SOLGM

ALGIM

Technologies for the 21st Century

Fit for the digital future

The influence of new information and digital technologies on the local government sector

leadinglearninglinking

ABOUT SOLGM

The Society of Local Government Managers (SOLGM) is the professional organisation for local government management in New Zealand. Its vision is

> *"professional local government managers, leading skilled staff, enabling communities to shape their future".*

SOLGM supports and represents its members, local government managers and staff through professional development and networking opportunities, membership support services, good practice resources and advocacy work.

SOLGM helps local authorities achieve their goals by providing them with practical resources, and advocate on the sector's behalf on the issues that impact on local government management.

ABOUT ALGIM

The Association of Local Government Information Management (ALGIM) represents the national and international interests of the information, communication and technology (ICT) sector within New Zealand's city, district and regional councils.

ALGIM's vision is

> *"to shape a world-class ICT local government sector".*

This will be accomplished by 'building tomorrow's ICT foundations today' ALGIM will achieve this by building a strong foundation around four key pillars:
- professional development and education
- networking and collaboration
- information provision and research
- leadership.

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FOREWORD

The evolution of information and communications technology is changing the way people live their lives and provides new opportunities for local government to improve the delivery of local services and the way we govern our communities.

Technology companies launch new products every day. The likely implications of a new launch may not always be apparent and the pace of change can be bewildering. The technologies discussed are in some cases evolving and are additive in their effect, still others are disruptive and change the way society operates. These technologies form a continuum from those that enhance the way the sector goes about its business, by increasing efficiencies and reducing costs to those that may completely change the way a service is provided.

As prudent and responsible managers of public resources, we must understand the likely, plausible and possible implications of new information and electronic technologies to the needs of the community, and to the role and operations of the local government sector.

This joint report between our two organisations identifies advances in information technology and demonstrates their relevance for our 78 local authorities. It intends to provide thought leadership, and to that extent is an example of the change in strategic direction to which SOLGM members have agreed.

This is not a document for the 'techies'. The report has been written to help non-expert local government managers understand the opportunities and implications of the most relevant advances in information technology today and into the future.

The report focuses on 10 evolving and emerging technologies. These are treated in a logical progression from the unconnected elements, that include mobile communication and 3D printing, to electric vehicles. The opportunities that connectivity brings are also explored with the Internet of Things, big data analytics and cloud computing.

Each chapter provides just enough of an introduction to allow management and leadership teams to understand the principles and potential of each technology. This is followed by a section on the opportunities for the sector that each technology offers. The impacts and implications of each technology are explored to round out the understanding and sector relevance.

Each chapter then has a section on potential implementation strategies, and if the technology is deemed relevant, this is supported by case studies and contact details of those involved. All the way through, the report liberally provides links and references to additional resource material to help understand the technologies, and the opportunities and implications of uptake.

Issues relating to security of data/information, privacy, transparency and savings, – common to the majority of the technologies – and transitional issues such as legal, resourcing and risks associated with adoption are addressed in the final section to avoid duplication.

Our thanks to the working party of Blair Dickie (SOLGM – Waikato Regional Council), Mike Manson (ALGIM), Stephanie Rose (SOLGM – Wanganui District Council), Gillian Payne (SOLGM – Western Bay of Plenty District Council), Marion Dowd (ALGIM – Western Bay of Plenty District Council), Jason Dawson (ALGIM – Hamilton City Council) and Billy Michels (ALGIM – Waikato Regional Council).

We commend this joint report from SOLGM and ALGIM to you as a resource to help you and your organisation come to grips with the coming revolution.

Barbara McKerrow
President, SOLGM

Mike Foley
President, ALGIM

EXECUTIVE SUMMARY

Technological change is a fact of life

This report considers the impact that 10 potentially disruptive emergent technologies will have for local authorities in the future. They are:

- unmanned vehicles
- 3D printing
- mobile devices
- wearable technology
- augmented reality
- electric vehicles
- renewable energy and distributed generation
- the Internet of Things
- big data
- cloud computing.

Technological change is a constant feature of life these days. And the rate of technological change is increasing. In just the past two days human beings have created more data than existed from the beginning of time to the end of 2003.

Local authority adoption is about improving services

Local authorities should never adopt new technology for its own sake. The aim should be to improve local service delivery, whether by changing the way people use or experience the service, or by making the service cheaper. A case built on these foundations stands a much better chance of success.

Local authorities should look to adopt new technology when the risks are obvious, mitigation strategies are known, some staff will be using the technology and have ideas about its use, and the market price has fallen. Local authorities won't generally be pioneers of new technology per se; their role will generally be to use an emerging technology to improve a service.

To demonstrate this point, each of the chapters in this report have been laced with examples of local or central government agencies that have adopted the technology for use. Most, but not all, are from New Zealand.

Unmanned vehicles

This report considers two types of unmanned vehicle. Unmanned aerial vehicles (UAVs), commonly known as drones, are powered, aerial vehicles that do not carry a human operator, use aerodynamic forces to provide vehicle lift, can fly autonomously or be piloted remotely, and can be expendable or recoverable. So-called driverless vehicles are motor vehicles that use artificial intelligence, sensors and global positioning system coordinates to drive themselves without the active intervention of a human operator.

UAVs have the potential for wide application in the sector. They could be used literally anywhere that aerial photography (either still or moving) could be applied. This includes functions such as emergency management (in particular search and rescue), environmental monitoring and regulation (e.g. detecting breaches of air quality regulations), security monitoring and infrastructure assessments.

The very qualities of UAVs are such that they will also trigger privacy concerns in the near future. Discussions are also under way about security and safety (e.g. what happens if a UAV crashes during a sports event). The sector may need to develop a code of good practice for the use of UAVS, either on its own or with others.

By contrast, the opportunities with driverless vehicles tend to lie in the area of cost savings, at least initially. The driverless vehicle has the potential to reduce fleet and insurance costs. Beyond this, these vehicles could allow the public to buy a unit of transport rather than own an automobile. This could reduce the need for transport investment as a customer could use a vehicle in much the same way as a taxi, and it would then go on to the next user.

3D printing

3D printing creates a physical object from a three-dimensional model, typically by laying down small layers on composite or other material until the object is complete. Simple versions of this technology are already in retail outlets.

Local government does not generally produce a huge number of physical objects. Our main direct benefit from 3D printing would be to reduce our inventory of consumables.

The impact of this technology is of a second order nature and far wider in scale.
There are examples of 3D printing being used to produce simple housing overseas . The implications for a country concerned about housing affordability are self-evident. There are no transport costs with 3D printing meaning no need for mass co-location of industry. Smaller scale “industrial park” developments could become the norm, as well as making real change to patterns of road use.

3D printing will also have regulatory implications. The physical acquisition of an object can be left until the point at which it is ‘needed’, making the detection of ‘unlawful’ objects that much harder. Also, 3D printing of housing or assets such as pipes raises an issue about the nature of inspection functions – to what extent should an inspection focus on the ‘programme’ or the physical asset.

Mobile devices

Mobile devices are computers designed for transportation while in use, enabling use in a variety of locations (the smartphone is the textbook example). At the end of 2014 about 7.4 billion mobile devices were being used worldwide.

Of course, mobile technology is far from new. It is the development in processing power that is the new element of mobile technology.

Mobile computing makes accessing online council services and working from anywhere a viable proposition – as long as the communication network coverage is available. The ability to access council data as and where needed greatly improves its usefulness to the end user. Many of the applications of mobile technology rely in some way on this feature.

Some local authorities already use mobile technology as a means of detecting service issues. For example, the Fix My Street application is a volunteer smartphone application that enables real time reporting of problems and other requests. People take a photo, describe the problem and identify the location, and the application sends an email to the council concerned. This goes both ways – various Civil Defence groups have text alert services for emergency updates.

Mobile technology therefore relies on continuity of service, especially where the online service is a more complex transaction such as lodging an application for a permit. This also goes hand-in-hand with the so-called digital divide – the limits of slow broadband speeds on some customers' ability to access services.

The Privacy Commissioner has expressed concerns about the implications that the combination of mobile technology and sensors have for personal privacy. By their nature mobile devices are also difficult to secure.

Wearable technology

Wearable technology refers to computing devices that are worn on the body or incorporated into it. This includes various types of biometric chip, devices such as Google-glasses that provide hands-free connectivity, and devices that extend physical capabilities such as exoskeletons.

Wearable technology can help regulatory enforcement in several ways. Hands-free technology can gather evidential recordings, and enhance physical safety for occupations such as parking wardens. A wearable item might enable access to records 'in the field'. Wearables might also be used to track harmful substances in the environment, and in conjunction with mobile technology, be used to warn of areas to avoid.

In addition, wearables would enable applications built using augmented reality (AR) platforms.

Wearables are subject to many of the same privacy issues as other technologies in this report. Additionally, wearables raise intellectual property issues; who owns data that streams in from your body, especially where those devices are connecting to sensors via the Internet of Things? Unlike many other applications, wearables have the potential to distract from face-to-face interaction or distort non-verbal communication.

Augmented reality

AR applications would be particularly useful in land use and transport planning. Overlaying the digital and real worlds can produce a realistic impression of a proposed development, policy or plan. For example, Christchurch City has used AR technology and a mobile application to provide those interested in the Central City Development Plan with a visual representation of what the real city will look like.

AR's other primary use is to support education and training programmes. Simple forms of AR are already used in museums.

Asset management could also make productive use of AR applications to locate underground assets. Wellington City has adapted a commercial product (Augview) to present its networks and those of the utility providers, with special emphasis on those deemed a safety risk.

Electric vehicles

An electric vehicle is a vehicle that depends wholly or partly on electrical energy for motive power as opposed to internal combustion. A wide range of technologies fall into this category. While not an emergent technology in and of itself, advances in battery technology are making electric vehicles a more economic and more available alternative.

The obvious opportunities for adoption of electric vehicle technology lie in reducing the use of fossil fuels. The consequences include reducing transport-generated emissions and other by-products from the internal combustion engine. Mass adoption of electric vehicles would be a

significant step towards New Zealand meeting greenhouse gas targets. In a similar vein, there are balance of payments and strategic consequences in New Zealand reducing reliance of fossil fuels sources from overseas.

Central government supports a greater take-up of electric vehicles. Strategies to encourage the adoption of electric vehicles are generally about providing economic incentives such as parking fee exemptions, exemptions from road user charges and the like (this one already exists in New Zealand). Non-economic incentives might also be pursued, such as preferential parking in favoured locations and access to High Occupancy Vehicle lanes. In the medium term, councils may be asked to invest in facilities that support electric vehicles, such as charging stations.

Renewable electricity and distributed generation

In the context used in this report, renewable energy is the production of energy using a source in such a way that the source is not destroyed in the process (such as hydroelectricity), or where the source can be replaced (such as biomass). New Zealand already has a high level of renewable energy use – with about 70 percent of our electricity coming from hydroelectric and geothermal sources.

Other options for renewable energy are emerging, including marine-based generation and biomass. At this time it appears only a few sites are suitable for marine generation, and the main sources for biomass are in the same areas as geothermal energy.

Distributed generation is a complementary and emergent technology. Distributed generation (also sometimes called microgrids) is the generation of electrical energy at the point of consumption. Advances in battery technology make the large-scale storage of energy feasible and take some of the variability out of some renewable sources such as solar and wind. In effect the so-called national grid could become a resource akin to the internet where users "download" energy as and when needed.

Taken together, renewable energy and distributed generation/storage could further reduce New Zealand's reliance on fossil fuels as an energy source. Distributed generation has the potential to smooth out some of the peaks in electricity demand, improve energy security and place downward pressure on costs. Some local authorities have already invested in facilities to generate part of their electricity needs 'onsite'.

Local authorities can promote the uptake of renewable energy through regulatory means (such as adopting planning rules that preserve access to sunlight) and through successful trialling and uptake themselves.

Internet of Things (IoT)

The IoT is a network of physical objects that measure either the object's internal state or some factor in the external environment. The objects are equipped with transmission technology and connected to a monitoring agency via the internet. The IoT is already a pervasive feature of life, and will become more so.

IoT applications can deliver 'real time' data continuously with much lower reliance on site visits. IoT applications can be used literally anywhere that relies on the monitoring of data. For example, IoT-connected sensors might easily be used to monitor the condition of an underground asset, or replace water meters as a demand management tool. Overseas jurisdictions are dabbling with the so-called 'crowd sourcing' of environmental monitoring and as a tool for better energy management.

The IoT is often closely linked to 'big data'. The sheer volume of data generated can, if mined properly, gain far deeper and richer insights into the state of the environment, or the way people use a service. But IoT applications also enable the collation of a vast array of data about individuals. Applications such as facial recognition are no longer the stuff of science fiction. It is this technology (in conjunction with mobile devices) of all of those surveyed that will attract public concern for privacy, especially as much of the monitoring will be passive. The sheer volume of IoT connected devices also multiplies the security risks.

Big data

Big data is an implication of the technologies described elsewhere in this report. Big data has three key characteristics – volume (every day 2.5 exabytes of data are created worldwide), velocity and variety. The potential of big data lies in its aggregation and analysis. For example, consider the analytical power of linking LINZ data, the Census and your own Rating Information Database together.

Big data is a powerful tool for discovering correlations between variables. However, the characteristics of big data are such that extracting meaning from big datasets requires both specialised analytical tools and a meld of personal skills that is not readily available. Sectoral use of big data analysis will require some workforce planning and seeding of capability.

Big data applications will be useful with any activity that depends on the IoT. This includes environmental monitoring, asset management and capturing demand and use information. Big data analytics are also a tool for forecasting and predicting non-lineal systems – applications overseas cover everything from the accumulation of gravel in a riverbed to ripple effects in urban development.

The linking of data and availability of so much unit record data do not sit well with the principles of the Privacy Act, especially though not exclusively, those relating to use of data for anything other than collection.

Big data comes with temptations to predict action based on propensity. This has some benefits – for example a local authority might note an application for a particular nature of consent and use that to predict a future application elsewhere. But it comes with ethical risks; to what extent are we liable to condition our response based on a statistical relationship as opposed to an individual's action?

Cloud computing

Many readers will be familiar with cloud computing in concept. Those who are using programmes such as Office 365 will be using one variant of cloud technology known as software as a service.

Cloud computing solutions will benefit any programme or activity that depends on scale, access to specialist computing software or resources, or access/sharing across multiple sites. The sheer volumes and complexity of data created from IoT-generated monitoring may only be stored and processed on cloud solutions.

Knowledge of 'the cloud' is already widespread. It will drive a customer expectation that all services will (or should) be available online, and available continuously and cheaply.

There are very few standards for the delivery of cloud services. For example, not all cloud services are interoperable. Caution in the selection of a provider is recommended.

The physical location of a cloud provider can have serious consequences. If your provider is located overseas your data will be subject to the laws of that country (as well as New Zealand). We are aware that work on a bilateral agreement with Australia is advancing. In other cases the sector should consider advocating for a 'safe harbour' policy for all data.

So where to next?

The applications we describe in this report are not flights of fantasy, they are based on actual use. These technologies have arrived in New Zealand. Each has the potential to improve the delivery of local services or has a second order impact on the community. While we do not recommend adoption for adoption's sake, ignoring the opportunities (and impact) they have is not tenable long-term.

The most immediate issue for the sector is the existence of the so-called digital divide. Failure to address the differential in internet access means some parts of our communities will not receive the same services. The sector must reach a coherent position to support the rollout of UFB and Wi-Fi. As a sector we also need to explore common approaches to providing access in council facilities such as libraries and service centres.

The sector should walk the talk on data privacy. The Privacy Act and other legislation governing public registers must be reviewed for consistency, and to determine whether the legislation is 'fit for purpose' in an age when so much data is generated passively. Whatever the legislative framework, the sector must commit to ensuring all staff are aware of the rights of those supplying information, and that this is periodically 'refreshed'. In addition, non-compliance issues, whether accidental or otherwise, must be treated seriously.

The other issue of concern to the public is data security. We know that no internet connected device can ever be 100 percent secure, and that the nature of security threats evolves over time. The sector needs to develop common practice for modelling security threats, and set protocols to share information around security and security-related concerns, both within the sector and (judiciously) with government agencies overseas.

Cloud computing applications will become more prevalent. Software as a service and infrastructure as a service have great potential. But data sovereignty should give local authorities pause – rights to access and use our data might be more open than we think. New Zealand is negotiating a common approach with Australia, but we need to encourage central government to do more. The safe harbour approach taken in the European Community offers one practical way forward.

Resourcing the adaptation of new technology requires careful consideration.
The sector needs to develop a workforce strategy to attract a steady flow of younger people and others who are technologically savvy. Some skills, such as data science, may require 'growing from within'. The sector might also consider joint procurement approaches to acquiring some resources such as a local government cloud.

Part of the sector acknowledging the digital future is that we need to find more and better ways of sharing these technologies and their potential. This report is a start.
SOLGM and ALGIM both consider that this should not be seen as the sole preserve of IT management. The success stories should be identified and celebrated much more widely.

Adaptation of new technology does not happen for its own sake. We must avoid the perception of 'toys for the staff'. Adaptation is, or should be, developed out of a business case that has improvements in the delivery of local services at heart. Good news stories from the public-facing functions are critical to gaining public acceptance of new technology.

Finally, adapting technologies is not a 'one-shot' deal. The sector, and individual local authorities, should continually test its service delivery against current and potential new technologies, and close proximities of those. For example, big datasets provide the first steps in developing true artificial intelligence.

The potential for successful adaptation is limited only by the bounds of the imagination.

1 INTRODUCTION

"It would appear that we have reached the limits of what is possible with computer technology, although one should be careful with such statements, as they tend to sound pretty silly in five years."

John van Neumann (American mathematician)

This report discusses the implications of 10 emerging technologies for local authorities now and in the future. This report is focused on the practical rather than speculative science fiction. Each of the technologies discussed here is either commercially available now, or will be in the medium term.

New Zealand has been described as a 'technophile' country, which in combination with the small population and geographic isolation makes us an ideal place to test new technologies.[1] For example, at the time of writing Microsoft is 'Kiwi-testing' Sway – an application for creating websites. We can expect emergent technology to reach us quicker in future.

In some cases these technologies will enhance the capability of local authorities to deliver our activities. For example, the introduction of wearable technology is likely to enhance regulatory capability by supporting the safety of occupational groups such as parking wardens, and enable more accurate collection of evidence. In a similar vein, the proliferation of sensor technology and its connection through the Internet of Things (IoT) might make user charging (and true marginal cost pricing) feasible.

In other cases the technology might be what is sometimes called a disruptive innovation or disruptive technology, where the new technology either displaces an existing technology or creates an entirely new industry. One often cited example is the creation of email, which has largely displaced letter-writing as a means of communication, with dramatic consequences for the postal service and greeting card industries. By way of a more current, and local government-specific example, this report will argue that the introduction of 3D printing technology will reduce reliance on traditional mass-produced manufactures and reduce the need for co-location of industry, with consequences for urban form.

Each of the subsequent chapters of this report discusses a separate technology focusing on the following key questions:

- what is the technology and how does it work?
- what opportunities does the technology create for the sector?
- how does this change what our customers might expect from us?
- what are the implications and effects of the technology?
- what is the sector's likely implementation path for the technology?
- how is the technology being used by government agencies here or overseas?

Many, though not all of these technologies, raise common questions around privacy, security and skill acquisition. Chapter 12 discusses these issues, together with the wider issues of resourcing and the adoption decision.

To date, sector adoption of these technologies has been very focused on adoption of piecemeal, incremental gains that don't concern the public much. A concluding chapter is designed to position the sector to adapt to emergent technology.

1 *Economist Magazine*, "Kiwis as Guinea Pigs", 23 May 2015 edition p45.

This chapter considers what the sector might need to make the most of the opportunities that emergent technology creates. In particular, this section focuses on developing the supporting infrastructure, legislative and policy change, workforce planning and procurement as the way forward.

1.1 The rate of change

> *"The technology that both brings us all closer together, yet separates us even from those sitting next to us allows a web of activity to be woven."*
>
> MG Taylor Corporation

The local government sector is well versed in predicting change. Rarely a month goes by without some change in our operating environment. Often it is not the fact of change, but the pace of change that we underestimate. To give some examples of the pace of change, 10 years ago:

- Helen Clark was NZ Prime Minister, Don Brash was the National Party leader and Tariana Turia had just formed the NZ Maori party following the Foreshore and Seabed issue
- George W Bush was re-elected as US President
- the first privately funded space flight occurred
- Facebook had just launched in February 2004 and there were barely a million users worldwide
- the web 2.0 had just been released
- Google had just launched Gmail
- YouTube had yet to go live
- there was no Instagram, Twitter, Pinterest or LinkedIn
- USB flash drives had yet to replace floppy discs, and
- iPhones were still three years away.

Another signal of technological change is from the changing face of employment. The following list compiled by LinkedIn shows the top 10 trending job titles that didn't exist five years ago. They are from a sample size of 259 million members:

1. iOS developer
2. Android developer
3. Zumba instructor
4. Social media intern
5. Data scientist
6. UI/UX designer
7. Big data architect – (fastest growing title)
8. Beachbody coach
9. Cloud services specialist, and
10. Digital marketing specialist.

Eight of the 10 emerging job titles have direct links to new information technology. It is not just the changes per se that are interesting, but also the implications of such change – arguably with less opportunity in the past to constantly update our status or bombard our friends with photos of our kids, our pets, or that fancy meal we just ate. We were less self absorbed.

Historically the rate of change has increased as, for example, the number of transistors on a single chip increased exponentially, begetting microprocessors, sensor technology and the Internet of Things. It is an open question whether the pace of change in technology will continue unabated. Some futurists hypothesise that the pace of technological change will 'flatten' somewhat. Others such as Kurzweil argue that the nature of technological change is such that when a technological

barrier is approached, the technology is created that enables humankind to cross that barrier.[2] Regardless, the rate of change for society to adopt new technologies and its implications will probably exceed the local government sector's ability to respond appropriately. There is a lead time in developing policies and instituting practice changes to enable the best use of new technology, when in some cases the technology itself may advance at a rate that exceeds this capacity. In the last chapter of this report we look at some of the institutional and regulatory changes that might enable local authorities to respond better.

How is technological change introduced into society? Rogers suggests that there is a life cycle approach to adoption of new technology. That is to say an emergent technology is initially developed and adopted by a few (typically educated, prosperous and less risk averse); followed by a generally younger, prosperous, less risk-averse set of early adopters; then the majority.[3] Later adopters tend to be more conservative and generally older.

We suggest that this model is not dissimilar to the manner in which local authorities adopt new technologies. The chapters that follow each highlight one or more local authorities which have provided an early example, or examples, of adoption and use of a new technology in their day-to-day business.

The cycle has been further developed by MG Taylor Corporation.[4] The widespread adoption of the new and emerging technologies introduced in this report will challenge local government into the future, including the ability: to anticipate and track internal and external changes to respond quickly and appropriately to new conditions, and thus "turn turbulence into opportunity" to readily reconfigure internal operations to meet changing demands to align members of an organisation to address new challenges to design new processes and develop the conditions to support high-performance to master complexity, and continually be able to discern the critical events and trends in an era of information overload for each individual to see the whole as well as the parts, and to apply a systems perspective to their work.

1.2 The 10 technologies

We have identified 10 emergent technologies for consideration in this report. These are:

- *unmanned vehicles* – vehicles that operate autonomously from human control. In this report we discuss two such applications, unmanned aerial vehicles (or drones) and driverless vehicles
- *3D printing* – the creation of a physical object from a three dimensional model, typically by laying down small layers of composite until the physical object is complete
- *mobile devices* – computers designed for transportation while in use, enabling use in a variety of locations
- *wearable technology* – computing devices worn on the body or incorporated into it
- *augmented reality* – the overlay of computer generated sensory input (such as graphics) over a live direct or indirect view of the physical world
- *electric vehicles* -– vehicles that wholly or partly depend on electrical energy for motive power as opposed to internal combustion. While not an emergent technology in and of itself, advances in battery technology are making electric vehicles a more economic and more available alternative
- *renewable electricity and distributed generation* – renewable energy is the generation of energy from sources that are not 'used' up in the conversion to electric energy, or are replaceable. Examples include solar, wind, and geothermal

2 Kurzweil 1999, *The Age of Spiritual Machines*, Viking Press.
3 Rogers 1962, *The Diffusion of Innovation*.
4 http://www.mgtaylor.com/mgtaylor/whatis_mgmtcenter.htm

- *the Internet of Things (IoT)* – a network of physical objects that measure either the object's internal state or some factor in the external environment. The objects are equipped with transmission capability and connected to a monitoring agency via the internet
- *big data* – the creation of datasets that have a high number of observation points and/or a high velocity of creation and transmission and/or a high degree of complexity
- *cloud computing* – using a remote server or servers hosted on the Internet to store, manage and process data, rather than a local server or a personal computer.

We do not pretend that this list is in any way exhaustive. What we have done is select 10 technologies that are here now or whose arrival is reasonably certain, and where the effects will be felt. For that reason we have not directly considered artificial intelligence (though it is one downstream implication of big data analytics) or nanotechnology. Each exists in some form, but each is considered unlikely to advance sufficiently in the medium term.

Of course there are different types of effect. In the report that follows we will consider both the direct effects on local authorities and the second-order effects (that is to say, those where the effect is through an impact on the community). We have already seen examples of each in our discussion. The widespread prevalence of 3D printing and the move to bespoke rather than mass production will have second-order implications for local communities, and ultimately local authorities.

2 UNMANNED VEHICLES

2.1 Technology

In this chapter we focus on two robotic applications:

- unmanned aerial vehicles (UAV) – also known as 'drones', and
- driverless vehicles.

2.1.1 UAVs

A UAV is defined as a "powered, aerial vehicle that does not carry a human operator, uses aerodynamic forces to provide vehicle lift, can fly autonomously or be piloted remotely, can be expendable or recoverable, and can carry a lethal or nonlethal payload".

Essentially, a drone is a flying robot[5]. The aircraft may be remotely controlled or can fly autonomously through software-controlled flight plans in their embedded systems2 working in conjunction with GPS[6]. UAVs have most often been associated with the military but they are also used for search and rescue, surveillance, traffic monitoring, weather monitoring and firefighting, among other things.

