Local Government Infrastructure Services

Remotely Piloted Aircraft – the essential tool to enhance Local Government service capabilities

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1 Executive Summary

Remotely Piloted Aircraft (RPA), commonly known as Drones or UAVs (Unmanned Aerial Vehicles), could soon be the essential tool within each Local Government's *toolkit* with the assistance of a local government-wide service. The opportunities are clear and this innovative technology has the potential to significantly enhance council service capabilities across a number of operational areas in the long-term and immediate future. Assisting councils to transition quickly and effortlessly to this new technology will provide far-reaching benefits. Plus, build local government capacity to effectively respond to increasing resource demands and environmental challenges.

With increasing demands put on local government resources each year, councils throughout Australia are under immense pressure to review the way that they do business. Recognising the benefits available from RPA systems, the Local Government Association of Queensland (LGAQ), Local Government Infrastructure Services (LGIS) and Telstra collaborated through the Industry Development Fund to investigate how this emerging technology can cost-effectively assist councils with managing increasing operational challenges.

This report details the findings from this investigation and showcases the success stories of councils and water utilities that have trialled and demonstrated the benefits available from RPA technology. Based on the findings from these trials and a market sounding activity, LGIS identified five key operational areas where RPA use could bring immediate and significant benefits to councils. These areas of opportunity are:

- Asset management (ie, asset condition inspections)
- Disaster management (ie, capturing live disaster footage to inform the emergency control centre or post-event condition assessments)
- Landfill and quarry management (ie, volumetric assessments)
- Pest and weed management (ie, pest/weed detection, mapping, control and monitoring), and
- Compliance management (ie, surveillance of unlawful activity, capturing pool registration data).

Further to this, as the technology is still in the infancy stages of development the growth of RPA innovations are likely to be exponential, as are the potential opportunities for early adopters. While this report has captured where the greatest efficiencies could be currently gained by councils, these efficiencies are expected to spread over time.

The trials detailed within this report demonstrate an impressive list of benefits that are available from RPA technology, including:

- Significant reduction in workplace hazards
- Increased efficiency by reducing man hours involved in routine surveillance and mapping
- Increased accuracy and consistency in data capture
- Increased accessibility to assets and unique views/perspectives
- Increased productivity and value for money by the efficient allocation and targeting of resources
- Increased quality, quantity and speed in which information is available to decision makers.

1.1 Barriers to operationalise

Despite a number of successful trials, clearly demonstrated benefits and cost savings, few councils have taken the steps to establish RPA activities within their ongoing operations. LGIS

has identified a number of barriers and perceived risks preventing councils from incorporating the new technology and the lack of a driving force or an enabler to overcome these issues.

When innovative technology of this nature is introduced to council operations there are definite risks and issues if it is not appropriately managed. RPA systems are no different and this report details how councils can access the benefits from RPA technology without the burden of their RPA activities becoming costly, resource intensive, ineffective and posing significant safety and privacy risks by adopting the proposed strategy.

LGIS has identified that whether establishing internal RPA capabilities or outsourcing, there are a number of barriers for councils to overcome. On the one hand, outsourcing can be an overwhelming, expensive and time consuming process with a market plentiful in under experienced, over-stated suppliers. On the other hand, building internal RPA capabilities can also be expensive, become cumbersome and require the careful management of a number of risk factors, including but not limited to:

- liability for damage resulting from unqualified or inexperienced staff or poor quality technology.
- liability for breaches of privacy, nuisance or trespass due to inexperienced staff or council not being aware of legal requirement for RPA use and management of collected data.
- liability for breaches of the *Civil Aviation Safety Regulations* or other legislative requirements due to inexperienced or negligent staff, poor quality technology or by not maintaining required operating and maintenance procedures, documentation and approvals.
- purchased technology becoming ineffective and not meeting council's needs due to an insufficient assessment of requirements, technology advances or changing council requirements.

For councils to overcome these barriers and successfully incorporate this technology into their operations they require cost-effective, efficient access to effective and reliable RPA services.

This means having access to a range of high-quality RPA technology solutions, plus a range of critical associated support frameworks (such as data infrastructure, policy and standards, community and stakeholder engagement). As highlighted repeatedly throughout the trials within this report, different RPA equipment is often required for different jobs and councils may find that purchasing one type of RPA will have limited applications and not meet their wider and future needs. Additionally, a number of councils may not have the resources for managing safe and effective RPA operations internally.

1.2 The solution

To ensure councils enjoy the full benefits available from RPA technology, LGIS recommends the implementation of a *gateway service* to provide councils with the support to remove all barriers to establishing RPA operations.

Similar to the introduction of smart-phone and tablet technology, the benefits from RPA use are council-wide and require a holistic management approach to effectively transition council operations to the new technology. A *gateway service* would provide councils with, essentially a 'one stop shop' service that covers a broad range of council operations. To be effective and provide councils with access to low risk, low cost and tailored RPA technology solutions, this offering must be a local government-wide service combining procurement, contractor coordination, data management and reporting. Moreover, it must also foster innovations in hardware and software specifically targeted at enhancing council operations.

The proposed *gateway service* would be beneficial for councils by providing them with:

- economies of scale cost savings
- convenient access to services when required via an efficient booking and scheduling system
- access to a range of highly skilled RPA service providers with demonstrated experience
- access to professional and experienced advice on equipment and methodology for their particular activity to achieve the best result
- access to secure offsite data storage and efficient data management solutions
- access to a suite of tools to help communicate with stakeholders regarding RPA operations
- coordinated quality control informed by local government-wide advice
- a stronger presence within the RPA market to inform *best practice* quality standards and stimulate an innovative agenda for RPA systems and future applications within council services.

Such an initiative will ensure RPA activities are properly scoped, timely scheduled and efficiently carried out to achieve further cost reductions and high quality outcomes without the risk and effort required to manage internal RPA capabilities.

Establishing the proposed *gateway service* will allow councils to access immediate cost savings for the following operational activities:

- Maintenance asset condition inspections, such as bridge inspections
- Landfill and quarry volumetric assessments and other geospatial mapping activities
- Pest control application
- Compliance surveillance.

The service would also significantly reduce the time required to complete these activities and immediately reduce safety risks.

A *gateway service* would also bring significant benefits to the following operational activities over the short to long-term through a coordinated effort to inform regulation, software and technology developments to allow for broad-scale RPA data capture (BVLOS):

- Disaster surveillance
- Pest and weed mapping and monitoring
- Automated road condition assessments.

There are significant opportunities in these areas to use RPA technology to automate detection of defects, pests and other areas of operational interest. Through a coordinated effort and development, a *gateway service* could significantly reduce very labour intensive processes, freeing up human resources, plus achieve a level of accuracy currently unachievable with conventional methods.

1.3 LGIS supporting innovation

LGIS is experienced in designing and delivery gateway and change management services to local government. This experience includes assisting councils with transitioning council operations and their communities to new technology or to align with new regulatory requirements. Delivering such services involved research and development, state/regional procurement, extensive stakeholder engagement, supplier management, logistic management, quality assurance, marketing and data and information technology management. LGIS believes this experience makes it well-suited to coordinate the delivery of the proposed RPA *gateway service* across interested councils. LGIS proposes to investigate the development of this initiative further with LGAQ and Queensland local government representatives.

2 Introduction

2.1 Overview

With increasing demands put on local government resources (resulting from growing community needs, tighter budgets, regulatory requirements or extreme weather impacts), councils throughout Australia are under immense pressure to review the way that they do business. The Local Government Association of Queensland (LGAQ), Telstra and Local Government Infrastructure Services (LGIS) have collaborated through the Industry Development Fund to investigate cost-effective innovative solutions to assist councils with managing these increasing demands.

Similar to the introduction of tablet software and smart phones to commercial activities, Remotely Piloted Aircraft (RPA) are fast becoming a 'game changer' for how local councils and utilities manage their assets. Described as 'the fastest growing area of aerospace research and development globally'[1],RPA have already been identified as having significant economic and safety benefits to a broad range of organisations. And due to their continually evolving capabilities are becoming the essential tool for operations classified as 'dull, dirty or dangerous'.[2] Gone are the days of dangerous asset inspections with scaffolds, abseiling equipment and exposure to other hazards; lengthy manual inspections and surveys; and, having incomplete asset information due to inaccessible assets.

The uptake of RPA technology is widespread in the mining and construction industries and is on the increase within the emergency services, energy, agricultural and media industries. However, like any new technology, if an RPA system (RPAS) is not appropriately managed, it can be costly, resource intensive, ineffective and poses significant safety and privacy risks for the user and the community. Managing the pilot, the RPA technology, the flight, the data and the outputs are all critical elements to a well-managed RPAS.

2.1.1 The investigation

Recognising the benefits that a well-managed RPAS can bring to council operations, LGAQ, Telstra and LGIS have investigated the current use and potential opportunities for use of RPA technology to enhance service capabilities within councils.

This investigation was carried out in three phases:

1. **Understanding local government needs** - a Technical Stakeholder Group was established with the State's Office of the Information Commissioner, RPA regulatory and research representatives, innovative technology specialists from industry, LGAQ and LGIS. The group was utilised to explore local government operational areas where RPA could be beneficial, plus highlight barriers to the uptake of the technology. The group also looked into the legal, compliance and policy issues councils may be exposed to when using RPA.

2. **Understanding the technology** – utilising the input from the Technical Stakeholder Group, a market sounding brief was drafted and released to the RPA market to determine how the market could respond to local government needs. The process sought to determine the market's ability to meet local government's operational needs, the capability of the technology and services currently available, market pricing and contract parameters for the provision of services.

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[1] Marchbank, Margo (Mar – Apr 09) *Flight Safety Australia https://www.casa.gov.au/sites/g/files/net351/f/_assets/main/lib91122/28-32.pdf*

[2] House of Representatives Standing Committee on Social Policy and Legal Affairs (July 2014) *Eyes in the sky – Inquiry into drones and the regulation of air safety and privacy.* The Parliament of the Commonwealth of Australia, Canberra, piii.

3. **Proof of concept - incorporating a well-managed RPAS into local government operations -** split into two pieces of work, this phase sought to determine the key elements required to effectively incorporate an RPAS into different council operational areas. Firstly, detailed desktop research was completed to identify councils or water utilities (as identified with similar operations to councils) throughout the country that have already investigated and successfully trialled RPA technology. The identified councils were interviewed (where available) and trial learnings and results were utilised to determine key requirements for effective RPA use.

   Further to this, LGIS conducted a number of field trials with leading RPA suppliers (identified from the market sounding process) to test the proposed RPA market solutions in real council scenarios. The trials investigated the suitability of the technology for the required outputs and explored the benefits and limitations of the technology compared with conventional practices.

This report details the findings from the investigation and covers:

1. **The current RPA market**
   Based on information gathered from the Technical Stakeholder Group and the market sounding process, this section provides a brief overview of the RPA technology that is currently available and the market capabilities identified as relevant to local government operations.

2. **Enhancing service capabilities with RPA**
   This section looks into key local government operational areas that have been proven to benefit from RPA technology. It includes case studies and research from councils and utilities throughout the country demonstrating how RPA have been successfully trialled in the field. It should be noted that this research doesn't claim to cover all potential opportunities available for RPA use and only key council operational areas have been investigated.

3. **Critical requirements of a well-managed RPAS**
   Taking the learnings gathered from the research and trials completed, this section explains the critical elements required to achieve a well-managed RPAS. This covers the legal and regulatory requirements of RPA use; technology and operational considerations to get required outcomes; and, data management considerations.

4. **An opportunity for a cost-effective solution**
   This section looks at the limitations and barriers to councils incorporating an effective RPAS within their operations. Recognising that the identified issues are common across a number of Queensland councils, this section explains a cost-effective solution to not only make RPA technology more accessible for local government but also reduce risk and make RPA use less cumbersome.

