate compliance were estimated at $84 million over 15 years.

After taking costs into account, the report estimated the present value of the net benefits to be $56 million over 15 years or around $5 million per year (ACIL Allen Consulting, 2016).

10.2 Bio banking and biodiversity offsets scheme

The New South Wales Biodiversity Banking and Offsets Scheme (BioBanking) is a voluntary, market-based scheme designed to help conserve biodiversity and streamline the biodiversity assessment process for development. It has operated since 2008.

Under BioBanking, a proponent of a development is required to undertake an assessment of their development using a Bio Banking assessment methodology (BBAM). The BBAM defines red flag areas that development must avoid unless a variation is obtained, and requires the minimisation of impacts where possible. It then quantifies any remaining loss in terms of biodiversity credits. These credits are identified as either ecosystem credits or species credits and matching credits are required to offset the loss of biodiversity (threatened species, populations, ecological communities, or habitats) from the impact of development.

Proponents can seek to create credits on their own land or purchase credits on the market to satisfy their environmental liabilities. A registry of prices and credits has been developed to provide the base data for the scheme's operation. There are 99 regions currently in the scheme and trading in credits occurs within a sub region and contiguous sub regions. The current registries depend on base maps to record and monitor the biodiversity features such as woodland or rain forest. However the mapping data is at a base GIS level.

Following a review of the scheme in 2014, the Government decided to introduce reforms to the scheme to improve its efficiency, effectiveness and scope. As part of this review, the scheme is to be moved to a new management system that has greater spatial capability that can include more information on regions and sub regions, and information on landscapes as well as biological features. This will include development of a biodiversity investment spatial viewer that can identify strategic locations of biobank sites and investment in biodiversity.

Before biodiversity agreements can be made with a landowner, an assessment is made of the biodiversity credit status. These are done by local consultants who generally use GIS and other mapping technologies to investigate and prepare their reports.

Spatial information therefore underpins the management of this program now. The use of spatial information, mapping and other spatial techniques can be expected to increase in the future.

To date the scheme has used fairly basic maps from a GIS system. However the move to a newer management system that has greater spatial capability will improve the productivity of the management of the scheme, as well as deliver better outcomes from the biodiversity offsets scheme itself with better assessments of landscapes and biological features.

Productivity impacts

The value of the price for certificates in the ecosystem and species markets reflects the biosecurity value through the preservation of ecosystem and species at defined locations. The number and value of transactions in the 2015-16 financial year are shown in Table 10.1.

TABLE 10.1 NUMBER AND VALUE OF TRADES UNDER BIOBANKING

	Transfers	Value	Average price per credit
		$	$
Ecosystem credits	1,501	16,417,743	10,938
Species Credits	57	200,665	3,520
Total	1,558	16,618,409	10,667

SOURCE: CREDIT TRANSACTIONS AND SALES - HTTP://WWW.ENVIRONMENT.NSW.GOV.AU/BIMSPRAPP/SEARCHTRANSACTIONREPORTS.ASPX?START=1

The table shows that the current market size is around $16.6 million. The average price is around $10,000 per credit. A 6 per cent increase in the size of the market would reflect an increase in the value of biodiversity protected by around $1 million.

Clearly the benefits of making this market more efficient through better management of the market and improved information by both buyer and seller through the greater use of spatial systems are likely to be significant. There is insufficient evidence at this stage to assess how effective these reforms might be.

10.3 Location analytics

Managing the balance between economic activity and a sustainable environment is a key challenge for policy makers. OEH is developing tools for better environmental accounting to match established financial and economic accounting that underpins government processes. In 2012 the United Nations endorsed a System of Environmental – Economic Accounting (SEEA)[28]. The SEEA is a system for organising statistical data for the derivation of coherent indicators and descriptive statistics to monitor the interactions between the economy and the environment, and the state of the environment, to better inform decision-making.

A National Working Group under the Meeting of Environment Ministers of the Council of Australian Governments (COAG) has been established to implement environmental – economic accounting to inform decision making on environmental matters in Australia. Under the agreement, jurisdictions must acquire data to support environment-economic accounting.

The data base for this system will utilise GIS systems for locational analysis. This will be complemented by work that the Australian Bureau of Statistics is undertaking to geocode some of its economic and demographic data. Such developments can be expected to enrich the quality of environmental-economic accounting.

The data collected will be important for NSW to enable evidence based decisions on issues such as forest clearing and coal seam gas development. It will also be important for management of the national parks program which is worth around $3.1 billion per annum, infrastructure development and coastal zone management.

The potential for use of such data in location analytics to inform future decision making is very high. Location analytics is recognised as an important component of data analytics generally. The NSW Data Analytics Centre in the Department of Finance, Services and Innovation is engaged in developing capabilities in NSW government departments. The Data Analytics Centre and OEH recognise the potential economic and environmental benefits of better outcomes from well informed evidence based decisions in the future. Such objectives are aligned with the economic and social objectives of the NSW Government.

10.4 Economic impacts – planning and environment

Efficient management of the state's natural and environmental resources, in conjunction with achieving economic objectives, is an imperative for the future socio-economic welfare of NSW communities. The overall budget of the

[28] See http://unstats.un.org/unsd/envaccounting/seea.asp

organisations within OEH was $1,146 million in the 2016 financial year. Many of the work units draw on spatial information systems to implement programs or assess policy options.

This chapter assessed one activity undertaken by the OEH – vegetation mapping – and found that remote sensing from earth observation satellites had derived net savings of $5 million per year in operating costs. ACIL Allen has not been able to estimate the organisation wide impacts but from discussion believes that the benefits would exceed this amount by an order of magnitude.

Spatial information also supports management of market based activities in the Biobanking program that is currently operating a market worth around $16.6 million in the 2016 financial year. Reforms to the operation of this program, including greater spatial capability, are aimed at improving the operation of the bio-banking certificates market through provision of greater spatial context for both buyers and sellers in the market as well as lowering the cost of market operations.

In summary, ACIL Allen considers that the $5 million in savings for vegetation mapping represent only a small fraction of the benefits being delivered by spatial information to OEH and to the management of environment and heritage policies in NSW.

ACIL Allen notes that proposed developments in location analytical capability are likely to increase the value of the contribution of spatial information and services to OEH in the future years to 2022.

KEY FINDING 13 OFFICE OF ENVIRONMENT AHD HERITAGE

Spatial information services have delivered net savings in vegetation mapping undertaken in the Office of Environment and Heritage of around $5 million in 2017. This estimate is considered to be a low estimate on the basis of the wide use of spatial information in other areas of activity.

The Biobanking program had a market value of around $16 million in the 2016 financial year in traded biodiversity certificates. Increasing the spatial capabilities planned for the program could be expected to increase the value of this mechanism, possibly leading to further benefits of around $1 million by 2022. Development of a spatial analytical capability under the System of Environment-Economic Accounting has the potential to deliver significant benefits by 2022.

Location analytics is expected to play in increasingly important role moving forward in managing the balance between economic activities and maintaining a sustainable environment. The Office of Environment and Heritage is developing tools for better environmental accounting to provide better data for evidence based decision making. Development of rapid data analytical capabilities will further enable this endeavour.