UAVs are proliferating the globe with New Zealand also exporting these machines because of the high quality and sophisticated systems that have been developed. The future will produce many specialist drones. These will be all shapes and sizes and have a range of specialty sensors and cameras.

Drones can fly for up to 45 minutes on current battery technology and up to 25km. They are very stable even in extreme weather conditions, such as high winds, making them ideal for emergency services. If the battery pack becomes low, the drone calculates how long it will take to return to base and automatically turn around and fly back safely using the GPS co-ordinates of its flight path.

There is much debate about where, when and who can fly drones. Regulations in New Zealand provide the greatest flexibility to allow out-of-sight operation that may be necessary for farming operations, railway track surveillance, and many other uses.

2.1.2 Driverless vehicles

Driverless vehicle technology (or autonomous vehicles) are "a motor vehicle that uses artificial intelligence, sensors and global positioning system coordinates to drive itself without the active intervention of a human operator."[7]

Autonomous vehicles sense their surroundings with techniques such as radar, lidar, GPS, and computer vision. Advanced control systems interpret sensory information to identify appropriate navigation paths, as well as obstacles and relevant signage.

The technology has been advanced significantly with prototypes and trials under way for driverless cars, tractors, trucks, mowers and with even more potential for autonomous trains.

5 http://whatis.techtarget.com/definition/robot-insect-robot-autonomous-robot
6 http://searchenterpriselinux.techtarget.com/definition/embedded-system
7 http://searchmobilecomputing.techtarget.com/definition/Global-Positioning-System

The first commercially available driverless cars will be available within five years. Some applications are already in use in industrial and commercial settings. For example, London's Heathrow Airport already successfully operates driverless Pods (the ULTraPod) to take passengers between terminals. This is one example of intelligent transport systems technology.

The use of driverless vehicles will have the greatest impact on society if there is general acceptance that individuals don't need to own a vehicle, but can buy a unit of transportation. Just like a taxi service, autonomous vehicles could be summoned via a smart phone and deliver passengers to a destination. They are then freed up to provide a service to others.

This will have major effects on the number of vehicles required on the roads, the savings in vehicle ownership, reduced car-parking, reduced accidents, reduced insurance costs and many other opportunities.

One certainty is that for at least a decade we will have both self-drive and driverless vehicles on our roads. This will create challenges for local government in providing infrastructure that accommodates both types of vehicles. Current estimates are that existing cars could be converted to autonomous control for about NZ$6000.

2.2 Opportunities

UAVs can potentially overcome limitations on access, safety matters and resource demands. These qualities make them uniquely placed to enhance and deliver several local government functions:

- *emergency management* – including applications for search and rescue as well as rural fire (e.g. drones could be sent in to assess and track fire paths)
- *animal control* – particularly in relation to wandering stock as well as in locating roaming and/or dangerous dogs
- *land information (and any other activity that relies on aerial photography)* – by providing a more cost effective service than hiring a plane or helicopter and pilot
- *environmental monitoring and regulation* – for example, in terms of rivers, water testing, air quality assessments and identifying illegal dumping (for example, staff not having to walk the streets in the cold at night identifying smoky chimneys)
- *infrastructure assessments* – by being able to get closely alongside large and/or inaccessible pieces of network infrastructure such as bridges and water towers
- *building inspections* – for all building work but perhaps with particular importance for large-scale work with accessibility issues. Monitoring swimming pool fences would also be eased, with benefits for completeness of council information and risk mitigation
- *parks work* – particularly in the case of weed monitoring and spraying – both in terms of cost effectiveness, ease of service delivery and accessibility
- *security monitoring* – enhancements to the reach of surveillance (e.g. improvements to CCTV range) and the safety of response staff (e.g. in dealing with noise complaints).

The potential for autonomous vehicles to benefit local government are identified as follows:

- savings for local authorities in reduced vehicle fleets. If councils can share driverless vehicles then they will not necessarily need to own all, or any, vehicles to carry out activities. Council staff will call up the required transportation as and when needed.

- savings for local authorities in reduced car-park holdings. The total car-parking stock required could be reduced as vehicles will not require as many car-parks.
- savings in public transport subsidies. If communities did adopt driverless on-demand transportation then there could be reduced need for public transport, such as buses, because residents could opt for door-to-door transportation. This might then mean fewer bus stops will need to be installed and maintained.
- environmentally friendly vehicles will assist with concerns around carbon emissions and unwanted effects of pollution such as smog. Electric driverless vehicles with self-charging capability will give local authorities a range of opportunities around battery charging facilities which could include charging while driving along streets or in car-parks, or outside public facilities.
- fewer accidents from intelligent systems could reduce the need for expensive traffic signalling equipment as the vehicles could communicate with each other through their navigation systems.
- fewer regulatory staff required as vehicles would be programmed to comply with road rules and bylaws.

2.3 Customer expectations

UAVs will become a more frequent sight in our skies. Their frequency will come with greater public concern about safety and privacy. As a result, communities are likely to expect that local authorities will have a transparent and structured approach to what is collected, why and for what purpose. There could be legal ramifications here and these will need to be managed – including the establishment of 'rules of engagement' that are clearly communicated and enforced.

Driverless vehicles are being promoted as cheaper, safer, more convenient and reliable. Many sectors of the community will look to local and central government for education on the technology as they will need to build 'trust' that it is safe. Will parents one day send their children to school in a driverless vehicle and know they got there safely?

Customers will expect the council to provide up-to-date maps for the navigation system to be totally current. Councils will need to be able to signal any road works or detours electronically so that navigation systems respond accordingly. Local authorities will be expected to adapt the technologies that are complementary to driverless vehicles – including applications modelled on IoT.

Given these above applications the community could perhaps subsequently expect a reduction in the cost of council services and the number of council employees.

2.4 Impacts and implications

2.4.1 UAVs

UAV technology is likely to raise significant privacy concerns. Many of the benefits of UAV technology – their size, stealth, ability to access remote, difficult and non-public locations, speed and agility can equally be perceived as 'invasive'. These negative connotations are not helped by their military connections and relationship to spying and reconnaissance, so a focus on education and 'public relations' for the greater good would help counter some of these barriers to adoption.

Privacy will be affected by the roll-out of UAV technology because the sort of information we are able to gather will grow in completeness, volume and efficiency. We will have rapid

access to sometimes previously inaccessible data and what we do with this information and how we reassure the public about its end use will be important.

There are further implications in terms of the logistics of UAVs. Who will monitor the use of UAVs? Who will license them and what is their jurisdiction? Risk, liability, insurance and legal consequences are similarly opened up once drones are circling, recording and transmitting data. For example, should a drone fall from the sky in a public space or at an event, health and safety issues will also arise with serious penalties if adequate precautions are not in place.

The loss of traditional local government careers is also a realistic outcome, with roles such as building inspectors being superseded by this new technology. While there will be some additional jobs created, it is less so with this technology than with others. Being 'replaced by machines' is a reality here. In terms of benefits though, drones offer environmental advantages through the use of green energy, reduced reliance on cars and enhancements to environmental monitoring practices (e.g. the ability to take thermal readings and to monitor air quality). There are also health and safety impacts and resource efficiency and effectiveness gains – e.g. with staff not endangered in treacherous locations or risky situations, and staff time being better deployed through not having to be hands-on out of the office.

2.4.2 Driverless vehicles

The major implications of driverless vehicles will arise if and when there is a widespread move to buy these vehicles as units of transportation, as opposed to ownership of individual autonomous vehicles by households.

If the auto-taxi type of operation exists then this could mean up to 80 percent fewer car-parks required as commuters are dropped off and picked up from their desired location without the need to park. This, in turn, will affect city planning activities for CBDs and shopping centres as less parking is required, but more drop-off and pick-up facilities are needed.

It is predicted under this model that the number of cars on the road could reduce by up to 80 percent as vehicles today are typically parked about 95 percent of the time either in the garage or in a car-park. This means they are driven only 5 percent of the time and hence the large opportunity for efficiencies to be gained from a shared model.

If the unit of transportation model is not widely adopted then we will continue to need car-parking, but perhaps on a greater scale. This is because now even more citizens are able to travel who previously could not do so easily, and they will want to park when they arrive at their destination.

If fewer vehicles are on the road then there may be fewer fuel taxes collected – with a subsequent reduction in government revenue. This is likely to further add to the need for alternative tools for transport funding – such as road pricing.

Driverless vehicles are also predicted to reduce accidents and deaths. With currently 1.2 million people worldwide killed annually in road accidents, the implication of safer travel is that there will be less need for hospital emergency services, ambulance services, doctors and nurses.

A further implication of fewer vehicles being sold would be a reduced demand for car

sale yards and subsequent closure. Some vehicle manufacturers might go out of business or scale back significantly. There are some predictions that the world may need only two global manufacturers if there was an 80 percent reduction in demand. The alternative is that new niche manufacturers would enter the market providing greater choice.

Roading corridor planning, including the need to have high-tech traffic systems, may also have future effects. Roading staff might need greater technical skills and understanding of the vehicle systems as well as how their infrastructure will communicate with autonomous vehicles. In addition, a more mobile community might result in greater use of council facilities – and with greater use comes higher maintenance costs.

Planners need to consider how the modern city or town will accommodate driverless vehicles. What demands will they place on the city and will we even need traffic signals? These could be replaced by sensors. Early education of planners and asset managers could be highly beneficial and save money, if the right decisions are made in advance.

While traditional transport-related jobs might disappear, such as taxi and bus drivers, more highly skilled jobs might also emerge in the navigation and communication technology fields.

In the period when both self-drive and driverless vehicles share space on New Zealand roads, there may need to be an allowance for higher infrastructure maintenance costs to accommodate the differing requirements. Driver licensing conditions are also likely to remain. This will be necessary if using a converted autonomous vehicle and a malfunction occurs – for example, will the person in the vehicle have the ability or skills to take over the controls?

Privacy could be affected by autonomous vehicles as this technology will digitally track and log all travel movements. This could be an advantage to an anxious parent wanting to ensure their child made it to school, but in some cases individuals might not want their location made public.

2.5 Potential strategies

2.5.1 UAVs

There are certainly opportunities for local authorities to make use of UAVs to enhance service delivery. These would best be advanced through local authorities demonstrating that they are responsible users of the technology and being seen to lead the public sector.

In the initial stages public confidence might be enhanced through a code of responsible UAV use. Such a code might make it clear when UAVs will be operating and why. A code might also require council branding, reassuring the community that UAVs are being used for a specific public service. Councils might also take the lead by amending bylaws and by working with the Civil Aviation Authority on regulations relating to air space.

While job losses are likely as a result of this new technology, job gains are also to be had and local authorities could assume responsibility for the licensing of UAV operators and ‘pilots’.

Public comfort with UAVs is also more likely to be eased through early championing of the technology for public good in the public realm (e.g. through support services such

as emergency management and bridge safety inspections, as opposed to initiatives that target and potentially penalise individual users).

There is also a potential education role in educating the community about the use of UAVs.

2.5.2 Driverless vehicles

Driverless vehicles pose several questions for the way we deliver services in and around the road corridor. For example, how will we deal with road closures, detours, road works, and infrastructure renewals or maintenance? What infrastructure will be needed to support driverless technologies? Agencies such as ALGIM and IPWEA may need to develop standard protocols or procedures.

There are potential benefits from working with providers (such as Google) to get one or more local authorities adopted as a ‘test bed’ for driverless technology. Given the variety of landscapes, road terrain and mix of urban and rural, along with a tech-savvy society they may look to use a highly connected country such as New Zealand as a trial facility.

Local government might partner with central government to deliver education on driverless technologies – or provide this through community programmes. This is vital to prepare local residents for how this could affect them. The positives and negatives need to be explained and with knowledge there will be reduced uncertainties.

2.6 Case studies

2.6.1 Checking infrastructure condition – South Taranaki District Council

South Taranaki District Council received a report that questioned the seismic safety of the water tower in Hawera.[8] It used several drones to visualise every inch of the tower and identify risks to the tower’s structural integrity.

2.6.2 Disaster relief

A New Zealand team has been contracted by the World Bank to provide UAV footage of Vanuatu in the wake of Cyclone Pam. This footage is used to assess the condition of critical infrastructure and damage to crops to help relief organisations better identify and target aid where it is needed most.[9]

2.6.3 Google and public roads

Google has permission to test its prototype vehicle on US public roads in Mountain View, California. In six years of testing and millions of miles of driving, the Google driverless car has had only 11 minor traffic accidents. Google has not committed to a date for release but indications are within four years.

2.6.4 Autonomous taxis

In Milton Keynes, UK, a small fleet of autonomous taxis will be on the roads in 2017. The LUTZ Pathfinder is the UK’s first autonomous car. The two-seater prototype pod has

8 *Taranaki Daily News*, “Drone Swarm Helps Check Water Tower’s Strengh”, article dated 10 May 2014 downloaded from http://www.google.co.nz/url?sa=t&rct=j&q=&esrc=s&frm=1&source=web&cd=8&cad=rja&uact=8&ved=0CFAQFjAH&url=http%3A%2F%t2Fwww.stuff.co.nz%2Ftaranaki-daily-news%2Fnews%2F10030119%2FDrone-swarm-helps-check-water-towers-

9 Television New Zealand, report of 20 April 2015.

been built by Coventry-based RDM Group, and was first shown to the public in February 2015.

The LUTZ (Low-carbon Urban Transport Zone) [1] Pathfinder pod is part of the UK Government's Transport Systems Catapult Autodrive project, a £20 million initiative.

Three pods will be tested initially in Milton Keynes during 2015 to ensure that they can comply with the Highway Code, and if successful a fleet of 40 will be rolled out.

2.6.5 Remotely piloted boats – Waikato Regional Council

The Waikato Regional Council uses remotely piloted boats for flood gauging. This allows for measurements at the most appropriate place(s) and time(s) while minimising the risks to staff safety.

Waikato Regional Council staff monitoring in the Waikato River.

3 3D PRINTING

Three-dimensional printing makes it as cheap to create single items as it is to produce thousands and thus undermines economies of scale. It may have as profound an impact on the world as the coming of the factory did. Just as nobody could have predicted the impact of the steam engine in 1750, or the printing press in 1450, or the transistor in 1950 – it is impossible to foresee the long-term impact of 3D printing. But the technology is coming, and it is likely to disrupt every field it touches.

– The Economist

Soon, anyone, anywhere can be an inventor.[10]

3.1 Technology

There are many applications for 3D printing, including architecture, construction, industrial design, automotive, aerospace, military, engineering, dental and medical industries, biotech (human tissue replacement), fashion, footwear, jewellery, eyewear, education, geographic information systems and food. It is for this reason that 3D printing has recently been rated as one of the top 10 emergent technologies by the World Economic Forum.

Most people associate 3D printing with the creation of relatively small components and/or products. Home-based printers, and even those used in 'light' industry are only capable of creating objects measured in centimetres. Some industries are beginning to create much larger printers for generating components used in heavy industry, aerospace and building.

Practical demonstrations and pilots of 3D printing are now being used on this scale to produce entire buildings. Using methods similar to those described above, large 3D devices are being used to extrude and lay down concrete and other materials. In this way an entire house, or at least the foundations and walls can be laid down in a continuous 24-hour process with minimal human supervision. While still far from being an everyday process, this does give some indication of the direction in which this technology is heading.

In China they are building 10 houses a day, in part with 3D technology.[11] While 3D technology isn't capable (yet) of building to 'home-of-the-year' standards, it is capable of producing basic accommodation. This, coupled with lower costs and the use of recycled materials, provides the opportunity to create cheaper housing, but could also be used to create secure, weather resistant accommodation after a natural disaster.

Though 3D printing has yet to reach critical mass, the basic technology is already available and many of the applications presented here have been piloted. The mass production of homes or office blocks using this technology may still be years away but how local government deals with the possibility of the printing of structures, and the social impacts of significant change in manufacturing and building, must be considered.

There are three main methods of 3D printing, differing mainly in the way layers are built to create the final object. Some methods use melting or softening material to produce the layers. Selective laser sintering (SLS) and fused deposition modelling (FDM) are the most common technologies using this way of printing. Another method of printing is to lay liquid materials that are then

10 Rabe J, 3D Printing's Challenge to Big Government and Big Business, downloaded from http://valuesandcapitalism.com/3d-printing-s-challenge-to-big-government-and-big-business/
11 *Computerworld*, 3D Printer Constructs 10 Buildings in One Day from Recycled Materials downloaded from http://www.computerworld.com/article/2489664/emerging-technology/3d-printer-constructs-10-buildings-in-one-day-from-recycled-materials.html

cured with different technologies. Stereolithography (SLA) is the most common technology using this method.

Selective laser sintering (SLS)

This technology uses a high-power laser to fuse small particles of plastic, metal, ceramic or glass powders into a mass that has the desired three dimensional shape. The laser selectively fuses the powdered material by scanning the cross-sections (or layers) generated by the 3D modelling program on the surface of a powder bed. After each cross-section is scanned, the powder bed is lowered by one layer thickness. Then a new layer of material is applied on top and the process is repeated until the object is completed.

Fused deposition modelling (FDM)

The FDM technology works using a plastic or wire filament which supplies material to an extrusion nozzle. The nozzle is heated to melt the material and can be moved in both horizontal and vertical directions controlled by a computer-aided manufacturing (CAM) software package. The object is produced by extruding melted material to form layers as the material hardens.

Stereolithography (SLA)

This technology employs a vat of liquid ultraviolet curable photopolymer resin and an ultraviolet laser to build the object's layers one at a time. For each layer, the laser beam traces a cross-section of the part pattern on the surface of the liquid resin. Exposure to the ultraviolet laser light cures and solidifies the pattern traced on the resin and joins it to the layer below.

After the pattern has been traced, the SLA's elevator platform descends by a distance equal to the thickness of a single layer. Then, a resin-filled blade sweeps across the cross section of the part, re-coating it with fresh material. On this new liquid surface, the subsequent layer pattern is traced, joining the previous layer.

3.2 Opportunities

The cost of 3D printing technology has fallen dramatically over the past five years. Printers which once cost more than $20,000 now cost less than $1000 and are available through retail outlets. These printers are not able to produce high resolution models, or have the speed for mass production, but are certainly capable of creating small, relatively high quality end products for very low cost.

As the cost comes down and performance improves, 3D printing could become a mass market product enabling consumers to 'print' common household objects. Instead of going to a store to buy an object created in a factory (most likely somewhere overseas) a person would download the 3D model, for say cutlery, and print it at home.

This allows the consumer to customise or personalise the final output, saves them the cost of the trip to the store and is more sustainable than transporting the object from distant factories. The less positive effects of this are the effect on jobs in manufacturing, transportation and retail.

3.3 Customer expectations

Local government is not generally in the business of creating and selling physical product, but 3D printing has implications and uses of which the sector should be mindful.

The technology will reinforce consumer expectations of immediacy of service, for example, by eliminating the need to carry physical inventories of some objects ("we'll have to order that in" becomes an invalid excuse). While local authorities are not retailers, users of our services will become accustomed to immediate responses in all transactions and will expect it in their dealings with local authorities. Immediacy of service in local government is likely to translate into lower tolerance of service failure – for example, the user might ask questions such as "why has it taken two days to fix that pump – can't you just make the part on your 3D printer?".

The time when large numbers of people possess the skill (or access to skills) to 'tweak' a computer program to customise 3D printing is some way off. But as the technology is adopted, or complementary technologies are developed (such as an 'app' that changes the colour of a product), users are likely to expect more customisation and choice in the services they consume.

And, of course, 3D printing will take transportation and distribution costs largely out of the equation. This is likely to sharpen customer sensitivities to the cost and price of their services.

3.4 Impacts and implications

> *"A prototype is worth a thousand pictures"*[12]

The impacts of 3D printing for local government are significant, but are more in the nature of second-order effects. The sector itself is unlikely to be a significant user of the technology to produce, but the impacts for transport and land use planning, for communities and for the workforce are significant.

Ultimately this technology could lead to new ways for consumers to buy products. Instead of centralised manufacturing, followed by expensive and environmentally damaging distribution, it is possible to design products remotely and then deliver them digitally, on demand, and print them locally – either by a local agency or at home.

This technology means that mass production is no longer the only means to create economies of scale. Small crafted items will become cost-effective to produce. There will not be the same need for large manufacturing operations, and the potential for 'cottage' industries capable of designing new products without the need for factories to produce them en-masse. Co-location of businesses becomes less of a need and more of a habit.

This technology will make some aspects of manufacturing and distribution redundant – especially relatively simple items. It is one of the more disruptive technologies presented in this paper. It is, however, an open question as to the extent of the impact on New Zealand, where manufacturing tends to focus on conversion of primary products into a manufactured good. (This may be an excellent topic for a Masters or PhD candidate.)

A higher level of smaller scale, distributed industry, will affect transportation demand, and patterns of transport use. Transportation demand from commercial operators may well reduce, and is likely to become less concentrated on a few key routes or in a few key areas. Likewise, if the employer is moving, employees are likely to move 'in sync'.

A de-concentration of industry will carry huge challenges for land-use planning. Great areas of industrial and commercial use may be replaced by smaller 'pockets' of industrial (those local authorities that are working with business to develop technological and industrial parks have,

12 Statetech, "Exploring the Angles of 3D Printing, downloaded from ww.statetechmagazine.com/article/2015/01/exploring-all-angles-3d-printing/

however unconsciously, begun future proofing). What does this mean, however, for a great industrial area such as Wiri, or Penrose, or Te Rapa/Pukete?

A significant urban renewal challenge is created – though on the upside, this may be one source of land for housing development! In our work the development of 3D models may be useful in planning and consenting. A 3D model of an area to be developed could enable ratepayers to better visualise the effects of the planned changes.

Mass-ownership of 3D printing technology raises some headline-grabbing challenges in law enforcement and regulation. Readers can doubtless see the potential for the technology to produce illegal items. For example, it has been used to produce a working gun.[13] Licensing regimes become much easier to circumvent because the items need only be produced a short time before use, and can be disposed of at far lower cost.

Regulatory regimes, such as building inspection, will need to adapt to allow for the use of new materials and methodologies. An inspection regime for building might, for example, need some mechanism or mechanisms for inspecting/auditing the computer design program. Inspection would most likely be needed both on its creation and before 'printing' begins (to check any customisation has not compromised the program or that the program has not been corrupted). In some regulatory professions knowledge of the subject matter will no longer be sufficient; the inspector may need the skills to interpret source code.

The creation of spares for field assets could reduce costs and shorten repair times. But even this has risks, for example, might printing a part for a vehicle infringe on the intellectual property of a Toyota or a Rolls-Royce? And if you install a 3D printed part, what implications does that have for consumer law e.g. have you just invalidated the warranty?

3.5 Potential strategies

Local government is unlikely to be a large-scale user of 3D printing in and of itself. The applications of this will be small scale and should not come with the privacy and security implications that the technologies elsewhere in this paper will come with. Public response is more likely to be positive than with other technologies, that is to say the response is more likely to be 'wow' than 'but …'.

Applications that enable local authorities to better show or demonstrate the implications of planning proposals in tangible form might be one appropriate place to start. The Palmerston North town centre model is one working application of this. A local authority such as Auckland that is undergoing significant debate about intensification and brownfields or greenfields development might likewise use 3D printing to produce several models of each variation in building height, movement of the urban limit etc. This could be replicated at quite a small level, down to neighbourhood and structure plans.

The other place where 3D printing might be picked up directly, but more in the medium term, is in the acquisition of fittings and fixtures. 3D-printed library shelving, office furniture and the like are not that far distant.

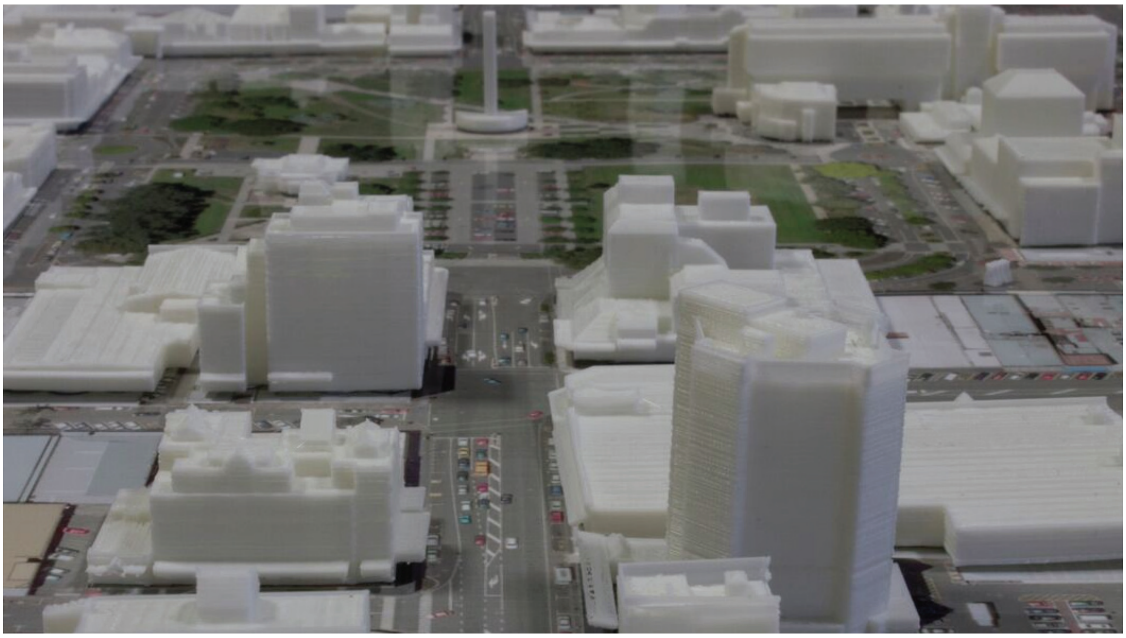
The second-order effects of 3D printing for land use and urban planning will be felt within the life of current spatial plans and infrastructure strategies. The time before 2018 gives local authorities the opportunity to do some basic thinking about the levels of manufacturing and distribution in their area, and whether and how the technology is likely to affect those industries.