2.2 The current RPA market

Previously known as Unmanned Aerial Vehicles (UAVs), the Civil Aviation Safety Authority (CASA), the regulator of RPA use, has since adopted the term Remotely Piloted Aircraft (RPA) for these commercial/civil use aircraft to emphasise the human component still involved in controlling these vehicles.[3]

RPA technology has developed significantly in the past five years with improved design, greater use of robust and light-weight composite materials, improved connectivity and data capture

[3] https://www.casa.gov.au/operations/standard-page/rpa-background

hardware, such as high-definition cameras. These innovations have driven a market plentiful with suppliers (currently over 570 Australian certified commercial operators) with a greater range of software and hardware options. According to CASA there are over 650 identified applications for RPA[4] suggesting the opportunities to utilise RPA technology is endless. Examples of proven commercial applications are:

- Asset / structural and equipment inspections
- Land surveying, mapping and 3D terrain modelling
- Project/asset documentation (including GIS, CAD and BIM data integration)
- Agricultural and environment monitoring and management
- Landfill/stockpile volumetric and slope stability and condition analysis
- Aerial photography and community engagement.

2.2.1 Aircraft hardware

RPA come in many shapes and sizes and range from small handheld units with a flying time of a few minutes, to aircraft weighing hundreds of kilograms with endurance flying times of over 24 hours. The two most common types of RPA are fixed wing or multi-rotor, each with advantages in their application. Fixed wing Unmanned Aerial Vehicles (UAVs) offer advantages in their range and payload carrying capacity, which makes them more suitable for surveying and mapping of large spaces quickly. Whilst multi-rotor types offer more precision flying and can launch and land within constrained areas making them more suitable for inspections, detailed site aerial surveys and assessments, and surveys in difficult terrain.

Figure 1: UAV types – multi-rotor and fixed wing models[5]

Put simply, an RPAS is the integration of five components:[6]

1. The remote controlled aircraft
2. Auto pilot - an electronic device that controls the plane's flight path and photo points from a predefined mission created with associated software
3. Payload/sensor to capture the required data, ie, high definition camera
4. Image processing software ie, used to join the images captured into a larger mosaic photo map. Software can also be used to create a 3D model or to identify target images/areas through the use of programmed commands/algorithms.
5. Data storage facilities to store captured data from the RPAS, plus support any required post-processing and analysis.

2.2.2 Data capabilities

Depending on the information required and budget constraints, RPA can be fitted with a range

[4] https://www.casa.gov.au/operations/standard-page/rpa-background
[5] Images sources: http://www.asctec.de/en/uav-uas-drones-rpas-roav/asctec-falcon-8/; http://www.mavinci.de/
[6] Holloway and Plumb (October 2015) *To drone or not to drone – the timely, targeted and terrifying aspects of remote weed mapping.* 18th NSW Weeds Conference, Cooma, NSW, p. 2.

of sensors and payloads for capturing data that can be processed to provide valuable insight and information. The table below summarises the most common payload options available.

Table 1: Summary of RPA payload options

Payload option	Description
High definition RGB (Red Green Blue) camera/video	Often an 'off the shelf' high definition consumer camera is suitable for most applications. A typical camera contains RGB sensors which means they are capable of detecting the red, green and blue channels of visible light that are mixed together to form an image. The different channels can also be split with a data processing tool to achieve different perspectives on images.
Near Infrared (NIR) camera	Used heavily for vegetation, a camera with a NIR sensor can capture light not visible to the human eye by capturing the light channel just off the visual spectrum, known as the "Red Edge".
Infrared/thermal-sensitive camera	Mostly used for surveillance (security, animals, rescue), the sensors allow heat and radiation to be seen by converting infrared energy into electrical signals which are then used to produce a thermal image.
Multi/Hyper-Spectral	These cameras allow for a combination of the above sensors to achieve detailed detection, such as disease on a plant. For example, a combination of Green, Red and NIR sensors are highly effective at detecting vegetation.
LiDAR (Light Detection and Ranging)	Utilising laser technology, a sensor rapidly measures the time it takes for laser pulses to bounce back from a surface. Depending on pulse density, a detailed network of elevation points is collected (also known as a point cloud) and used to create precise 3D models of the area surveyed.
Other options	Plus the evolving list of other payload options that are not cameras, such as gas detectors, pest control applicators, etc.

The technology is capable of capturing millimetre accurate images with resolution over 100 times greater than satellites. The technology is GPS enabled to accurately control its position and information can be streamed in 'real time' to provide instant feedback.

Not only can data be captured in various formats to suit the application but post-processing using powerful software can add significant value to usability of the outputs. Through proprietary software or development of bespoke algorithms it is possible for data to be presented in ways that highlight particular areas of interest, identify anomalies, define trends, calculate volumes or provide graphical interpretation. Software output options have also increased over time to meet client demands and come in a range of options to integrate with council IT infrastructure and reporting requirements. To emphasise the range of data format output options, the market sounding process identified the following outputs have been made available for clients:

- Mapping - JPEG, JPG, PNG, TIFF, ECW, GeoTiff, Google Earth KML, XY Colour, GMP, Idirsi
- Point Cloud - Wavefront OBJ, Stanford PLY, XYZ text, ASPRS, LAS, ASTM E57, U3D, Potree, Photoscan OC3, MM Terrain, Rockworks grid, SRTM1-3, USGS, Terragen Grid
- 3D Modelling - Wavefront OBJ, 3DS, VRML, COLLADA, Stanford PLY, STL, Autodesk DXF, Autodesk FBX, Google Earth KMZ, PGM, U3D, Adode PDF, PLS Cadd, Binary v6
- Field software - DSM/DTM, GeoTiff, Optimi, Arc/Info ASCII ASC, BIL/BIP/BSQ, Erdas, XYZ, Sputnik KMZ.

2.2.3 The overarching benefits

While still in its infancy phase, RPA technology is already providing an impressive list of benefits:

- Significant reduction in workplace hazards
- Increased efficiency by reducing man hours involved in routine surveillance and mapping
- Increased accuracy and consistency in data capture
- Increased accessibility to assets and unique views/perspectives

- Increased productivity and value for money by the efficient allocation and targeting of resources
- Increased quality, quantity and speed in which information is available to decision makers.

In the Commonwealth enquiry into RPA regulation, Dr Luis Mejias Alvares from the Australian Research Centre for Aerospace Automation (ARCAA) stated new RPA are hitting the market "every six to 12 months".[7] As research, technology and software developments continue, RPA will become more intelligent, faster, lighter, stronger, more accurate, require less power and become more affordable. Frank Courtney, Melbourne Water's Technology Enablement Specialist and strong advocate and user of RPA says, "as the capability and flexibility of UAVs increases and the cost falls, expect to see UAVs become a standard part of the toolkit".[8] This is already the case for a number of utility providers and councils as discussed in the next section.

3 Enhancing service capabilities with RPA

Previously, RPA technology may have only been considered applicable for specialist and limited applications. However, that is no longer the case. Councils have responsibility for a wide range of services and obligations that can benefit from RPA technology. Utilising feedback from the market sounding process and the Technical Stakeholder Group, LGIS has identified key opportunities for RPA use. Key opportunities were defined as areas where RPA use could bring immediate and significant benefits to council operations. These areas of opportunity included:

- Asset management
- Disaster management
- Landfill and quarry management
- Pest and weed management, and
- Compliance management.

Following the market sounding process, LGIS completed detailed desktop research to identify success stories across the country where councils or water utilities have successfully trialled RPA technology within the key operational areas. While it is expected that this list is not exhaustive, it clearly demonstrates key benefits and learnings to inform future RPA trials and activities. The following councils and two water utilities were identified and a summary of their experiences is tabled below. The summary also indicates whether the trials have resulted in the successful uptake of RPA technology within ongoing operations.

Table 2: Summary of Council and water utility RPA trials conducted throughout the country

Trial owner	Trial description	Uptake
Logan City Council	Successfully trialled an RPA survey of its Browns Plains Waste and Recycling Centre for Council's Quarterly Volumetric Report. After a successful trial, Council further utilised an RPA for surveying one of its quarry sites for rehabilitation and investigated a compliance issue that involved illegal works and tree clearing on a property.	✓
Gold Coast City Council and Kyogle Council (NSW).	GCCC was the first to trial an innovative RPA bridge inspection and management system. Utilising advanced RPA technology, the system incorporates detailed automated physical inspection and detection of defects, data modelling and condition reporting for bridges and culverts. The system has since been adopted by Kyogle Council (NSW).	✓
Moreton Bay Regional Council	Successfully trialled RPA as a new cost-effective method for controlling mosquito outbreaks and aquatic weeds utilising an RPA for pesticide application.	✓
SEQ Water	Also successfully trialled RPA to control aquatic weeds in Somerset Dam. The RPA was effective at treating weeds in difficult to reach areas.	✓

[7] House of Representatives Standing Committee on Social Policy and Legal Affairs (July 2014), p. 6.
[8] Utility Magazine (February 2015) *Aerial drones: the future of asset inspection* - http://www.utilitymagazine.com.au/aerial-drones-the-future-of-asset-inspection/

McKinlay and Winton Shire Councils	In collaboration with AECOM, trialled the first long-range RPA to survey road assets beyond the line of sight for non-military purposes.[9] The RPA surveyed more than 500kms of the road network spanning between McKinlay, Winton, Cloncurry and Flinders Shire Councils.	
Sunshine Coast Regional Council	Completed a number of successful trials using an RPA to survey coastal and environmental conditions. Plus, has completed a demonstration to test the effectiveness of an RPA providing live footage to its emergency control centre during the time of a disaster.	
Kempsey Shire Council (NSW)	Trialled the use of an RPA for surveying a landfill site to compare the accuracy with a conventional ground survey.	
Singleton Council (NSW)	Trialled flights over its waste and water facilities and livestock saleyards to gather information to assist with planning and development.	
Palerang Council (NSW)	Successfully trialled the use of an RPAS for weed mapping and has incorporated the system within ongoing operations.	✓
Sutherland Shire Council (NSW)	Successfully trialled and now utilises an RPA for regular (monthly) inspections of Council's bushland and the Gandangara State Conservation area for illegal dumping and tree clearing.	✓
Melbourne Water (VIC)	Trialled RPA infrastructure inspections of its Thomson Dam Spillway and the Main Southern Corridor of the Western Treatment Plant. After impressive results, Melbourne Water is now taking steps to integrate RPA technology into its long-term asset management strategy.	✓
Northern Inland Weeds Advisory Committee (NSW)	Encompasses State and Local Government representatives from the New England and North West regions of NSW. The Committee completed an extensive trial and feasibility study on the cost effectiveness, early detection and monitoring capabilities of RPA to identify invasive weed species as an alternative to conventional ground inspections.	

Case studies with the highlights from these trials have been included below to showcase the innovative steps taken to enhance operations.

As only a handful of councils throughout the country have investigated RPA technology options, LGIS further tested the suitability of the technology and completed a number of in-field trials. Three Queensland Councils were selected for the trials based on their service geographical requirements (rural/remote, regional and metropolitan) and having no previous experience working with RPA. The trials included:

- Longreach Regional Council – trialled the effectiveness of the RPAS identifying wild dogs over a significant geographical area. Also, investigated the suitability of high-resolution imagery to support an application for State funding for the development of its livestock saleyards.
- Scenic Rim Regional Council – utilised the trials to investigate two resource intensive compliance issues. The first set of flights gathered evidence to investigate claims of unapproved site activities. The second trial completed aerial mapping of a large residential subdivision development to assess adherence to development and environment regulations.
- Cairns Regional Council – trialled the suitability and effectiveness of the technology in five priority areas identified by Council – (1) Stoney Creek Bridge inspection; (2) aerial survey of Walker Road Sporting and Recreation Precinct; (3) footpath defect inspection; (4) Gordanvale drainage inspection; and (5) residential pool conformance inspection.

Case studies on the above-mentioned trials have been included below to demonstrate how RPA have and can enhance the service capabilities of councils within the identified priority operational areas. As highlighted earlier, this research does not claim to cover all potential

[9] Keeping RPA within the line of sight is a CASA flight requirement. See Section 4 for more details on RPA regulations.

opportunities available for RPA use and only key council operational areas with the greatest potential benefit have been investigated.