11

LOGISTICS

The logistics industry is concerned with the movement and storage of physical freight on land plus the associated support services. According to the Council of Supply Chain Management Professionals:

Logistics management activities typically include inbound and outbound transportation management, fleet management, warehousing, materials handling, order fulfilment, logistics network design, inventory management, supply/demand planning, and management of third party logistics services providers. To varying degrees, the logistics function also includes sourcing and procurement, production planning and scheduling, packaging and assembly, and customer service. It is involved in all levels of planning and execution--strategic, operational and tactical. Logistics management is an integrating function, which coordinates and optimizes all logistics activities, as well as integrates logistics activities with other functions including marketing, sales manufacturing, finance, and information technology.[29]

The transport and storage industry is estimated to have added around $23 billion to the NSW economy. However the footprint of the logistics industry is larger than this figure, as the ABS statistics in this division do not include logistics embedded in other industries. ACIL Allen estimates that if this extra component is added into the statistics the value added by the logistics industry would be around $41 billion for NSW (based on a national assessment by ACIL Allen, adjusted for relative value added contributions (ACIL Allen Consulting, 2014)). This represents about 8 per cent of Gross State Product.

On the basis of a rough calculation it is estimated that the sector employs around 375,000 people.

The application and value of spatial technologies to the logistics sector are discussed in section 11.1 and section 11.2, respectively.

11.1 Spatial information systems in the logistics sector

The logistics industry comprises both small and large firms, the latter who often contract to the smaller players for transport services of different kinds. The major players are Toll Holdings, Linfox Pty Ltd and K&S Corporation Limited.

Productivity is a critical factor in maintaining competitiveness in the sector and there has been considerable innovation in the application of spatial and location technologies to manage goods movements and track transport operations. This is often referred to as Fleet Telematics.

Over the last decade the industry has exhibited a trend towards the development of integrated logistic supply networks which span across transport modes and borders (IBIS World, 2016). This has accompanied the development of leaner supply chains and consolidated transport hubs.

One company consulted reported that it depends heavily on spatial information and precise GNSS for its operations. The company is investing heavily in its analytics technology and have embarked on a long term

[29] http://cscmp.org/imis0/CSCMP/Educate/SCM_Definitions_and_Glossary_of_Terms/CSCMP/Educate/SCM_Definitions_and_Glossary_of_Terms.aspx?hkey=60879588-f65f-4ab5-8c4b-6878815ef921

project to standardise their in-cab vehicle tracking systems. It reports that their truck tracking system enabled them to operate with 24 per cent fewer trucks and reduced turnaround time of 25 per cent.

They are employing a spatially enabled software that provides location and logistics analytics. They are also looking to automate warehousing and processes as much as possible.

They aim to be able to predict delivery times based on weather, congestion, speed limits and other traffic constraints using predictive analytics. They can also use the system to set goals and measure and reward productivity. The system leads to real time reporting and smarter decisions.

11.1.1 Adoption rates and productivity impacts

Wider industry consultations suggests there is a varying use of spatial information across the logistics sector. Companies such as Linfox, Toll and Cube Logistics are at the forefront of innovation in this area and have embraced the use of GNSS positioning data and real time tracking/tracing, such as retail stocking, parcel delivery and postal services.

Spatial data is widely used in ports operations. For example, the Port of Brisbane has been fully automated since about 2010.

However, on average, across all logistics sectors, the current adoption rate of spatial technologies is only 20 to 30 per cent. The key barrier inhibiting adoption is that people do not know the benefits that spatial information can bring to their businesses nor an indication of the magnitude of the value of those benefits. Consultation suggests that costs will decrease over time, and this may help to increase the adoption rate. The greatest area of benefit will be supply chain integration.

The adoption rate is expected to increase to between 30-40 per cent by 2022 but the sector needs to develop its analytical capabilities to properly utilise spatial information. Most adoption will be in the private sector; the public sector will only adopt the technology if it is reinforced by the government.

Examples of non-market benefits associated with spatial technologies in the logistics sector, since 2000, include:

— in the trucking industry, improved safety (e.g. number of hours on road), and work force incentives for on time delivery
— in the retail sector, the ability to map demand patterns by location, which has led to improvements in distributional networks.

11.1.2 Productivity impacts

2017

It is estimated that, on average, the productivity improvements attributable to spatial information and services over the last 16 years account for around 15 per cent for the logistics functions.

Allowing for the fact that these productivity impacts apply to costs in the logistics areas, ACIL Allen has estimated that the productivity impact across the logistics sector would be in the order of 10 per cent.

2022

It is estimated that the benefits of spatial technologies to the logistics sector over the next 5 years will be around 20 per cent for the use of GIS and GNSS services for the logistics functions.

11.2 Economic impacts – logistics sector

For this study, ACIL Allen focussed on the top three logistics companies in the road transport sector. These three companies have a 16 per cent share of the market. From our consultations with stakeholders, it is understood that these companies are early adopters of IT and spatial solutions to improve productivity, and compete in the logistics and transport sectors.

The costs for NSW were estimated on the basis of the ratio between industry costs for NSW and industry costs for Australia from the ABS input output tables. This ratio was found to be 20 per cent.

Productivity and impacts were estimated from consultations with selected industry stakeholders. They were adjusted for our understanding of likely costs of implementation of spatial information systems within the overall context of IT budgets. They were also adjusted by an estimate of the proportion of logistics activities to total activities of the organisations.

The estimate of the economic value of spatial information systems to the logistics sector are summarised in Table 11.1.

TABLE 11.1 PRODUCTIVITY AND ECONOMIC IMPACTS IN THE LOGISTICS SECTOR

		2017	2022
Productivity improvement – logistics operations		15%	20%
Productivity improvement for organisation		5%	5%
Operating costs for top 3 companies (16% of market share)	$ million	1,410	2,115
Savings attributable to spatial information services	$million	70.5	105.8

Note: Productivity and impacts were estimated from consultations with selected industry stakeholders. They were adjusted for our understanding of likely costs to implement spatial information systems within the overall context of IT budgets. They were also adjusted for the proportion of logistics activities to total activities of the organisations based on consultations with stakeholders.

SOURCE: ACIL ALLEN, IBIS REPORTS, ANNUAL REPORTS, CONSULTATIONS

KEY FINDING 14 LOGISTICS

The logistics industry uses positioning, GIS and tracking devices to maintain competitiveness in what is a very competitive industry. Levels of adoption are around 20 to 30 per cent and are expected to rise to around 40 per cent by 2022. The industry is characterised by large and small players. The lead players in the sector are the leaders in the adoption of these technologies. Productivity gains are believed to be around 5 per cent.

ACIL Allen estimates that the benefits of spatial technologies to the logistics sector are $71 million in 2017. They are expected to rise to $106 million by 2022 with increased adoption of spatial technologies across the industry.

12

SUMMARY OF IMPACTS

Section 12.1 summarises the main findings from this report, section 12.2 summarises the economic value off spatial information systems to the NSW economy in 2017 and 2022, and section 12.3 summarises the potential benefits of spatial information systems post 2022.

12.1 Main findings of the report

12.1.1 Land and property administration

The value of spatial information services (including cadastre, topographic mapping, and imagery) is estimated to have delivered around $4 million in net savings to the office of the Valuer General. Greater savings are anticipated by 2022 through data analytics and further automation of the valuation process.

The value of the Cadastre NSW project was estimated to be around $8.5 million per year from 2022 in savings to registered surveyors or $67 million in present value terms (over 15 years). This is based on 10 per cent savings in professional and technical time that would be achievable with the full implementation of a single digital cadastre.

With the completion of the full Spatial Services Road Map for Spatial Data Infrastructure, these benefits could increase to as high as $240 million per year through improved delivery of permit approvals in the property development supply chain. Efficient planning approvals processes are important to overall costs in the land and property development supply chain.

Implementation of the Road Map for Spatial Data Infrastructure will also have important implications for other areas of government activity. Stamp duty, land tax and parking space levies comprise around 46 per cent of total NSW state revenue. These taxes are location based taxes. Full implementation of the NSW Spatial Services Road Map will create the capacity for location based information on taxes to be stored in 3D registries. This will ultimately support improved location based analysis of ownership and land tax payments. Broader development of rapid spatial analytical capabilities will be facilitated by these developments.