13 BBC, "3D Printing Used to Produce a Working Gun", downloaded from http://www.bbc.co.uk/news/science-environment-22421185

3.6 Case studies

3.6.1 Palmerston North City Council town centre modelling

Palmerston North City Council has used 3D printing to produce a working model of 'the Square' as the basis for its town centre planning, earthquake strengthening work and to support its place-making initiative. The intent is that buildings identified as having differing levels of risk will be coloured differently showing any common patterns.



3D printed model of the Palmerston North City Centre and environs.

3.6.2 Housing construction

Yingchuang New Materials Inc (of China) has used 3D printing technology to construct 10 buildings in 24 hours and at a cost of US$5000 per building. Yingchuang used four huge (20 feet tall, 30 feet wide and 132 feet long) FDM concrete printers to print the shell of the houses (minus a roof). These hardened at the factory and were then transported to the site and assembled onsite. Think of the implications for a nation concerned about housing affordability.[14]

14 *Computerworld*, "3D Printer Constructs 10 Buildings in One Day from Recycled Materials", downloaded from http://www.computerworld.com/article/2489664/emerging-technology/3d-printer-constructs-10-buildings-in-one-day-from-recycled-materials.html

4 MOBILE DEVICES

4.1 Technology

Mobile devices are computers that can be transported while in use and used in several locations. People can carry around and have instant access to more and more information about matters that would have required days to amass in the past. Mobile devices allow users to buy, sell, order, report, monitor, track or request service at any place, any time.

Already the use of mobile devices has taken over from stationary PCs, providing:

- communication – voice, text, images and video
- access to information and information storage
- mail, calendar and scheduling
- managing finances and transactions
- navigation
- GPS
- camera
- entertainment, and
- identification and security.[15]

By 2019 it is expected that there will one and a half times as many mobile devices as there are people on Earth. Almost 500 million mobile devices and connections were added in 2014, bringing the total to 7.4 billion. Smartphones accounted for 88 percent of that growth, with 439 million net additions in 2014. It is expected that from 2014 to 2019, the share of smartphones will increase from 29 percent to 40 percent of total mobile devices, while the share on non-smartphones will decrease from 61 percent to 27 percent. Laptops (2 percent) and tablets (3 percent) will make up a much smaller share of the total. There is also expected to be significant growth (from 7 percent to 28 percent) in machine-to-machine connections, for example GPS systems in cars, asset tracking systems, and wearable devices linked to smartphones.[16]

As organisations respond to demand for mobile applications, further growth will be encouraged. As more resources are applied to meet demand, so demand will grow as it becomes easier to accomplish everyday tasks on mobile devices. Similarly, as the devices become more powerful and more integrated with other emerging technologies (such as wearables) the range of applications offered will grow exponentially. Global mobile data traffic is expected to increase ten-fold between 2014 and 2019.

People will be able to work effectively anywhere – provided there is adequate communication network coverage. The separation of work from leisure and the distinction between work-place and home will become increasingly blurred. Good time management skills will become more important for everybody and personnel policies will have to keep pace with the changing ways of working.

Paradoxically the more powerful mobile devices become, the less individuals need to know and remember, and the greater the potential consequences of security issues, disruptions to networks or charging cycles, and damage to the device. Such challenges to business continuity are not confined to mobile technology (stationary PCs are also susceptible to power failure for example), but the options for mitigating the risk are fewer and the expectation of continuity from customers is likely to be greater.

15 Bosomworth (2015), Mobile Marketing Statistics 2015, downloaded from http://www.smartinsights.com/mobile-marketing/mobile-marketing-analytics/mobile-marketing-statistics/

16 Cisco Systems Inc (2015), Cisco Visual Networking Index: Global Mobile Data Traffic Forecast Update 2014–2019 White Paper downloaded from http://www.cisco.com/c/en/us/solutions/collateral/service-provider/visual-networking-index-vni/white_paper_c11-520862.html

4.2 Opportunities

4.2.1 Services and information

The advantage of mobile devices is that council services and information can be delivered when and where required. Providing information where and when it is needed increases its usefulness to the end user.

4.2.2 Monitoring and response

If councils can encourage instant reporting of service issues by the public, it would enable rapid response intervention without the cost of extensive traditional monitoring and inspection contracts. Councils can harness the eyes and ears of the public by crowd-sourcing the monitoring of things such as pot-holes, graffiti, fly dumping and littering. If the reporting was automatically combined with GPS location identification, there could well be improvement in the accuracy of reporting and service requests, enabling faster and more cost-effective responses. An example of this is fixmystreet.org.nz which is discussed in the case studies below.

4.2.3 Augmented reality

Applications that combine GPS, asset management information and aerial photography could generate augmented reality information that would be useful to both staff and customers working outdoors. For example, an image of underground utilities laid over the immediate landscape would be useful for people planning earthworks, building or landscaping projects. (See section 6 Augmented Reality.)

4.2.4 Immediate feedback

Using mobile technology, the public could be encouraged to provide on-the-spot opinions on issues, proposals or presentations, which might get people more involved in decision-making processes. The use of technology familiar to a younger audience could encourage youth to provide their opinions.

Key to getting effective feedback would be judging when and where to use particular tools. Given the reduced screen size in mobile devices, it would be important to keeping things simple and focused. Polling or making choices between a few simple options could be effective.

4.2.5 Emergency management

The widespread use of smartphones makes instant mass communication a practical option for emergency situations, particularly where more than an audible warning is required. It also provides an alternative for people with hearing difficulties. For example, the Bay of Plenty Civil Defence Group encourages people to subscribe to text alerts for emergency updates.[17]

4.2.6 Working anywhere

Tablets and smartphones have already liberated many staff from their desks, enabling more face-to-face interaction with the public and customers without losing access to vital information. It also means for many site-based processes, such as building inspections, information can be captured electronically on the spot, avoiding desk-bound input and the associated delay and risk of transcription errors.

17 See www.bopcivildefence.govt.nz

As the range of mobile devices increases and employers can more easily accommodate personal preferences for ways of working, there could be more Bring Your Own Device (BYOD) arrangements with staff. Allowing such flexibility could help attract skills to councils that are prepared to take a lead and address the accompanying challenges relating to security of networks and information, asset management and control.

4.3 Customer expectations

4.3.1 Council services and information

Officials and elected representatives will have to ensure that councils' communication channels meet reasonable public expectations. Competition drives commercial service providers to develop sophisticated and attractive 24/7 mobile applications, which in turn creates customer expectations for dealing with councils in this way. Ignoring these expectations risks frustrating customers and missing opportunities to engage with individuals in the community.

It goes without saying that customers expect to be able to transact electronically, but they increasingly expect that interfaces will accommodate the smaller viewing format of mobile devices. It is important when developing applications that the technical platform can support responsive design e.g. HMTL 5, so that it is legible regardless of the device.

Customers value the immediacy of mobile interactions and being able to conduct their business at the hours that suit them, no matter where they are. They also want to help themselves through self-service to track the progress of requests, applications and payments.

Councils hold large amounts of public information about their districts, regions and cities that can be accessed by residents and visitors. Making it easily accessible on mobile devices could enhance their experience of a place.

Interested members of the public want it to be easy to provide feedback and get involved in decision-making. This means providing information and communication channels that suit the lifestyles of busy, mobile people – simple, straightforward, and easy to understand.

4.3.2 Access to the internet for mobiles

Providing free Wi-Fi in public places enables affordable access to mobile users – particularly visitors – and is an effective way of attracting and retaining people in city and town centres. As free access becomes more widespread around the world, so it will become a normal expectation for travelers.

4.4 Impacts and implications

4.4.1 Security, access and privacy

By their nature, mobile devices and the data on them is more difficult to secure compared to a stationary equivalent. Mobile devices are vulnerable to physical loss of the device and compromise through unsecure networks. Some of the risk can be avoided by giving staff access to secure mobile networks so they never have to connect their phones, tablets or laptops to public networks.

The responsibility of staff for complying with security procedures remains crucial, requiring clear policies, backed up by staff education and monitoring. Policies for reporting lost or

stolen equipment and procedures for remotely securing or wiping data are part of those requirements.

4.4.2 Network stability

Relying on mobile devices to undertake business processes means having to manage the risks of unreliable connectivity. Outages or poor service can result from bad weather, internet service provider down-time and loss of signal due to network traffic or malicious attacks. Besides, many places in the country still have poor connectivity, even on a good day, so other channels of communication should also be provided.

Managing these risks should be included in business continuity plans, which should be updated regularly as reliance on mobile devices increases.

Whether mobile technology disrupts business practices by prompting a complete redesign or merely provides opportunities for greater efficiency and flexibility, is largely a matter of choice for each organisation. It's not an all-or-nothing decision.

Mobilising the entire workforce would transform the way people work. Change management and education would be necessary to get buy-in from staff, particularly from groups that may be less comfortable with the change.

At the other end of the spectrum, mobile devices could be introduced as part of automation or of business process reviews that have a wider scope not limited to technology solutions. This approach would be less disruptive, slower, but possibly more easily accepted by risk-averse staff and elected members.

4.5 Potential strategies

4.5.1 E-plans

Opportunities for delivering services and information on mobile devices are limited only by budgets and availability of skills. Making decisions about the order in which various services and transactions should be mobile-enabled will be crucial. An understanding of customer views about the relative potential benefits will be important, particularly in the current environment of political and economic pressure to reduce costs and improve efficiency. By undertaking transparent planning processes that consider business priorities and risks, customer preferences and resource availability, councils will be able to develop plans that will help drive progress.

4.5.2 Cooperation

Having a clear plan also means councils can cooperate with others on a similar journey, to avoid each re-inventing the wheel. One of the strengths of local government is its cooperative nature and the willingness of councils to share good practice and tools. More importantly, council customers across jurisdictions should not have to negotiate their way through different applications to achieve the same thing in different parts of the country.

By working together councils could develop mobile capability more quickly and for less cost, compared to working alone. This would be made easier if data frameworks were standardised, which would involve give and take from all participants and commitment to making it happen. Where standardisation of the back ends of processes is not practical,

the front end (or what the public sees) offers more opportunity to be standardised across councils, for the benefit of customers.

Cooperation does not have to be limited to other councils. For example, in developing the MarineMate application, regional councils worked together with Maritime NZ, ACC and Land Information New Zealand.

4.6 Case studies

4.6.1 Tablets for building inspections

Master Business Systems (MBS) GoGet tablets[18] are now used by 18 councils for their building inspections, and implementation is under way for six more. The technology has been available for about eight years, with Tauranga and Manukau being early adopters. Building inspectors load the tablet with jobs for the day and use it to complete checklists, make notes and take photos of the jobs as they go. The tablet learns to read their handwriting and converts it to text, which is then uploaded to the council's main systems once the inspectors return to the office. This eliminates transcription errors and speeds up processing. Mobile printers can also provide trades people with paper copies on site.

Western Bay of Plenty staff, who have been using the tablets since 2008, say it has helped them improve their overall efficiency and job scheduling, and they can now give customers a better estimate of the timing of inspections. At the moment inspectors upload to the server at one of the council offices in the district, but soon they will be able to do it anywhere. Remote access to the server will mean inspectors no longer need to check in at the office at the beginning and end of each day, which will reduce travel, saving fuel and time.

Manawatu District Council, a more recent adopter, does about 300 inspections a month, and reports similar benefits[19] – they estimate it could save 75 hours a month in staff time.

4.6.2 Fix My Street

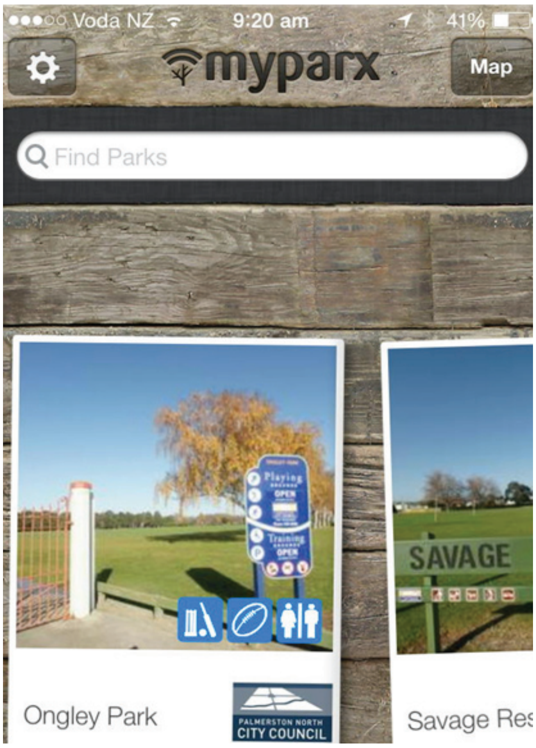
Fix My Street[20] is a volunteer funded application that runs on smartphones. It helps to report problems and request fixes from councils across the country. People take a photo, describe the problem, identify the location using post codes, street names and maps, or GPS and the application prepares an email to send to the appropriate council.

From the stats on the website, the vast majority of issues reported and resolved are in Auckland, Wellington and Christchurch, but smaller centres have also received requests. Wellington City Council has a similar app called FIXiT.

18 www.master.co.nz
19 See http://www.master.co.nz/mdc-building-mobile/
20 See http://fixmystreet.org.nz/

4.6.3 My Parx

Many councils have listed their parks in My Parx which provides information on local, regional and national parks across the world.



A sample from the MyParx webpage.

4.6.4 Marine Mate

Regional councils, together with Maritime NZ, ACC and Land Information New Zealand, developed MarineMate, a mobile application providing marine and water safety information to people heading out for a day on the water.

5 WEARABLE TECHNOLOGY

5.1 Technology

Wearable technology refers to computing devices comfortably worn on the body, or even incorporated into it. They fall into several groups:

- devices that adapt older technology to provide hands-free connectivity such as Google-glasses
- devices that enhance the capability of one's body, for example robotic exoskeletons
- monitoring and diagnosing devices that measure and track vital signs or indicators of disease
- embedded chips or bio-metric identification as the basis for preventing or allowing access.

Wearable technology tends to be more sophisticated than hand-held technology, providing advanced sensory and scanning features that enable immediate feedback of information, as well as tracking of physiological functions.

In the UK, research suggested in October 2014 that 2.8 million people (6 percent) owned a wearable device and that by September 2015 this would rise to 6.1 million people (12 percent).[21]

5.1.1 Hands free connectivity

Advances in miniaturisation, wireless technology and materials have enabled computer technology to become lightweight and robust enough to be comfortably worn. Technology formerly used by the military has been redesigned to be practical and aesthetically acceptable to everyday consumers.

Using glasses or headsets, information is typically projected to an area in the peripheral vision of the wearer, or laid over real-life vision, providing augmented reality. Devices typically include GPS, camera, microphone, sound and/or gesture control. Standard devices such as Google-glasses are aimed at the mass market, but customisable versions are available for industrial use.

Wearable cameras can make efficient recordings of events to be used for evidential and training purposes. Glasses and headsets provide 'point of view' recording, but cameras can also be clipped onto a pocket or belt.

By linking with other transmitting devices, information captured through wearable technology can be shared in real-time with others, enabling off-site experts to provide advice to technicians in the field who are able to remain hands-free.

5.1.2 Enhancing human capabilities

From improving or altering the senses to increasing the power of typical body movements, wearable technology can enable people to undertake 'super-human' tasks or see, smell, touch, feel, or hear the world in a different way.

21 Farmer (2014), "6.1 Million to Have Wearables in the Next Year", downloaded from, ihttps://yougov.co.uk/news/2014/10/10/6-million-have-wearables-next-year/

Combining the strength of robots with the judgment of humans, exoskeletons[22] and similar intelligent devices can increase the capacity of people in physically demanding situations,

such as emergency workers and firefighters, as well as providing mobility options for the disabled. Sight and hearing are the senses we rely on most, but are the most likely to deteriorate as we age. Wearable directional microphones that clarify and amplify desired sounds and cut the background noise, can help many older people, as well as children with attention deficit disorders.[23] Advances in vision enhancing technology could help people with macular degeneration and diseases of the retina.[24]

5.1.3 Monitoring and diagnosis

At present, the most visible use of wearables is in health and fitness tracking, with devices that track steps, heart rate, calorie burn and other metrics being within reach of ordinary consumers. The information is not routinely shared with health professionals or services, but as wearable sensing technology develops, data collected could be interpreted and remotely assessed by health professionals (or programs). This could enable early diagnosis of diseases, targeting of health care initiatives and may prompt changes to the way health insurance premiums are determined. It may reduce the need for people in fragile health to live close to medical facilities, if they are confident of receiving early warnings of trouble through their monitoring devices.

In combination with emerging nano-technology, the opportunity exists for internal diagnosis of emerging disease (diabetes, cancers, and ageing related diseases) by swallowing smart pills that send information mobile devices. This would also allow medical assessments by health professionals for early diagnosis of diseases.

Monitoring the immediate environment could help people make informed decisions about their health, for example asthmatics could monitor air pollution in busy streets and choose other routes.[25]

5.1.4 Biometrics, sensing and automatic control

By using wearable or embedded sensors, or biometric recognition, people and animals can be identified to trigger or deny access to facilities or services. A local example is the Positive Outlook[26] system proposed to monitor excluded problem gamblers from playing gaming machines.

5.1.5 Smart clothes

Development of intelligent fabrics means that physiology can be monitored without having to attach additional sensors – they can be integrated into clothing fabric. A home-grown example is the Smart Sock invented in Christchurch. Even more advanced are the fabrics that not only sense, but also adapt and respond, such as the Wearable Senses[27] survival clothing and biofeedback underwear which nags you about your posture. Generating energy to charge your phone using your clothing could soon be a practical option, using either solar cells or the kinetic energy of your own movements.

22 A commercially available example of exoskeletal technology used to help carry heavy weights can be found at http://bleex.me.berkeley.edu/research/exoskeleton/exohiker/
23 Zoundy (2013), Eidos Allows Users to Tune Their Senses, downloaded from http://www.gizmag.com/eidos-allows-users-to-tune-their-senses/27438/
24 Holton (2013), Four Emerging Vision-Enhancing Technologies, downloaded from http://www.afb.org/afbpress/pub.asp?
25 Climate Confidential and Westerveldt (2014), Wearable Tech Helps You Live in the Moment, downloaded from https://www.scientificamerican.com/article/wearable-tech-helps-you-live-in-the-moment/
26 Positive Outlook, An Anti-Problem Gambling Solution downloaded from http://www.layerx.co.nz/portfolio-isolate.html
27 Nanne (2013), Adaptive Survival Clothing, downloaded from http://wearablesenses.net/adaptive-survival-clothing/

5.2 Opportunities

In October 2014 a panel of wearable technology experts gave their predictions of the technology most likely to be useful in a business setting over the next few years. The most commonly mentioned was smart glasses. Local authorities could use these in many ways, including:
building inspections, consent monitoring – augmented reality by overlaying plans on real-life buildings or infrastructure; hands-free photo or video evidence; live-streaming visual information to experts for advice; recording events for training; using location aware apps for navigation and capture of site-related data; visual or audio checklists;

regulatory enforcement – improving staff safety by enabling remote visual and audio monitoring; hands-free evidential video recordings; facial recognition;

improved customer service in the field – hands-free access to records and reference material; receiving and processing service requests in the field;

recreation – creating augmented reality experiences to enrich enjoyment of the outdoors, historic places and museum exhibits using location-specific information and visual aids;

delivering a GPS-like service to pedestrians would allow businesses and councils to promote events, facilities and services in the pedestrian's immediate location.

5.2.1 Monitoring health

Monitoring health and diagnosing disease can bring widespread benefits to the community and reduce the need for people to live near medical services. If medical staff can routinely diagnose and provide advice at a distance, current expectations that ageing populations will be drawn to live near medical facilities may be challenged. Local government planning for medical facilities and social infrastructure should take this possibility into account.

5.2.2 Monitoring the immediate environment

Monitoring the immediate environment (e.g. air and water quality and traffic congestion) can help people choose where they go. Companies such as Chemisense have a device to track real-time exposure to harmful everyday substances that could compromise the health of vulnerable people. By sharing the data with others using a smartphone app and crowd sourcing, people can be advised of places to avoid.

5.3 Customer expectations

Councils' customers are likely to welcome efficiencies or better services enabled by this technology, as long as they can be confident their privacy is protected. Concerns about privacy are not unique to wearable technology, but when devices are wearable it is less obvious when they are being used. This means people could become suspicious, uncooperative or inhibited when dealing with staff wearing devices that are capable of things such as facial recognition and video recording. On the other hand, positive changes in behaviour could also result.

Councils will be expected to have robust, transparent and appropriate policies about the use of data and images collected, and that compliance with the policies is monitored ongoing.
Customers are entitled to expect that when dealing face-to-face with council staff using such technology, that effective interaction is not hindered by the multi-tasking demands made on the staff member. Staff would need training to become confident and adept in operating the technology while dealing with the public, and show good judgment in deciding when it will be useful.

5.4 Impacts and implications

5.4.1 Council services to the public

Just as mobile technology has become standard, wearables are likely to quickly become commonplace. As a result, local authorities could see increased demand from users to provide a suite of information to feed wearable devices, for example data about the environment, locations and council facilities and services.

5.4.2 Staff

For local government staff working in remote locations, wearable monitors or smart clothing could give them a measure of safety by monitoring their health and wellbeing, particularly if they are alone and doing heavy physical or dangerous work.

Some of the strength-enhancing applications of exoskeletons could also be used in firefighting and emergency management situations.

Devices that enable hands-free computing could enable redesign of some council processes, both for greater efficiency and for greater staff safety. Wearable cameras and smart glasses could be useful in training staff, demonstrating standard operating procedures, and enabling live coaching of tasks as they are being done.[28] They could be very useful in delivering on-the-job training for complex technical processes, and as a practical means of accessing specialist advice when in the field. Given the cooperative nature of local government, this could be a rich vein that could be mined for opportunities.

Staff policies relating to using wearable devices at work (security, privacy, using your own device) may have to be developed or updated regularly as technology evolves.

5.4.3 Privacy issues

Wearables and biometrics can collect, store and transmit deeply personal data about people, sometimes with their knowledge and sometimes without. The Privacy Commissioner suggests there is a balancing of intrusion with the degree that identification is necessary and the importance of the objective. Where the system is not optional, it is more intrusive and the rationale for using a biometric system would have to be that much stronger. In a 2010 speech, the Commissioner provides guidelines on managing the privacy risks. In addition to the generic points about access to information, encryption, and storage, the Commissioner notes that biometric scanners have a margin of error so there should also be a non-automated back-up system.[29]

As wearable devices become more linked to social media, the potential to gain from knowing people's likes, dislikes, movements and interactions is enormous, whether for commercial gain or public benefit. Most people do not want their information to be shared with third parties unless there is something in it for them.

The conjunction of the Internet of Things and wearable technology raises deeper privacy issues around what constitutes consent, adequate notice and need for information when everything is always on, when machines are talking to each other, and when technology is concealed in garments and park benches.

28 Gartner (2013), "Smartglasses Will Bring Innovation to Workplace Efficiency" downloaded from http://www.gartner.com/newsroom/id/2618415

29 Shroff (2010), "Protecting Biometric Data: Privacy by Design", paper given to the 2010 Biometrics Institute of New Zealand Conference, downloaded from https://www.google.co.nz/url?sa=t&rct=j&q=&esrc=s&frm=1&source=web&cd=2&cad=rja&uact=8&ved=0CCIQFjAB&url=https%3A%2F%2Fwww.privacy.org.nzpercent2Fnews-and-publications%2Fspeeches-and-presentations%2Fprotecting-biometric-data-privacy-by-design%2F&ei=qrVfVfnDJ4u78gWF-4PQDA&usg=AFQjCNE-t29yBqKtcJ6OdTTcbTUXiuUkAw

5.4.4 Who owns it?

Intellectual property issues arising from wearable technology are well canvassed in Poole (2014).[30] These include concerns about ownership and control of data as well as the economic value of personal information that may have been effectively traded for the free use of software.

5.4.5 Data vs information

With more and more sensors creating data about ourselves and our surroundings the challenge will be to turn the data into useful information.

5.4.6 Quality of face-to-face interaction

Having a face-to-face conversation with someone wearing smart glasses could be even more unsatisfying than trying to maintain the attention of someone repeatedly glancing at their smart phone. Unless appropriate 'smart-glasses etiquette' is developed and practised, there is a risk that the quality of engagement in face-to-face interactions becomes inhibited by distractions in the peripheral vision.

E-WasteAs electronics and sensors become more integrated into clothing, the nature of e-waste may be more difficult to identify and dispose of in an environmentally friendly way. This is more likely to be a concern in the short term; it is reasonable to expect that if the technology becomes common-place, recycling and recovery of toxic and valuable materials will occur.

5.5 Potential strategies

The pattern and uptake of wearable technology is likely to mirror what we have already seen in small mobile devices such as smartphones.

To date, local and central governments in the United States have been mainly concerned with what information they should be providing to developers of wearables. Enabling governments to make use of the data being generated by wearables (labelled the 'Human Cloud') has been more difficult, generally because of people's concerns with privacy issues.

By providing data about local environments to wearable technology apps, local authorities can help users derive greater benefit from the devices they wear. While it may be tempting for cities to develop their own apps in a race to be more tech-friendly than others, for consumers, more value would derive from being able to use apps across districts and cities. For this to be practical and economically feasible, authorities need to find ways to make datasets available seamlessly across districts, irrespective of differences in how the data is held or arranged within each authority.

For wearables that rely on internet connectivity, providing public Wi-Fi in recreation venues is key to supporting the technology and may also increase use of parks. Enabling communication between wearable technology and the Internet of Things in public spaces has potential for providing relevant information to passers-by, which could enrich recreational experiences and provide helpful location-specific information to visitors. Keeping such information relevant and fresh could mean partnering with other organisations, businesses and recreational groups.