3.1 Asset Management

Local governments are responsible for managing a vast array of assets and infrastructure including water and waste facilities, buildings, bridges and road infrastructure, sporting and community facilities and livestock yards for remote councils (to name a few). To prevent accidents, damage, faults and service interruptions, assets are required to be regularly inspected and maintained. Inspecting assets manually is time consuming, labour intensive, can come with significant safety risks and comprises a significant percentage of operating costs each year.

Based on the investigations for this report, LGIS has identified maintenance asset inspections as a key area where RPA can enhance council service capabilities. As highlighted in the below table, RPA have the potential to enable more frequent and accurate condition assessments, access difficult areas and inform a more targeted and effective prevention and maintenance regime. They can provide detailed images and information quickly without exposing operators to risk or having to shut down operations. The ability to accurately capture data and information and provide comparative analysis also lends it to monitoring potential movements such as slips, subsidence or corrosion.

Table 3: Comparison between manual and RPA asset inspection attributes

Manual	RPA
Time consuming	Most inspections <1hr
Labour intensive	Labour cut by at least two-thirds
Many inspections 'High Risk'	Low risk to 'Zero harm'
Operations are disrupted or shut down	Minimum to no disruption
Unable to accurately inspect all areas	Can increase access to some inaccessible areas
Potential for inconsistent inspections	Images tagged with date, time and spatial coordinates for easy reference and comparison with subsequent inspections
Lag time between inspection and response to high risk defects	Prompt access to data allows for efficient work flow and immediate response time

LGIS further recommends the use of RPA to assist with rectifying national issues with inconsistent asset inspection processes and documentation. According to the Institute of Public Works Engineering Australasia (IPWEA), many councils have lobbied for the production of a nationally consistent and authoritative reference to achieve consistent classification of road defects. IPWEA has developed a Roads Practice Note (PN9) that "provides a nationally consistent way of assessing the condition of road pavements by visual inspection through the application of a comprehensive defects based condition grading system".[10] Utilizing these guidelines, RPA software can be used to efficiently survey road networks, identify and prioritise defects according to the guideline's grading system and provide accurate and consistent condition reports to decision makers for funding. Similarly for bridge inspections, inspection procedures have been found to be inconsistent amongst asset owners.[11] Again, RPA software could assist with consistent defect classification and inspection documentation for funding.

3.1.1 Asset management case studies

The following case studies have been selected to demonstrate how RPA can:

- remove hazards and enhance staff safety

[10] *IPWEA to create consistency in road condition assessment with new Practice Note* - http://www.ipwea.org/blogs/ipwea-australasia/2015/08/31/ipwea-to-create-consistency-in-road-condition-assessment-with-new-practice-note

[11] Andrew Sonnenberg (May 2014) *Australian Bridge Inspection Process*. Paper presented at the 2014 Small Bridge Conference, Sydney.

- streamline and enhance asset inspection and reporting procedures, and
- assist with development planning and funding applications.

The case studies have also been selected to demonstrate that there is no 'one RPA package that fits all' and to emphasise the importance of planning prior to sending an aircraft into the air. Platforms, cameras/sensors, suppliers all have different capabilities that need to be properly assessed to match the business' requirements. Councils may also need assistance with mapping out their own business processes to ensure they are reaping the full range of benefits - available from this new multifaceted technology.

Case study – Melbourne Water asset inspection of water facilities

Outcome: "Trials were very successful and identified numerous benefits of using UAVs over manual inspection methods".[1]

Trial 1 – Thomson Dam Spillway

Purpose[2]***:*** The assessment of the entire structure to identify and locate anomalies such as cracking, shifting, chipping, surface degradation and weed encroachment. Overall, to assess effectiveness over manual inspections.

Process: Under instruction from Melbourne Water's Asset Manager, a multi-rotar Falcon 8 RPA was flown over the spillway for 20 minutes and took a number of high quality images of areas identified with issues. Images were available for analysis by Melbourne Water within an hour from flight completion.

Cost savings[3]***:***

• Reduced pre-inspection safety training that took 36+ staff hours down to under three staff hours by removing the requirement to have staff enter a hazardous location. This meant that the costs and manpower required to apply safety mitigations for the traditional manual process were removed.

• In addition to this, the inspection work, usually completed by five to six persons for two days, was reduced to two people for a little over an hour.

Other benefits[4]***:***

• Improved safety by transforming a high-risk activity to one that is consistent with Melbourne Water's 'Zero Harm' safety policy. A typical manual inspection of this asset requires two people to abseil down the face of the spillway whilst attempting to locate and document anomalies in the concrete structure.[5]

• Access to higher quality detailed data. The imagery was tagged with date, time and spatial coordinates allowing Melb ourne Water to quickly return to trouble spots. The detailed data also provided a reliable baseline for analysis and future planning.

• Efficient access to data allows for a faster response time to identified issues (potentially also reducing the costs associated with rectifying those issues later).

Sources:
1,2. Utility Magazine (February 2015), p. 2. & 3.
3. Advice provided by Frank Courtney (Melbourne Water's Technology Enablement Specialist) to LGIS on 13 November 2015.
4. http://www.melbournewater.com.au/aboutus/news/Documents/Innovative_Case_Study_-_Drone_Inspections.pdf
5. Ry Crozier (May 2015) Melbourne Water sends drones into sewage. IT News for Australian Business - http://www.itnews.com.au/news/melbourne-water-sends-drones-into-sewage-403723

Trial 2 – Melbourne Water's Western Treatment Plant's Main Southern Carrier

Purpose: To locate and identify anomalies such as cracking, shifting of panels and surface degradation. Overall, assess the effectiveness over manual inspections.

Process[1]***:*** Two different flight missions were conducted over the Main Southern Carrier:

(1) Aerial photographic survey – using a multi-rotar Microdrones MD4-1000 RPA, a 3.9km flight was pre-programmed and guided by GPS coordinates with the option of a manual override if necessary. The RPA flew over the Carrier at an altitude of 22m at 2.8m/sec with a downward-facing camera set to capture images every four seconds.

(2) Aerial video survey – using a Falcon 8 RPA, a flight path was programmed to fly just over the bank height and over the Carrier's bridges. Manual override was available to investigate detected anomalies more closely. Continuous video footage was captured by a forward-facing camera. Footage allowed for close detailed inspection of a variety of potential issues including gaps in between panels and erosions.
Utilising specifications provided by Melbourne Water on its defect grading system, image processing tools were used to partially automate the identification of anomalies and to identify 'hotspots' where multiple defects were found. The high resolution of the images and the aircraft's consistent position above the ground meant that the size and dimensions of anomalies could be accurately measured.

Cost savings[2]***:***

• The inspection of the Western Treatment plant inlet channel is usually a two day / two person task. The RPA flight was completed in 28 minutes (for a 4km run). Total time required for flight, site induction and safety planning was approximately three hours.

Other benefits[3]***:***

• Safety, safety, safety. Manual inspections often involve exposing staff to working at heights, near high voltage assets, biological hazards and large bodies of water. RPA inspections allow staff to stay at a safe distance from these hazards.

• Detailed images were able to be incorporated directly into the utility's GIS and immediately included into capital forecasting plans.

• The ability to record the size and dimension of identified issues meant that they could easily be reviewed in subsequent inspections to monitor changes.

Learnings[4]***:***

• A RPA and/or the sensors used for one inspection will not always be suitable for a different inspection. Time needs to be taken to work with the RPA provider to determine the scope and payload specifications to ensure that they are suitable for the business process that the inspection activity is looking to support.

• Whilst a RPA will be capable of flying in cloudy and windy weather, it may cause problems for the payload – particularly, thermal inspections.

Additionally, in January 2015, damaging winds battered Melbourne Water's Western Treatment Plant's lagoon cover. Due to the size and location of the tear, ground inspections proved unreliable as biogas in the area prevented safe access close to the tear. The RPA provided a quick, cost-effective and safe way to inspect the damage.[5]

Sources:
1, 3 & 4. Utility Magazine (February 2015), p. 2-4.
2. Advice provided by Frank Courtney.
5. Melbourne Water 2014-15 Annual Report, p. 35.

Image: Melbourne Water's Western Treatment Plant[12]

Case study – Cairns Regional Council bridge inspection and aerial mapping of construction site

Outcome: The RPA operated extremely well in all trial scenarios and gathered required data and images in a safer and more efficient way than manual inspections.

[12] Melbourne Water website - http://www.melbournewater.com.au/whatwedo/treatsewage/wtp/pages/western-treatment-plant.aspx

Trial 1 – Stoney Creek Bridge

Purpose: To inspect Council's Stoney Creek Bridge to demonstrate the detailed imagery and data available from a RPA inspection and to assess effectiveness over manual inspections.

Process: After completing Council's general site safety inspection and training, Council briefed the RPA operator on the key elements of a bridge inspection to inform the flight plan. An AscTech Falcon Trinity was used for the flight fitted with a high-definition camera to capture high-definition video and high-resolution still images. The flight was carried out manually which meant the pilot directed the aircraft from point to point allowing the pilot to zoom in on elements of interest to Council. The aircraft had a GPS guidance system and an on-board Inertial Measurement Unit to assist with the control. This meant when the pilot stopped controlling the unit it remained fixed in position until it received the next command. This ensured that at any time the controller needed to focus on something else (like capturing video or imagery) they could focus on controlling the camera whilst the unit remained in position.

The flight took one hour and captured imagery of the entire bridge structure (flying above and below the bridge) and close-up footage of the anchor bolts and rail fittings. The unit flew within one metre of the riverbed, the underside of the bridge and the banks of the river during the flight. Despite it being a very windy day, images were produced in perfect condition.

Cost savings[1]***:*** All bridges in Queensland require three types of assessment:

Level 1 - visual inspection for routine maintenance issues.

Level 2 - visual inspection to assess the condition rating of the structure and its components.

Level 3 - detailed engineering inspection to identify and quantify deterioration and provide a load rating if required.

Based on market sounding advice and advice from Council, RPA inspection costs for Level 1 inspections are slightly higher than the cost of inspecting manually. However, the data output from the RPA inspections is far richer and allows for more informed and efficient follow-on workflows and subsequent inspections. Although the trial did not investigate a Level 2 or 3 inspection, it is expected savings can be achieved from using a RPA for these more detailed inspections due to the significant reduction in man hours and equipment that can be required for detailed manual inspections.

Other benefits:

- No disruptions to service. In most cases for a manual inspection, the bridge would need to be closed for a number of hours.
- Minimal risks. Staff are not exposed to heights or required to use ropes, harnesses, scaffolding and inspection units. This also reduces the costs and time associated with managing these risks.
- Access to high quality asset data. The high quality data output from a RPA bridge inspection can allow accurate virtual off-site condition assessments, comparison analysis with previous inspections and other planning works.

Learnings:

- When flying under an object the GPS assisted function is lost and the pilot needs to entirely control the direction and stability of the unit while capturing the imagery. In this trial, Council requested to see the RPA fly under the bridge. For future inspections, the RPA could be positioned down below bridge level and zoom into the areas of interest to obtain the same information without having to put the aircraft or data quality at risk.

Sources:
1. Andrew Sonnenberg (May 2014), p. 2.

Images: Imagery of side and under bridge captured by RPA during trial.

Trial 2 – Walker Road Sporting and Recreation Precinct

Purpose: To determine how efficiently and effectively the RPA could produce a mapping outcome of the Precinct without impeding on the site's operations.

Process: The construction site for the Recreation Precinct was approximately 600m x 400m in size and was scattered with equipment and workers so taking off from a confined area was critical to avoid disturbing construction. The AscTech Falcon Trinity was flown over the area 100m above ground level, which yielded a 2cm ground sample resolution. Five flights of 30 minutes each were completed over two days (the last two flights being used to cross check that all required points were collected). Ground control targets were used to allow for the output to be of survey grade accuracy. Then by collecting parallel lines of overlapping imagery, an Orthorectified aerial image and accurate 3D surface model was created that could be incorporated into Council's planning and development systems. Field time was 2.5 hours on site and the post-site image processing took approximately five hours.

Cost savings:

• Project delays can be quite costly, so the ability to monitor construction progress effectively to keep it on track is very valuable to Council. There are also additional cost and time savings from completing surveillance without disruption to construction.