The Spatial Services Road Map will create a whole of government validated address file that will provide one source of authoritative geocoded address data. This will be of benefit to government agencies such as emergency services and the ambulance service but will also be of value to the insurance industry and other industries dependent on accurate address data. The benefits across government services, including emergency management, are likely to be significant.

12.1.2 Building and construction

The use and application of spatial information in engineering surveying and construction process is estimated have delivered significant operational efficiencies. This has resulted in greater accuracy and fewer errors, 60 per cent reduction in double handling of materials, improved utilisation of graders and excavators, less machine wear and tear, fuel savings, increased safety and reduced hours required from automatic machine guidance.

The net impact of spatial information services on engineering surveys was estimated to lie between $13 million and $19 million in 2017. These numbers could rise to between $41 million and $50 million by 2022 with a higher rate of adoption of spatial technologies in this sector.

12.1.3 Smart buildings and infrastructure

Smart spatial referenced operating systems have significant potential to deliver improved infrastructure services. They have potential applications in smarter delivery of infrastructure, Advanced Train Management Systems and in traffic management. Many of these applications are still in the early stage of adoption in Australia but their potential is significant. One example that has been implemented is the Sydney Coordinated Traffic System that has delivered estimated savings of $3.6 billion per annum. Spatial information systems would represent a component of the system. If this were 10 per cent, for example, the value of spatial information to the system would be around $360 million per year.

The use and application of federated 3D models, such as BIM, has the potential to deliver significant savings in costs associated with engineering construction in the longer term. ACIL Allen estimated that the present value of benefits for NSW could range from $266 million to $1,330 million over 15 years based on productivity benefits ranging from 1 per cent to 5 per cent. ACIL Allen believes a productivity benefit of 3 per cent is a reasonable estimate resulting in savings with a net present value over 15 years of $798 million.

Realisation of these benefits is based on the assumption that the adoption rate for federated 3D models commences at 10 per cent of building projects in NSW in 2026 rising gradually to 70 per cent by 2034. Completion of the proposed Cadastre NSW project will be important to realising these benefits.

12.1.4 Asset management

The use and application of spatial information in asset management in the Department of Education, the Land and Housing Corporation and local government was conservatively estimated to have delivered net benefits of $43 million by 2017. This is expected to increase to $59 million by 2022.

Longer term benefits from the use of BIM and 3D modelling in asset management for non-residential buildings was estimated to deliver additional benefits in the longer term. These were estimated to be between $236 million and $471 million in present value terms assessed over a 20 year period. Benefits are assumed to commence in 2026 and increase gradually from 10 per cent adoption levels in 2026 to 70 per cent of adoption levels in 2034.

12.1.5 Utilities

Spatial information technologies have become integral to the management of water, electricity and gas utilities. They are also critical to the overall management of water resources in the state.

The use of spatial information technologies in these sectors is estimated to have delivered net benefits of around $57 million in 2017 based on net productivity impacts of 3 per cent of labour costs. This figure is expected to rise to $85 million by 2022 based on productivity impacts increasing to 5 per cent of labour costs.

12.1.6 Smart cities and local government

The use of spatial information in support of smarter management of cities and in particular local government services has been an important source of cost savings and productivity improvement.

The impact of spatial information and Smart Cities techniques on local government was estimated to have delivered accumulated benefits for local government of $7 million in 2017. This is expected to increase to $11 million by 2022.

These figures do not include the use of spatial information for asset management by local government that are included in the asset management category.

12.1.7 Emergency services, insurance and ambulance services

The socio-economic cost of disasters such as fires and floods has been steadily rising in Australia. The costs of natural disasters is a function of mitigation actions, response measures and recovery action. The Productivity

Commission concluded in a 2014 report that governments can do better in terms of policies that enable people to understand natural disaster risks and also to give them the incentive to manage the risks effectively.

Spatial information can be used in many ways to reduce the impact of natural disasters and emergencies. In many cases it is mission critical. This can be in the mitigation of, response to, or recovery from, fires and flooding and other natural disasters. It is being used by the insurance industry for risk assessment, peril modelling and better customer engagement.

The benefits were assessed as $18 million in savings to the insurance industry and State Emergency Services in 2017. These are benefits are expected to increase to $23 million with increased adoption by the insurance industry and improved applications in State Emergency Services.

The report also explored the value of lives saved through the use of spatial information to reduce response times for the NSW Ambulance Service. It estimated that the use of spatial information had contributed to increasing survival rates by around 10 per cent for cardiac arrest patients through faster response times. The report estimated that the value of lives saved was of the order of $322 million in 2017 and could rise to $386 million by 2022.

12.1.8 Agriculture

The use of spatial information in agriculture, including precise positioning using CORS and other augmentation systems, has been growing steadily over the past 10 to 15 years with applications in yield monitoring, variable rate fertiliser application and controlled traffic farming (autonomous farm machinery and vehicles). These applications are often referred to by the term precision agriculture. It is also finding applications in improving weather forecasting and decisions on the timing of planting of crops.

For this report, we examined the use of spatial information in precision agriculture in broad acre cropping in NSW. Assuming a 10 per cent cost saving and a 30 per cent adoption rate over the 7 million hectares cropped in NSW, ACIL Allen estimated a cost saving of $21 million in 2017 by using precision agriculture in cropping . With an increase in the adoption rate to 80 per cent, the benefit is estimated to be $84 million by 2022.

12.1.9 Forestry

Spatial information is used by the forestry industry for a number of purposes including remote sensing, production monitoring, fire management, habitat modelling and fire management.

The benefit to forestry of spatial information is estimated to be around $5.5 million in 2017 based on an adoption rate of 30 per cent and cost savings of 20 per cent. By 2022 this is expected to increase to $9.3 million with an increase in the adoption rate to 80 per cent and cost savings rising to 30 per cent.

12.1.10 Planning and environment

Spatial information services have delivered net savings in vegetation mapping undertaken by OEH of around $5 million in 2017. This estimate is considered to be conservative as it does not capture the full extent of the use of spatial information by the OEH. The contribution is likely to increase by around 20 per cent to $6 million by 2022 as pressures on land development grow.

The Biobanking program administered by the OEH has established a market in traded biodiversity certificates worth around $16 million in the 2016 financial year. Increasing the spatial capabilities of the program could be expected to increase the value of this mechanism by around $1 million by 2022.

Location analytics is expected to play an increasingly important role moving forward in managing the balance between economic activities and maintaining a sustainable environment. The OEH is developing tools for better environmental accounting to provide better data for evidence based decision making. Development of rapid data analytical capabilities will further enable this endeavour.

12.1.11 Logistics

The logistics industry uses positioning, GIS and tracking devices to maintain competitiveness in what is a very competitive industry. Levels of adoption are around 20 to 30 per cent and are expected to rise to around 40 per cent by 2022. The industry is characterised by large and small players. Major players such as Toll, Linfox and

K&S Corporation are the leaders in adoption of these technologies. Productivity gains are believed to be around 5 per cent.

ACIL Allen estimates that the benefits of spatial information to the logistics sector are $71million in 2017. They are expected to rise to $106 million in 2022 with increased adoption of spatial technologies across the industry.

12.2 Productivity impacts in 2017 and 2022

A summary of the net benefits from improvements in productivity attributed to the use of spatial information, services and analytics is provided in Table 12.1. The table shows total net benefits of $923 million in 2017 and $1,395 million expected in 2022.

These benefits comprise a mix of productivity improvements and social values, such as the value of lives saved. The totals therefore do not represent total changes in economic activity, but are an indication of the total value from the case studies selected.