30 Poole (2014), "Wearable Technology: What Implications for IP?", *WIPO Magazine*; No 3 June 2014 downloaded from http://www.wipo.int/wipo_magazine/en/2014/03/article_0002.html

5.6 Case studies

5.6.1 Wearable cameras

Cameras can not only provide evidence to resolve issues, but also they can help avoid them because people tend to modify their behaviour when someone is watching. This has been the experience of the UK Hampshire Police[31] who have made a decision to equip all their officers with the technology after having done a pilot of 500 cameras since 2013. They expect a reduction in complaints, building of greater trust, provision of evidence, higher conviction rates and improved overall conditions for staff.

Whakatane District Council parking staff have tested and now adopted three types of wearable cameras. They were motivated by the increasing number of incidents they had to report to the police. They say all three cameras had a positive effect on the way the public accepted their tickets. After hearing of the Whakatane experience, Western Bay of Plenty District Council has trialled a wearable camera for one of their parking staff for almost a year and reports similar changes in behaviour.

The next stage of maturity in using wearable cameras will be in knowing when and how much to use them.

A Whakatane District Council staff member with a wearable camera.

31 Body Worn Video Steering Group (2015)., "Hampshire Police Look To Roll Out 2300 Body Worn Video Cameras", downloaded from http://www.bwvsg.com/news/hampshire-look-roll-2300-body-worn-video-cameras/

6 AUGMENTED REALITY

Often associated with the realm of science fiction, augmented reality (AR) is a live direct or indirect view of a physical, real-world environment whose elements are augmented (or supplemented) by computer-generated sensory input such as sound, video, graphics or GPS data. As a result, the technology enhances one's current perception of reality.[32]

6.1 Technology

Augmentation is conventionally in real-time and in context with current environmental elements. With the help of advanced AR technology (e.g. adding computer vision and object recognition) the information about the surrounding real world of the user becomes interactive and digitally manipulatable while information about the environment and its objects can be overlaid on the real world.

How reality is augmented can be done in many ways. The voice tours often used in museums are a simple version of augmented reality insofar as viewing a display is augmented with information from a recorded history.

New technology takes this several steps further. Handheld devices, such as smartphones and tablets, can provide augmented reality but there are significant developments in the areas of eye glasses, contacts and heads-up displays (HUD). Special head-mounted systems can provide a fully immersive experience for users.

6.2 Opportunities

AR technology provides a wide variety of opportunities and applications for local government. These include, but are by no means limited to the following.

6.2.1 Landuse and transport planning

Using AR in planning allows the public to 'see' and understand how new developments will look and affect the surrounding area. A failure to understand, however unintentional, or realise the effects of urban changes often causes controversy for local government and developers. By overlaying the real world with digital information from the planning process AR software can create an accurate composite of the physical and virtual. So instead of wading through complex diagrams, proposals and planning applications, anyone can visit the site and, with the help of a smartphone, tablet or AR glasses, get a much more realistic impression of the proposed development.

Through AR devices urban landscapes can be enhanced with tags and 3D models indicating planning consents and building. For instance, using 3D modelling the effect of a new high-rise building can be demonstrated by showing the viewer how it might look in context with neighbouring buildings and how it might be enhanced with planting e.g. the effect of shade such as planting, or the effect building shadow will have on the surrounding area.

6.2.2 Emergency management

AR systems are already being used in emergency management situations. Smartphones and tablets can use overlays showing terrain, roading, location of social services and evacuation points and real-time updates to provide situational awareness of risks. For

32 Downloaded from http://en.wikipedia.org/wiki/Augmented_reality

example, AR might be used in conjunction with an application such as Google-glasses to show people the quickest route to safety in the event of a coming emergency (such as a flood or tsunami) or the quickest route in for first responders. Applications could be used to show likely paths for volcanic detritus (magma, mudslides etc) – it has already been used to show the predicted route of storms.

6.2.3 Education

AR can enhance a standard curriculum. Text, graphics, video and audio can be superimposed onto the students' real-time environment and AR can provide hands-on experiences through simulation (for example in rural fire). Existing materials could be enhanced with codes or markers, such as bar codes or QR codes, that, when scanned, produce additional information digitally rendered in a multimedia format. To give an example, AR could show how quickly a plant or animal pest might spread if left unchecked (a boon for those local authorities with residents sceptical or apathetic about pest control).

6.2.4 Asset management

The use of AR in asset management and planning offers considerable productivity and communications advantages.[33]

Rather than having to mentally visualise the location, depth and direction of underground assets (or dig them up) staff will be able to instantly see where they are, what their relationship is to the local surroundings and also what contextual information is available such as age and materials. This will save a lot of time but will also lower the risk of damaging the asset, or other localised services. Making the information publicly available will also minimise the risk of unintentional damage, especially if linked to wireless technology.

6.2.5 Regulatory and planning applications

AR can be used in conjunction with LIM and other property data, to show things such as how prone a property is to flooding or where the coast might be if sea levels rise. It can be used in conjunction with Resource Management Act (RMA) and building planning, to show how a new development "might look". There are already smartphone apps which can show the location of the Sun at any given date or time, allowing the user to see how much light or shade various parts of a house will get at different times of the year.[34]

6.2.6 Tourism

Simple forms of AR are already in use in places such as museums. These could easily be incorporated into other tourist facilities or attractions. For example AR could superimpose an historical view of an area over an existing landscape, direct people who are lost to a particular location or translate a road sign (even giving people an early warning of which lanes they need to be in).

33 See for example, *DirectionsMag* "Augmented Reality is a Disruptive Technology in Utility Asset Management", downloadable at http://www.directionsmag.com/articles/augmented-reality-a-disruptive-technology-in-utility-asset-management/411375

34 See for example, *The Guardian*, "Augmented Reality Adds a New Dimension tio Planning Decisions", downloadable at http://www.theguardian.com/local-government-network/2012/may/18/augmented-reality-planning-applications

6.3 Customer expectations

The full potential of AR technology is recognisable only if the technology is portable. The technology is of limited value if users have to go to a service centre to view a planning model. People can't generally carry a PC with them if they are trying to look for the quickest way out in an emergency. AR applications must be able to run easily on a handheld or wearable device.

As anyone who has missed a motorway exit by relying on GPS will tell you, AR technology must be accurate. The degree of accuracy may vary depending on the intended use. For example, an AR application designed to find underground assets would probably need to be accurate within a few centimetres to gain maximum value. In other cases, such as showing areas prone to coastal erosion or inundation, a failure to be accurate within a few metres could place a property at risk, and open up a local authority to legal action.

Generally speaking, accuracy of AR will depend both on the quality of input information – the factors that drive accuracy of the GPS system[35] – and the quality of the wireless network. Both of the above expectations will therefore be met if, and only if, there is sufficient connectivity in your district or region.

6.4 Implications and impacts

6.4.1 Enhanced engagement

AR applications in planning areas can provide the kind of accessible engaging information that a reliance on maps and text will simply not generate. Rather than slogging through a district plan and infrastructure strategy or asset plan, a developer can see straight away where their development is in relation to headworks or arterial routes.

It may be that AR applications become regarded as an essential part of the engagement toolbox; in some cases they may become 'supporting information' (in the legal sense) in their own right. Staff who can 'think visually' and communicate in pictures will find themselves well suited to engagement using AR as a tool.

6.4.2 Accessibility

The eventual widespread use of AR technology will add further to public demand for universal coverage of Wi-Fi or other means of wireless transmission of data. Without it, the potential of AR to enhance tourist experiences in the more remote areas will not be recognised. As less connected areas such as the West Coast lose to those areas that can reliably provide AR experiences, public pressure will come on local authorities to direct or support investment to upgrade for connectivity.

And the network must be available continually – otherwise a network outage might, for example, inhibit people's ability to find underground assets and pose a risk of unintentional damage to the assets, or worse, an accident. Mission-critical applications will need redundant systems as a back-up.

6.4.3 Security

Access to a secure wireless network and appropriate protocols for protecting data will be necessary. A large number of devices will be trying to connect to the public-facing AR applications.

35 Recent developments in the GPS network will ultimately make GPS accurate to within centimetres.

6.4.4 Privacy

AR technology can be used to store and present a mass of data in a particularly accessible way. Applications in some areas such as planning could compromise personal privacy. For example, AR makes it possible to look at a street photo or map and determine which houses are the subject of planning applications.

6.4.5 Safety

Like any information technology, AR carries personal safety risks through the repetitive nature of the tasks and the sedentary nature of some applications.

6.5 Potential strategies

Deloitte Australia has produced a useful document of interest for local authorities thinking about augmented reality.[36] While it is slanted towards central government the thought processes are similar for local government.

There will be few areas that 'need' AR – after all you've got along without it so far! Start by identifying those areas of your local authority which would benefit from real-time data for decision-making. For example, data from sensors might be used to construct predictive models of where congested spots are likely to exist and provide a stronger case for transport investment. Focus on those where real-time data will provide some measurable cost saving (and for that reason asset management applications may well be the early candidates).

AR is a technology that may come across as a bit 'buzzwordy' or even as 'toys for the staff to play with'. The place to start with AR technology is with the public-facing applications where the benefit is readily captured and easily explainable, e.g. linking AR to programs such as 'dial before you dig'. To give an example of what can happen otherwise, as this report was being finalised the authors saw the following in a press release from the Auckland Ratepayer Alliance:

"This is backdoor funding of business groups. Among the grants is one for 'augmented reality way finding technology' - whatever that is"[37] (note the heavy emphasis on the term augmented reality).

Local authorities are frequently criticised for their engagement. One early way for the sector to embed the technology in the public consciousness would be to strategically pick some upcoming engagement where AR will add value. The successes of those engagement processes can then be readily celebrated and publicised.

Local authorities would be advised, in the initial period, to be cautious about the use of technology in areas such as showing future sea-level rise or climatic risk. These remain controversial in some areas of the public consciousness, especially in the areas most directly affected.

Rural local authorities may need to work with their communities to identify 'dark spots' in the coverage of Wi-Fi and other transmission technology.

36 Deloitte Australia, "Augmented Government: Transforming Government Services through Augmented Reality", downloadable at http://www.google.co.nz/url?sa=t&rct=j&q=&esrc=s&frm=1&source=web&cd=2&cad=rja&uact=8&ved=0CCIQFjABahUKEwj8ysH76JDGAhVNgbwKHYnKAHU&url=http%3A%2F%2Fwww2.deloitte.com%2Fcontent%2Fdam%2FDeloitte%2Fnl%2FDocuments%2Fpublic-sector%2Fdeloitte-nl-ps-govlab-us-fed-augmented-government.pdf&ei=5k5-Vfy_Lc2C8gWJlYOoBw&usg=AFQjCNFYRbiHZYK28HPWE9uxdMqk5-7LaA&bvm=bv.95515949,d.dGY

37 Auckland Ratepayer Alliance, "Council Funds Augmented Reality and Business Groups", downloaded from www.scopp.co.nz on 20 April 2015.

6.6 Case studies

6.6.1 Urban planning and renewal

Christchurch City Council has used an AR engine developed by the University of Canterbury to publicly launch its plans for the redevelopment of the Christchurch central business district. The mobile application 'CCDU - 3D' enables a citizen to stand at street level, stream re-development plans and other spatial information to their mobile phone and superimpose the new design over the environment as it currently exists.[38]

6.6.2 Asset management

Wellington City Council has used a commercially available product, Augview, to locate and map the underground assets in its city.[39] The result is valuable information not only for the local authority's planning, but also for other users of the road corridor (such as energy and telecommunications companies). It is understood the council is also using AR technology to develop applications to enable visitors to find parks and reserves and public sculpture.

6.6.3 Oculus Rift – Air New Zealand

Oculus Rift is being used in countless imaginative new ways by all sorts of industries these days. One of these is Air New Zealand, using the virtual reality headset to launch a captivating exhibition of its past, present and future.

The airline wanted its 75th anniversary to be something extraordinarily special, and it obviously achieved that goal with this virtual reality tour of its history and future. The showcase presents a view of how the airline came into being as well as talking about the past carriers that have come before Air New Zealand, i.e. TEAL and NAC. After the history has been covered sufficiently, the exhibition moves on towards what the future could look like with an airline as dedicated as Air New Zealand.

Using the Oculus Rift virtual reality headset, the development and creative team at Air New Zealand shows interested fans a view of a futuristic cabin in the aircraft. The basic idea behind using the virtual reality headset was to make people think about how exciting it would be to travel while the environment around them changed to whatever scene they wanted, using this digital technology. Travelers could customise their surrounding area and set it to whatever pleased them the most. Talk about good client servicing!

This futuristic cabin, to show its diversity can also change into a scene straight from the forests of New Zealand, complete with its flora and fauna. Kereru, tui and moa can also be found in the virtual reality forest area. The Oculus Rift headset lets the user view the entire surrounding in 360 degrees, by just turning his or her head in the right direction. Besides this, two more locations have been added to the simulations: the cabin can also turn into a scene from a beach on Fiji and the last location is the waterfront in Shanghai, during a firework display arranged for the New Year. Jodi Williams, the head of global brand in Air New Zealand, was quoted as saying: "It was really important to leave a sense of momentum for the future and innovation. What would a future cabin look like? Our IT team has already started working with Oculus Rift on virtual reality so we put the two together."

38 See http://crcsi.com.au/research/4-5-urban-planning/4-52-using-ar-in-urban-design/
39 A short video presenting this can be seen at www.youtube.com/watch?

The whole exhibition was a collaborative effort between Air New Zealand and the Museum of New Zealand Te Papa Tongarewa. The exhibits inside the museum for the public were collected from all over the country. They included the propeller, drive shaft and motor from Kiwi aviation pioneer Richard Pearse's craft. Virtual Reality Times will keep following the progress on this project and report back with as many updates as possible.

7 ELECTRIC VEHICLES

7.1 Technology

At the turn of last century the dawn of the automobile era saw electric vehicles (EVs) in competition with steam power and the internal combustion engine (ICE) powered vehicles (ICEV).

There are fundamental differences between ICEVs and the EVs that have clearly distinguished the two technologies for the past 130 years.

In most respects electricity has a clear advantage over liquid fossil fuels for transport. In particular EVs are:

- more efficient than ICE equivalents and do not need as many ancillary systems to keep them going. The typical efficiency for an ICE converting liquid fossil fuels into rota-motion is 26 percent compared with the electric motor's efficiency of more than 90 percent.
- much simpler than ICE equivalents as there is only one moving part to an electric motor, the rotor. In contrast ICEs have many hundreds of moving parts to contain and transfer the radial explosive detonation
- more durable than an ICE – EVs do not generate heat to the same degree as an ICE, the EV engine is designed to suppress heat (and noise)
- more environmentally friendly – waste energy, in the form of loud sound, is muffled through an exhaust system often with the dual purpose of conveying waste combustion gases (carbon dioxide and water) and any gas contaminants from engine wear (oil residues, nitrous oxide, carbon monoxide etc) to the rear of the vehicle and to the atmosphere. They are better able to support and suit high population density and often congested urban areas or areas where the topography lends itself to the development of an inversion layer. This does not mean that the technology is emission free as the electricity must be generated somewhere, and when this is from fossil fuels, the emissions are concentrated at another location.

Electric motors have considerable advantages over comparable ICEs, however fuel storage is more problematic for EVs. Present battery technology is the primary factor limiting uptake.

It is the design (range of products), cost (economies of scale) and greater range that tips the balance in favour of ICE powered vehicles at present.

Last year the global registered number of EVs was 740,000,[40] double the 2012 number with 320,000 registered in 2014. Locally, 8525 hybrid and electric vehicles were registered in New Zealand[41].

In May 2015, the number of registered EVs increased to 551, showing an increase of nearly 200 percent in seven months. This is similar to the shift in fuel from petrol to diesel for light vehicles and passenger cars – in 2000, there were very few diesel cars and now there are about 220,000 or nearly 8.5 percent of the fleet. The regional breakdown reflects a concentration around regions with large metropolitan centres as evidenced in the following table:

40 http://www.alternativetorque.com/automotive/global-ev-registrations-reach-740000/
41 NZ Transport Agency Vehicle registration and licensing Palmerston North.

Council/ Unitary council area	Electric	Hybrid	Total EV plus hybrid	Registered passenger car/vans	Percent
Northland	42	210	252	106,941	0.23
Auckland	234	6382	6616	985,903	0.67
Waikato	40	828	868	307,181	0.28
Bay of Plenty	16	472	488	189,053	0.26
Gisborne	4	26	30	25,115	0.12
Taranaki	7	234	241	77,833	0.31
Manawatu-Wanganui	8	420	428	152,579	0.28
Hawke's Bay	11	252	263	100,134	0.26
Greater Wellington	67	1738	1805	291,696	0.62
Marlborough	4	82	86	31,568	0.27
Nelson -Tasman	16	145	161	69,805	0.23
West Coast	0	29	29	22,693	0.13
Canterbury	68	1019	1087	433,341	0.25
Otago	29	259	288	145,522	0.20
Southland	5	70	75	145,522	0.10
TOTAL	**551**	**12,166**	**12,717**	**3,011,752**	**0.42**

New Zealand is fortunate to have most of its electricity generated from renewable sources (80 percent), and it has the opportunity to enhance its 100 percent pure branding by becoming the world's pre-eminent EV nation using renewable fuel. As electricity storage technology improves, the advantages of electric vehicles (EVs) begin to outweigh, and are being seen as desirable replacements for, internal combustion engines both for efficiency and for emission reduction reasons. This may confer a competitive advantage to the community that invests to attract EVs. Transitioning to electricity as a motive fuel would also lead to cheaper running costs, allowing financial resources to be freed (privately and corporately) for other uses.

7.1.1 EVs and battery storage

In addition to the many positive reasons for converting to EVs, recent advances in battery technology (capability and cost) are at the heart of the renaissance in EV acceptability. The ability to store large and useful amounts of electricity compactly and safely for later use gives flexible charging options for EVs in the future. As most cars are used during the day and are garaged at night, a network of 1.5 million chargers ensures that each day the EV starts with a full 'tank' using cheaper 'off peak' electrical energy.

On a recent visit to New Zealand, Stanford University Professor Tony Seba predicted that the further falling cost of lithium-ion battery packs (having fallen 14 percent per annum

over the last 15 years) would mean that by 2030 all new mass market vehicles will be EVs with an average price of US$31,000 (NZ$41,000)[42].

7.1.2 Hybrid vehicles

Hybrid vehicles are powered by a regular ICE with auxiliary batteries which are charged by capturing energy when braking (using regenerative braking that converts kinetic energy into electricity). This energy is normally wasted in conventional vehicles and shed as heat. Hybrid vehicles typically offer between 25 and 40 percent better efficiency over ICE examples and are extensively used for high mileage fleet operations such as taxis.

While these vehicles have an electric motor and battery, they can't be plugged in and recharged from mains power. The batteries on a Hybrid vehicle are not designed to power the vehicle for an extended range; rather they act to reduce overall fuel consumption. This technology has been available in New Zealand for some time.

One new development is the potential for plug-in hybrid vehicles (PHEV). These have a battery with sufficient capacity to power the vehicle for the majority of urban trips. They confer the advantages of a true EV for a limited range, typically between 80-100km. This may not be a problem for urban commuters given that 90 percent of urban trips are less than 100km[43] in length.

7.1.3 Battery electric vehicles (Battery EV)

Battery electric vehicles are wholly powered by one or more electric motors with on-board batteries charged by plug-in mains power and topped up during use through regenerative braking.

The number of batteries is typically greater than the PHEV variants and this extends the driving range. No auxiliary ICE is installed so the weight saving can be used with more batteries without significant effect on vehicle performance.

These vehicles are limited to the availability of charging infrastructure and are highly suited to urban commuting. Examples are the Nissan Leaf and the Tesla range of cars and suburban utility vehicles (SUVs).

7.1.4 Fuel cell powered EVs

These are electric vehicles with the electricity able to be developed in-situ to charge an on-board battery and feed an electric motor directly. In low load situations the electricity powers the motor and in high load (e.g. overtaking situations) the motor is augmented with electricity from the high voltage battery. Like electric motors and the ICE, fuel cell technology has been around for well over 100 years. However, the technology came into its own during the NASA manned space programme.[44] The World Economic Forum has recently rated hydrogen-based fuel cells as one of its top 10 emergent technologies.[45]

This process eliminates the long charging times associated with EVs. The limitations for Fuel Cell EVs are the current lack of (and expense of) fuel generation and refuelling facilities, although they could be deployed at traditional petrol stations.

42 *NZ Herald* Monday 06 April 2015
43 http://www.eeca.govt.nz/deploying-electric-vehicles
44 Fuel cells provided power for the space craft and water for the astronauts
45 World Economic Forum (2015), "The Top Ten Emerging Technologies of 2015", page 4.

7.2 Opportunities

There are many benefits following conversion to electric vehicles. The most obvious direct benefit for local authorities is as a buyer. The cheaper the price is per kilometre travelled, followed closely by the lack of local polluting and climate altering emissions.

EVs typically have much lower sound and exhaust emissions, which makes them a suitable vehicle for use in high density population areas. Mass adoption of EV technology means less need for mitigation measures in and around the road corridors (such as setback areas). At present EVs have a relatively limited range which makes them an ideal vehicle for relatively short commutes and further encourages high density development. Over time though, improvements in battery life and wider availability of support infrastructure (such as charging stations) may see some of these benefits reduced in future.[46]

This is supported in the New Zealand context by the ability to source electricity from renewable sources, either grid based or locally generated. This opportunity removes the strategic implications of sourcing portable transport fuels from unstable parts of the world and from areas where the costs of extracting oil is financially high and environmentally risky.

Converting a significant proportion of the national fleet to electricity would help meet the country's unconditional greenhouse gas target of 5 percent below 1990 levels by 2020[47]. Currently the transport sector is the largest growing contributor of greenhouse gases (CO_2) in New Zealand, with an increase of 60 percent above 1990 levels, and a projected increase of 100 percent from a little over 8000kt CO_2-e to 16,000kt CO_2-e by 2030[48].

Expanding the country's EV fleet has been recently seen by Transport Minister Simon Bridges as an option for:

> *"quickly reducing New Zealand's carbon footprint. Around 20 percent of New Zealand's carbon emissions came from transport, and 60 percent of all transport energy consumption came from light passenger vehicles".*[49]

7.3 Customer expectations

Owners of EVs can expect that they will have the clean hassle-free motoring that the technology promises and will not need to pay for the consumables and tune-ups demanded on an ICE and associated ancillary equipment.

Owners could also expect that EV technologies will be cheaper to run than traditional vehicles and this is supported by evidence from Nissan[50]. Nissan has released the results of a five-year study showing that 99.9 percent of its EV battery packs are performing according to warranty, operating at over 80 percent capacity after five years. UK insurance specialist Warranty Direct says this finding means the Nissan Leaf drive train is 25 times more reliable than the internal combustion engine.

Some recognition from authorities and rewards for early uptake such as convenience of parking, use of bus lanes etc may be expected by some owners.

46 For example, we are aware that some of the larger shopping centres in Auckland have put in, or are putting in charging stations.
47 https://www.climatechange.govt.nz/reducing-our-emissions/targets.html
48 Page 33. Ministry of Transport: Briefing to Incoming Associate Minister of Transport January 2013.
49 http://www.nzherald.co.nz/business/news/article.cfm?c_id=3&objectid=11412263
50 http://www.alternativetorque.com/automotive/nissan-leaf-drivetrain-25-times-more-reliable-than-conventional-cars/

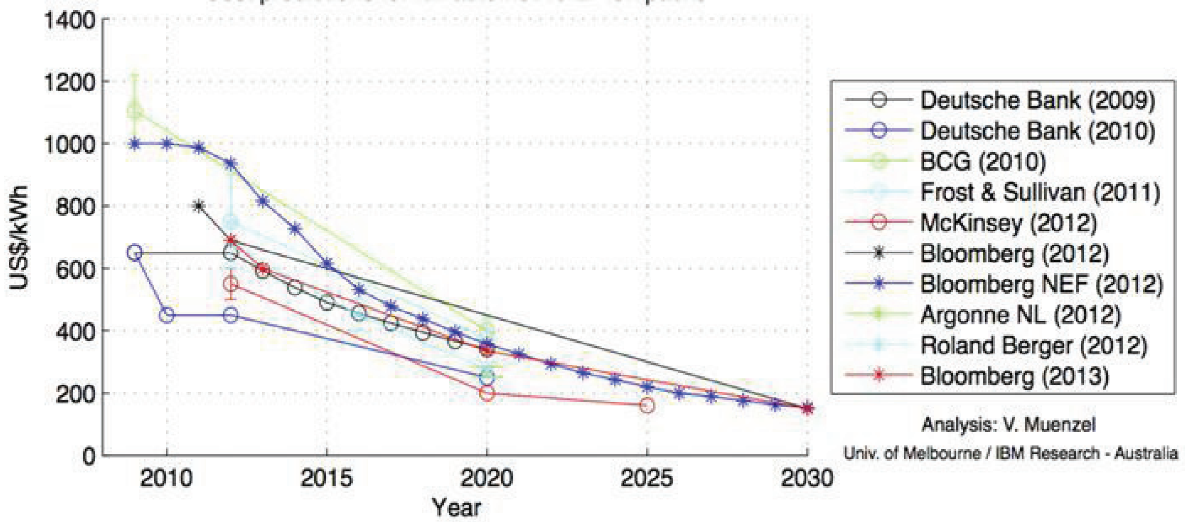
Most buyers will be aware of the use they intend for their EV and will expect to be able to charge their car when stationary at home on low tariff electricity, as well as at conveniently dispersed public charging stations.

7.4 Impacts and implications

The greatest limitation on EV adoption has historically been the high price and limited storage (range) of batteries.

Advances in battery storage technologies leading to an anticipated lowering of costs[51] of electric vehicles means they will be more affordable (batteries account for 25 percent of the cost of a Tesla S) and will be able to travel further – two aspects that will drive uptake.

Cost predictions for full automotive Li–ion packs[52]



The wider implications of EVs are largely positive to society and implications to the local government sector depend on the initiatives taken to support adoption and advance uptake. For instance, the costs and implications of incentives such as preferential parking can be decided by the authority and are therefore predictable and controllable, as opposed to implications (such as cost and range constraints) that come embedded with the technology.

Not all fleet and personal transport requirements can be met by EV technology, and chosen vehicles must be fit for purpose. It is interesting to note that although Mighty River Power has embarked on a fleet conversion to EVs (see section 7.6 Case study) it has identified a 70 percent conversion as possible with current EV and PHEV options.