Other benefits:

• The map/model produced can be compared to subsequent surveys to show progress for comparison to the project timeline.

• Access to detailed data that can be incorporated into Council's GIS for planning and reporting and utilised by project managers onsite to coordinate works.

• Data gathered without disturbance to operations.

Learnings:

• A significant amount of data came from these trials, which can become cumbersome for file transfers and reviewing data for specific items. Consideration needs to be given to efficient methods to transfer and manage data to get Council the best outcome.

• Five trials were investigated with Council to assess the suitability of the technology for a range of operations. The results from two trials highlighted the importance of thorough scoping of the inspection activity to define the desired output and the suitability of the aircraft/payload for the output. One trial looked at footpath defects, however, the resolution of the RPA system used for this trial was not suitable to identify small footpath defects (<20mm). A different camera could have been more suitable.

Similarly, another trial involved a drainage inspection to identify areas requiring vegetation removal. The trial could not be completed because of the drains being inaccessible by the selected RPA. As the RPA market develops, a different vehicle may be more suited for this work. Regulation changes in the near future may also allow commercial RPA operators to fly RPAs beyond the line of sight (if safe to do so). This may assist with flying though vegetation to inaccessible areas.

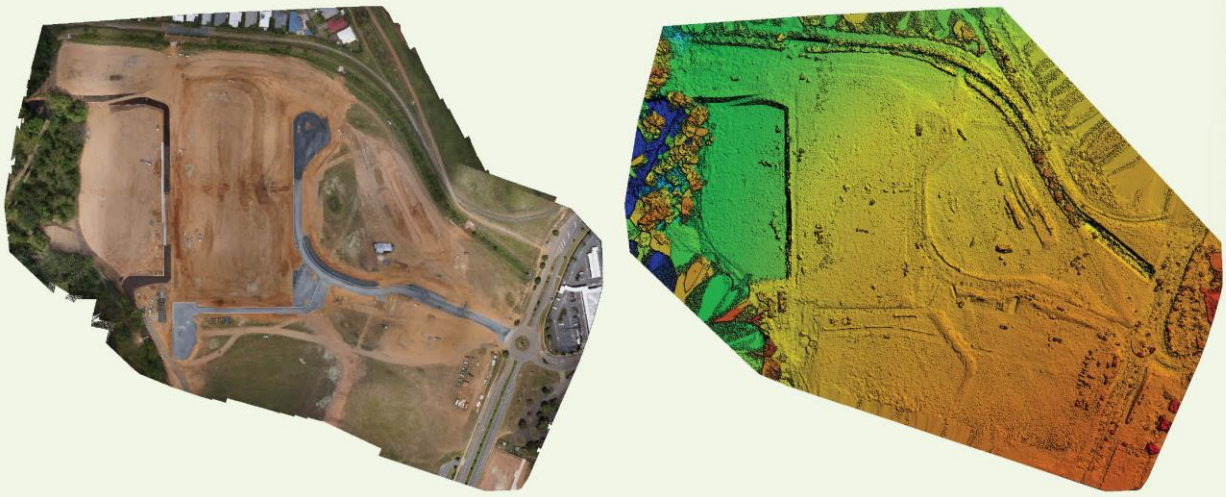


Image: Geospatial mapping of Precinct construction site captured by RPA during trial.

Case study – Longreach Shire Council

Agriculture funding development application

Outcome: Aerial imagery was detailed and captured quickly to support the funding application.

Purpose: To provide detailed aerial mapping to enhance Council's funding application.

Process: Using a multi-rotor V-TOL Hornet fitted with a high-definition camera, a 10-minute flight was programmed and carried out covering the two-hectare site. The aircraft was flown at 200ft above ground level to achieve a 1cm resolution. Using a photogrammetry application, Council was supplied with a detailed 2D Map and 3D Model of the area with original raw JPEG images for further information if required. The imagery clearly identified all key elements to meet application requirements.

Cost savings: Council was able to obtain imagery more detailed and quicker than conventional methods.

Other benefits:

- Council could easily integrate the data into its IT systems for future use.
- A tight timeframe was not an issue with the surveys completed within ten minutes.

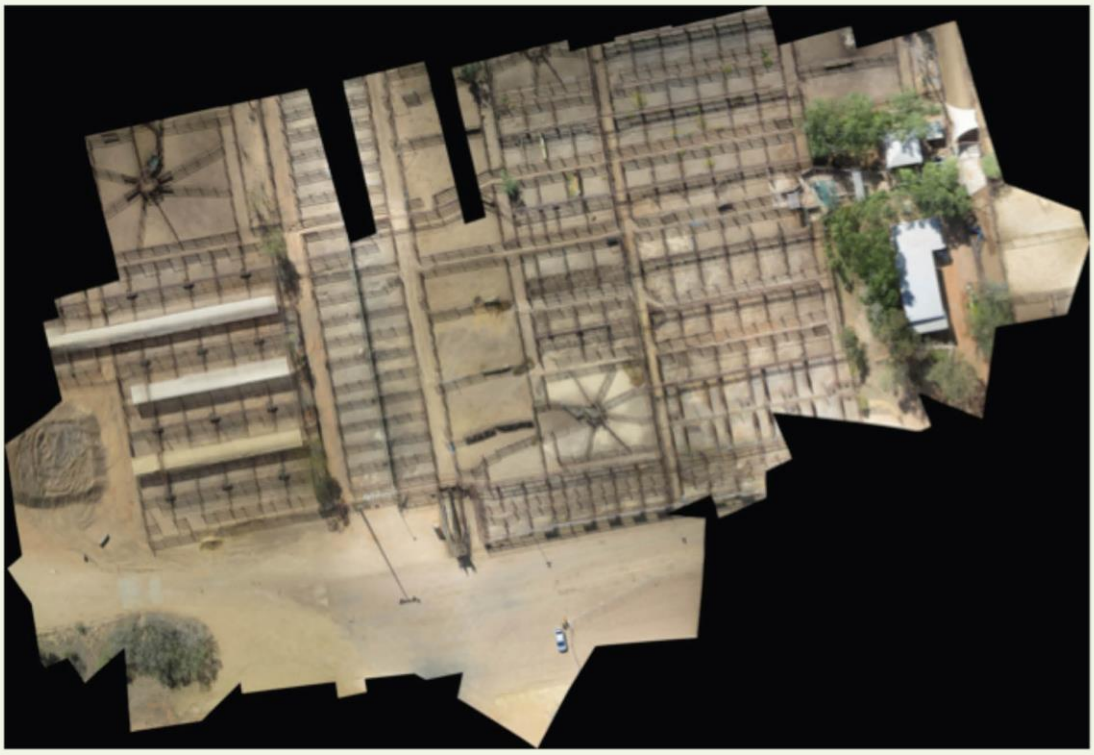


Image: Orthorectified image of Longreach Shire Council's stockyards captured during the trial.

3.1.1 Disaster management

Every year millions of dollars are spent to repair damage caused to councils in Queensland from natural disasters. It is predicted that the weather events causing such disasters are to continue and for some regions, may get worse. LGIS has assisted a number of councils throughout the State with assessing and repairing damage within their regions from such events. Based on this experience, LGIS recommends the use of RPA to assist councils with 'bouncing back' from such disasters quicker than previously achieved. The technology can assist councils in two ways:

1. Allow councils to have complete and thorough documentation of assets pre-disaster event for comparison to post-event damage assessment information. The data can then be fundamental evidence when seeking State and Federal disaster relief funding. Plus, imagery could also be applied to map potential disaster zones and assist councils with preparing for an event.

2. Allow councils to complete post-event damage assessment more effectively and efficiently than conventional ground assessments. While traditional ground assessments can sometimes take months to complete, one RPAS can collect imagery and map a region within a day allowing for detailed assessment offsite. As mentioned above, an image processing tool could also be utilised to automate defect identification and classification further enhancing the efficiencies of the RPA assessment. The ability to use aerial images to track the progress of restoration works would also be of significant benefit.

Feedback from the Market Sounding process also recommended RPA use during a disaster event to survey the damage for community announcements and potentially provide live footage back to the Emergency Control Centre. Use during this time would be dependent on weather (specifically wind speeds) and emergency airspace regulations to ensure that the RPA does not interfere with emergency air services.

3.1.1.1 Disaster management case study

As demonstrated in the below trial, military-type RPA are now being considered for commercial operations and could be useful tools during disaster events. Hailed as a "world-first",[13] the trial outlined below involved the use of the two-metre long Aerosonde Mk 4.7 that has a ten or more hour endurance and ability to carry a range of payloads.[14] With an advanced navigation system and CASA approval to fly beyond visual line of sight (BVLOS), the aircraft can fly over a 500km radius.[15] The aircraft has a “rugged all-weather” capacity and has been successfully flown through a sandstorm and the eye of a hurricane for scientific trials.[16] Therefore, potentially making it a resilient and safe RPA for use within a disaster event.

LGIS recommends further investigation into the use of this type of RPA for disaster surveillance during an event. Then if deemed suitable, taking preparatory steps to ensure all necessary approvals and procurement procedures are carried out for councils prior to an event.

Case study – McKinlay and Winton Shire Councils

Aerial survey of road network

Outcome: McKinlay Shire Council’s Mayor, Belinda Murphy advised: “the trial opened up a world of opportunity for remote councils enabling them to better manage, improve and provide value for money for their road networks. Council looks forward to assessing the potential uses for this technology in the future”. [1]

Purpose*[2]*: Having recently completed Natural Disaster Relief and Recovery Arrangements (NDRRA) work for McKinlay Shire Council, AECOM trialled the use of a specific long-range RPA to investigate the efficiencies available to the councils in the region from using such technology for future disaster damage assessments and other road surveying work.

Process*[3]*: For this trial the Aerosonde Mk 4.7 aircraft was fitted with IR, RGB and Video for photogrammetry. Two flights were completed in one day as part of the trial covering 500km of road network[4] spanning the region from McKinlay to Richmond, Cloncurry, Winton and Flinders Shire Councils. The aircraft flew between the Winton and Julia Creek airports and was launched from the back of a moving vehicle fitted with launch tracks. Flying at 100-120m above ground level, the RPA system achieved a ground resolution of 30-40mm and captured a 120m-width road corridor image. With traditional surveying picking up a road corridor of 20-40m (at best), the RPA system captured much more of the road reserve area and adjacent terrain which could prove very useful is post-disaster assessment to inform road redevelopment plans.

After the field trial, 3D mapping software was used to provide the Councils with detailed survey data and digital terrain models of their road surfaces and bridge conditions. The data clearly identified defects and stresses and can be used to inform condition ratings and asset checks.[5]

[13] Sally Cripps (26 June 2015)
[14] http://www.aerosonde.com/pdfs/aerosonde-mark-47.pdf
[15] 500kms being the limit of CASA approval. The aircraft flight capacity is far greater than this.
[16] http://www.aerosonde.com/products/products.html

Cost savings:

• While the initial outlay for this advanced aerial surveillance is currently priced higher than ground (manual or vehicle) surveillance[6], traditional surveys of 200km can take months. This survey covered more ground and was completed in six to seven hours showing the significant savings in man-hours.[7]

• When comparing the aerial survey data to the ground survey data collected as part of McKinlay Council's NDRRA damage assessments it was found that more defects were picked up with the RPA. Using the RPA for road condition assessments removes the potential for human error "and limitations of the eye, in particular checking deflection or displacement"[8] and therefore, ensures councils are getting access to all available funding.

• If councils struck by disaster have access to pre-disaster RPA surveys then this can be easily and quickly compared with post-disaster survey data to provide detailed and accurate evidence of event damage. This will allow councils to access funding significantly quicker and get rectification works underway reducing costs associated with managing interim road conditions.

Other benefits[9]:

• By using RPA technology, councils will be better able to respond to government funding and regulation requirements that are increasingly becoming more reliant on rigorous asset management records. As stated by Mckinlay Shire Council's Mayor Murphy, this technology can be a 'game changer' for road management - "I think it is really exciting, it could change the way we actually capture our road data. It could give us a level of accuracy that we currently don't have".[10]

• The data can be utilised by road managers for much more than road condition assessments and NDRRA funding evidence and can be used for planning and development works such as route planning, drainage design, flood mapping, detailed design and construction progress reporting.