TABLE 12.1 SUMMARY VALUE OF SPATIAL INFORMATION

	2017		2022	
Case study	Assumptions	Value $ million	Assumptions	Value $ million
Land and property administration	Savings from the use of spatial information (cadastral information, topographic mapping and imagery) in valuation processes. Savings estimated to be 15 per cent of operating costs less cost of spatial information services including imagery and graphics.	4.4	Further savings from higher resolution imagery, automation and data analytics are expected to deliver further productivity improvements, but these have not been estimated for this report.	4.4
			Improvement in the land permit approvals processes through implementation of the Road Map for Spatial Data Infrastructure – spatially enabled data infrastructure, a single digital cadastre and development of improved assess to spatial data services.	240.0
Building construction and infrastructure	Savings from integration of spatial information data and systems in data acquisition, planning and route selection, and machine guidance, based on cost savings of 30% and an adoption rate of 25%	13.5	Savings from integration of spatial information data and systems in data acquisition, planning and route selection, and machine guidance, based on cost savings of 50% and an adoption rate of 45%	40.5
Smart buildings and infrastructure	Contribution to savings from the use of the Sydney Coordinated Traffic Management System (SCATS)	360.0	Longer term benefits from the coordinated use of BIM models in federated registries (discussed separately)	360.0
Asset management	Benefits of the use of GIS and positioning technologies in asset management in selected applications in the Department of Education, the Land and Housing Corporation and in Local Government.	43.2	Additional benefits based on a 33% increase in school facilities and a 15% increase in productivity, increased use of airborne LIDAR to record building footprint and map underground service lines to improve productivity in maintenance, and an increase in the adoption rate in local government from 25% to 40%.	58.7

	2017		2022	
Case study	Assumptions	Value $ million	Assumptions	Value $ million
Utilities	Net benefits of the use of GIS and positioning technologies in the management of water, gas and electricity assets.	57.1	Water estimates unchanged. Productivity impact in electricity and gas increasing from 3% to 5% of operating costs.	84.5
Smart cities and local government	Benefits to local government and local authorities in the use of spatial information systems in planning, development approval, crime management and services to rate payers assuming benefits of 0.2% of operating expenses based on UK experience. Does not include the value to asset management use in local government (which is included above).	7.0	Increased use of spatial systems increasing benefits to 0.3% of operating expenses. Does not include the value to asset management use in local government (which is included above).	11.0
Emergency services, insurance and ambulance services	Benefits of spatial data to the insurance industry of $14.9 million and to the SES of $2.6 million.	17.5	Increase in the rate of adoption of spatial information in the insurance industry from around 80% to 95%, and an increase in the benefits to the SES to $5.2 million.	22.8
	Value of reduction in mortality rates for cardiac arrest events arising from faster response times	322.0	Value of reduction in mortality rates for cardiac arrest events arising from faster response times	368.0
Agriculture	Net benefit of $75 per hectare in the cropping industry from use of precise positioning and GIS in the grains industry	21.0	Increase in the adoption rate from 30% to 80% and increased production in the grains sector	84.0
Forestry	20% gain in productivity and an adoption rate of 80%	5.5	Increase in productivity from 20% to 30% and an increase in the adoption rate from 80% to 90%	9.3
Planning and environment	Savings in vegetation mapping costs.	5.0	Small increase in value to biobanking	6.0
Logistics	5% productivity improvement.	70.5	Increase in adoption rate from 25% to 40%	105.8
Total		927.1		1,395.5

SOURCE: ACIL ALLEN

12.3 Longer term benefits post 2022

A summary of the net present value of benefits that are expected to accrue between 2026 and 2036 is provided in Table 12.2. The table shows additional benefits of $918 million in present value terms, over a period of 15 years, which are estimated to accrue from developments in the single digital cadastre and from the integration of the digital cadastre and federated 3D models. If the analysis is extended to 20 years, this value rises to around $3 billion in present value terms

These longer term benefits assume that a single digital cadastre is implemented in NSW by 2026 and federation of 3D models of the built environment (including BIM) is achieved. Adoption is assumed to start at 10 per cent in 2026 and reach 70 per cent by 2033.

TABLE 12.2 LONGER TERM BENEFITS FROM DIGITAL CADASTRE AND FEDERATED 3 D MODELS

Case study	Assumptions	Present value over 15 years $ million	Present value over 20 years $ million
Smart buildings and infrastructure	Savings from integration of digital cadastre and BIM in federated registries of 3 D models of the built environment. Productivity improvement in the building and construction sector of 3 %. Benefits from 2026 to 2036.	798	2,622
Asset management	Application of BIM and 3D models in asset management for non-residential buildings. Benefits from 2026 to 2036.	120	471
Total		918	3,093

SOURCE: ACIL ALLEN

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A

METHODOLOGY

There are two main approaches to valuing applications such as spatial information.

Willingness to pay surveys can provide information on the value users place on spatial information and services enabling an estimation of producer and consumer surplus which is an indicator of economic value[30]. An alternative approach is to examine the impact on productivity of an application and value added by a sector as a result of the use of spatial information.

An initial literature review revealed very little data that would support a willingness to pay analysis and the cost of undertaking such a study would have been prohibitive. This report therefore adopted the second approach and examined the impact on productivity of selected case studies. In some cases a present value of future benefits was calculated. These are reported separately.

A.1 The approach

To estimate the impact of spatial information on the economy in 2017 and a forecast to 2022, two scenarios were considered:

— a "with spatial information" evaluation scenario, which assumed that the spatial information was applied – effectively the situation in 2017

— a reference case which assumed that the development of modern spatial information since 2000 was not applied in the economy.

An estimate of where the market is likely to be in 2022 was also made for cases where this was possible.

In addition, it became evident during research that significant benefits are likely to accrue after 2022 following from proposed developments of a single digital cadastre and parallel developments in the use and application of building information and modelling (BIM) that are foreshadowed to arrive after 2025. These were also estimated in terms of net present value and are additional to the benefits estimated to 2022.

ACIL Allen met with representatives of the Spatial Services Division in March 2016 and a workshop was held in April 2016 with government and private sector users. These discussions identified case studies for the report.

Additional research was undertaken into these and other case studies to provide an estimate of the direct impacts of specific applications, and to use these as a guide to estimating direct impacts on selected sectors of the economy.

Consultations on some case studies proved difficult due to commercial in confidence concerns, particularly those organisations subject to a sale process, such as the electricity sector, and in relation to developments that were

[30] Consumer surplus is the difference between the price a consumer is willing to pay for a product or service and the market price. Producer surplus is the difference between the price a firm receives of the product or service it produces and the cost of producing that service. The sum of producer and consumer surplus is considered to be the economic value created.

subject to Cabinet consideration. In these cases, ACIL Allen drew on desktop research and benefits transfer from other research and studies.

The following sections outline the details of the methodology.

The steps in the process were:

— research into case studies in each major sector to identify verified productivity improvements or resource increases attributable to spatial information
— using the results of cases studies to assess the rates of adoption and the impacts of spatial information in each sector
— estimate productivity impact in each sector and compile estimates of net economic impact for 2017 and 2022
— estimate productivity impacts for applications arising after 2022 and estimate the net present value of those impacts as at 2017 and report separately to the estimates for 2017 and 2022.