7.5 Potential strategies

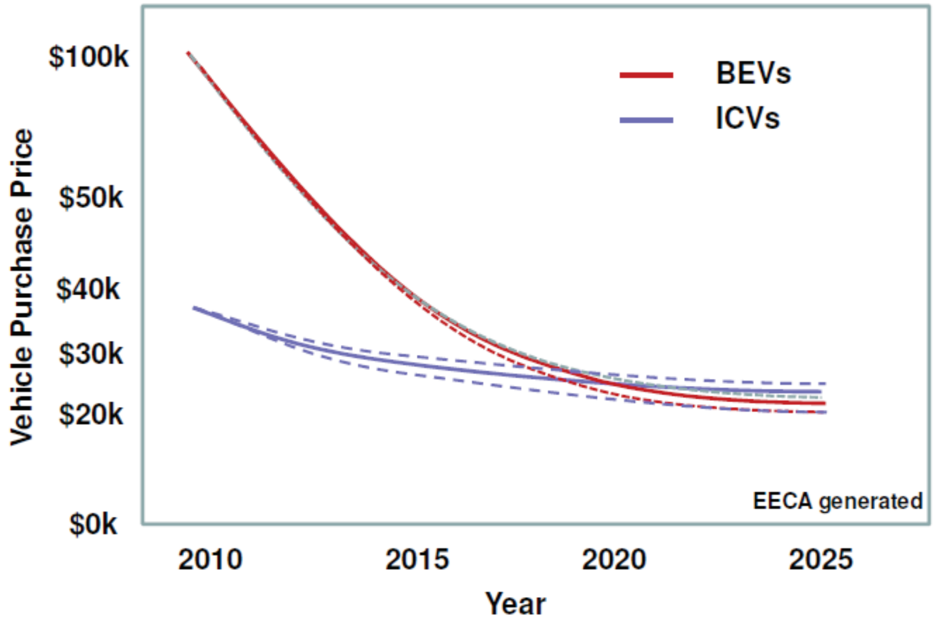
There are a range of sound practical business reasons as well as branding opportunities are available to councils for fleet conversion to electricity, and to implement strategies that support uptake of the technology by businesses and private citizens. The unseen pay-off is the opportunity to attract talent in the form of businesses who find it easier to attain their own high environmental performance goals in a locality that supports low emission transport. Such actions also recognise and support early adopters of the technology. Opportunities fall into the following categories.

51 http://theconversation.com/affordable-batteries-for-green-energy-are-closer-than-we-think-28772
52 *Carbon News* 20 April 2015 : http://www.carbon news.co.nz/story.asp?storyID+8610&src+newsletter

7.5.1 Economic and financial

The nascent technology for small, light high-capacity battery storage, and its current place on the development/cost curve, suggests a positive reduction for the future cost of EVs. The Energy Efficiency and Conservation Authority (EECA)[53] projects an intersection with ICE costs by 2020 and EVs becoming cheaper after that.

Actual and projected reduction in capital cost of EV vs ICE



Source: EECA

Currently EVs are exempt from New Zealand road use charges, and at the time of writing, this is the only additional incentive to assist adoption. Uptake in other jurisdictions has been assisted by: purchase subsidies, tax reductions, exemptions from tolls, parking fee exemptions and free vehicle charging.

A combination of these incentives has been extremely successful in Norway with 50,000 electric car registrations, almost three years earlier than expected. This means that 20 percent of all new cars sold in Norway have been electric so far this year, and Norway, with just 5.1 million people, accounted for a third of all European battery powered car sales last year[54].

The prospect of subsidies and tax cuts over and above the current exemption from road user charges, while not realistic in New Zealand, may not hinder EV uptake, given the reducing costs of the technology.

7.5.2 Other incentives

While the running costs compare very favourably with ICE powered vehicles, uptake can be further enhanced by increasing the convenience for users. Councils can help users of electric vehicles by providing preferential parking close to stores and public amenities and by providing rapid charging locations. This can be achieved through signage as is already

53 "Taking Charge of Fleet Purchase decisions – the role of electric vehicles: PPT" Andrew Campbell Transport Development manager May 2015
54 http://planetark.org/wen/73085

provided for mobility card holding drivers. This would only be relevant for public streets as private car-parks (supermarkets, businesses, schools, malls etc) can already provide for such convenience.

Another convenience could be the ability for EVs to use dedicated traffic lanes such as those currently reserved for buses. This would reinforce the financial advantage of using cheaper off-peak electricity by factoring in the benefit of avoided commuter time.

The cost of fleet conversions could be reduced by councils working collectively to settle on a standard vehicle mix and pooling purchases to benefit from economies of scale. Procurement opportunities would be enhanced with a whole-of-government approach that included central government's vehicle needs. This would also provide sufficient quantity to make it economical for importers and suppliers.

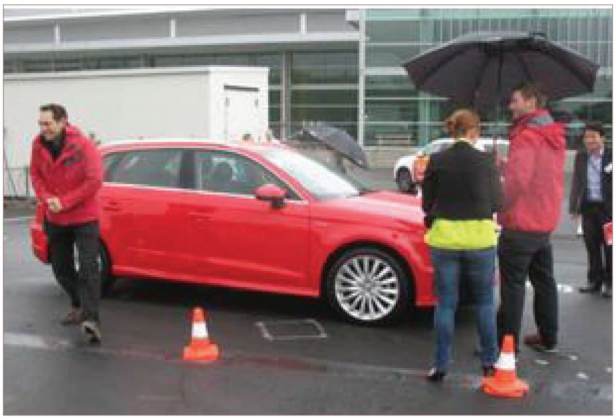
Commercial fleet applications are the usual way new technologies and newer vehicles are introduced into the New Zealand vehicle fleet. Many New Zealanders buy cars after the first few years' depreciation when there is still useable life in the vehicle. In such situations, fleet use by local government could accelerate this process.

A recent speech by Napier MP and Labour Energy spokesperson Stuart Nash[55] stated that as the Government is the biggest car buyer, the Prime Minister and all civil servants should use electric cars unless there was a reason not to. A strong second-hand market would then be created, making them more affordable for everyone.

Councils could take a leadership role in educating potential new owners by providing information and access to new EVs – such as with drive days – by putting fleet managers, CFOs and CEOs in touch with industry leaders, early adopters and providing the opportunity to try out the increasing variety and new models.

Fleet sponsorship of Drive day at Auckland Showgrounds April 2015

55 http://driveelectric.org.nz/electric-car-solar-panel-policies-pushed-by-nash/



BMW i3 City car PHEV

Driving Audi e tron PHEV

In March 2015 the Electricity Networks Association (ENA) recognised that New Zealand was EV ready and announced an initiative that could see New Zealand become one of the first countries in the world to have a complete network of charging locations for plug-in electric vehicles covering the length of the country. The initiative is called the *Renewables Highway*. The ENA working group comprises representatives from lines companies along with Contact Energy, Mighty River Power and Drive Electric[56].

An opportunity exists for local government to work with the ENA and relevant central government agencies such as the Energy Efficiency and Conservation Authority (EECA), and seek alignment with any wider government policy development in this area.

Local government could also be involved in development of EV-specific branding for information such as charging locations. These may also link to mobile apps and maps including identification of relevant EV-related convenience opportunities and charging sites for on-board navigation systems.

At the time of writing, the Drive Electric website[57] identifies 56 charging stations around the country with most public chargers in the northern North Island . In addition to these facilities, businesses converting their fleets to electricity have installed their own chargers for this purpose.

56 www.driveelectric.org.nz
57 http://driveelectric.org.nz/chargers-map/

Local governments may need to consider the implications of providing the appropriate infrastructure to support such a transition, including smart and possibly rapid charging facilities linked to public amenities where patrons are likely to spend a couple of hours or more, such as swimming pools, malls, libraries, sports facilities etc.

ABOVE: Nissan Leaf charging stations under solar PV shelter: Google Mountain View, Ca.

LEFT: Mercury energy's corporate parking/charging, Auckland.

The ability to charge public transport vehicles indirectly through induction charging may also possible in the future as charging can occur at intersections and bus stops or special parking stations automatically, as soon as the charger senses and identifies the vehicle requesting the service.

7.5.3 Regulatory

It is doubtful if there are many regulatory barriers (or any at all) that would prevent the large scale uptake of EVs in New Zealand. Local government could support efforts to lower the costs of owning EVs by supporting central government action, should it be of a mind to reduce tax on EVs or extend the 2020 exemption from road user charges.

Recent announcements by Transport Minister Simon Bridges[58] positively encouraging uptake of EVs cited New Zealand as:

"the most electric vehicle-ready country in the world" and along with ruling out subsidies for EV users and manufacturers, he has asked the Ministry of Transport to investigate options to "nudge New Zealand in the direction of higher EV pickup".

Central government can assist the uptake of EVs by setting minimum fuel emissions standards for imported vehicles. This would not only help the nation meet its intended nationally determined contributions but, in the process, favour EV technology as zero emission second-hand vehicles. This is not an option for individual councils but it may be an area where concerted advocacy may be effective.

58 http://www.nzherald.co.nz/business/news/article.cfm?c_id=3&objectid=11412263

7.6 Case studies

7.6.1 Wellsford Library – Public charging facility

Auckland Council has installed 115 solar PV panels on the roof of the Wellsford Library which opened on 22 June 2014[59]. During the day, the panels produce more electricity than the library uses and becomes an electricity exporter. EV charging at this time is essentially free and the public is not charged. At other times the cost is met by the council, however, this has not been an issue during the trial period as, on a monthly basis, generation has exceeded use and the facility is a net exporter of electricity.

Auckland Council's Wellsford library showing 29Kw solar PV array and insert of charging station.

7.6.2 Mighty River Power fleet conversion to EV and PHEV

The following extract provides the business case considered by Mighty River Power for the staged conversion of 70 percent of its vehicle fleet by 2018.

59 http://www.aucklandlibraries.govt.nz/EN/News/NewsArticles/pages/welcometowellsfordmemoriallibrary.aspx

MIGHTY RIVER POWER
BUSINESS CASE FOR EV/PHEVS

With an increasing number of EV/PHEV models in the New Zealand market, Mighty River Power saw an opportunity in 2014 to make greater use of New Zealand's clean, home-grown electricity as a transport fuel for our fleet.

While the concept is a great fit for an electricity company with a focus on renewable generation, we wanted to first thoroughly assess whether there was a sound business case for plug-in vehicles. Important considerations were the choice of vehicles, charging, purchase/lease and running costs along with the sustainability of the decision.

Mighty River Power saw an opportunity in 2014 to make **greater use of our clean, home-grown electricity** as a transport fuel for our fleet.

Vehicle choice

There are already a variety of plug-in vehicles in New Zealand to suit different needs, from smaller vehicles to full-sized SUVs. The selection of plug-in vehicles in the country is expected to grow over time.

Type of vehicle	Economy	Emissions	Range
Full Electric (BEV)	5/5	5/5	2/5
Range Extender (REx)	4/5	4/5	4/5
Plug-in Hybrid (PHEV)	3/5	3/5	5/5
Internal combustion (ICE)	1/5	1/5	5/5

Charging

Charging up can be as simple as plugging into a 3-pin plug. There are a range of charging options available for homes and work-sites and these vary depending on needs and budget.

Type	Charge per hour (km)	Estimated Installation Cost
3-pin plug 2kW	10	n/a
15A plug 2.5kW	15	$200
Standard charger 3-7kW	16–32	$1,500 - $3,000
Fast charger 22kW	96	$15,000 - $25,000
Rapid Charger 50kW+	200+	$30,000 - $50,000

Financials

Key financial considerations are the purchase or lease costs along with running and maintenance. It was important to consider the current higher capital/leasing costs for EV/PHEVs against potential longer-term savings in running and maintenance costs.

The payback for a Nissan LEAF compared to its petrol equivalent is just one year at current prices on a 30,000km distance.

Fuel, Maintenance and Road User Charges (RUC)

Fuel savings:

As a transport fuel, electricity costs the equivalent of 26¢ per litre according to EECA, compared with petrol at more than $2 per litre.

Drive a Nissan LEAF from Auckland to our Hamilton office at a cost of $3 on electricity, compared with $17.20 for a similar sized car on petrol.

Lower maintenance costs:

There are fewer moving parts to maintain in plug-in vehicles.

Nissan estimates their LEAF costs 40% less to maintain than comparable internal combustion engine vehicles.

No Road User Charges (RUC):

All plug-in vehicles (full electric and plug-in hybrids) are currently exempt from RUC until 2020.

Savings in Road User Charges are about $586 per year for the average travel distance of 12,200km.

Lease costs and Fringe Benefit Tax

Higher Lease Costs:

Lease companies allocate lower residual values to plug-in vehicles meaning lease costs can be slightly higher for plug-in vehicles. This is expected to become less significant as the second-hand market for plug-in vehicles develops, the cost of plug-in vehicles continues to decrease and there is more certainty around residual values.

Higher Fringe Benefit Tax (FBT):

Because FBT is based on the cost of the vehicle it can be higher for plug-in vehicles which have a higher purchase cost. However, it only applies to cars for personal use and would be expected to become less significant as the cost of plug-in vehicles decreases.

With regard to Mighty River Power's fleet (predominately leased) the focus was on company leasing costs. The comparisons below were used for the two most common models in the fleet, the Nissan LEAF and Mitsubishi Outlander:




	Mondeo Diesel	Nissan Leaf	Santa Fe Diesel	Outlander PHEV
Lease costs (including tyres and maintenance)	$9,500	$5,400	$11,100	$11,700
Fuel	$2,000	$800	$2,600	$2,300
Road user charges	$1,700	0	$1,700	0
Annual Cost	**$13,200**	**$6,200**	**$15,400**	**$14,000**

Based on estimated Mighty River Power fleet costs and average fleet distance of 30,000 km/yr.

Sustainability

Plug-in vehicles can significantly reduce your company's, and New Zealand's, carbon emissions thanks to the use of renewable electricity from hydro, geothermal and wind. Every electric vehicle on the road, powered by 80% renewables, would take more than two tonnes of carbon out of our environment.

Based on the average travel distance of 12,200km/yr, there is a clear advantage in terms of carbon emissions for plug-in vehicles

Type of vehicle	CO_2e
Full Electric	0.3 tonnes/yr
Plug-in Hybrid	1.2 tonnes/yr
Internal combustion	2.8 tonnes/yr

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8 RENEWABLE ELECTRICITY AND DISTRIBUTED GENERATION

8.1 Technology

This section addresses the changes that are expected to revolutionise the supply of electricity to power new and emerging technologies. Electricity carries energy that can be transmitted through wires and stored in batteries. The term renewable electricity refers to electricity generated from renewable sources.

Energy is contained in many natural resources and must be either used at source (e.g. process heat from geothermal systems, water wheels for milling) or be converted to a form to be transmitted to where it can provide services.

There are losses when energy is converted from one form to another and with the transmission of electricity through wires. Efficiency can be improved and losses reduced with technology and generation close to the point of use. New Zealand population centres (and hence demand) tend to have developed around harbours, while the natural resources containing energy are often many hundreds of kilometres away.

In 2006 -2007 the Energy Efficiency and Conservation Authority (EECA) commissioned consultants Sinclair Knight Mertz (SKM)[60] to provide a first order magnitude resource potential of renewable energy region-by-region. The assessments were designed to help councils identify what renewable energy resources they had in their area, and how to integrate this information into their planning and strategy processes.

Natural resources that are considered renewable include:

- hydro electricity;
- wind, the kinetic movement of air molecules from areas of high to low pressure;
- solar, photovoltaic and passive;
- biomass, the chemical storage of energy in molecular bonds from the process of photosynthesis; and
- marine, the kinetic rotational motion of water molecules in response to wind.

A recent survey of consented but unbuilt electricity generation highlighted the efforts generation companies have gone to secure favourable sites, particularly for wind generation. A return to economic growth following the 2008 Global Financial Crisis has not translated into growth for electricity, which remains flat. This can be interpreted as a sign that the country is using energy and electricity more efficiently and that a decoupling is occurring between the economy and energy use.

In mid 2014 there was 4443MW consented but unconstructed generation with 81 percent of that being from renewable sources. At the same time there is uncertainty about the future of one of the largest users of power, the Tiwai aluminium smelter. If the smelter closed, about 800MW capacity would be released onto the market.

Generally, renewable energy is managed by local authorities under the *RMA* and the National Policy Statement on Renewable Electricity, either directly by allocating the resource through regional plans (water, geothermal and coastal space) or by managing the effects through district plans for wind. Some solar installations may be managed through the *Building Act*.

60 http://www.eeca.govt.nz/central-and-local-government/local-government/renewable-energy-planning-resources

8.1.1 Geothermal

New Zealand lies on the 'Pacific Ring of Fire'. The geothermal resource lies along the subduction zone directly below the North Island's volcanic plateau.

Geothermal energy has been a feature of New Zealand generation since 1958. It contributes 15 percent of New Zealand's electricity. Currently there is 709MW of installed generation, with 95 percent of that in the Taupo volcanic zone. A further 279MW is consented but unbuilt, also in the Taupo area.

Geothermal energy is available all the time, contributing as base load generation. As with all renewable sources of energy, the fuel is free; however, the technology to convert the energy into electricity is specialised and very expensive. A production well for a geothermal power station costs about $3m per kilometre. Most stations have multiple wells many kilometres deep; all stations require reinjection wells and ancillary equipment before the generating plant is factored into the cost.

8.1.2 Hydroelectricity

Hydroelectric generation captures the kinetic energy of falling water to generate electricity.

The need for falling water limits the location of hydro stations to areas where topography creates a difference between the water level above and the turbines below. Generally a dam is required to provide the head of water and to smooth out hydrological fluctuations. That is to take advantage of the ability to start quickly and adjust to fluctuations in electricity demand. It also means the fuel (water) can be stored behind the dam so there is less likelihood of intermittent supply.

Regional councils are responsible for the allocation of water for hydroelectric generation through relevant regional plans and are subject to the requirements of the National Policy Statement for Freshwater Management 2014.

Hydro generation is a mature technology in New Zealand with more than 5000MW installed and 55 percent of electricity coming from hydro generation, mostly from the South Island. The construction of dams and generating infrastructure typically shares the project characteristics of high upfront costs. In the case of hydro generation, the footprint is large with a shift from a river to a lake environment, often with associated population dislocation.

8.1.3 Wind

Wind turbines take kinetic energy from the wind and convert it to electricity. New Zealand has a world-class wind resource that requires heavy duty machines for durability. As with any form of energy driven by a meteorological system, the energy produced is intermittent.

Turbine blades can be scaled with the larger utility versions typically generating between two and five megawatts. Wind turbines are often grouped into arrays colloquially referred to as 'farms'. The output from wind generation is intermittent in that there are very few places where the wind is blowing all the time. This contrasts with the generation characteristics of hydro power.

Air pressure is not a natural resource per se and therefore not consentable. It is managed predominantly by territorial councils as an effect of the use of land (RMA section 31) which includes noise and landscape, and potentially biodiversity matters. Regional councils have the role of the strategic integration of infrastructure with land use through the mandatory Regional Policy Statement.

8.1.4 Marine

Marine energy comes in two forms. Wave energy is created by wind blowing over the sea surface and through friction transferring energy to waves. Emerging technologies to convert waves to electricity are being trialed internationally. There are no current proposals for the large-scale deployment of wave conversion devices in New Zealand. However, trial devices have been deployed to test designs and the New Zealand wave environment in Wellington Harbour, Banks Peninsula and offshore from Waitara.

Tidal currents (astronomical) are the result of gravitational differences between the Moon, Earth and Sun and are highly predictable, as they follow a regular cycle. Crest Energy has a 201MW project consented but unbuilt at the entrance to Kaipara Harbour. Cook Strait is another prospective area. The marine environment is very harsh on machinery, being wet and corrosive to metals and expensive to operate in. Although predictable, it is unlikely to become a major generation source for New Zealand in the medium future.

Both forms of marine energy by definition relate to area and effects in the Coastal Marine Area and are managed by regional councils.

8.1.5 Biomass/Woody residues

Biomass already makes a major contribution to the nation's primary energy needs[61], and there is also potential for co-generation (generating electricity using heat from industrial processes). Genesis Energy runs a 40MW station at the Oji Pulp Mill at Kinleith.

An estimated 12 percent of forestry biomass is currently discarded as waste and as much as 50 percent of logs processed at sawmills results in residues (bark and sawdust) that can provide fuel for electricity generation.

Most of the North Island plantation forests are co-located with the geothermal systems in the volcanic plateau and in Northland. The opportunity exists for substitution of woody biomass as primary heat and to use geothermal energy for this (a more efficient use than conversion to electricity) while at the same time using the wood residues to form feedstock for bio-fuels and organic plastics manufacturing.

8.1.6 Solar (Photovoltaic)

Solar PV (photovoltaic) is the generation of electricity from sunlight. Direct sunlight is not required as electricity can still be generated on a cloudy day. Panels can be roof-mounted or on special-purpose frames, and the electricity used, stored or transmitted is connected to the grid.

With the reducing costs of distributed electricity generation, particularly solar, it may be that communities that depend on grid-supplied electricity become disadvantaged because they have to pay for the maintenance of a high capacity grid delivery system for fewer users. New technologies may also be useful to provide services. As electricity generation and storage becomes cheaper, large scale electricity generation facilities may be better used to separate hydrogen for industrial and other transport uses.

8.1.7 Changing battery technology and the advent of distributed storage

The ability to store energy takes the intermittency out of renewable energy sources such as solar PV and to a lesser extent wind. Storage has traditionally been used to smooth generation and to match demand by:

- pumping water up penstocks in the reverse direction during off-peak times to use it again to generate electricity during peak times when prices are higher;[62]
- heating reservoirs of molten salt during the day to be used as a heat source to drive steam turbine generators during the day and at night or in the early morning peak demand;[63]

61 http://www.eeca.govt.nz/efficient-and-renewable-energy/renewable-energy/bioenergy
62 Tumut 3 Power Station as part of the Snowy Mountains Scheme, NSW Australia
63 Solana 280Mw Power station, Phoenix, Arizona, USA

- chemical storage, using electrolysis from renewable sources to separate hydrogen and oxygen to produce hydrogen fuel in compressed form for fuel cells for either EV or domestic use;
- direct storage of electricity using a battery of rechargeable cells. These are becoming increasingly cheaper with time (see chapter 7.1.2 EVs and battery storage) and are being developed by Tesla industries for domestic and commercial application. The Tesla Powerwall is being promoted as a realistic option to displace coal, oil and gas-fired generation worldwide.

A Tesla Powerwall (sourced from Wikipedia with permission from Tesla Motors)

Advances in this latter technology have disruptive potential. They make storage at dispersed or distributed locations viable (while noting that distributed generation is currently possible, though dependent on either the weather or the consumption of fossil fuels).

In effect, the grid could become used in a similar manner to the internet where people are able to upload and download energy from anywhere. The Tesla Powerwall battery pack is an example of the storage technology that could revolutionise solar powered distributed generation. Even without distributed generation, the idea of buying electricity during cheaper off-peak times to top up a house battery for use during the peak times has appeal.

New Zealand is beginning to adapt to this technology. Vector has been working to increase the take-up of solar PV on its network and has joined with Tesla in a partnership to provide Powerwall technology to deliver real network benefits to Vector and its customers. Chairman Michael Stiassny recently said that the energy sector has been preparing itself for this disruptive technology and that customers are at the forefront of wanting choices in the way they produce, use and manage their energy, and Vector will be providing that choice.[64]

64 *Energy News*: "Vector eyes Tesla battery offering", Gavin Evans, 5 May 2015.

8.2 Opportunities

As with EVs, the main direct benefit for local authorities from distributed generation and storage is as a consumer of energy, especially if local authorities invest in the technology to capture energy onsite. For example, Palmerston North has installed solar panels on the roof of its main council building.

The main implications for local government lie in the second order impacts. One of the often cited advantages of renewable energy is the reduced carbon footprint over conventional fossil fuels. In New Zealand this is important as the national carbon emissions are trending at 21 percent above 1990 levels. This compares to a -5 percent commitment by 2020. The expectation for following years is likely to be a more ambitious target and, as a consequence, it will be important to consider the source of climate affecting emissions. In New Zealand's case, the fastest increase is from transport and agricultural sources. The latter is something that is problematic to deal with at present but something can be done to reduce transport emissions – conversion of the domestic light vehicle fleet to electricity. This has already been covered in chapter 7 of this report.

Indigenous supply of electricity from renewable sources has distinct geo-political advantages as the supply is not subject to provision from politically unstable or dangerous places and immune from supply disruption either through embargo, transport choke points or price fluctuations.

The current location of renewable electricity generation sites reflects the asymmetric distribution of the resources themselves. These need to be connected and in New Zealand they are through a recently upgraded national grid that some now consider to be over-built for future needs. The bottom line is that there is already a national system to link supply (generation sites) with areas of demand (e.g. Auckland). This is a good situation as one of the most positive attributes of a grid is that everything is connected.

8.3 Customer expectations

Citizens recognise the convenience and low emissions benefits of renewable electricity, and also note the increasing cost of energy. As a result there is an expectation that if they become more efficient that this will be rewarded through lower costs. Unfortunately this may not be the case, with the proportion of transmission and distribution costs masking any economies made.

As costs come down, the expectation from users will be for storage options to come standard with solar installations, as well as retaining grid connections. This will allow flexibility about whether to store or export generation and when to buy electricity. It will also add an element of continuity for areas at risk of supply disruptions. For rural areas with overhead supply lines this is already an issue due to damage from traffic incidents and trees falling on lines during storms. This latter outcome is projected to increase as the effects of climate change are expressed more as severe weather events.