Learnings[11]:

• Accuracy improves the more a section is flown - the more coverage you have of a particular point will enhance error correction and data accuracy. AECOM recommend a minimum of three readings to fix a point. Each reading after that will improve accuracy but has to be managed within budget constraints.

• Having a RPA and a camera does not mean that you will get the output required. Highly specialised equipment and skills, quality control of the data collection, data interpretation and processing capability is of utmost importance in achieving an accurate result.

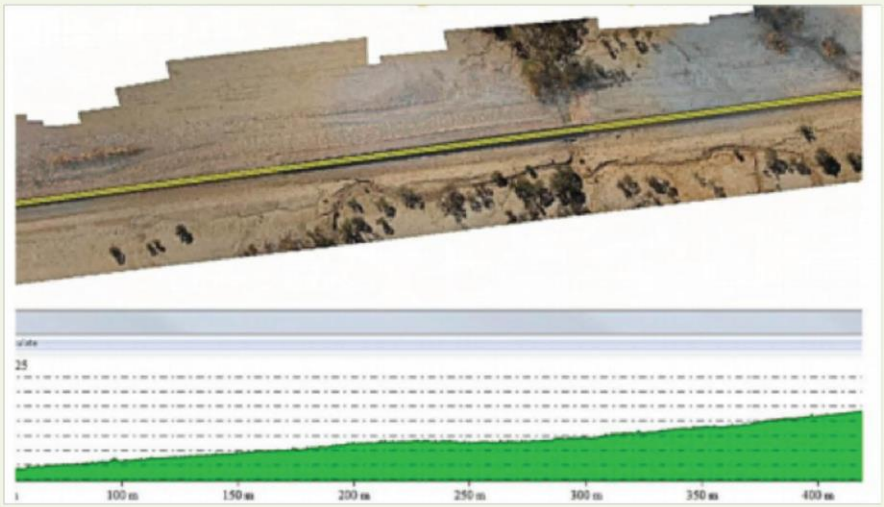


Image: Long section data captured by RPA with 100mm line sections.[12]

Sources:

1 & 7. Sally Cripps (26 June 2015) Queensland Country Life - http://www.queenslandcountrylife.com.au/story/3295547/world-first-drone-check-on-shire-roads/

2. Advice provided by Aaron Childs (McKinlay Shire Council's CEO) to LGIS on 23 November 2015.

3. Unless specifically referenced, summary is based on advice from Dyrick Hobbs (AECOM) to LGIS on 1 December 2015.

4. A total of 1,000km was travelled between the two airports.

5. Advice provided by Aaron Childs (McKinlay Shire Council's CEO).

6. Based on cost estimates provided to LGIS by suppliers.

8, 9 & 11. Advice provided by Dyrick Hobbs (AECOM).

10. Blythe Moore and Ash Moore (25 May 2015) Drone trials capturing a snapshot of outback Queensland road conditions - http://www.abc.net.au/local/stories/2015/05/25/4241748.htm

12. Provided by AECOM

3.2 Landfill and quarry management

LGIS has identified landfill, quarry management and other areas requiring geospatial mapping and analysis as operational areas to significantly benefit from RPA use. RPA can be readily applied to carrying out extensive site surveys and volume calculations, making them a more accurate, efficient and safer tool to monitor landfill sites, quarry volumes and can even be used to monitor beach erosion. By capturing a mosaic of images, the RPA software produces a Digital Terrain Model (DTM) that can then be assessed to calculate volumes and when compared with subsequent surveys can calculate changes/movements in those volumes.

After discussions with a number of councils, LGIS identifies landfill operations, in particular, as a significant opportunity for efficiencies from RPA use. As waste management regulations increase, landfill operators have a constant struggle with the efficient management and reporting of their landfill operations. Short and long-term planning of landfills is heavily reliant on accurate and reliable data to make informed decisions on tip face movements, design (batters, drainage, roads stockpiles, etc), when future cells will be required and the remaining capacity and life of the facility.[17] To keep abreast of planning and reporting requirements, most operators are resorting to one of two survey methods: (1) a manual ground survey which can often take days to complete and can cause disruption to operations or (2) an expensive aerial survey with photography taken from a manned aircraft.

3.2.1 Landfill and quarry management case studies

Recognising the benefits available from RPA technology, Kempsey Shire Council and Logan City Council trialled the use of RPA for their landfill surveys and investigated the accuracy of the technology compared with ground field surveys. Tony Green, Kempsey Shire Council's Manager of Engineering Works, advised that while the RPA made the surveying and volume analysis tasks easier, the Council experienced excessive discrepancies between the ground survey calculations and the RPA calculations.[18] On the other hand, Logan City Council found the technology to be accurate.[19] Although Kempsey Shire Council is still working through the cause of the discrepancy, it could be due to product/software limitations or the use of inconsistent or insufficient survey ground control points as demonstrated in Logan City Council's trial summarised below. Utilising a methodical testing process, Logan City Council found that RPA exceed the accuracy of field surveys for volumetric calculations and now has integrated the technology into its ongoing operations.

Logan City Council's trial also demonstrates the time and cost savings from completing the survey work more efficiently and the reporting and planning benefits from capturing such rich data. The trial also highlights the need to consider a data management solution due to the size of the data files being captured by the RPAS. This issue is discussed more in Section 4 of this report.

Case study – Logan City Council landfill volumetric survey

Outcome: "Trial results clearly showed that for volumetric surveys on open areas the UAV is able to meet and exceed the current accuracy obtained by field surveys provided sufficient controls are used." [1]

Purpose: To investigate the accuracy and suitability of using RPA to replace or compliment ground surveying for quarterly volumetric reporting.

Process[2]: The test site was Council's Browns Plains Waste and Refuse centre. To create a base model for comparison a field survey was completed using the

[17] Scott Grattan and Grant Lacey (5-7 May 2015) *UAV suitability for volumetric surveying and spatial awareness at landfills*, Waste 2015 Conference, Abstract.
[18] IPWEA - http://www.ipwea.org/tasmania/blogs/intouch/2015/11/17/civil-engineering
[19] Scott Grattan (2014) *Suitability of using UAVs for survey information within Logan City Council*. Logan City Council Report, p. 9.

Council's Volumetric Survey Standards. The survey included the location of physical features including the top and bottom of banks and surface locations. This was then processed in Council's existing 12d surveying software to produce an accurate 3D model of the cell surface.

Due to high winds, the RPA survey was not carried out until one week later. This did not affect the trial results as Council was able to isolate and exclude the refuse collected within that week. Utilising a CASA approved pilot contractor, two flights were completed with a Asctec Falcon 8. For ongoing surveys, it could be reduced to one flight. However, the extra flight was completed for this trial to ensure that there was sufficient data to compare calculations with the field model and also to compare the models from the two RPA flights. Council also wanted to investigate the ideal number of Ground Control Points (GCP) required to achieve the most accurate comparison between the field and aerial surveys.[3] Therefore, the two flights were programmed to reference four GCPs around the outside of the survey area and two additional central GCPs. Each flight was completed in around one hour and it took approximately ten minutes to produce the data for Council's analysis.

The information from the flights was provided to Council as 4 LAS (point cloud) files. Council processed the data to produce a model for each flight referencing the four external GCPs and then produced another model for each flight referencing the additional two central GCPs. These models were then compared to each other and the model produced from the field survey. The analysis found that there were significant discrepancies when only four control points were used. However, the flights that used six GCPs produced the most accurate models because the "sheer number of points picking up every bump and divot, created a more detailed overall surface" than the other models.

Field surveys can have spacing of up to 20 metres between some points and the RPA data allowed Council to significantly increase accuracy and create a grid mesh with spacing of two metres. Council could have decreased the spacing further, however, found the data (with spacing <2 metres) to be too large and difficult to work with. Taking this additional accuracy into consideration plus the refuse that was collected during the week between the field and aerial surveys, the volumetric calculations were well within tolerance.

Cost savings[4]:

• Significant saving from reduced man hours. The conventional survey took approximately six hours with post-field processing taking a further three hours. There was also a need to revisit the site to collect additional information that was missed in the original field survey. A typical RPA survey would take less than one hour in the field and it is expected post-processing time will also be reduced when required systems and calculations are in place. Given that this was a trial activity, time had to be spent setting up required data system and processes.
• Long-term savings from informed decisions. By being able to better assess volumes and landfill changes such as compaction and settlement, landfill operators can improve efficiencies and achieve a longer life for the site.
• Reduced health and safety issues from manual capture will also contribute to cost savings in the long-term.

Other benefits[5]:

• Enhanced safety and reduced field time.
• Can be used on a regular basis to calculate compaction density and VENM (Virgin Excavated Natural Material) usage to assess the operator's performance and achieve maximum efficiency. This would in turn extend the landfill's life.
• 3D imagery can be used to simulate a range of events to minimise/prevent operational issues, such as:
- Drainage/storage design to minimise leachate and storm water runoff.
- Sinkage of completed cells.
- Management of final contours to prevent batter collapses and manage repairs of such issues.
• Models can be used to assist with contractor management by assessing the volume being removed from ponds being constructed to monitor against contractor estimates. Leachate pond volumes can also be assessed to calculate processing costs.

Learnings[6]:

• Additional data manipulation was required in this trial to remove stockpiles and machinery from the final surface model. The extra reduction excluded points that were taken on machinery, stockpiles, waste lids and other non-ground features. These items may need to be manually removed from the survey area prior to carrying out flights if post-processing capabilities to remove these items are not available.
• Processing large file sizes was an issue for Council and required greater computing power than standard PCs.

In addition to using RPA for its volumetric reporting, Council has also successfully completed other projects with the technology. Using the same aircraft, aerial photography was captured to investigate illegal operations and tree clearing on a property. A RPA was also used to complete an aerial survey of a decommissioned quarry using LiDAR scanners to capture a ground surface to inform rehabilitation work. LiDAR was selected for this work as images were not required and there was significant vegetation on the site.[7]

Sources:
1, 2, 4, & 6. Scott Grattan (2014), p. 3-9. And advice provided by Scott Grattan (Logan City Council's Surveyor) to LGIS on 19 November and 7 December 2015.
3. Other RPA models may have sophisticated GPS systems that set the GCPs automatically for the survey area.
5. Scott Grattan and Grant Lacey (5-7 May 2015)

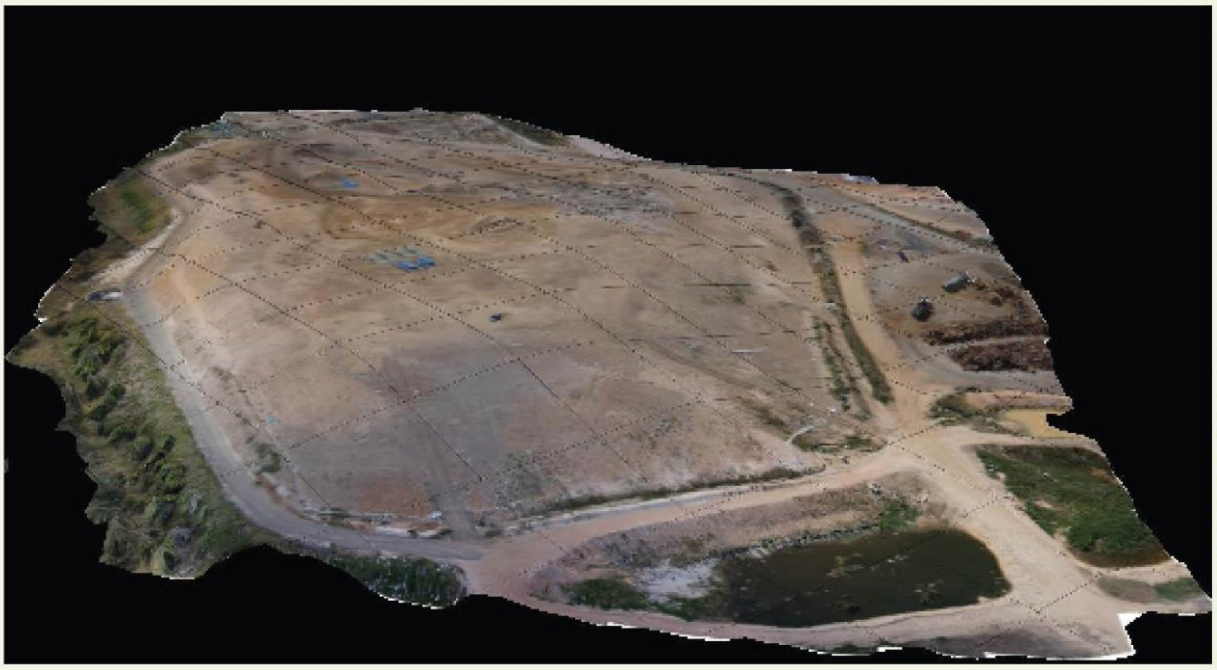


Image: Perspective view of landfill cell captured during RPA trial

3.3 Weed and pest management

Each year declared pests and weeds cost the country billions of dollars in management costs, production losses and have significant impacts on agricultural sustainability and biodiversity.[20] All levels of government and industry are continually looking for cost-effective ways to detect, monitor and eradicate pests. LGIS has identified weed and pest management as a key operational area to benefit from RPA technology and believes there are significant opportunities to utilise and customise the technology to cut costs, achieve efficiencies and enhance management practices.