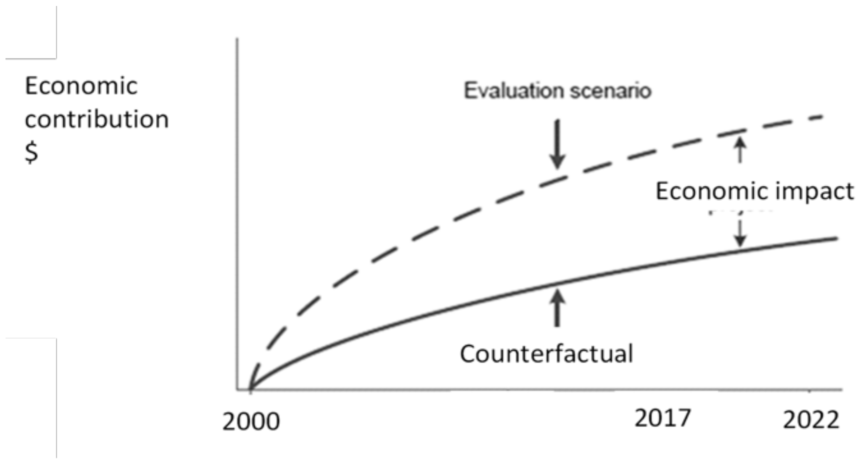
A.1.1 Assessing the direct impacts

The direct impacts are the impacts on businesses within each sector of the economy, typically expressed in terms of cost savings, revenue gains or the facilitation of new applications (which are typically reflected in either revenue gains or cost savings). Regardless of whether the impact at the firm or industry level is a cost saving, a revenue gain or the facilitation of new applications, we quantify the impact in terms of a change in productivity.

The approach taken in this report has been to collect and analyse as much relevant information as possible to estimate the direct economic impacts. Our estimates were based both on case studies and desktop research.

We then compared the scenario with the use of modern spatial information to a counterfactual which is the hypothetical situation without modern spatial information. The economic impact is the difference between the scenario we are evaluating and the counterfactual. This is illustrated in Figure A.1.

FIGURE A.1 COMPARING THE SITUATION WITH AND WITHOUT SPATIAL INFORMATION



SOURCE: ACIL ALLEN

A.1.2 Steps taken in the assessment

The following key steps were involved in building up the assumptions that underpin the modelling exercise:

1. Identification and characterisation of modern spatial information technologies by economic sector − in some instances assisted by in-depth case studies – and a review of existing evidence on productivity growth in each sector.
2. Probing of specific applications and possible impacts in clearly identified areas. This step included literature surveys and discussions with various stakeholders (including technology adopters) and

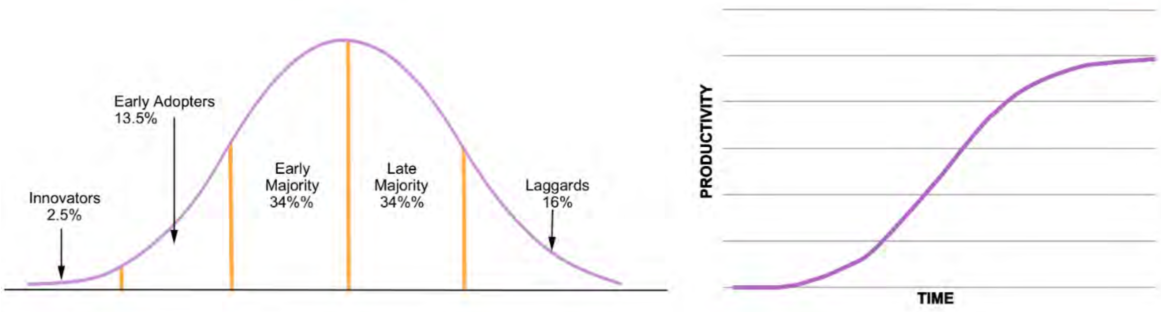
experts on the costs and benefits of adopting specific spatial information technology. The possible impacts included quantitative and qualitative impacts, but for the purpose of modelling only the quantifiable impacts were utilised. The discussions and analysis also took the 'counterfactual' scenario into account, i.e., what might have happened in the absence of the new technology.

3. Identification of current 'stage of adoption' following (Rojers, 1983) for each specific application in the sector it is used, as a proxy for the actual current rate of adoption. Where evidence on adoption patterns was available, this was preferred over the proxy.
4. Verification of these current adoption rates as being plausible or reasonable through discussions with experts and/or by drawing on existing literature.
5. Recognition of possible generic productivity impacts – the methodology applies industry concentration as a proxy to identify sectors in which generic impacts are likely to have been largest to date.

A.2 Rates of adoption of spatial information technology

The classic textbook on adoption by (Rojers, 1983) estimated the categories of adopters as being innovators (2.5 per cent), early adopters (13.5 per cent), early majority (34 per cent), late majority (34 per cent) and laggards (16 per cent). This is shown on the left of Figure A.2. When this is translated into a level of productivity for a given innovation, it appears as the "S" curve on the right of Figure A.2.

FIGURE A.2 ROGERS MODEL OF ADOPTION



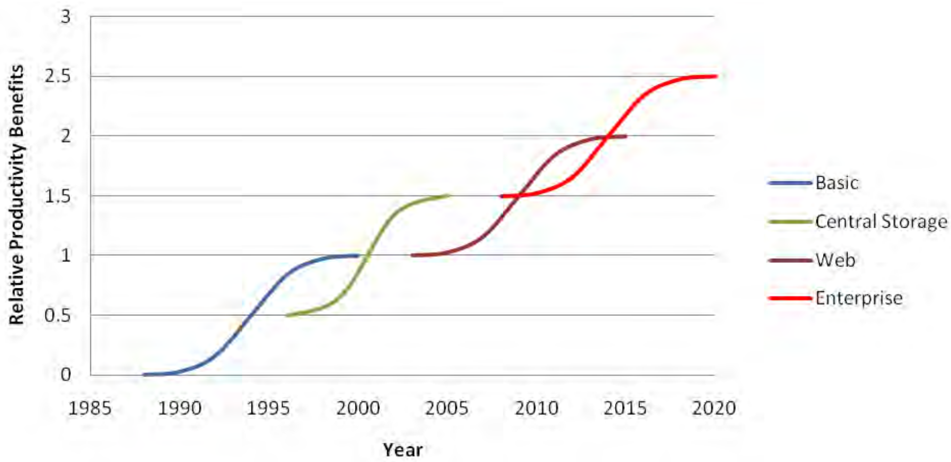
SOURCE: (ROJERS, 1983)

The uptake of spatial information technologies has been a series of adoption curves, as each innovation builds on the one before. For example, we found in a 2010 report for the UK's Local Government Association that waves of adoption had been the norm in the adoption of spatial information technologies. These waves are illustrated in Figure A.3 below.

An initial increase in productivity occurred in local government through the introduction of GIS into the engineering departments. This is the basic curve in the chart. Further productivity improvements arose when the GIS was stored centrally so that more than one department could draw on its contents. Subsequent productivity improvements occurred when the centrally stored GIS was made available on the web and then became integrated into enterprise systems. Each innovation wave built on earlier productivity gains delivering even higher productivity levels.

We observed a similar trend in many of the case studies examined for this report.

FIGURE A.3 RATES OF ADOPTION



SOURCE: (CONSULTINGWHERE AND ACIL ALLEN, 2011)

A.3 Economic impact

The economic impact is calculated by multiplying the productivity impact by the economic variable to which the productivity impact refers. For example, the economic impact of an increase in labour productivity is the product of the productivity impact and the cost of wages and salaries. Most of the productivity impacts in this report are labour productivity.

Multifactor productivity refers to total costs.

The overall impact in a sector is estimated by the economic impact multiplied by the level of adoption in that sector.

The economic impacts in this report are the direct first round effects. They do not take account of resource shifts in the economy as the changes in productivity in once sector work through the economy. For example, an improvement in productivity in a transport application will also increase the competitiveness of industries that use transport. Some industries will grow in response to lower transport costs while others may contract.