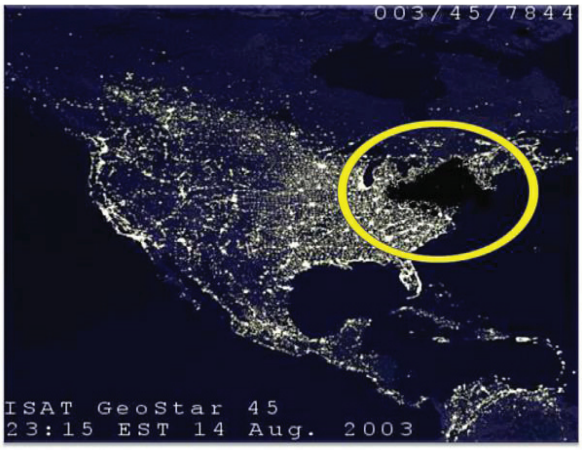
The real disruption will come once generation and storage capacity have been amortised and some owners may wish to go off-grid. In such circumstances those who have not invested in solar collectors and rely on grid systems supplied by utilities will be paying a lot more for their electricity, so it could exacerbate the divide between the haves and the have-nots.

8.4 Impacts and implications

All conversions of energy from renewable sources to electricity have environmental effects to some extent. Possibly the most obvious is that the natural resources that contain energy in its

various forms are not evenly spread around the country (with the possible exception of solar, but then the amount of sunlight varies with latitude and with prevailing weather).

Utility scale renewable generation infrastructure needs a grid to connect to the place to service them. This can be very positive as it allows electricity to be moved around the country to areas where and when it is needed. The 'just in time' provision of electricity through a grid system is analogous to the iCloud for data.



As mentioned in the previous section a transmission system is needed to connect dispersed areas of generation with areas of demand. In New Zealand this is a positive situation, with everything being connected. However, the single biggest risk of a grid system is also that everything is connected, as can be seen in the accompanying picture from space of the 2003 north-eastern North America power cut which left 48 million people without power[65].

The reducing cost of battery storage will put pressure on the grid-connected supply chain, as the need to pay for recently ungraded transmission lines eats into the cost of supply.

The positive aspects of distributed generation from solar panels can insulate consumers from price rises and to unintentional disconnections that may be geographically some distance from the effect. However, there are downsides to on-site generation as domestic and commercial systems operate at lethal voltages and this poses health and safety issues. This was highlighted in the Queensland (Australia) floods of 2011. State policy requiring a percentage of electricity supplied to households and businesses to be from renewable sources had led to an expansion of solar PV panels across existing and new housing stock. This included homes that were built in low lying areas that became floodways and were inundated in 2011. People became stranded and families were observed[66] escaping from the floodwaters onto house roofs. Unfortunately for those with solar PV installations which generate electricity as long as there is light, the risk and incidence of electric shock was high.

Local government has a role to assist the uptake of solar PV distributed generation for those that wish to by protecting citizens' access to sunlight, and preventing unnecessary shading of individual properties. This may, at times, be incompatible with the push for compact cities and the increase in multi-storey apartment blocks. Innovation with the design and location of solar PV panels may be required in such circumstances.

8.5 Potential strategies

Local government, through collective procurements, could buy solar panels for installation on public structures or for citizens to install on private houses to be paid back with rates – possibly as a lien on the property linked to an individual rate as opposed to the individual? The use of innovative procurement and potential lease arrangements could advance adoption of new renewable generation and storage options.

65 http://blog.cheaperthan dirt.com/survive-summer-power-outage/
66 http://www.remotesolarisolator.co.nz/news/rsi-solar-safety-switch-for-your-roof

The development of renewable electricity generation infrastructure could be enhanced through a positive regulatory environment. Rather than require all developments to go through a common regulatory process, policies and rules that make it easy to site generation and transmission infrastructure in areas where adverse environmental effects are reduced and difficult where they are pronounced could steer development in a sustainable direction.

Innovative leasing arrangements to help citizens install solar PV and storage options may also be used to kick-start uptake of new technologies.

Councils could become significant generators of electricity and demonstrate savings to their respective communities by installing solar PV panels on public infrastructure such as building roofs, and those of ancillary structures. Transparent publication of energy ($) saved is a vital part of such a strategy.

ABOVE LEFT: Palmerston North City Council Civic Admin Building generates power from solar panels on roof. ABOVE RIGHT: Incorporating solar panels into public infrastructure in San José, California.

8.6 Case studies

8.6.1 Auckland Council – low carbon future

The Low Carbon Auckland[67] project identifies a 30-year pathway and a 10-year plan of action to transform Auckland towards a greener, more prosperous, liveable, low carbon city, powered by efficient, affordable, clean energy and using resources sustainably. It sets clear unambiguous objectives to guide the Auckland Council's policy design and corporate actions as well as influencing the development and purchasing decisions of policies to incentivise.

8.6.2 Waikato Regional Council Regional Energy Strategy

Local government, particularly regional councils, have roles and responsibilities under the *Resource Management Act* to allocate often scarce renewable resources that contain energy. Examples include water for hydro-electric generation, geothermal energy and sites for conversion of wind and marine energy into electricity.

67 http://www.aucklandcouncil.govt.nz/EN/planspoliciesprojects/plansstrategies/theaucklandplan/Documents/lowcarbonauckactionplanfullversion.pdf

The recently reviewed second generation Waikato Regional Policy Statement[68] incorporates recommendations from the Waikato Energy Strategy[69] to include the need to provide for energy demand with an objective for energy such that energy use, and electricity generation and transmission, is managed in a way that among other things:

- maximises efficiency while recognising the need to meet growing energy demand;
- recognises and provides for the national significance of renewable electricity generation;
- recognises and provides for the national, regional and local benefits of renewable electricity generation;
- reduces reliance on fossil fuels;
- addresses adverse effects on natural and physical resources; and
- recognises existing and future renewable electricity generation activities and their essential contribution to regional and national energy needs and security of supply.

The Regional Policy Statement maps areas of regionally outstanding natural landscapes and features and uses supporting policies to be implemented by regional and district plans directing large scale infrastructure to places outside of these areas. In this way the Regional Policy Statement provides direction as to where electricity generation and transmission infrastructure is to be located and directs the relevant plan to provide for it.

The Waikato Regional Plan – Water module[70], Policy 15, exempts generation of electricity from the typical 15 year consent duration for other takes of water in recognition of the near permanent investment in dam and generation infrastructure, and that electricity is considered by many as an essential public good.

The Waikato Regional Plan – Geothermal module[71] provides clarity for how the geothermal resource is to be used to satisfy the community requirement to access geothermal energy alongside the cultural, spiritual and economic requirement to maintain geothermal features in perpetuity. It does this by clearly identifying and partitioning the geothermal resource into mapped systems. It unequivocally states that seven of the 15 larger high temperature systems are available for large scale development of the energy, while five are protected to sustain the significant fluid dominated natural features. The other three large systems are in intermediate categories[72].

8.6.3 San José – new technology procurements for employees

An employee process operates in San José California where the council's human resources department catalyses purchasing of solar technology, including solar panels[73],[74] and manages to beat the market by 40 percent through aggressive purchasing. Employees get the benefit of the city screening products and of low Employees get the benefit of the city screening products and of low interest loans, as well as the low initial purchase price. The scheme is seen as a good model for roll out to other employers in the San Francisco Bay area.

The use of local government employees creates a critical mass of early adopters of beneficial technology that assists its further adoption into the community and integration into society. It is a tangible next step to the leadership display of modelling new technologies.

68 http://www.waikatoregion.govt.nz/PageFiles/10522/Volume_4_-_Merged_RPS_Decisions_Clean_version.pdf
69 http://www.waikatoregion.govt.nz/Council/Policy-and-plans/Energy/Regional-energy-strategy/
70 http://www.waikatoregion.govt.nz/Council/Policy-and-plans/Rules-and-regulation/Regional-Plan/Waikato-Regional-Plan/3-Water-Module/33-Water-Takes/333-Policies/
71 http://www.waikatoregion.govt.nz/Council/Policy-and-plans/Rules-and-regulation/Regional-Plan/Waikato-Regional-Plan/7-Geothermal-Module/721--Background-and-Explanation/
72 Proceedings World Geothermal Congress 2010 Bali, Indonesia, 25-29 April 2010: Sustainability and the Democratic Process Katherine Luketina
73 www.sunshares.org
74 http://www.mercurynews.com/breaking-news/ci_17707523?nclick_check=1

9 INTERNET OF THINGS (M2M)

9.1 TECHNOLOGY

"The data are no longer in the computers, the computers are in the data."[75]

The Internet of Things (IoT) is the network of physical objects, accessed through the internet, that are able to communicate with other objects in the network independently of the need for human intervention. The objects in the network are equipped with some form of sensor which assesses either (or both) the object's internal state (such as its temperature) or some factor in the external environment (such as the presence of a nearby contaminant). Each object in the network is also equipped with a form of communications technology (such as RFID, 3G etc) that enables it to communicate with other objects via the internet.

This system allows billions of objects to be connected that know their location and/or status and communicate with another object, system or a person. The IoT will be key in enabling technology for digital business, including opportunities for smart cars, smart logistics, smart wearables, smart environmental sensors etc.

An IoT connected device might be as simple as a security camera, automatic locks, and sensors of all kinds. Currently data generated by about 3 billion human users has the potential to swamp existing capacity and additional sensors will require: new unique addresses; micro-energy sources to power sensors (nano-generators); and standards for privacy, security, and communications protocols.

It is estimated that about 15 billion objects are currently connected to the IoT. Estimates of the likely future 'size' of the IoT range from 30 billion to as many as 50 billion objects connected to the IoT by 2020. The authors of the quote that opens this chapter foresee a world where the number of IoT capable objects run into the trillions.

Internet of Things is closely associated with so-called 'big data'. Sensors are capable of detecting and communicating information on more or less a continuous basis, or as a predetermined event occurs. For example, think of a sensor automatically detecting and counting traffic on a motorway off-ramp or arterial road – just a raw count is thousands of pieces of information per day (or even per hour!). One of the biggest issues that an organisation considering IoT-capable technology will face, lies in 'knowing what to do with the massive amounts of information that have been collected'.[76]

For the most part data will arrive in a relatively unstructured form, sometimes described as a 'data deluge'. One of the key challenges for any organisation drawing on IoT-generated data will be to ensure that the data that is useful is not lost among a flood of other less relevant data. The IoT is likely to hasten both the need for analytical tools to mine big data, and the people needed to 'drive' those tools.

75 Lucas, Balay and McManus (2012), "Trillions, Thriving in the Emerging Information Ecology"
76 Violino (2013), "The Internet of Things Will Mean Really, Really Big Data", *Infoworld*, July 29, 2013 retrieved on 29 October 2014.

9.2 Opportunities

"The IoT is not just about the gathering of data but also about the analysis and use of data."[77]

IoT-connected technologies and the information they generate have a wide range of potential applications in local government. These are not 'pie in the sky' – many are either in current use or have prototypes in development.

9.2.1 Environmental monitoring

Environmental monitoring becomes a lot more cost-effective with IoT applications. Rather than having someone visit a site to take regular readings or gather samples (as might be the case with air or water quality testing), conditions can be monitored more or less continuously and in real time, without anyone having to visit a site other than to do maintenance. One example of this technology is the so-called 'air quality egg' network. It is where individuals buy a package of sensors for reading carbon monoxide, nitrous oxide and other airborne pollutants at their homes or other sites near them.[78] The data is shared via the internet and is available to all (it has been described as crowd-sourced environmental monitoring).

9.2.2 Demand management

Any demand management technique that measures actual levels of use becomes more cost-effective. Rather than employing an army of people to read meters on a quarterly cycle (or whatever your cycle might be) you might need only one or two to administer the information coming in from sensors. Your risks as an employer are reduced as people are having to visit sites less. Because the data is arriving in real-time it makes greater disaggregation and discerning of use patterns possible – you can detect peak use, seasonal use, leaks (or other water loss) as it happens. True marginal cost pricing of everything from water use to road trips is enabled (imagine being able to charge a road user based not only on their destination, but also the road they take, the time of day, and even factors such as their level of emissions).

9.2.3 Asset management

The capability for greater, more accurate and more timely monitoring has a myriad of asset management implications. Installing IoT-connected sensors can detect leaks and blockages in reticulated networks more or less as they happen (reduced reliance on customer complaints and detection of leaks only during a meter reading and billing cycle). Asset condition can be more accurately assessed without having to use more expensive techniques such as miniature cameras, or placing large reliance on condition modelling.

IoT-connected technology also has a wide range of applications in the land transport area. Some New Zealand cities are already using IoT-connected technology to provide passenger transport users with more accurate information about just how far away their bus or train really is. Sensors can be used to measure traffic conditions on key routes and traffic management systems on other routes (such as street lights) can be managed in such a way as to avoid gridlock. IoT-connected sensors could interact with others in motor vehicles to let users know where parking is available in real time, or getting traffic off central

77 Hess (2014), "The Internet of Things Outlook for 2014: Everything Connected and Communicating", downloaded from www. Zdnet.com on 29 October 2014.
78 For example, see www.airqualityegg.com.

city streets in a more timely fashion – reducing the environmental impact of transport and optimising parking revenue. (This might also help design parking networks.)

Installing sensors in street lighting could be used to 'power down' lighting if there is no-one in the vicinity or 'power up' based on light conditions in the area (e.g. street lights are often timed to switch on half an hour before sunset and half an hour after sunrise, but do not 'go on' when there are poor light conditions such as fog).[79] Some overseas jurisdictions have reported reductions in energy use of up to 30 percent by using this technology. Other applications of this technology can be used to promote public safety (e.g. lights could be configured to 'flash' outside a property that has called for an emergency service, or detect which microchipped animals are in the vicinity).

9.2.4 Regulatory applications

Overseas jurisdictions are experimenting with IoT-connected technology in refuse management applications. Sensors can be used to detect when public refuse bins are full and need emptying. The City of Cleveland is trialling technology that can detect when recycling bins are put out for emptying, and is getting supervisors to sort through the trash coming from addresses where recycling bins are not being put out.[80]

IoT technology might even help to detect offences. Sensors might interact with facial recognition software to detect those who are, for example, known vandals as they enter council facilities or identify people who have threatened council staff. Although facial recognition technology currently struggles to identify people quickly, the time it takes is improving rapidly.

9.3 Customer expectations

The IoT is already far more pervasive than many of our customers and stakeholders may be aware of. That degree of pervasiveness will only increase in future years and as it does, use of IoT technology will create a tension with 'customer expectations'.

Firstly, and most obviously, local authorities will hold extremely large amounts of information about many of its residents and ratepayers. While much of it will be at a disaggregated level, taken as a whole it could tell authorities a great deal about the personal behaviour, habits and lives of individuals. Customer concern about the security of their information is likely to be heightened as recognition of the volume that is actually collected grows – a good indicator can be seen through the degree of public concern that the use of the 'internet' has raised through current discussions around online voting. These concerns are likely to include security of the information collected by the local authority, but also security of the means of transmission, and that only the information sought is being collected (e.g. that transmission is not being used as a vehicle for 'skimming').

With such a large volume of rich data available, the potential for misuse (whether intentionally or unintentionally) multiplies. More data is available for matching – for example, WINZ or ACC might be interested to know whether this sickness beneficiary or ACC claimant has sought a building consent or a resource consent, the Police might be interested in knowing whether a gun licence holder has recently taken Catcher in the Rye out of the library. Customer expectations that data will be used only for the purposes it was collected for and that data will not be collected and used in an unnecessarily intrusive manner will likewise increase.

79 The cities of Amsterdam, Eindhoven and Copenhagen are cited as good examples of users of this type of technology. We are aware that Kaipara District Council is trialling the technology in the settlement of Bayly's Beach (this is thought to be the first town in Australasia to trial smart street lights).

80 High-tech carts will tell on Cleveland residents who do not recycle – and they face a $100 fine, downloaded at www.blog.cleveland.com.

This is likely to add further momentum to calls for the so-called 'digital bill of rights'. Indeed, given that current discussions in New Zealand have focused on an individual's use of the internet and telecommunications, such an initiative may be inadequate to deal with information that is generated just by people being in a particular place or using a particular service.

As customer awareness of the use and potential of IoT is generated, customers are likely to demand extensions to the range and complexity of local authority information and services online. Those local authorities that have not already placed services and information online are likely to find these pressures hard to resist (e.g. 'you can tell me which roads I travelled on, but I can't look up my property value online). And with this will come an increasing expectation that local authorities will 'know everything' or be able to get information by putting an IoT-connected device somewhere.

Many of the applications of IoT-connected technology arise from the ability to monitor and gather information in real time, without human intervention. The public may expect to see some reduction in the cost of local authority services and/or the number of staff employed in each local authority.

9.4 Implications and impacts

9.4.1 Privacy

When used to monitor human behaviour, IoT-connected technologies have the potential to generate a large volume of information about our personal lives, including where we travel (and when), what services we use and to what extent, how we pay for things and the like.

The existing privacy principles and law seem designed for information that is consciously gathered with the intent of being specific to an individual, and is in either alphabetical or numerical format. This may not be the case with IoT-generated information. Much of the data will be collected in a non-discriminating fashion – that is to say the sensor will merely register that you were in a location or used this much of a service without further analysis. It is not clear how well information gathered in this way sits within existing privacy laws.

Some will be raw unprocessed data simply recording that you were in a particular place at a particular time, and may not even be readily searchable or identifiable to you without detailed work or some qualifying frame of reference (such as a date or time). While this has been collected and is definitely held by your local authority, it's not clear whether a local authority could reasonably be expected to provide people with a right to view, and if necessary, correct all of the information that a local authority holds. In some cases it will be difficult to avoid collecting information other than that which was originally sought.

9.4.2 Aggregation and analysis

IoT-connected technology is the best example of the generation and potential uses of 'big data' of all of the technologies presented in this publication. Much of this technology will be used for monitoring purposes either as the basis for determining policy effectiveness or supporting revenue generation. The processes of aggregating and sifting for the key information will need to be robust and capable of independent audit or verification.

9.4.3 Transmission and storage

The existing infrastructure held by local authorities for transmitting, receiving and storing

data is likely to be inadequate to capture and store that which is generated by IoT devices. In addition, new data is arriving more or less continuously, making it more challenging to take systems down for maintenance, freeze data for 'snapshot type' analytics etc. This is one reason why the IoT is often also associated with cloud computing solutions. Some technologists are beginning to discuss so-called 'fog computing' (also called edge computing) where data is stored at the logical extremes of networks as opposed to centralised nodes.[81]

Additionally, IoT technology might well be gathering information other than pure numbers and text (for example, video) which may mean local authorities need to access more bandwidth to move IoT data to and from the storage point. Some information may have value for short periods of time – minutes or hours.

9.4.4 Security

A local authority that makes even minimal use of IoT technology is likely to have or need large numbers of devices connecting to, or attempting to connect to, the network via RFID. Because IoT-connected applications collect data in real time, and in a generally unsupervised fashion, they are particularly vulnerable to security threats. A study conducted by HP indicated that up to 70 percent of IoT-connected objects had security vulnerabilities.

These might include:

- *device security* – the devices that sense and collect information are vulnerable to theft and physical compromise (think tampering with a water meter). Solutions to these types of issues are almost always physical e.g. locks, locking cases, secure placement (there's a reason security/speed cameras are placed out of reach), or tamper alerts.
- *data security* – data could be compromised on the device itself or in transmission. Data on a device is particularly vulnerable because devices that are stolen provide the thief with plenty of time to access and analyse the information on the device. Encryption at source is one common solution.
- *communication security* – security for data 'in transit'.

The volume of IoT-connected devices might be such that local authorities may have to consider whether a separate network is needed for data from IoT-connected applications and how these would or should interface with their 'main' systems.[82] The nature of cyber threats and their ability to compromise networks is continually evolving. The nature of the security necessary to prevent, detect and resolve these issues must also continually evolve.

9.4.5 Loss of the human element

IoT-connected technology is currently being held up as the next big step on from the internet, or the next 'megatrend'. While not in itself a disruptive technology the potential applications of IoT might represent disruptive technologies in the future.

IoT works by removing the human element from many transactions, e.g. the need to have people visit a site to collect samples. To that extent it allows for the redesign of any business process that involves monitoring, be it ensuring compliance on the conditions of a resource consent, or counting traffic on a particular arterial. While there are initial set-up costs with any IoT applications, sensors don't go on strike, they don't require a

81 Goldman Sachs (2014), "The Internet of Things: Making Sense of the Next Megatrend", page 6.
82 An analogous situation occurs with online voting, where it is commonplace for online votes to be received and stored on one network and then transferred to another for processing.

performance review, and the only ongoing costs are the costs of managing the information, energy and maintenance or replacement.

The range of IoT technology applications is limited only by the availability of energy sources, the size of sensors and the acceptability of the technology to the public.

9.5 Potential strategies

Public resistance to IoT technology would most likely be overcome by starting with applications that are non-controversial and low risk. Risk can be minimised by starting with technology that has already been trialled or is in use overseas (or could be introduced with minimal alteration). Such an assessment would require careful analysis.

These types of application are more likely to be found in the management of reticulated assets or monitoring of environmental conditions. These technologies could then be used as a test case to demonstrate the financial and non-financial benefits and for testing the technology necessary to provide for security and management of information. Public acceptability is more likely to be quickly generated in the initial stages, the sector should avoid applications that are intended to support user-charging and/or prosecution (or at least have reliance on the IoT technology as the sole evidence). The 'air quality egg' or close variants of it, might be one good place to start (and may already be in use).

Where technology monitors human behaviours, or something that bears some relationship with human behaviour, it will be important to start with applications that deliver personal benefits. Trialling on a small scale with careful monitoring and evaluation will also help. For example, smart street lights have both a personal safety benefit and the benefit of generating some cost savings.

Many of the existing IoT applications have their roots in tools or applications developed by members of the public. This may be one good means for taking people with you. One technique used is the 'hackathon' (in this context the word 'hack' is used to mean 'make ordinary things extraordinary'). A self-selected group meet at a time, and are given or take on a particular challenge and develop solutions. One such example is shown in the case study below.

Many of the public will have concerns about the privacy and security of information they hold. Yet we have seen that IoT-generated information may not sit comfortably with existing law around privacy and collection of information. There is no apparent evidence that agencies such as the Privacy Commission or the Ministry of Justice are giving any particular consideration to the policy and operational issues associated with the IoT and privacy. There may be some benefit in the sector commissioning (in the broad sense) its own thinking either on its own or alongside other organisations (such as the Consumers Institute or Internet New Zealand). In the meantime local authorities wanting to adopt IoT applications beyond the low risk might consider their own set of operational and policy protocols.[83]

83 See for example, Sophisticated Surveillance coming to Auckland, downloaded from http://www.google.co.nz/url?sa=t&rct=j&q=&esrc=s&frm=1&source=web&cd=2&cad=rja&uact=8&ved=0CCIQFjAB&url=http%3A%2F%2Fwww.stuff.co.nz%2Fnational%2F10567293%2FSophisticated-surveillance-coming-to Auckland&ei=_QmzVLmNFsKwmAXFtoLADQ&usg=AFQjCNFdN7d9LkdTsTBuNn0Yg17xLVAYMw on 12 January 2015.

9.6 Case studies

9.6.1 Wellington City Council 'Hackathon'

Wellington City Council wanted to engage the community to develop transport solutions for Wellington, especially for the road corridor between the central business district and the eastern suburbs (including Miramar).[84]

The event was held over the weekend of 1 and 2 November 2014 and was open to the public. Registration was free – with the council providing food, coffee, data and a GIS specialist. The Mayor and many of the councillors attended at points during the weekend.

Hack Miramar came up with five viable ideas, each of which involves the application of IoT technology.

The Taxishare prototype was one such application. Taxis moving between the airport and the CBD move in surges driven largely by the arrival of flights. An average of 2500 travel from the airport to the CBD in peak periods, each in a taxi or private car. Those involved in the Hackathon took data from Bluetooth sensors, airport barrier arm data, rubber strips and live airline timetables. The application allows travellers to connect with each other on arrival at the airport to share taxis, reducing traffic, business costs, congestion and with a spin-off for the environment.

A second application labelled 'traffic visualisation' also used AraFlow sensors to visualise traffic flows across the city intersection by intersection. This visualisation could be used to show drivers which was the next least congested intersection on their route into the city, so as to follow a path with less traffic than the main routes. This is a locally developed version of technology in common use overseas.

9.6.2 Auckland Transport – sophisticated surveillance

In May 2014 Auckland Transport announced it would be tendering a contract to monitor footage generated by an already existing network of cameras in stations and some intersections. The contract is for the back end of the system that monitors traffic flows, vandalism and safety – the system does not use capabilities that identify faces or number plates[85]. This project is described as a visionary big data project, but also relies on IoT applications to consolidate five existing systems into one.

84 For readers not familiar with Wellington, Miramar is the peninsula that sits alongside Wellington Airport. There is a single road corridor connecting the airport, Miramar and other eastern suburbs with the CBD which is one of Wellington's more congested roads.
85 *NZ Herald*, "Sophisticated Surveillance Coming to Auckland", 1 October 2014.

10 BIG DATA

10.1 Technology

‘Big data’ is not a new technology in the sense used elsewhere in this report. It is an implication of the technology and the large or complex amounts of data that these technologies can generate. This structured and unstructured data is so large or complex that it cannot be handled by standard database management systems.

To give a couple of non-local government related examples:

- when the Sloan Digital Sky Survey began collecting astronomical data in 2000, it amassed more in its first few weeks than all data collected in the history of astronomy. Continuing at a rate of about 200GB per night, SDSS has amassed more than 140 terabytes of information.
- decoding the human genome originally took 10 years to process, now it can be achieved in less than a day: the DNA sequencers have divided the sequencing cost by 10,000 in the past 10 years.

Big data is defined by three key attributes, namely:

- *volume* – the amount of data that is being collected through databases (transactions, images and text), sensors, machines and social media (every day something like 2.5 exabytes [2.5×10^{18} of data are created). Storage is cheap so size is no issue and the amount of data will keep increasing.
- *velocity* – the speed at which data is collected and the ability to deal with it in a timely and effective way. Technologies such as sensors and smart metering are providing information instantaneously.
- *variety* – data is in both structured and unstructured formats; it includes images, text and spatial information. It comes from the web, social media, transactional databases, GIS, emails and machines. The challenge is how to manage the different types of data, merge and integrate it and make it available for use. [86]]

Some of the types of data include:

- *structured data* – examples: transactions, data held in databases and corporate information systems
- *unstructured data* – examples: social media text, images, video, audio and emails
- *spatial* – GPS co-ordinates, GIS data layers, points, shapes positions in Earth or space
- *IoT sourced data* – sensors, devices and objects that have the ability to transmit data by the internet
- *metadata* – specific information about the data itself (eg creation date, title, description, author).