Under the *Land Protection (Pest and Stock Route Management) Act 2002*, local governments are required to work with "local communities, industry groups and State government agencies" to implement a collaborative pest management strategy.[21] Under this Act "Pest" encompasses both animals and weeds and is defined as "a live animal or plant declared to be a pest under the Act and includes reproductive material of the animal or plant".[22] Councils are responsible for developing their own Pest Management Plans and issuing Emergency Quarantine Notices to control declared pests in their areas.[23] A Council's Pest Management Plan includes:[24]

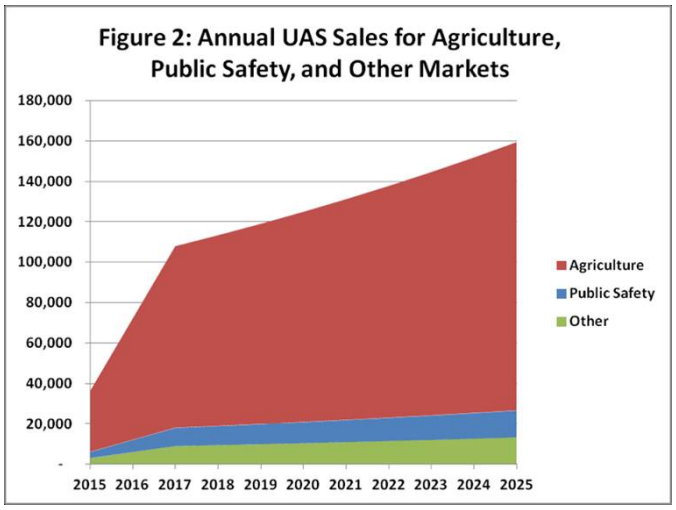
(a) achievable objectives under the Plan
(b) strategies, activities and responsibilities for achieving the objectives
(c) strategies to inform the local community about the content of the Plan
(d) monitoring implementation of the Plan and evaluating its effectiveness, and
(e) other matters the local government considers appropriate for management of declared pests in its area.

[20] Commonwealth of Australia (July 2015) *Agricultural Competitiveness White Paper* - http://agwhitepaper.agriculture.gov.au/white-paper/white-paper-at-a-glance, p. 110.
[21] S9 *Land Protection (Pest and Stock Route Management) Act 2002*
[22] Schedule 3 - *Land Protection (Pest and Stock Route Management) Act 2002*
[23] Division 2 - *Land Protection (Pest and Stock Route Management) Act 2002*
[24] S25(2) *Land Protection (Pest and Stock Route Management) Act 2002*

While aerial surveillance is not a new strategy utilised by councils for pest mapping and monitoring, traditional methods reliant on satellite imagery and manned aircraft have been identified as expensive and having limited effectiveness.[25] This is mostly due to the inflexibility of being able to access detailed timely imagery when required (within budget constraints) and poor data quality (resulting from insufficient resolution to identify specific pests or weather impacts, such as cloud cover).

RPA have recently come under the spotlight as the tool to overcome these barriers to aerial surveillance making them key to achieving an effective Pest Management Plan. As stated by, Dr Brian McCornack, a significant contributor to research in this field, "the future of effective and efficient pest management will require a higher level of automation and technical sophistication and an increased dependence on affordable technologies" such as RPA systems.[26] As depicted in Figure 2, the benefits available from this technology are already being realised within the Agriculture industry (comprising of entities with a primary focus on pest management). The Agriculture industry currently holds majority share of the RPA sales market and is forecast to be the "main driving force" for RPA technology research and development.[27]

Figure 2: Projected global annual RPA sales[28]



While only a few local governments have investigated the use of RPA for pest management, significant leading research has been carried out in this country showing the range of capabilities available for RPA. This research includes:

- Plant Biosecurity Cooperative Research Centre (PBCRC) – "completed a qualitative evaluation of RPA and onboard sensor technology" for use in plant biosecurity to be used as a guide to assist stakeholders with the adoption of the technology.[29] The evaluation looked at the advantages and opportunities RPA have over traditional tools used for pest/disease detection on Australia's key export crops. It also highlights the importance of selecting the right RPA and sensor/s for the job.

- Northern Inlands Weeds Advisory Committee (NIWAC) – completed a feasibility study on the potential use of RPA for aerial surveillance, mapping and classification of

[25] Simon Holloway and Neville Plumb (October 2015) *To drone or not to drone – the timely, targeted and terrifying aspects of remote weed mapping.* 18th NSW Weeds Conference, Cooma, p. 2; Plant Biosecurity Research Centre (16 May 2015) *Evaluating Unmanned Aircraft Systems for Deployment in Plant Biosecurity – Final Report*, p.13.
[26] *Optimising surveillance protocols using unmanned aerial systems.* Science Exchange Conference 2015, Abstract - http://www.pbcrc.com.au/sites/default/files/downloads/Concurrent%20Session%201-6%20B%20McCornack%20%2B%20Abstract.pdf

[27] Plant Biosecurity Research Centre (16 May 2015), p. 15.
[28] Extracted from Plant Biosecurity Research Centre (16 May 2015), p. 16. Original source – AUVSI (January 2014) *Precision agriculture will lead civil UAS* - http://aviationweek.com/blog/auvsi-precision-agriculture-will-lead-civil-uas
[29] Plant Biosecurity Research Centre (16 May 2015), p. 5.

vegetation as an alternative to conventional on-ground inspections.[30] Using fixed wing and multi-rotor RPA aerial imagery was captured in a number of scenarios to calculate the "optimum altitude to achieve the highest classification accuracy for four weeds" being tested.[31] Scenarios included the survey of weeds in a 20 hectare block, 250 hectare block, along a riparian waterway and in high risk pathways. An economic assessment was then carried out to determine the cost effectiveness of the different scenarios.

Findings from this research shows that by being able to "operate in remote/rural locations at lower altitudes with little to no environmental impact"[32] makes these aerial vehicles well-suited for a number of pest management activities including:

- **Early in-field pest detection** – current methods of pest detection generally focus on inspecting areas where pests have been identified previously or have been sighted by the public or ground sensors (where available). While ground inspectors are also known to transect areas of land it is uncommon for this to be done randomly (due to insufficient resources).[33] This means a significant area remains uninspected. RPA provide an opportunity to survey an entire council area (or regional area) that can then be assessed (manually or using automated algorithms) to identify invasive pests earlier than ground inspections.

  The use of automated classification could also assist with mitigating the risk of infestation caused by weeds being incorrectly identified by inexperienced field inspectors.[34] Plus, early detection of threats to plants/crops can be further enhanced by utilising RPA technology that captures multi/hyper-spectral imagery to locate and identify plants showing signs of stress from pests/disease.[35]

- **Pest mapping –** the NIWAC study found that RPA imagery along with image classification algorithms to accurately detect and map weeds in a rural landscape could be employed cost effectively as part of regional inspection programs.[36] Depending on the sensors and aircraft used, they can provide high-resolution spatial and temporal mapping over large areas down to a plant level (suggesting a higher resolution than that required for detecting vertebrae pests is currently available).

  The NIWAC study mapped four weeds (Water Hyacinth, Serrated Tussock, Tropical Soda Apple and Alligator Weed) with two different RPA platforms (fixed wing and multi-rotor). The weeds were mapped at different altitudes to demonstrate the range of accuracy depending on the altitude and how distinguishable the weed was from its surroundings.[37]Results are summarised in the below figure.

[30] Northern Inland Weeds Advisory Committee (June 2015) *Integrated Aerial Surveillance Innovative Project – Feasibility Report.* Prepared for NSW Department of Primary Industries, p3.
[31] Northern Inland Weeds Advisory Committee (June 2015), p3.
[32] Plant Biosecurity Research Centre (16 May 2015), p. 5.
[33] B. Sindel, O. Jhorar, I. Reeve, L. Thompson and M. Coleman (September 2008) *Best practice for on-ground property weed detection.* University of New England, p. 12; Environment, Land, Water and Planning (8 October 2015) *Targeting wild dogs from the air and the ground* - http://delwp.vic.gov.au/news-and-announcements/targeting-wild-dogs-from-the-air-and-the-ground
[34] Identified as the most common impediment to weed identification in B. Sindel, O. Jhorar, I. Reeve, L. Thompson and M. Coleman (September 2008), p. 38.
[35] Plant Biosecurity Research Centre (16 May 2015), p. 9.
[36] Northern Inland Weeds Advisory Committee (June 2015), p21.
[37]Northern Inland Weeds Advisory Committee (June 2015), p13.

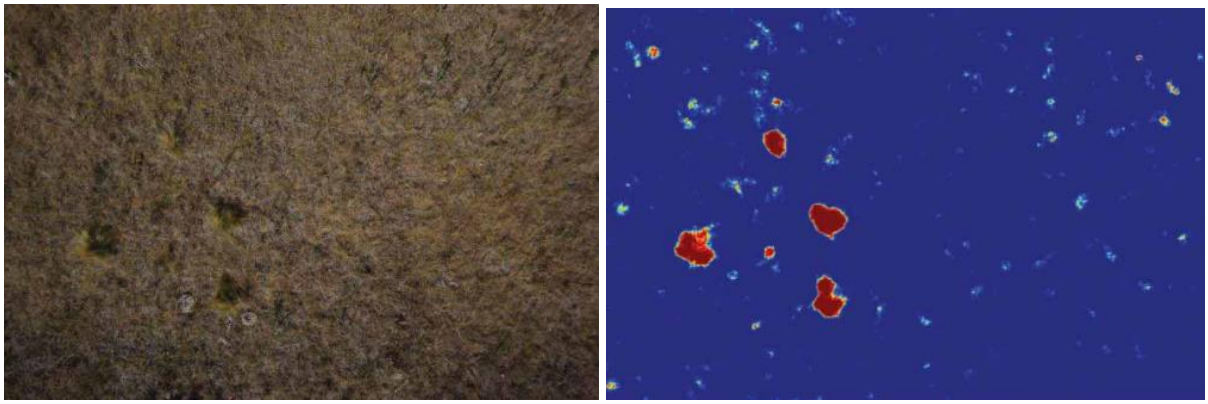
Table 4: Optimal altitude settings for weed classification[38]

Weed Type	Survey Altitude (m)	Pixel Size (mm)	Classification Accuracy (%)
Water hyacinth	30	7.8	90.0
Serrated tussock	20	5.2	90.7
Tropical soda apple	10	2.6	72.2
Alligator weed*	20	5.2	86.8

These results would increase if additional surveys were completed over time as the additional data would train the algorithms to identify weeds in different growth stages, seasonal changes and weather conditions. If budget constraints were not an issue, accuracy could be improved with a higher resolution sensor or alternatively, ground forces could be targeted to areas/weeds where the aerial surveillance has less accuracy.