The overall impact for the economy of the state will depend on the nature of the interactions between sectors. Estimating the overall effects would require macro-economic modelling such as the use of a Computable General Equilibrium model. In our experience the multiplier effects of the linkages between sectors are always positive for the economy as a whole.

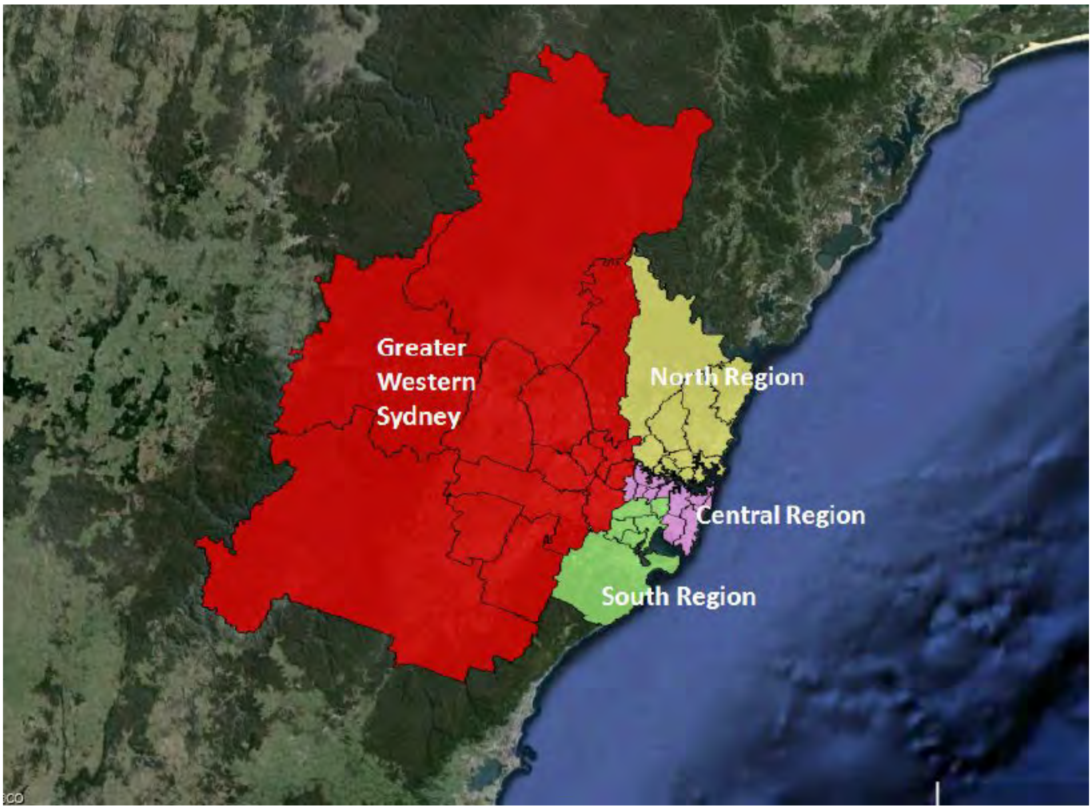
For the purposes of understanding the benefits of specific applications in the case studies, the direct effects are a good indication of their value.

B

SYDNEY METROPOLITAN REGION

The impact of spatial information technologies on local governments are considered in chapter 7. The impact of spatial information and Smart Cities techniques have been considered for local government in the Sydney metropolitan region. A map of the Sydney metropolitan region is shown in Figure B.1.

FIGURE B.1 SYDNEY METROPOLITAN REGION



SOURCE: (REGIONAL DEVELOPMENT AUSTRALIA, SYDNEY, 2015)

Value added by local governments in the Sydney metropolitan region was $2,672 million in 2014-15 based on the annual reports of the Local Government Authorities in the region.

C

CALCULATION OF ECONOMIC IMPACT – NSW VALUER GENERAL

The value of spatial information technologies to the NSW Valuer General is considered in section 2.2. Table C.1 provides details of the calculation of the savings to the NSW Valuer General by using spatial information technologies.

TABLE C.1 ESTIMATE OF SAVINGS TO VALUER GENERAL'S BUDGET

Item	Amount $'000
Base level budget	43,402
Staff costs	13,769
Valuation contracts	26,487
Total staff and valuation contracts	40,256
ICT operational	2,517
Proportion of spatial to ICT operational	10%
ICT operational budget attributable to spatial	252
Graphic services	1,347
Total ICT operational budget and graphic services attributable to spatial	1,599
Savings in staff and valuation contracts	15%
Value of savings	6,038
Less ICT operational budget and graphic services attributable to spatial	1,599
Net savings per annum	4,440

SOURCE: ACIL ALLEN

D CALCULATION OF ECONOMIC IMPACT – ENGINEERING SURVEYING

The value of spatial information technologies to the engineering survey sector is considered in chapter 3. Table D.1 provides details of the calculation of the economic impact of spatial information technologies on the engineering survey sector.

TABLE D.1 ECONOMIC IMPACT CALCULATIONS – ENGINEERING SURVEYING

Professional services		2017	2022
Value added	$ million	26,290	8,911
Labour	$ million	18,433	6,734
Gross operating surplus	$ million	6,863	1,871
Surveying			
Proportion of professional services		1.3%	
Engineering surveying			
Proportion of surveying		75%	
Proportion of professional services		0.975%	
Value added	$ million	256	256
Labour	$ million	180	180
Gross operating surplus	$ million	67	67
Adoption rates			
Low		25%	45%
High		35%	55%
Cost impact where applied – high		30%	50%
Productivity impact on engineering surveying			
Low		8%	23%
High		11%	28%
Cost impact			
Low	$ million	13	41
High	$ million	19	50

SOURCE: ACIL ALLEN

E

CALCULATION OF ECONOMIC IMPACT – FEDERATED 3D AND BIM MODELS

The value of federated 3D and BIM models to the engineering construction sector is considered in chapter 5. Table E.2 and Table E.3 provide details of the calculation of the economic impact of federated 3D and BIM models on the engineering construction sector for 2017-28 and 2029-40, respectively, with the results summarised in Table E.1.

TABLE E.1 PRESENT VALUE OF THE BENEFITS OF FEDERATED 3D AND BIM MODELS TO THE ENGINEERING CONSTRUCTION SECTOR

	Present value of the benefits		
Productivity gain	Over 23 years	Over 20 years	Over 15 years
	$ million	$ million	$ million
1%	1,406.0	874.0	266.0
3%	4,218.0	2,622.0	798.0
5%	7,030.0	4,370.0	1,330.0

Note: Cash flows are shown in Table E.2

SOURCE: ACIL ALLEN

TABLE E.2 CASH FLOWS FOR BENEFITS OF FEDERATED 3D AND BIM MODELS ON THE ENGINEERING CONSTRUCTION SECTOR, 2017–28

	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028
	$ m	$ m	$ m	$ m	$ m	$ m	$ m	$ m	$ m	$ m	$ m	$ m
Total engineering construction work completed	16,000	18,000	18,500	19,000	19,000	19,000	19,000	19,000	19,000	19,000	19,000	19,000
Adoption rate										10%	15%	20%
Benefit												
Productivity gain 1%	-	-	-	-	-	-	-	-	-	19	29	38
Productivity gain 3%	-	-	-	-	-	-	-	-	-	57	86	114
Productivity gain 5%	-	-	-	-	-	-	-	-	-	95	143	190

SOURCE: ACIL ALLEN

TABLE E.3 CASH FLOWS FOR BENEFITS OF FEDERATED 3D AND BIM MODELS ON THE ENGINEERING CONSTRUCTION SECTOR, 2029–40

	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040
	$ m	$ m	$ m	$ m	$ m	$ m	$ m	$ m	$ m	$ m	$ m	$ m
Total engineering construction work completed	19,000	19,000	19,000	19,000	19,000	19,000	19,000	19,000	19,000	19,000	19,000	19,000
Adoption rate	25%	30%	40%	50%	60%	70%	70%	70%	70%	70%	70%	70%
Benefit												
Productivity gain 1%	48	57	76	95	114	133	133	133	133	133	133	133
Productivity gain 3%	143	171	228	285	342	399	399	399	399	399	399	399
Productivity gain 5%	238	285	380	475	570	665	665	665	665	665	665	665

SOURCE: ACIL ALLEN

F

CALCULATION OF ECONOMIC IMPACT – ASSET MANAGEMENT

The value of spatial information technologies to asset management is considered in chapter 5. Table F.1 provides details of the calculation of the cost savings associated with spatial information technologies on the asset management function in the Department of Education, and Table F.2 provides details of the calculation of the cost savings associated of spatial information technologies on the asset management function in local government.