The real potential of big data for local government lies not from its acquisition, but what can be achieved by turning it into meaningful information that counts. The volume of data in a ‘big’ dataset provides a larger sample size, which if extracted in the right way, enables better analysis of correlations between different variables and provides better predictive power.

The growing volume of processing power needed to analyse different types of data has seen the growth of ‘big data’ technology and cloud environments that can store and process large volumes of data at speed. There is also a growing market of analysis and visualisation software

86 SAS, “Big Data – What if is, and Why it Matters”, downloaded from http://www.sas.com/en_us/insights/big-data/what-is-big-data.html

developed specifically for big data. Many applications are developed as open source applications (for example, Hadoop).

Growth in data and information has also seen service providers adding cloud and analysis services for big data to their offerings. These include consulting services for on-premise and in-cloud solutions and the products required to undertake processing and analysis.

10.2 Opportunities

Local government could leverage big data, and the technology that generates big data in literally any service where there is improved capability to analyse relationships, use predictive modelling as a decision-making tool, or present data in creative or compelling ways. For example, think of the potential uses of LINZ, Census and the council's Rating Information Database when used together.

But there are also opportunities to use big data to deliver frontline services, especially where there are relationships between patterns of use.

10.2.1 Environmental/land use research, planning and monitoring

Chapter nine discussed the use of IoT as a tool in any function where frequent monitoring and measurement is required. Big data is the receptacle through which the data captured via IoT can be stored, analysed and presented for best gain.

Big data analytics provide for faster solutions for managing complex non-linear processes such as hydrological modelling. The appropriate placement of sensors and big data analytics enables us to forecast non-lineal systems – everything from the accumulation of gravel in a riverbed to glacial retreat.[87] In urban planning, big data analytics can be used to, for example, analyse ripple effects.

10.2.2 Transport planning

When connected with IoT technologies, big data can be used to gain a better understanding of when, how and where people are travelling. The data could add richness to a raw traffic count, or passenger numbers, e.g rather than just knowing x cars passed this point on a motorway, a local authority might gain an understanding of the paths traffic took to get to a motorway. This could then be used as a tool for planning collector and arterial roads, and in planning passenger transport services.

Linking transport data with variables such as meshblock incomes might generate useful predictive analyses, e.g. this meshblock is statistically more likely to drive, as opposed to use, passenger transport.

10.2.3 Asset management

Asset management systems are becoming increasingly complex and data-hungry. Big data might be used to store past and present asset condition information and extrapolate/ predict future asset condition. When used in conjunction with AR technology, big data can marry asset location with asset condition in a visual form to give decision-makers a better idea of which areas really need the investment, and when. Linking information from resource consents, building consents and the like could be better captured and assimilated into demand forecasts.

87 For example, see "Building a Smarter Planet, Sensors, Big Data Analytics Propel Environmental Monitoring", downloadable from http://asmarterplanet.com/blog/2014/11/big-data-environment.html

10.2.4 Regulatory services

Big data applications could be used to implement and improve case management approaches in your regulatory services, and those of local authorities around you.

For example, if you have a resource consent to undertake a particular activity with an attached restaurant, you might then be able to use the information from the consent application as a predictor of a future building consent, future liquor licence and future environmental health inspections. The regional council might look at testing in nearby streams for nutrients and pesticide run-off. Big data can be used to identify predictive factors or patterns of offending that enable local authorities to better target enforcement activity.

The analytics necessary to do this are, in reality, not that much different from the tools that online retailers use to tailor offers based on searches or purchases that an individual customer has already made.

British local government has used big data tools to link patterns of use in social services (such as meals on wheels) with data from its programme for road-gritting in snow conditions to ensure that customers in need receive the service.

10.2.5 Engagement

Local authorities could use big data applications to discover the most frequently visited pages in a plan, or where people give up in reading a plan, as a tool for improving the readability of future plans (and dealing with any 'fires' that arise in the current engagement process). Big data analysis of social media (such as Twitter) can be used to identify shifting public opinion on issues in a more complete (and possibly more systematic) way than any amount of submissions or opinion research.

10.2.6 Providing open access to datasets for third party use (encouraging big data use)

Open data is an enabler to 'big data' technology as it enables data to be stored, processed and analysed more easily by anyone, on any environment. Steps towards open data are listed in the Potential Strategies section of this paper, below.

10.3 Customer expectations

Beyond some of the larger non-residential customers (such as bigger businesses and universities), access to big data and big data analytics will not be something ratepayers use or have access to, for now. Developments in processing and storage technology will put this data and these analytical tools into mass-circulation in the medium term (see chapter 11).

When the use of big data reaches the customer in their day-to-day lives, they will expect to have:

- *open access to trusted authoritative data*[88] – central government is increasingly moving to make data accessible through the declaration on open and transparent government (essentially data that can be released should be, and if possible at no charge). Increasingly local authorities will be pressured for similar release. This has implications for the so-called public register information – there will be pressure to make everything available, on demand. Users will expect authoritative data – which calls into question the relevance of citizen science (using citizens to gather or provide monitoring data).

88 http://ict.govt.nz/guidance-and-resources/open-government/declaration-open-and-transparent-government/

- *privacy controls in place* – big data and its analytical tools make the rapid sharing and comparison of multiple datasets much easier. Local authorities do not have the access to personal income and heath data that central government has. But matching data such as building consents and valuation rates accounts might provide useful, but sensitive data and conclusions (for example, "Mr Jones your rates account is $5,000 in arrears, but you are planning to add two rooms and a spa?"). If local government were serious about having access to the full Census dataset it might need to compromise on what data goes into a publicly available set.
- *security controls in place* – big data will also draw on sources that can be difficult to protect, especially where those sources are interfacing with other information systems (such as online regulatory systems). Local authorities won't hold that much data that can be used with criminal intent; the bigger risks are from automated attacks (spambots) and those with political motivations.
- *improved service* – increasing access to data on the part of local authorities, and knowledge of big data capabilities, will come with an expectation of improved customer service. Local authorities will be expected to be proactive and streamlined in their approaches, so in the regulatory example mentioned above the property owner would expect documentation that doesn't call for the same information in multiple places. It will drive customer demands for greater customisation and choice.
- *better quality decisions* – local authorities will increasingly be expected to back up their decisions with facts and analysis. Decisions made for purely political reasons will become more open to scrutiny and harder to justify.

10.4 Implications and impacts

"A new profession has emerged in recent years, the 'data scientist' which combines the skill of statistician, software programmer, infographics designer and storyteller. Instead of peering into a microscope to unlock the secrets of the Universe, the data scientist peers into databases to make a discovery."[89]

"Just because it's accessible doesn't make it ethical"[90]

The impact as data and information grow will mean that new opportunities and insights may arise that both provide better services to customers and provide opportunities to automate, digitise and change current business processes. Key to this will be focusing on providing solutions to problems rather than generating information for information's sake.

10.4.1 Big data as an analytical tool

Big data has its limits as an analytical tool. First, and chief, is that it is a tool for identifying correlation between data, not causal relationships. That is to say that big data can point to the existence of a relationship between two variables, but will not necessarily tell us what the nature of the relationship is. This is especially true of those activities that have a human element to them.

Cukier (2013) tells the story of outpatients and analysis that was done on the likelihood of repeat visits. Regardless of condition, one of the factors identified was the patient's use of terms, such as 'depression' (or close variations), at admission. That is to say that the patient's mental state predicted the likelihood of their return, regardless of the nature of the original condition. This kind of analysis might be used to predict which tenants are at risk of behaviours such as hoarding.

89 Cukier (2013), "Big Data: A Revolutiion that will Transform How We Live, Work and Think", kindle edition.
90 Boyd and Crawford (2012), "Critical Questions for Big Data", Information, Communication and Society, vol 15, no 5. pp 662-679.

10.4.2 A new digital divide?

Being able to successfully 'mine' (that is extract patterns and trends) from big data is currently a specialised skill. In New Zealand this skill is currently resident in a few firms, though Victoria University offers big data papers and Massey University is offering a degree.

Because those skills, and the ability to access big data are so limited at present, commentators such as Boyd and Crawford (2012) argue that the possession of big datasets, and those with skills to interpret them, create a new digital divide. In a government context, this means a division between the governing and the governed.

10.4.3 Privacy and ethics

"Just because government can do something with big data doesn't mean it should do it. In the final analysis if (the politician with political accountability) would not be comfortable with putting themselves or their family under the sort of scrutiny required by a big data initiative, then the initiative should not become policy."[91] (emphasis supplied)

This usefulness as a predictive tool does raise one potential (and very large) ethical risk – the risk of action based on propensity. That is, predictions based on big data do carry the risk that we judge and act on people based on some factor that suggests a likelihood of action, as opposed to an actual act. Returning to our orchard and restaurant example, we've made the judgement that the owner will want to sell alcohol and will need a liquor licence, when the owner may have no such intent. So-called predictive policing, that is, targeting enforcement activity based on predictive factors (let's call them risks) might seem a wise use of resources, but could also breach someone's civil rights.

The large volume of data coming from IoT technology can show when and where we move (and may even show with whom). Many of the potential uses of big data are those that are not thought of when the data is first gathered. Much data collection is passive, and the more revealing insights about personal behaviour emerge only on analysis.

That means the traditional keystones of our privacy laws, choice to engage in the transaction and consent (express or implied), may no longer apply.

The implication is that local authorities will need to exercise caution when collecting data to ensure that the purposes are spelt out, and that conditions of use and release are well understood.

10.5 Potential strategies

Big data is here now. Your downloading of this report has been recorded by whichever of SOLGM and ALGIM you got this from, by your ISP, and potentially by the so-called three letter agencies.

10.5.1 Seeding capability

If local government is to make successful use of big data it will need access to the appropriate skill. This is a skill that is in its infancy in New Zealand and so can be regarded as something of a 'seller's market' at present.

91 Yiu (2012), "The Big Data Opportunity: Making Government Faster, Smarter and More Personal", page 32

Rather than having local authorities compete with others, and the private sector, there may be value in the sector jointly hiring a small number of these experts for a medium term period (say five years). These people could be employed to:

- conduct analyses on trends and issues that provide a practical demonstration of big data
- develop sector specific tools for mining big data (or more likely customising other tools for use)
- train others.

In addition to building sector capability in this way, the sector should also consider the merits of identifying people from within the current ranks to undertake more formalised training (such as the Massey and Victoria options).

10.5.2 Privacy and ethical frameworks

The arrival of big data will serve to hasten the debate about the use and abuse of governmental datasets. The sector should undertake its own analysis of the privacy and ethical issues raised, not just by big data, but other technologies from this paper. The sector has an opportunity to raise the incoherence and inconsistencies in the legal framework that governs the use of information on public registers, and other information gathered during our processes.

Cukier (2012) argues that frameworks governing the use of information and privacy will move from a focus on individual consent, to regimes that hold agencies more accountable for their use, and define broad categories of permitted use and regulated use. A framework might also set expectations as to how agencies assess whether a particular use of big data poses risk, and some guidance on tools and procedures to apply where risk is indicated. The opportunity is there for the sector to work in conjunction with central government agencies, telecommunications companies and the research sector.

This work need not be done from a zero-base, these issues reached other jurisdictions in advance of New Zealand. For example, Yiu (2012), suggests that the British Government adopt a code of responsible analytics that established ethical use of data as a 'matter of fundamental principle'. Yiu specifically suggests that the code should:

- *"put outcomes before capabilities* – data and analytic capabilities will always be acquired on the basis of a clear and openly communicated public policy justification. Such capability will never be acquired for its own sake, and when redundant will be surrendered properly. Curiosity alone will never be a good enough reason.
- *respect the spirit of a right to privacy* - auxiliary data will never be used to infer personal or intimate information about citizens. Where this data is needed for public policy reasons, consent will be sought explicitly.
- *fail in the lab, not in the real world* – a 'sandbox environment and synthetic data will be used to test all big data initiatives – after which they will be subject to intense scrutiny and peer review. Initiatives that are deemed to overstep the mark on ethics or privacy will be dropped".[92]

10.5.3 Review and adopt government frameworks for information security

The New Zealand Government has produced a risk assessment process that may be useful for councils to use to determine the risks in information systems or datasets.[93] Its principles are generally applicable to any government dataset but may need review for consistency with the key local government related legislation.

92 Yiu (2012), page 31.
93 Downloadable at https://www.ict.govt.nz/assets/ICT-System-Assurance/Risk-Assessment-Process-Information-Security.pdf

10.5.4 Open data

The potential of big data will only be realised if the tools are applied to real problems and the results lead to more effective or efficient services to the public and better informed decisions. The challenge for champions of data analytics and visualisation will be to justify the cost of developing or acquiring the tools and skills, by demonstrating the potential benefits.

These benefits do not need to be limited to better council services. Data held by councils can be useful in the hands of others, helping them make more efficient and effective decisions about the services they provide. Key to realising this potential is open data.

Steps toward open data include:

- adopt New Zealand Government's initiative on open and transparent government
- implement data standards, structures and the use of metadata for datasets that can be shared
- put in place policies for governance and data stewardship. This should include statements on the organisation's position on open data and cost charging for data
- consider opportunities to share data with other councils using linked data, spatial data, regional portals, web services and shared services
- consider opening up data and web services on open data websites such as www.data.govt.nz

10.6 Case studies

10.6.1 Otago Regional Council – Open data platform

Freely available council generated data (i.e. Open Data) that is either connected to, or compatible with, other available sources (e.g. central government data) could convey an advantage for software/app developers to locate in the area and contribute to the region's economic success.

Otago Regional Council (ORC) has made about 40 datasets available on an open data platform. These datasets include data about various types of consents and permits, together with various types of telemetry throughout the region. This is supported by graphical capabilities.[94]

94 Viewable at data.orc.govt.nz

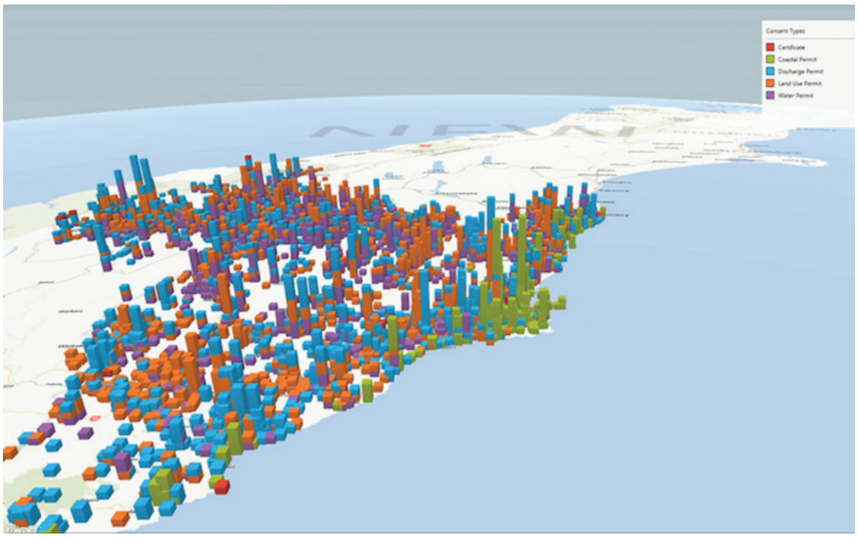


Chart showing different types of permit spatially derived from the Otago Regional Open Source Data Platform.

10.6.2 Gravesham Borough Council – Housing and council tax enforcement

Gravesham Borough Council is in Northwest England. In 2012 the UK Government asked local authorities to 'crack down' on tenancy, benefit and council tax fraud.

Gravesham securely transferred about 6000 records to a commercial provider of data analytics. It matched services against things such as the register of births and deaths, benefit information and council tax refund claims. The result generated a 'red list' of high priority properties for investigation by Gravesham's fraud team.

As a result, action was taken in respect of 75 properties, ranging from prosecution for criminal offending to transfer of a family in an overcrowding situation to a more suitable property. The initial work identified about NZ$320,000 in fraud. The council was also able to use the results to provide a more appropriate intervention for some families.

10.6.3 The Office of New Yorkology[95]

Congealed cooking oils are responsible for almost half the blocked sewer and stormwater drains in New York. The city's Environmental Protection Department decided that existing methods to detect restaurant waste oil dumping were too hit-and-miss. It drew on data from the city's Business Integrity
Commission, which certifies eateries to have a carting service to dispose of their waste oils. Those who did not have a carter were matched to geospatial data on the location of sewers to generate a list of statistically likely suspects. The process had a 95 percent 'hit rate' in those sites targeted for inspection.

We understand about 1TB of information passes through the city administration per day (about 143 million pages of data). Other uses of the data including doubling the number of successful prosecutions of stores selling bootleg cigarettes, faster removal of trees and other storm debris, and better targeted inspection and enforcement of the New York Fire Code.

95 Feuer A, "The Mayor's Geek Squad", *New York Times*, 23 May 2013.

11 CLOUD COMPUTING

11.1 Technology

In essence, cloud computing is the use of a network of remote servers hosted on the internet to store, manage, and process your data, rather than by local server or a personal computer. Cloud computing is far from a new technology, and many local authorities already use at least some cloud-based services.

The following are common characteristics of cloud computing solutions:

- *on-demand services* – services can be accessed as needed without direct contact with the service provider
- *broad access* – services can be accessed from a variety of devices
- *pooling of resources* – resources are shared by a number of users, with the provider facilitating that sharing
- *scalability* – the available service can be scaled up, and scaled down according to the user's needs at the time
- *measuring of use* – usage can be measured and controlled.

Cloud computing involves sharing resources with resulting economies of scale and maximising of effectiveness. Cloud resources (such as a piece of software) are shared by multiple users and are generally allocated and charged 'per unit of demand'.

Clouds may be private (operated solely for a single organisation – usually one that is spread over several sites) or public (a cloud that is open for public use). We have also noted the recent emergence of personal clouds (a subset of private clouds, where the cloud is intended for use by a single person or a small group).

There are a variety of different models of cloud computing. These are not mutually exclusive and include the following:

- *software as a service* – one of the more common models (and one readers with packages such as Office 365 may well be using on their home PCs). Users receive access to software applications and associated services. The cloud providers manage the infrastructure and platforms that provide the services. Local authorities and CCOs using applications such as Xero are using a software as a service application. These are typically charged either per use or as a subscription
- *infrastructure as a service* – a provision model in which an organisation outsources the equipment used to support operations, including storage, hardware, servers and networking components. The service provider owns the equipment and is responsible for housing, running and maintaining it. The client typically pays per-use
- *platform as a service* – in this model a cloud provider will provide a computing platform (typically including an operating system, database and website). Application developers can develop and run software solutions on this platform without the cost and complexity of buying and managing the hardware
- *unified communications as a service* – a delivery model in which a variety of communication and collaboration applications and services are outsourced to a third-party provider and delivered over an IP network, usually the public internet. Some simple examples of this technology include online meetings and videoconferencing technology.

Remote servers mean that small businesses and councils no longer need to invest in individually owned software. This has numerous advantages, including updates and security, as data storage

is typically backed up and stored in three independent locations – better than most individual users. Common storage areas also facilitate a move towards the analysis of co-stored datasets and the advantages of big data technology.

The financial advantages conferred by renting (not buying) software and storing data externally (triple redundant systems) and the logistical advantages of mobile accessibility over individual platforms mean that the cloud is an enabler of other technologies. For example, the sheer size of the data generated by applications connected to the Internet of Things often makes storage in the cloud the only viable option. We can expect the use of cloud computing to become the dominant model into the future.

11.2 Opportunities

As a general rule, the deployment of a cloud computing solution could be an enabler in situations where the success of a programme, project or service depends on any of:

- scale – for example where there are large volumes of information to store, manage and process
- access to 'specialist', new or not commonly available software or other computing resources, and
- access or sharing across multiple sites (especially if two or more different organisations are involved).

Cloud computing solutions are often linked with applications or technology connected to the Internet of Things (see chapter nine). Some IoT-connected applications will generate large volumes of data (so-called big data), sometimes in memory-hungry forms such as video, that could quickly consume the available storage on a local authority-owned server. Some cloud applications might provide the specialist software that can analyse big data and extract the key messages, themes or points of interest.

Cloud computing better enables shared services type arrangements. The data software is made available on the cloud, and each member of the shared services agreement can access via the cloud with a password or other unique identifier. This removes the cost of physical hardware (servers etc) from the shared service arrangement.

Solutions 'in the cloud' may also better enable applications that support direct democracy.

11.3 Customer expectations

Cloud computing is already in wide use. At least some of our customers and stakeholders will be familiar with applications such as Office 365 or STEAM (or at least have heard of these applications). Those experiences or that knowledge will play a considerable part in shaping the users' expectations of local authority-provided services.

Cloud computing services are very much related to the back end of service delivery, that is to say that the fact something is delivered 'in the cloud' will not generally be obvious to many casual users.

The availability of cloud computing solutions will create expectations that most if not all services 'should' (or even 'must') be available online or have an online component. This extends beyond the traditional application or permit-based services (various types of licences and permits) to other services (for example being able to search online to determine whether any copies of a particular book are available for borrowing and being able to get that issued online). There may also be an expectation of some degree of uniformity both in terms of levels of service, and in the

processes that they need to undertake to access those services (e.g. ABC district can turn around a request for a permit in a week, why can't your council).

Customers and stakeholders aware of the cloud will be savvy enough to appreciate the efficiencies that will or could arise from the cloud. There will be an expectation that the services delivered via the cloud will be cheaper to access.

Cloud providers generally configure their services in such a way that storage and hardware is located in more than one jurisdiction. So for example, a New Zealand provider of cloud services that serves New Zealand users during New Zealand business hours might draw on resources from Asian providers during Asian business hours. That means there will be an expectation that services will be accessible on a 24/7 basis (and, by the way, in this instance the expectation will also be held by your own staff in terms of help facilities). Users will also expect continuity of service, i.e. no breaks in service due to internet outages etc.

11.4 Implications and impacts

Cloud services are delivered remotely from the organisation. This remoteness is both a weakness and a strength of cloud computing models.

The remote hosting of the data has an advantage in that the providers have their own backup arrangements and host the data on multiple servers. The risks of data loss by accident are accordingly much lower. But this hosting remotely for the organisation can raise other issues. The cloud provider could access data 'owned' by a local authority. It could share the data with third parties, for example for law enforcement purposes. If the provider is overseas then there is a tangle of issues around whether the law of the provider's country or New Zealand law takes precedence.[96]

Another implication of cloud computing models is the security of the data (which in the case of a local authority includes a large volume of extremely personal data). As with any other internet hosted application, cloud computing solutions are vulnerable to cyber threats.[97] However, it should be noted that most applications now have at least some element of delivery or reliance on the internet, so to this extent the risk is present everywhere. At any rate, this is a risk about which councils need to take their own independent advice before signing up to cloud contracting arrangements.

At present there are very few standards for providing cloud computing services, and as we have seen by their very nature it can be difficult to regulate for a provider who operates in multiple jurisdictions. It can also be difficult to assess the quality of the service. In addition, because there are no commonly agreed standards at present, interoperability between cloud providers (beyond some common applications or services) may not exist.[98] It would be prudent for local authorities to adopt strategies such as dealing only with the recognised or well known names, seeking independent reviews of proposed service specifications and procurement decisions, investigating trial periods, or making the initial contract for a short time. The Department of Internal Affairs' document Information, Security and Privacy Considerations contains a useful list of considerations that local authorities considering cloud computing solutions will find useful.[99]

96 For example, one of the issues that central government is considering as part of the introduction of online voting is whether the votes should be stored on servers located overseas. One example is the so-called PATRIOT Act in the United States which extends to all US or US-subsidiary firms, information stored in US based data centres or any cloud provider with systematic and continuous contacts with the US. The Act has far reaching powers to obtain data from cloud users regardless of location.

97 As noted in the report of the Online Voting Working Group, online applications can never be 100 percent secure, only secure enough.

98 One commentator noted that "when everyone talks about the cloud, they talk about their cloud".

99 Department of Internal Affairs (2014), "Information, Security and Privacy", available online at http://www.google.co.nz/url?sa=t&rct=j&q=&esrc=s&frm=1&source=web&cd=2&cad=rja&uact=8&ved=0CEYQFjAB&url=httppercent3Apercent2Fpercent2Fwww.ict.govt.nzpercent2Fassetspercent2FICT-System-Assurancepercent2FCloud-Computing-Information-Security-and-Privacy-Considerations-FINAL2.pdf&ei=8Yu1VO3lMqTCmAX0v4KwCQ&usg=AFQjCNHBQOOeV2k5LM05G3wDXqrhfWazgA , information downloaded on 14 January 2015.

One of the strong points of cloud computing solutions is that data can be accessed any time from any device that has the necessary permissions to connect. It does, however, depend on the availability of internet access of the necessary standard – some rural local authorities may experience more difficulty than others for this reason. Network and connectivity problems are highly likely, which also means that your business continuity plan will need to provide for interruptions in service.

It is not clear whether applications that are more 'local government specific', such as rating software, would be supported in a move to the cloud. Some of the larger providers are experimenting with an applications program interface (API) which enables developers to adapt/customise their applications for a cloud environment. Again, this is something to keep in mind when making the decision to move to the environment.

Cloud computing and related applications are replacing the more traditional 'software in a box' model for delivering software, and outsourcing and premise-based delivery for other services. For the time being many of the gains from cloud computing lie in what is effectively a shift from computer services as a capex item, to an opex item, and in shifting back-office functions into the cloud. A lack of consistent standards and consequent interoperability act as a limiting factor on other gains in the short-medium term. Some commentators suggest that solutions to the interoperability issue, and fully functioning API technology, are five years away.

11.5 Potential strategies

> *"The shift from in-house to cloud computing – from the immediate physical control of data to control via contract – is as much psychological as technological."*[100]

Cloud computing solutions are widely available now, and are being used by local authorities. The only substantial technical barrier is the availability of a suitable internet service in some parts of the country.