Traditional pest mapping requires a large workforce to track and record pest numbers and their impacts. While neither research study suggests that RPA can entirely replace ground forces involved in pest management, both reports support that RPA have the potential to help manage an increasing proportion of the workload. This would achieve greater efficiencies and more effective outcomes by allowing ground forces to be targeted. Figure 3 demonstrates the accuracy available from automated pest mapping to allow for informed follow-up field activities. With a classification accuracy of 90.7% the image below shows the detection of the Serrated Tussock weed with red indicating high probability and blue indicating low probability for the weed's location within the surveyed area.

Figure 3: Aerial image compared with algorithm prediction of presence of Serrated Tussock[39]



- **Pest control treatments** – RPA mapping can also assist with restricting the spread of pests to other areas by promptly informing targeted quarantine and treatment activities.[40] RPA with a payload strength of 2-4kg have the potential to be incredibly effective at applying pesticides or fertiliser to targeted areas.[41] Using mapping to target pest control applications to specific areas will reduce negative environmental impacts, such as ground water contamination.

  Recognising these benefits, Moreton Bay Regional Council has successfully trialled the use of RPA for the application of treatment sprays to control difficult lake weeds and mosquito infestation (see case study below). The outcome of Council's trials supports that the RPA allows for more targeted application than that achieved from a manned

[38] Northern Inland Weeds Advisory Committee (June 2015), p8.
[39] Northern Inland Weeds Advisory Committee (June 2015), p10.
[40] Plant Biosecurity Research Centre (16 May 2015), p. 9.
[41] Plant Biosecurity Research Centre (16 May 2015), p. 40.

helicopter and is less costly than using manual application. Plus, the technology also reduces the risk of staff exposure to blue green algae and other hazards.[42]

- **Monitoring and evaluation** – subsequent aerial mapping data can be compared to efficiently highlight changes in pest movements and to evaluate the effectiveness of control measures. This information can then promptly inform a risk-based approach to the execution of follow-up strategies/treatment which may lead to cost savings by being able to further target resources or even reduce pest control applications.

While this research demonstrates the capabilities of current RPA technology, LGIS has found that few councils have taken steps to incorporate RPA use within their Pest Management Plans and operations. Despite the significant benefits available, LGIS has identified that this operational area is lacking a driving force or an enabler to incorporate the technology. The involvement of different levels of government could be a possible reason for this lag, leading to questions around where the investment for the technology should come from.

3.3.1 Pest management case studies

To assist with building a business case for councils (or other government stakeholders) to invest in RPA use for pest management, LGIS, in collaboration with Longreach Regional Council, undertook a trial to test the effectiveness of a specific RPAS for detecting and mapping wild dogs within the region. The trial also aimed to demonstrate that the research findings detailed above are not specific to weed management and extend to vertebrae pests. Similarly to the research detailed above, the outcomes from this trial highlighted the potential cost savings and reduced environmental impacts from using the aerial surveillance to target ground forces. It also identified that further efficiencies could be available from using different platform and software options than those used for the trial.

In addition to this, LGIS has identified one council in NSW, Palerang Council, where Council's weed management officers were unable to get funding support for RPA use so the officers took it upon themselves to set up and trial an RPA for weed inspections. As detailed below, the trial was successful and found that RPA surveillance for weeds reduced Council's surveillance costs and provided it with flexibility to access high-resolution detailed data on demand. Council has since gone on to integrate the technology within its pest management strategy.

While this personal investment is a level of enablement not expected from many councils, LGIS recommends that a coordinated effort is required to establish RPA technology within pest management operations. As pests know no borders, LGIS believes significant benefits exist from a regionally coordinated RPA procurement and management solution where costs and information can be shared amongst a number of councils. As discussed later in this report, LGIS could assist with establishing such a solution.

Case study – Longreach Regional Council
Aerial survey to identify wild dogs

Outcome: RPA surveillance could assist with identifying target areas for pest control treatments.

Purpose: To test a specific RPA technology solution as an option to detect wild dog packs more efficiently and effectively than conventional methods.

Process: A Hornet Multi-Rotor RPA with thermal video imagery was used to capture low-resolution thermal pictures. Two flights were completed at dusk to avoid the thermal camera capturing heat from the ground and other surfaces. The flights were 10 minutes each and covered around 10 hectares of land area with vision 1-2km in each direction captured from the rotating camera.

The RPA was flown at a height of around 90 metres above

[42] Advice provided by James Peet (Moreton Bay Regional Council's Chief Digital Officer) to LGAQ on 18 September 2015.

ground level with a slant range of 600m. This achieved a resolution of approximately 10cm. Digital image processing software was then used to analyse the data to detect wild dog packs/habitats within the area. A Video MPEG and low-resolution stills were provided to Council from the RPA contractor to demonstrate the results.

As identified with weed detection algorithms, algorithms require repeated use and reference to previous survey data to enhance detection accuracy. After the first trial of the developed algorithm to identify wild dogs, results showed that the software could identify and count wild dogs, however, required clarification from technical officers to confirm detected animals were wild dogs and no other species. Further use and developments would increase pest detection accuracy requiring less input from technical officers over time.

Cost savings: Manual tracking, pest capture and extermination processes currently cost Council hundreds of dollars per each wild dog exterminated. These costs could be reduced by targeting efforts with RPA surveillance.

Other benefits:

• Reduction in negative environmental impacts – the number of untargeted animals harmed may be reduced by the capability to better target baits and traps.

Learnings: This trial was specifically testing the suitability of a Hornet Multi-Rotor RPA with thermal

imaging for detecting wild dogs. Depending on Council's requirements for data use, a fixed wing platform may be more suited for this type of surveillance as it will cover a greater area in less time. Additionally, different processing software could be used to enhance the accuracy of pest detection with minimal input from technical officers.

Image: Close-up thermal image of kangaroos captured during trial.

Case study – Moreton Bay Regional Council

Pest control application

Outcome: The RPA removed the risk from the activity and increased treatment coverage by allowing for application in places previously inaccessible or unsafe for a helicopter or ground treatment.

Purpose: To investigate the suitability of a Yamaha R-Max RPA to reach inaccessible or unsafe areas for pest control application.

Process: During the construction of the Moreton Bay Rail Link Project, pest control application was required to eradicate a growing infestation of Saltmarsh mosquito larvae resulting from the perfect climatic and tidal conditions for mosquito breeding. Pest control utilising a traditional helicopter application was not possible for all targeted sites due to requirements to keep a safe distance from the Rail Link Project's construction areas. This led Council to consider other application options. Based on knowledge of effective RPA application for the agriculture industry, Council officers decided to investigate the suitability of RPA to combat their access issues.

Moreton Bay Regional Council initially trialled the use of a Yamaha R-Max operated by a CASA approved supplier and pilot. The RPA could fly for 30 minutes at a time with a payload consisting of a spray applicator and storage capacity of 16 Litres. As a robust helicopter-type model (approximately three metres long and just over a metre high), the RPA had demonstrated confined take-off/landing capabilities and could fly and hover low to the ground allowing for precise application.

Council selected a small low-risk area within the Moreton Bay Rail Project corridor to initially trial the RPA. After no issues were identified, Council continued to utilise the RPA to treat the remaining corridor areas inaccessible to a helicopter.

Council also considered the RPA for pest control application to treat aquatic weeds in its Thyme Court Lake. Treatment of the aquatic weeds was considered unsafe for manual application due to blue-green algae exposure and was inaccessible to a helicopter. Again, after trialling a selected area, Council found that the RPA application was specific and there was no pesticide drift to other properties. Council then continued to treat the remaining weed area.

All applications were considered successful and eradicated the targeted pests and weeds. Council now considers the RPA an effective pest control tool and will utilise it for future activities as part of its treatment strategy.

Cost savings: Conventional ground pest control application is expensive. RPA application is estimated to cost up to 50% less than ground treatment, plus provides 'invaluable' access to previously inaccessible areas.

Other benefits:

- Significant safety benefits by keeping people away from hazards and toxin exposure.
- Direct application to a greater area.

Learnings: Thorough scoping and concept testing is recommended to ensure effective operations. Moreton Bay Regional Council started small to test and understand the capabilities of the technology prior to undertaking an application of a large area.

Sources:

Pine Rivers Press (23 Jan 2015) Moreton Bay Regional Council enlists the help of UAVs to fight against mozzies - http://www.news.com.au/national/moreton-bay-regional-council-enlists-the-help-to-uav-to-help-in-the-fight-against-mozzies/story-e6frfkp9-1227194806827

B. Penfold (3 Dec 2014) RC Chopper joins the battle against weeds, Caboolture News - http://www.caboolturenews.com.au/news/chopper-joins-battle-for-weeds/2471827/

Image: Mayor Allan Sutherland inspects the RPA being used by Moreton Bay Regional Council for its pest control tirals.

Case study – Palerang Council (NSW)

Aerial surveillance for weed mapping

Outcome: "RPA are an important tool for the future of weed management in the Palerang area. The efficiency and effectiveness of broad scale weed inspections can be improved by combining aerial surveys with subsequent targeted on-ground surveys, particularly in peri-urban environments".[1]

Purpose*[2]*: Council investigated the potential use of RPA to improve the following areas :

1. *Efficiency* – specifically, could ultra-high resolution aerial images be captured and visually assessed by a trained weed inspector at a lower cost than traditional ground inspections?
2. *Consistency* – specifically, could parts of a property be viewed at similar intensity and can the RPA access previously inaccessible areas?
3. *Accountability* – specifically, is the RPA output more effective at detecting new weeds, monitoring weed management progress and can it assist with enforcing weed control actions?

Process*[3]*: In light of a limited budget, officers at Palerang Council personally invested (time and money) in training and RPA technology because they could see that the benefits would mean a significant difference to the way they did their job. Situated near Canberra, Palerang has a large area of peri-urban development. Officers identified an area with around 200 private properties plus 13km2 of public land as ideal for RPA weed surveillance. Usually, this area of land would take Council officers 20 days to inspect, however, utilising two RPA this inspection was reduced to two days. The RPA were flown approximately 100 metres above ground level and achieved a detailed resolution allowing for weed inspectors to clearly identify the following weeds: Serrated Tussock, Blackberry, Scotch Broom, Native Poa Tussocks and St. John's Wort.

Data was viewed as a mosaic image of the area in GIS software (ESRI) and basic mapping was completed to identify new weeds and infestations. It is estimated that ground inspectors would spend an additional three days to complete this initial data assessment and complete follow up field investigations to meet with landowners and take a closer look at suspicious plants. Council then references the data on an ongoing basis to carry out more detailed mapping where polygons or points are drawn to map weed infestation areas. This can then be compared to subsequent surveys to monitor changes.

Cost savings*[4]*:

• Council estimated the cost savings to be approximately a one quarter reduction in labour and a two-third reduction in vehicle use.

Other benefits*[5]*:

• Access – the ability to obtain targeted ultra-high resolution aerial photos on demand.

• Flexibility – by capturing natural colour ultra-high definition aerial photography, Council can utilise the images across a number of areas (such as, asset management, compliance investigations of unapproved developments and unregistered pools, bush fire risk maps and other environment monitoring). Council is planning to survey its entire area every four years allowing for a central repository of the imagery to be accessible across Council.

Learnings:

• Weed classification from RPA imagery can be enhanced by completing surveys during times of the year when weeds have more distinct visual characteristics, such as flowering. This applies to manual or automated weed classification.

• To establish RPA technology capabilities internally is a "complex, time-consuming and costly process".[6] Plus there are a number of safety and privacy risks if the technology is not managed appropriately. If the cheapest solution is not a priority, all of this can be reduced/ mitigated by outsourcing to a qualified experienced RPA supplier.

Sources:

1, 2, 4. Simon Holloway and Neville Plumb (October 2015), p.1-5.