TABLE F.1 DEPARTMENT OF EDUCATION – ASSET MANAGEMENT SAVINGS ASSOCIATED WITH SPATIAL INFORMATION TECHNOLOGIES, 2017

Item	Savings $000
Savings from the Asset Management System	
Asset management	8,925
Building code compliance	1,964
Maintenance	1,785
Cleaning	140
Demountable transport and siting	456
Administration and productivity	405
Planning, review and queries	116
Transport claims	69
Briefings	46
Data reporting	39
System operating costs	30
Valuations	10,000
Total savings	23,975
Annual costs	800,000
Spatial component of annual costs	17,981
Productivity improvements	
Asset management function	2.25%
Over whole department	0.15%

SOURCE: ACIL ALLEN

TABLE F.2 DEPARTMENT OF EDUCATION – ASSET MANAGEMENT SAVINGS ASSOCIATED WITH SPATIAL INFORMATION TECHNOLOGIES, 2017 AND 2022

			2017	2022
Value of infrastructure				
	Roads	$ million	45,400	45,400
	Water Supply	$ million	7,900	7,900
	Sewers	$ million	8,400	8,400
	Stormwater	$ million	9,400	9,400
	Buildings	$ million	8,300	8,300
	Other structures	$ million	1,600	1,600
Total value of infrastructure		$ million	81,000	81,000
Operating and maintenance				
	Proportion of written down capital value		3%	3%
Operating and maintenance – total		$ million	2,430	2,430
Proportion with GIS asset management systems			25%	40%
Operating and maintenance – GIS asset management systems			607.5	972.0
Savings	5% less 0.5% for GIS costs		4.5%	4.5%
Value of savings		$ million	27.34	43.74

SOURCE: ACIL ALLEN CONSULTING

G

CALCULATION OF ECONOMIC IMPACT – APPLICATION OF BIM MODELS FOR ASSET MANAGEMENT

The value of BIM models for asset management of non-residential buildings in the long term is considered in section 5.4. The calculation of the benefits from the application of BIM models for asset management of non-residential buildings is provided in Table G.1 and Table G.2, for 2017-25 and 2026-36, respectively.

It is assumed that all buildings from 2017 are using BIM models for design and construction. However it is assumed that the use of BIM models for asset management is not implemented until after 2025, after development of more coordinated registries of buildings are established and the asset management systems are applied to these buildings.

The rate of adoption is assumed to commence in 2036 at 10 per cent, rising gradually to 70 per cent by 2032 after which time the rate of adoption remains constant.

TABLE G.1 BENEFITS FROM THE APPLICATION OF BIM MODELS FOR MANAGING NON-RESIDENTIAL BUILDINGS, 2017–25

	Unit	Total	2017	2018	2019	2020	2021	2022	2023	2024	2025
Value of total non-residential construction	2016-17 $ million		10,000	10,100	10,201	10,303	10,406	10,510	10,615	10,721	10,829
Estimated operating costs	2016-17 $ million		300	303	306	309	312	315	318	322	325
Cumulative estimated operating costs			300	603	909	1,218	1,530	1,846	2,164	2,486	2,811
Rate of adoption											
Savings from BIM models											
NPV over 20 years	2016-17 $ million	172									
	2016-17 $ million	343									

SOURCE: ACIL ALLEN

TABLE G.2 BENEFITS FROM THE APPLICATION OF BIM MODELS FOR MANAGING NON-RESIDENTIAL BUILDINGS, 2026–36

	Unit	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036
Value of total non-residential construction	2016-17 $ million	10,937	11,046	11,157	11,268	11,381	11,495	11,610	11,726	11,843	11,961	12,081
Estimated operating costs	2016-17 $ million	328	331	335	338	341	345	348	352	355	359	362
Cumulative estimated operating costs		3,139	3,470	3,805	4,143	4,484	4,829	5,177	5,529	5,884	6,243	6,606
Rate of adoption		10%	15%	25%	35%	45%	60%	70%	70%	70%	70%	70%
Savings from BIM models												
NPV over 20 years	2016-17 $ million	3.14	5.21	9.51	14.50	20.18	28.97	36.24	38.70	41.19	43.70	46.24
	2016-17 $ million	6.28	10.41	19.02	29.00	40.36	57.95	72.48	77.41	82.38	87.41	92.48

SOURCE: ACIL ALLEN

H

CALCULATION OF ECONOMIC IMPACT – ELECTRICITY

The value of spatial information technologies to the electricity sector is considered in chapter 6. Table H.1 provides details of the calculation of the economic impact of spatial information technologies on the electricity sector, with the estimates of productivity improvement to labour costs applied to electricity transmission and distribution only.

TABLE H.1 PRODUCTIVITY SAVINGS FROM SPATIAL INFORMATION TECHNOLOGY, ELECTRICITY SECTOR

		Transgrid	Ausgrid	Endeavour Energy	Essential Energy	Total
Revenue	$ million	887	2,628	1,478	1,552	6,545
Labour costs	$ million	148	490	258	384	1,279
Profit before tax	$ million	292	193	213	- 8	690
Value added	$ million	440	683	471	376	1,969
Total value added for sector in NSW						5,555
Economic benefit						
3% of labour costs	$ million					38.38
5% of labour costs	$ million					63.97
Proportion of value added						
3% of labour costs						0.7%
5% of labour costs						1.2%

SOURCE: ACIL ALLEN, ANNUAL REPORTS

I

CALCULATION OF ECONOMIC IMPACT – GAS

Calculation of economic impact – Gas

The value of spatial information technologies to the gas sector is considered in chapter 6. Table I.1 provides details of the calculation of the economic impact of spatial information technologies on the gas sector. These calculations are based on information published by the Australian Energy Regulator on regulated gas distribution pipelines. There is no data in the public domain on the revenues and costs for gas transmission pipelines.

TABLE I.1 PRODUCTIVITY SAVINGS FROM SPATIAL INFORMATION TECHNOLOGY, GAS DISTRIBUTION SECTOR

	Jemena	ACTEW / AGL	AGN	Total
	$ million	$ million	$ million	$ million
Revenue 2016 (a)	411	62.2	10.4	483.6
Salaries and wages	75.91	11.5	1.92	89.3
Estimated cost savings				
3% of labour costs				2.68
5% of labour costs				4.47

Estimate based on AER State of the Energy Market 2014 and 2015

Note: Salaries and wages cost estimated at 19 per cent of total revenue based on Jemena annual report.

SOURCE: ACIL ALLEN, JEMENA ANNUAL REPORTS, AER STATE OF THE ENERGY MARKET 2014 AND 2015

CALCULATION OF ECONOMIC IMPACT – EMERGENCY SERVICE

J

The value of spatial information technologies to the emergency services and insurance industry is considered in chapter 8. It was not possible to exhibit detailed data on the insurance industry owing to commercial in confidence considerations.