The quote that opens this section is intended to highlight the key non-technical barrier – which is that cloud computing requires the buyer to trust the provider's systems and protocols to deliver consistent, secure services of the appropriate standard. One of the ways sector organisations can assist with this is to develop or adapt consistent guidance for the sector on matters such as contract design and monitoring. There is also the potential for the sector to develop and implement its own cloud – this has been done in the United Kingdom with the formation of G-cloud.

Local authorities are unlikely to move the entirety of their computing needs into the cloud in the short-term. Back-office type applications such as finance and (corporate) performance management may be good initial first steps for local authorities interested in cloud computing solutions. The sector might consider whether there is a case for jointly funding or approaching providers to develop cloud-based applications of commonly used software/applications in local government.

It should be noted that the 2014 Productivity Commission report into the services sector recommended that:
"the Government should address the data sovereignty, security and privacy risks associated with offshore cloud computing through international negotiations. Bilateral negotiations with Australia could be resolved quickly, so should be pursued as a first step. Resolving such issues will help New Zealand firms adopt cloud computing."[101]

100 New Zealand Productivity Commission (2014), "Boosting Productivity in the Services Sector" – Final Report. page 11.
101 New Zealand Productivity Commission, page 237.

The Commission made this one of the top 10recommendations from the inquiry. The Government has not responded to this report as of the time of writing. The sector might wish to put the case for a review to the Government.

11.6 Case studies

11.6.1 UK Government G–Cloud

The UK Government G-Cloud is an initiative designed to generate cost savings by giving government agencies access to a common set of services provided through the internet. The G-Cloud consists of:

- a series of so-called 'framework agreements' with suppliers, from which public sector organisations can call off services without needing to run a full tender process
- an online store – the "Digital Marketplace" (previously "CloudStore") that allows public sector bodies to search for services that are covered by the G-Cloud frameworks.

12 COMMON ISSUES

In this chapter we pick out the recurring themes from each of the technologies we've presented, together with some of the key policy and practical concerns and how these can be addressed.

These issues are important. A failure to address any one of them could give rise to a failed information technology project and the consequences that this brings for your local authority, and your local community (and for you).

12.1 The adoption decision

12.1.1 Benefits

The business case for the adoption decision should be clear, and realistic about the benefits of the technology. The tendency to oversell is one of the key reasons for the failure of IT projects. Often it will be useful to distinguish between internal and external benefits. Some of the places to look for benefits include:

- *efficiency gains* – the technology may enable you to do things at a lower cost or with a level of commitment of non-financial resource. Drones or sensor technology might enable you to replace regulatory staff involved in monitoring water or air quality, locating plant and animal pests etc.
- *improved service* – new technology might streamline business processes or make processing easier and improve response times. Sometimes, as is the case with the Go Roam application, the technology can even enlist the beneficiary as a delivery agent (or at least partly). Applications such as Augview solve an issue that is a major frustration both for the public and for the local authority. Where data is available for use, then linking regulatory data may enable better case management.
- *better information* – technology that measures and self-reports removes the human factor and removes one major source of data error. Sensor technology enables a continuous flow of information (big data) which can, if used appropriately, provide you with an improved understanding of patterns, such as who is using it, when and where? Better information means better informed decisions, and (hopefully) better decisions
- *environmentally friendly* – some applications have environmental spinoffs. Sensor technology means more monitoring of air and water quality can be undertaken cost effectively. Renewable technology and electric vehicles reduce a carbon footprint.

12.1.2 Costs and risks

Likewise a business case for the adoption decision should be clear, complete and realistic about the risks involved in the adoption decision. Privacy and security are two that will most readily arise, and for that reason are discussed separately below. Some of the other risks that need to be accounted for are:

- *loss of the internet* – IoT and AR applications depend on the internet. Where and when this is lost, the ability to report is lost. While some backup capability could be built into the system (e.g. sensors that can record say the last few days worth of readings) that adds cost.
- loss of power – most of the technologies discussed here rely on energy to drive them. A loss of service power means that robotic applications are so much dead iron, and the data from IoT isn't captured at the receiving end. A prolonged loss of power might see electric cars left on the roadside. Some applications might come with their own energy sources, or local authorities might invest in generators or solar technology.

- *disaster recovery* – local authorities will (should) have a business continuity plan and any new technology will need to be integrated into that plan. Sometimes the amendments will be significant.
- *misuse of data* – this covers a multitude of risks from those looking for curiosity's sake (a comparable central government example would be the Inland Revenue staff dismissed for calling up the tax records of celebrities), use of data for commercial gain (hard to control with public registers); to mischievous use of data by interest groups (clear descriptions of datasets and what they do and don't show mitigates the risk but does not remove it).
- *e-waste* – and how to deal with a new stream of silicon-based products that reach the end of their useful lives.

12.2 Privacy

> *"AOL Research released a compressed text file on its website containing twenty million search keywords for over 650,000 users over a 3-month period, intended for research purposes. AOL themselves did not identify users in the report; however, personally identifiable information was present in many of the queries, and as the queries were attributed by AOL to particular user accounts, identified numerically, an individual could be identified and matched to their account and search history by such information.*
>
> *"The New York Times was able to locate an individual from the released and anonymized search records by cross referencing them with phonebook listings. Through clues revealed in the search queries, the New York Times successfully uncovered the identities of several searchers. With her permission, they exposed user #4417749 as Thelma Arnold, a 62-year-old widow from Lilburn, Georgia ."*[102]

Almost all the preceding chapters have mentioned privacy as an important implication or impact of the technology. As is the case with other Western democracies, New Zealand has a long established tradition of valuing individual privacy and looking unfavourably on compromises of privacy.

Although the Privacy Commissioner considers that New Zealand has a relatively robust framework for managing data, he considers that it may not cover the range of tasks required of New Zealand in the future.[103] While New Zealand may be regarded as among the leaders in international practice, it is arguable that this translates into public perception that their identities are safe.

One of the identified areas of particular weakness is the lack of protection for re-identification of data from which identifying data has been removed, such as in the case above. Even quite innocuous pieces of information can, when put together, identify an individual.[104] This is a particular risk with local government data where some is publicly accessible by law, and the nature of our regulatory responsibilities means that records of related transactions are kept (remember the orchard on a restaurant example).

The other area of weakness that the Privacy Commissioner has identified lies with the public registers, which the Commissioner considers are not adequate for the digitised environment. He recommended repealing public register principles and reviewing each statute that establishes registers case by case. From a local government standpoint, we would probably prefer a uniform framework.

102 Wkipedia, entry for AOL Online Leak cited in Cukier, kindle edition
103 Office of the Privacy Commissioner (2014), "New Zealand's Data Future: A View from the Privacy Commissioner", page 2.
104 In "Simple Demographics Often Identify People Uniquely", Sweeney demonstrates that 87 percent of American citizens can be identified by date of birth, gender and zip code.

Issues get more complicated where data is held in a foreign jurisdiction and that jurisdiction's privacy laws (which it appears will often not be as robust as New Zealand) apply. It appears from a privacy standpoint our cloud and 'backup cloud' need to be in New Zealand (or in a jurisdiction where the law is equally robust).

The sector's understanding of privacy issues is 'spotty' (though this is a criticism that can fairly be levelled at most government agencies, the private sector and most citizens). A sound understanding of the privacy principles and what they do and don't allow is a core knowledge set that should reside well beyond the designated privacy officer. Privacy should be ingrained into all local government staff as part of the induction process, and those with access to data need regular refreshers (say once every two years).

12.3 Security

> *"Simply put, the Internet is not secure and the concept of '100 per cent secure' does not exist. This means that no system can ever be secure – it can only be secure enough."*[105]

The quote that opens this section is a stark illustration of a very simple fact – there is no such thing as a piece of information technology that is completely secure. Security decreases over time, IT systems are continually evolving and so are the nature of the threats to security (for example, the so-called cryptolocker viruses did not reach public consciousness until 2014).

Arguably security risks may be greater for government entities. As government entities we are always in public view, interact with the public continuously (and sometimes say 'no') and are more likely to become a target for the disaffected (and hence targets for the malicious attack). Unless authorised by the Chief Archivist under the Public Records Act 2005, local authorities must hold records more or less indefinitely.

The following broad areas of security risk are:

- *poor controls around access and use of data* – the best examples of this risk are the personal datasets that staff at the Accident Compensation Corporation and at the Earthquake Commission inadvertently made available by relying on predictive email addressing. In each case the staff were legitimately entitled to access data and were using it for a legitimate purpose, but it was questionable whether this data should have been emailed, and certainly whether agencies such as these should be using predictive addressing.
- *lack of physical or device security* – IoT applications will be particularly vulnerable to this. Anyone can make off with a sensor if sufficiently motivated.
- *environmental hazard* – what happens to systems if and when the internet is compromised, or the power goes off.
- *automated attacks* – programs such as malware that scan the internet looking for targets to infect, not necessarily with personal gain in mind.
- *criminal activity* – those looking for, or targeting vulnerable systems to attack with personal gain in mind. These include attacks such as phishing, trojans and the like.
- *publicity seekers* – those seeking to compromise a system with personal or political motivations in mind. For example, when Washington DC piloted online voting (and claimed their system was secure), researchers from the University of Michigan concerned about security of the vote compromised the system in 48 hours.[106]

105 Online Voting Working Group (2013), "Online Voting in New Zealand: Feasibility and Options for Local Elections", page 36.

106 It is understood the researchers were able to: overwrite the online ballot and successfully elect HAL9000; cast a number of ballots equal to 150 percent of the eligible voters; and change the exit page to play a song used by the Michigan football cheerleaders.

Different types of system may face different types of security risk. For example, any system designed to support billing and collection of a user charge would be subject to a higher risk of people compromising the system for publicity purposes or removing a device (the digital equivalent of tampering with a water meter).

As an aside, the law may not recognise tampering with sensors as an offence (it may be treated as vandalism or in some cases as theft). However, short of installing cameras, it would be difficult to prove that an identified individual deliberately tampered with a gantry-mounted sensor. And based on the police's track record in prosecuting tampering with water meters, there isn't much chance of a prosecution.

It is therefore important to consider the risk profile and security risks inherent in each new piece of technology before introduction. This is sometimes called threat modelling or threat assessment.

Approaches to security are grounded in what are referred to as the 'triad' of security: integrity, availability and authenticity. Integrity ensures maintaining and assuring that data cannot be modified in an unauthorised or undetected manner. Availability – means the information must be available when it is needed and security controls and communication channels must be designed to function correctly.

Detailed discussion of the means for ensuring security are well beyond the scope of this paper. The exact mix of methods will vary from technology to technology, and from threat to threat.

In addition to the technical means for ensuring security, local authorities can take additional measures to build public confidence through:
willingness to spend to achieve security – the best security measures are developed alongside systems, rather than after the fact. Mitigation of security risks and the associated costs should be a core part of any business case for a new technology. The sector should take the stance that security systems are not the place to 'trim' to fit within a budget.

seeking advice independent from the vendor before implementing systems – all information technology vendors are passionate about their products and services. This can sometimes blind them to the risks. An independent security review or security audit is a must, especially for those systems that are public facing.

zero tolerance for breaches of privacy and security – it is not known whether those responsible for the inadvertent disclosures of data were subject to disciplinary action. Our policies on breaches should treat even an inadvertent breach as serious misconduct. This also applies to conduct by members of the public that compromises security – when detected prosecution should automatically follow.

being open about the general elements of our approach to security – that is letting the public know that we are complying with international practice and other general practice such as subjecting each service to a regular security review.

12.4 Resourcing

"... the failure of IT projects was rarely due to the technology itself. Failures occur due to failures of the underlying process itself, or to the implementation."[107]

12.4.1 Sources of failure

There is a history of poorly implemented information technology projects in the public sector (though most of the major failures in New Zealand have been in central government). Reviews of IT tend to highlight the following as likely causes of failure:

- scope creep and 'overselling' of project benefits
- poor project governance
- lack of a smart buyer i.e. a lack of understanding of the system being bought or built and how it matches the expectations
- lack of interoperability between systems (sometimes unforeseen)
- a failure to integrate IT into a wider policy or service delivery change, i.e. the system becomes the master rather than the servant (watch out for this one with off-the-shelf performance management systems)
- failure to plan for contingencies
- procurement failure.

12.4.2 Budget processes

Some readers may consider this the most important of the common issues raised by our selection of technologies. Any technology, disruptive or not, needs people to install it, operate it, mend it, and interpret the things the technology may tell us. It also needs a funding stream to cover the building and operating costs.

A decision to adapt a new technology should ideally never be an impulse decision (though in 'burning platform' circumstances it may be unavoidable). Each investment needs a clearly thought out and rational business case that sets out the expected benefits and a plan for capturing them. Information technology is an asset and needs to have its own asset plan that covers the whole of life of the asset. Where the technology is to support another asset or activity (say applying AR for asset location purposes) then the technology should be incorporated into the asset management plan for the asset (in this case the utility).

Don't forget most implementation of a new technology involves operating parallel systems for a time, i.e. the old system remains running for a time while the new beds in and any last implementation issues are dealt with. Time and resource (including dollars) must be built into project plans and business cases for this.

12.4.3 Human resource implications

What about the human resource implications? Previous chapters in this report have shown that new technologies bring a need for new skills and new occupations (remember eight of the 10 fastest growing professions are technology related). When new technologies arrive there is always a transitional period while people beyond the creators acquire the new skills necessary to drive the technology. Chapter Ten noted the short supply of skills in analysis of big data – ensuring there is a sufficient flow of people into the sector skilled in the use of new technologies is critical to the successful adoption of big data.

107 House of Commons (2011), "Government and IT – a recipe for ripoffs", page 9. Downloaded from http://www.google.co.nz/url?sa=t&rct=j&q=&esrc=s&frm=1&source=web&cd=1&cad=rja&uact=8&ved=0CBwQFjAA&url=httppercent3Apercent2Fpercent2Fwww.publications.parliament.ukpercent2Fpapercent2Fcm201012percent2Fcmselectpercent2Fcmpubadmpercent2F715percent2F715i.pdf&ei=7nRSVeE8iOWgBMy0gKAO&usg=AFQjCNHg-zZhoNUIB2b45D7yKD60lelQ3A

Those skills are more likely to reside in younger workers. In addition to the digital divide created by access to the internet, there is also a similar divide in skills and (possibly) mindset. Some key occupations are already noteworthy for their older age profiles (such as building inspectors). The rollout of new technology into these occupations comes just at a time when retirement is an option – there are risks technology might hasten older workers out of the sector. This points to a need for consideration of the potential to retrain and redeploy workers in these areas, and how to capture their knowledge as they leave.

Don't forget that those jobs that may no longer be needed due to application of technology, are filled by people who have rights under employment legislation and their employment agreements. Procedures for retraining, redeployment and (if necessary) redundancy still have to be followed, including consultation with the affected staff. Do not underestimate these obligations – you will need to show how and why technology has changed the organisation's needs.

There are health and safety issues with the new technology that should be identified and planned for just as you would with any other health and safety risk. Technology needs someone to monitor it, meaning some employees will be seated and keyboarding for long periods. Constant connection means that there will be blurring of work and home lives (already many local authorities that supply cellphones do so on the expectation that the user will be available outside work hours).

12.5 Legal matters

Privacy and security law are not the only legal concerns that the local government sector must consider when contemplating how it adopts to technology.

12.5.1 Data sovereignty

As a general rule, data sovereignty is governed by the concept of territoriality – that is to say that information converted to binary form is subject to the laws of the country in which it is stored, regardless of where the actual owner of the data is situated. For example, any data stored in the United States would be subject to the surveillance and seizure provisions of the *PATRIOT Act*. This has implications for storage on the cloud, where the main providers are resident in Australia (where both Federal and state law may apply).

This issue has already surfaced in the policy framework for online voting, where all electoral data and the systems that process the votes and all backups must be held on servers in New Zealand.

Verifying that data exists only at allowed locations requires something of a leap of faith on the part of the cloud customer to trust that their provider is completely honest and open about where their servers are hosted.

One approach to data sovereignty is the so-called safe harbour agreements. These are modelled on a policy agreement between the United States and the European Union that regulate the way that US companies manage the personal data of European citizens. US companies sign up to a protocol which requires that:

- companies collecting personal data must inform people that the data is being gathered, and tell them what will be done with it
- they must obtain permission to pass on the information to a third party
- they must allow people access to the data gathered

- data integrity and security must be assured, and
- a means of enforcing compliance must be guaranteed.[108]

12.5.2 Data security

The nature of security threats is that they are constantly changing, including those that are criminal in nature. It is not always easy for the law around data security to keep up with the means used to compromise it.

As with privacy law, international law around data security varies from jurisdiction to jurisdiction. The law often links closely with the state of a nation's contract law.

Internationally there is an international standard ISO/IEC 17799 which covers data security. New Zealand has jointly developed a national equivalent standard with Australia (this has existed since 2006).

12.5.3 Intellectual property

There are two issues that local government needs to be 'on top of' in the intellectual property space. The first is protection of any innovations a local authority makes to a product. One of the strengths of local government as a sector is the willingness and ability of local authorities to share their innovation with others in the name of the common good.[109] But we need to be careful that we do protect our intellectual property from being purloined by others from outside the sector, and that this sector-good approach to intellectual property is inculcated across the sector.

Some of our potential uses of technology raise intellectual property issues in and of themselves. For example, if we use 3D printing to create a spare part for a council vehicle (that we have designed ourselves) have we infringed upon a design owned by the vehicle manufacturer (there are real instances of this).

12.6 Digital divide

The term digital divide is used to denote differences in the ability to access the internet. The World Internet Project New Zealand 2013 puts New Zealand's internet access at 92 percent.[110] There are demographic and socioeconomics differences in access to the internet – those with access are likely to be younger, higher income, more urban and European or Asian. Developing or moving services online could be seen as disadvantaging those parts of the community who do not use the internet. As local authorities introduce new technologies (for example, by smartphone app) the risk of additional divides is created (only 69 percent of New Zealanders have access to a smartphone).

There is also an element of personal choice. Not all those with access to the internet will be comfortable using the internet to access services – especially where the services involve disclosure of personal data. This self-imposed divide is real – the World Internet Project NZ found that only 47 percent of New Zealanders have accessed a central government or local government site.

108 Techtal.co, "What is Safe Harbour?", downloaded from http://searchcio.techtarget.com/definition/Safe-Harbor
109 So for example, Selwyn District's end to end online building consent system was quickly made available to Kaipara District with no concern about patents, and has since been shared with others.
110 Crothers et al (2013, "World Internet Project New Zealand 2013, Internet Trends in New Zealand", page 3.

The obvious implication of the digital divide is that local authorities cannot fully move to digital services. Some mechanism will be needed to allow for those who cannot or choose not to access service online. Inland Revenue is encouraging online filing of tax returns, but still have the facility to file manually.

The other implication is that access to technology and how to manage barriers created by differential access to the technology is a factor that must be identified and planned for.

Rural difficulties with access are in part due to relatively low internet speed (though the author suggests this phenomenon is not limited to rural areas!). Akamai (2014) rated New Zealand 28th of 54 surveyed countries for internet speed, though our internet speed was almost twice the survey average.

13 CONCLUSION

Technological change is something to which local authorities are constantly adapting. We are at the start of what some of us are referring to as the third digital revolution. The first was the creation and mass adoption of the personal computer. The second was the globalisation of information created by the internet.

And what of the third? It is a fact that in the past two days, humans and the technology we use have created more data than was created from the big bang to 2003. The third digital revolution lies in creating and exploiting the so-called 'big data' for personal, organisational and societal benefit.

We showed how pervasive the so-called Internet of Things and mobile technology will become, and how the sheer volume of data generated can replace the human element in our monitoring and measuring. Extracting meaning from this data provides us with insights and opportunities that were not available to us. But the collection and potential use of this data pose privacy and ethical considerations that can and will challenge us in the years to come. While Big Brother may not be watching us, he certainly has the tools to do it far more effectively than Orwell ever envisaged.

Many of the technologies presented in this report make use of big data easier, or are tools for extracting meaning from the data. The combination of augmented reality, mobile devices and wearable technology turn data into information and link to our senses. The applications range from cost effectively locating infrastructure, to presenting a visual picture of what our plans look like at fruition, or enhancing a visitor or tourist experience. Using 3D printing enables us to turn computer code into a physical object, for now simple objects such as cutlery, but increasingly complex in the future (such as a working gun).

The two technologies that are a little different from the others are electric vehicles and renewable energy. It is easy to see both of these primarily in terms of reducing the carbon footprint and the potential for cost reduction. But producing energy from renewable sources and micro grids are each important tools for reducing technology's dependence on the transmission network.

While technology has a direct impact on the way we deliver our services, as local authorities we must be aware of the second-order impacts of technology. That is to say, what impact is technology having on the community now and in the future? Widespread use of robotics and 3D printing will change the way manufacturing and distribution are undertaken. Co-location is no longer a necessity, so does this mean that the day of the 'industrial zone ' has passed?

The pace of change in the next five years will be greater than ever before in the history of mankind. Local authorities will be expected to adopt technology into our business practices, to generate savings, to make information more readily available, to improve services in general. Our challenge as community leaders is to identify the right points to adopt, and where to apply these challenges.

This is not a challenge that should intimidate the sector. As a sector we have long operated on the premise of sharing and adapting good ideas – Selwyn's construction of an online end to the building consent system is now in use in 23 local authorities.

13.1 So where to next?

There will doubtless be many differing views around the country how the sector should arm itself for the third digital revolution. But as a starting point, SOLGM and ALGIM consider that the sector's most immediate needs are to:

13.1.1 Support resolution of the 'Digital Divide'

Access to internet facilities of appropriate speed and reliability is one of the biggest barriers to local authorities and communities capturing the benefits of many of the technologies listed here. Local government needs a single coherent position that supports and empowers the rollout of UFB, and encourages a wider availability of Wi-Fi. This doesn't mean providing cash; it may mean ensuring our organisational policies and processes support the activity necessary to help as much of the community cross the divide as possible. We also need to provide those without access to the internet with a means of accessing internet-dependent services – for example, by having facilities available in council offices.

13.1.2 Walk the talk on privacy and ethics

We need a single coherent legislative framework that governs privacy and access to data across the entire scope of our activity (UAVs, IoT applications et al). That would include a review of the Privacy Act to ensure that it is fit for purpose in the third digital age, for example, that it adequately provides and protects data gathered via passive monitoring. The framework would also include a review to better align what is and isn't a public register, and the uses of the data therein.

Unifying so many codes is likely to be a significant task, and bluntly may not be high on central government's list of policy priorities. As a sector, and as individual local authorities, we need to commit to being responsible and ethical. Mechanisms such as the code of responsible drone use, and codes of responsible analytics, should be developed as 'models' at sector level and adapted for use locally.

As a sector we also need to demonstrate that we respect and protect the privacy of those who supply us with information. Simply having a designated privacy officer is not enough. Privacy training should be part of induction for all staff (and elected members), but especially those managing information. Staff understanding of privacy requirements should be updated regularly. Breaching privacy, whether intentionally or not, should be regarded as a serious matter, and practices that put privacy at risk should be discontinued.

New Zealand is not yet in a mature market for cloud computing services. Data sovereignty will be an issue in the medium term. As a sector we should support the current discussions with Australia around joint approaches to data sovereignty. The sector should also debate whether the safe harbour approach should be pursued (at least with our common providers from outside Australia).

13.1.3 Take a collective approach to security threats

No internet or digital technology can ever be 100 percent secure. As a sector we need to demonstrate that our protective systems are 'secure enough'. Achieving the best level of cyber security is not, and should not ever be, a political issue. It is therefore no place for false economies.

Many of the systems and digital collections we operate are extremely similar (e.g. we all have a Rating Information Database) and as a sector we should be funding regular assessments of cyber threats across the range of our digital activity. We should also have systems to share information around potential breaches and unexpected risks that are detected.

We should also check that law governing the physical security of our technology is adequate. Our experiences with non-digital technology will inform this – for example tampering with a water meter is theft, but not many cases are investigated and fewer are prosecuted.[111] These types of risk place an unnecessary barrier to successfully implementing new technologies.

13.1.4 Develop a sector workforce strategy

We have seen that the sector, and possibly the wider economy, are short of the skills to make full use of emerging technologies. In particular, data scientists are in short supply. The sector needs to identify what skills are necessary, in what quantity and develop the recruitment strategy (be it poaching or the seeding of capability discussed in chapter 10).

That strategy should also identify and plan for the impacts of technology either changing skill sets or removing the need for the occupation. This should include an assessment of the skills of these occupations and their transferability into other areas.

As the professional membership body for the sector, SOLGM is best placed to lead on behalf of the sector.

13.1.5 Better identify and share lessons from current examples

One of the strengths of the local government sector is its ability to share and learn from the good ideas generated within the sector. The smart use of information technology is a textbook example. There are opportunities to transplant local authority use of tools such as Augview across the sector. At present much of this learning is occurring through networks of information technology specialists – opportunities must be made more widely available. SOLGM and the other more occupationally focused organisations need to better coordinate:

- what types of ICT projects are recognised by which organisation and in what way – for example SOLGM-led awards might focus on examples of good policy and decision processes that use ICT generated evidence, or transform the way a service is delivered.
- better coordination of development opportunities – for example SOLGM might focus on the broad level, these are the implications of emerging technologies, and organisations such as ALGIM on the specifics of implementation.

111 As of this writing the authors are unaware of any successful prosecution, and people who are on public record showing people how to tamper are likewise not prosecuted.

13.1.6 Regularly scan the technological environment

Not every technology with the potential to affect local government has been covered here. It may be that the fourth digital revolution occurs and is linked to artificial intelligence. We've also focused mostly on silica-based technology in this report – agencies such as the World Economic Forum are looking regularly at other emergent technology (such as genetic engineering and recyclable thermoset plastics). This report will be regularly updated.

The thought processes covered in this report represent the beginning of an ongoing journey. How far your local authority chooses to travel is a matter for it to determine, but doing nothing means you're turning your back on opportunities to improve the delivery of services in your community.

Professional excellence in local government

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