Table J.1 provides details of the calculation of the economic impact of spatial information technologies on the State Emergency Services. Stakeholder consultations suggested that the SES had operating cost savings in the order of 80 per cent of total operating costs, which were attributable to spatial information technologies, over the last ten years. This is equivalent to around $4.1 million per year. Annual set up and training costs have been estimated to be around $1 million per year over this period.

The SES estimated that productivity would increase by 50 per cent which increases scope for use of public information products and for further benefits from open data.

TABLE J.1 ESTIMATED COST SAVINGS FROM USING SPATIAL INFORMATION BY THE SES

Annual expenses		2017	2022
Annual expenses			
Employees	$ million	37.1	37.1
Other operating expenditure	$ million	39.5	40.5
Total	**$ million**	76.6	77.6
Value of savings	$ million	3.6	5.43
Costs associated with spatial information	$ million	1.0	0.2
Net benefit	$ million	2.62	5.23
Percentage of operating costs		4%	3%

SOURCE: ACIL ALLEN, SES NSW ANNUAL REPORTS

CALCULATION OF ECONOMIC IMPACT – LOGISTICS

K

The value of spatial information technologies to the logistics sector is considered in chapter 11.

There is no industry classification in the ABS series that accurately captures the logistics sector. Division I of the ASIC codes covers the transport sector including logistics. However it underestimates the size of the logistics sector because many logistics functions are embedded in other organisations operations.

For this study ACIL Allen, focussed on the top three logistics companies in the road transport sector. These companies are Toll Holdings Pty Limited, Linfox Pty Limited and K&S Corporation and between them hold a market share of 16 per cent. From our consultations with stakeholders, it is understood that these companies are early adopters of IT and spatial solutions to improve productivity and compete in the logistics and transport sectors.

The general structure of the revenues and costs of these companies are summarised in Table K.1.

TABLE K.1 REVENUES AND COSTS OF THE TOP THREE COMPANIES IN THE TRANSPORT AND LOGISTICS SECTOR

		Total revenues	Total costs	Costs for NSW
Toll	$ million	3,984	2,988	873
Linfox	$ million	1,992	1,494	437
K&S Logistics	$ million	457	342	100
Total	**$ million**	**6,433**	**4,824**	**1,410**

SOURCE: IBIS REPORTS, ANNUAL REPORT OF K&S CORPORATION

The costs for NSW were estimated on the basis of the ratio between industry costs for NSW and industry costs for Australia from the ABS input output tables. This ratio was found to be 20 per cent.

Productivity and impacts were estimated from consultations with selected industry stakeholders. They were adjusted for our understanding of likely costs of implantation of spatial information systems within the overall context of IT budgets. They were also adjusted for the proportion of logistics activities to total activities of the organisations based on consultations with stakeholders.

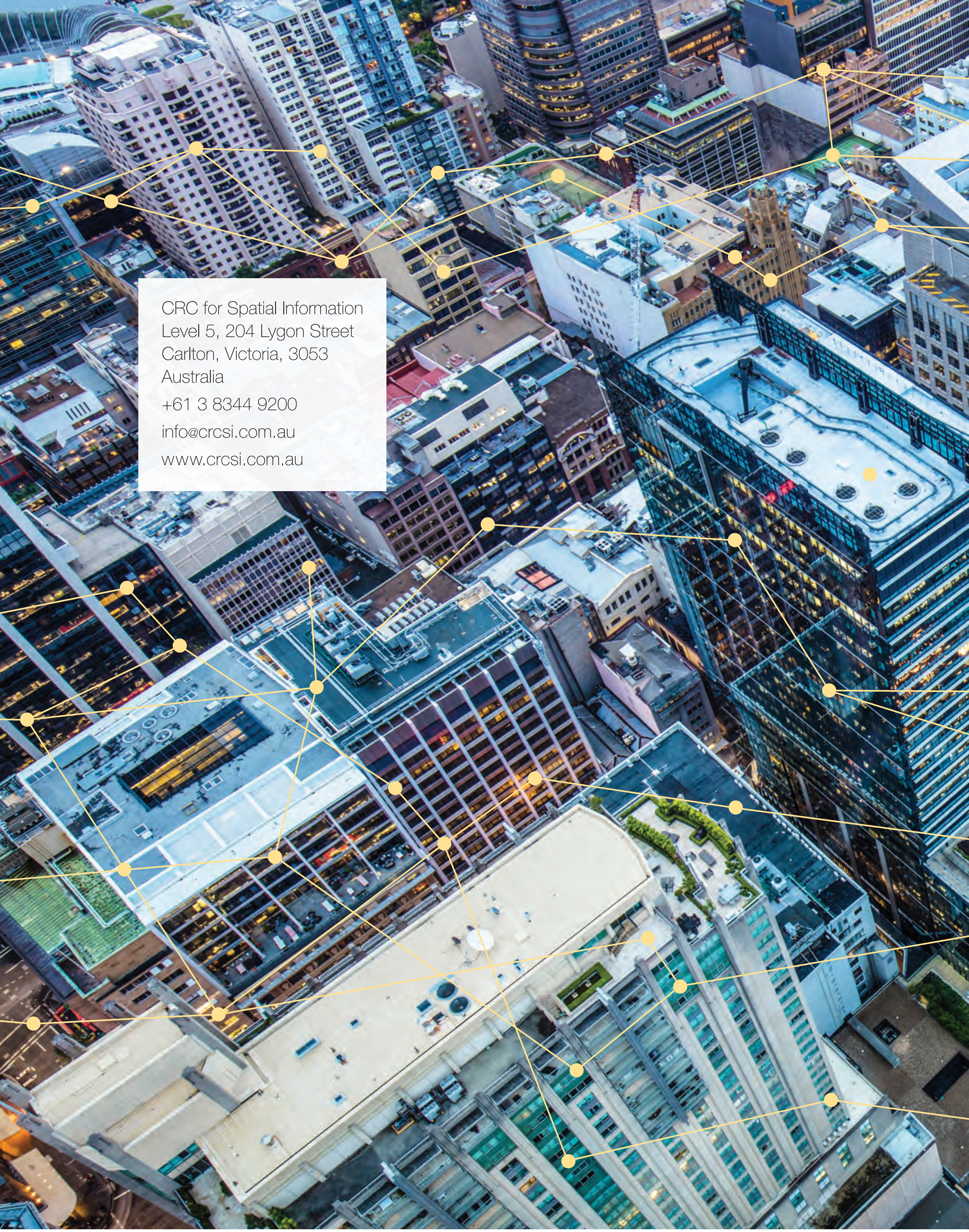
The findings are summarised in Table K.2.

TABLE K.2 ESTIMATED PRODUCTIVITY IMPACTS AND COSTS SAVINGS ASSOCIATED WITH SPATIAL INFORMATION TECHNOLOGIES, LOGISTICS SECTOR

		2017	2022
Productivity improvement – logistics operations		15%	20%
Productivity improvement for organisation		8%	10%
Operating costs for top 3 companies (16% of market share)	$ million	1,410	1,410
Savings attributable to spatial information services	$ million	106	141

Note: Productivity and impacts were estimated from consultations with selected industry stakeholders. They were adjusted for our understanding of likely costs of implantation of spatial information systems within the overall context of IT budgets. They were also adjusted for the proportion of logistics activities to total activities of the organisations based on consultations with stakeholders.

SOURCE: ACIL ALLEN, IBIS REPORTS, ANNUAL REPORTS, CONSULTATIONS



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