3. Advice provided by Neville Plump (Palerang Council's
5. Senior Environmental Services Officer
– Weeds) to LGIS on 14 December 20

3.4 Compliance management

Local governments currently enforce local community compliance across a variety of state and federal government Acts. Under these Acts, local governments have the power to legally enter land or properties to determine if breaches have occurred. Monitoring for compliance is labour intensive and most councils have to rely on reports from the community to target resources as there are insufficient resources to inspect all properties within a council's boundaries. The

collection of evidence ‘on the ground’ can also expose staff to unnecessary risks from difficult/inaccessible terrain, animals or landowners. LGIS recommends the use of RPA as a cost-effective way to reduce that risk and collect detailed evidence efficiently to support enforcement actions.

3.4.1 Compliance management case studies

As detailed in the case study below, Sutherland Shire Council was one of the leading councils to utilise RPA technology for compliance investigations. Rather than completing surveys and post-field data analysis, the Council uses the RPA as an inspecting officer's 'eyes in the sky' when the officer is out in the field. All surveillance is, however, completed over public land and few councils in the country have used the technology to investigate compliance issues with private landowners.

To investigate this further, LGIS in collaboration with two councils – Scenic Rim Regional Council and Cairns Regional Council undertook field trials to test the effectiveness of RPA aerial surveillance for three compliance areas - development application assessment, illegal operations and pool registrations. The results from these trials are detailed below.

Case study – Scenic Rim Regional Council

Aerial survey to support compliance investigations into a residential sub-division development site and unlawful operations

Outcome: Detailed evidence was collected more efficiently than conventional methods and was suitable to support further enforcement action.

Trial 1 – Survey of a residential sub-division development site

Purpose: To investigate a residential sub-division development to determine if the property developer had complied with required development approval and environmental regulations.

Process: A Hornet Multi-Rotor aircraft was used with a high definition camera. A Council officer advised the pilot on key environmental aspects that were of interest for the inspection. The pilot then programmed the RPA to complete a flight approximately 75 metres above ground level covering the 11 hectares sub-division development. Three 15 minutes flights were completed in total to ensure that sufficient detail was collected to inform the compliance process.

Council was provided with a 10mm resolution 2D map and 3D model of the area with supporting high-resolution photographs if officers needed to zoom in on particular areas of interest. The provided mapping could easily be uploaded into Council’s system and allowed officers to overlay the property developer’s development application with the captured data to easily identify any discrepancies. The 3D model also allowed officers to easily calculate information such as slope, volume, and distance between points within the site.

Cost savings:

The high-definition aerial perspective allowed for a more efficient and effective review, reducing staff costs associated with the compliance activity.

Other benefits:

- Improved safety management – no staff were required to enter the construction site to capture data.
- Rich data – normal practices could not capture the type of high definition camera footage and rich outputs obtained. The data could be easily integrated into Council’s IT systems and overlayed with approved plans and other information to allow for an efficient and thorough investigation. The outputs were highly detailed to sufficiently inform stakeholder communication, dispute resolution and legal proceedings.

Image: Perspective view captured by RPA during trial

Trial 2 - Compliance Investigation

Purpose: To test the effectiveness of a RPA investigating unlawful operations on a residential property.

Process: After being briefed by Council officers on the suspected unlawful activity being undertaken on the property, the RPA pilot conducted two flights around the boundary of the property. Each flight was at a different height ranging between 45 and 60 metres above ground level. Two cameras (a 24 and a 35 Megapixel camera) were used during the flights to capture different angles of the suspected unlawful activity. All footage was captured within 30 minutes.

Council was provided with video and high resolution photographs (date, time and location stamped) immediately after the flights to allow for prompt follow-up enforcement action. The video footage allowed Council to recreate the flight paths for further investigation and could be used for any future legal proceedings. The high-resolution images provided officers with the flexibility to zoom in on areas of interest and could be easily included within compliance documentation.

Cost savings:

As evidence is more comprehensive and detailed than that obtained from conventional ground investigations (especially in cases with access issues) there is a potential cost savings from more efficient enforcement and legal proceedings.

Other benefits:

- Improved safety management – no staff were required to enter the property or communicate with the landowner to capture data.
- Efficient investigation – some compliance matters require a large logistical exercise to enter the property and capture data, the RPA allowed this investigation to be quick and effective.
- Rich data – the high-resolution imagery greatly contributed to communication with the landowner.

Learnings:

- Accessing large data files required greater computing power than standard PCs

Case study – Cairns Regional Council

Aerial survey to investigate compliance with pool safety standards

Outcome: RPA were found to be highly effective at capturing high resolution imagery to update Council's pool registration records and inform compliance communication with residential landowners.

Purpose: Under the Building Act 1975, residential pool owners had until 30 November 2015 to meet the required pool safety standards including pool registration and fencing requirements. Recognising that councils are going to be burdened with an increased number of pool inspections and pool related compliance issues, Cairns Regional Council was interested in investigating ways to enhance existing inspection procedures. In collaboration with Council, LGIS arranged a trial to explore how council could use RPA to capture data on pool locations and fencing in an effective and practical way with fewer resources.

Process: The aim of this trial was to demonstrate how a RPA system could assist pool inspectors to target their resources to avoid a door to door inspection effort. An AscTech Falcon Trinity multi-rotor RPA was utilised for this trial as it had a vertical takeoff and landing capacity and could easily be launched from a residential footpath. Using a high-definition camera, the RPA was programmed with a 15 minute radius flight area over residential properties.

High-resolution video and images were provided to Council that clearly showed swimming pool locations and pool fences (if present). Council could use this data to match with its existing pool registration data to identify pools that are not registered and pool fencing that has not been inspected or Council does not have inspection information for.

Cost savings:

• A significant reduction in ground force costs is expected from more effectively targeting resources.

Other benefits:

• Efficient inspection process without disturbing the community to capture basic data. While imagery could not be used to determine whether pool fencing met all specific height and spacing requirements, it would allow Council to target its inspection efforts.

Image: Perspective view of residential pool captured by RPA during trial.

Case study – Sutherland Shire Council

Aerial survey to identify illegal tree clearing and dumping activities

Outcome: The RPA surveillance allowed for safer and more efficient deployment of resources to investigate illegal activity.

Purpose: Inspecting officers at Sutherland Shire Council are tasked with inspecting over 180kms of dense bushland across Council owned land and the Gandangara State Conservation area. Manual ground inspections require officers to drive for hours each day along difficult terrain and motorbike/vehicle tracks to identify areas where trees have been cleared illegally or land/waterways have been used for illegal dumping. Officers are exposed to significant risks every day and many tracks explored result in dead ends and wasted time. Council investigated the use of a RPA to more efficiently inspect difficult to access areas for illegal activities.

Process: Inspecting officers were not interested in capturing data for post analysis. Instead they wanted a tool to act as their 'eyes in the sky' to view the track ahead of them for potential compliance issues. To avoid driving down dangerous terrain and vehicle tracks, the inspecting officer sent the Phantom 3 RPA into the air to capture video footage of the area which the officers could then view live on their mobile phone. The RPA flew a 15 minute radius area around the takeoff point and allowed the inspecting officers to identify whether there were any compliance issues in the area worth further investigation. When no tree clearings could be seen, the officers did not have to waste time travelling down difficult tracks and could move on to the next inspection area.

Council found the trial successful and has since integrated RPA use into its regular monthly inspections.

Cost savings:	Other benefits:
• The RPA use allows officers to cover many kilometres of land in a day and identify many more compliance issues.	• Improved environment management from the rectification of more compliance issues.

4 Critical elements of a well-managed RPAS

As highlighted in the above-mentioned case studies, harnessing the full potential benefits of RPA technology involves more than sending an aircraft into the air. If the RPAS is not appropriately managed, it can be costly, resource intensive, ineffective and poses significant safety and privacy risks for the user and the community.

Based on the research and trials completed for this report, LGIS has identified the following critical elements required to allow councils to realise the potential of RPA technology while protecting against risks are:

1. Highly skilled and certified pilot
2. Understanding of the legal parameters of RPA use
3. Specialised equipment to match the required output
4. Data infrastructure to support business reporting, analysis and storage needs
5. Community and stakeholder support.

These elements are explored in more detail below.

4.1 Highly skilled and certified pilot

With over 570 Australian certified commercial operators available, it can be a daunting task for councils to select the best suited to local government operations. Especially, as a high number of operators claim to have expertise in areas that they do not, seemingly confusing clients with technical jargon because of their limited knowledge about the technology and the capabilities available.[43] To avoid this decision, councils may decide against outsourcing and prefer to establish internal pilot capabilities. This, however, can increase a council's risk exposure and, as identified by Palerang Council (see earlier case study), is a "complex, time-consuming and costly process".[44]

Whether deciding to outsource or not, councils need to ensure RPA pilots meet three requirements:

1. **Pilot has a UAV Controller's Certificate or a Remote Pilot Certificate to fly the RPA required**

To fly any RPA for commercial work either a UAV Controllers Certificate or a Remote Pilot Certificate is currently required under the *Civil Aviation Safety Regulations (CASR) Part 101 (Unmanned Aircraft and Rockets)*. These certificates apply to the individual who would be employed by an RPA Operator Certificate holder for commercial work operations. [45]

The training required for these certificates is competency based and comprises of a combination of theory and practical training covering aerodynamics (including effects of controls), aircraft

[43] Finding from the market sounding and research completed for this report.
[44] Simon Holloway and Neville Plumb (October 2015), p. 4.
[45] CASA (March 2015) *Application for Remote Pilot Certificate / UAV Controller Certificate* https://www.casa.gov.au/sites/g/files/net351/f/_assets/main/download/new_cc_info_ver0_2aug13.pdf

systems, performance, navigation, meteorology, airspace, rules of the air, radio telephony procedures and emergency procedures. Both certificates require the successful completion of:

- an Aeronautical Radio Operator Certificate
- an English Language Proficiency Assessment
- Manufacturer Training & Assessment on the RPA type the controller/pilot will be flying.
- five logged hours of practical flying of the RPA type the controller/pilot wants approval to fly demonstrating that the controller/pilot can control the RPA "throughout its design parameters and potential operating conditions, including dealing correctly with emergencies and system malfunction."[46]

The Remote Pilot Certificate has been created to allow the option of gaining a Certificate that is focused entirely on the operation of an RPA and is suited for most commercial operators. Whereas the UAV Controller's Certificate additionally requires the successful completion of a Private Pilot License theory exam for a manned aircraft (required for flying larger, sophisticated RPA). Both training courses are provided by CASA approved training organisations.

Civil Aviation Legislation Amendment (Part 101) Regulation 2016[47]

CASA recently announced amendments to the *CASR Part 101* and other related legislation that are due to come into effect on 29 September 2016.[48] The amendments replace the current Controller/Pilot Certificate with a Remote Pilot Licence (with reduced aeronautical knowledge requirements) and introduce a new weight classification to define operating, licence and certification requirements:

- very small (<2 kg)
- small (2-25kg)
- medium (25-150kg)
- large (>150kg)

Weight is defined as the "gross weight" or "maximum take-off weight" (MTOW) and includes the weight of the RPA and the payload it is carrying.

The amendments removed the requirement for commercial operators flying very small RPA to have a Controller or Remote Pilot Certificate or Operator's Certificate. Instead such operators are now only required to provide one (1) notification via an online system to CASA at least five days before their first commercial flight outlining the locations that they intend to fly within and the RPA systems that the operator will be using. The operator is also required to operate within the standard operating conditions (outlined in section 4.2.1 below) and must notify CASA within 21 days of any changes to the details provided within the operator's initial notification.

The amendments have also introduced an "Excluded RPA" category that applies to "private landowners" as explained on CASA's website[49] and the Explanatory Statement for the legislation amendments *"permits private landowners to carry out some commercial-like operations on their own land under the 'standard RPA operating conditions' without requiring them to hold an Unmanned Aircraft Operator's Certificate or Remote Pilot License, if using an RPA weighing up to 25 kg provided that none of the parties involved receive remuneration*."[50]

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[46] CASA (July 2002) *Advisory Circular AC 101-1(0): Unmanned aircraft and rockets* https://www.casa.gov.au/sites/g/files/net351/f/_assets/main/rules/1998casr/101/101c01.pdf - p.16.

[47] Australian Government Federal Register of Legislation, *Civil Aviation Legislation Amendment (Part 101) Regulation 2016* - https://www.legislation.gov.au/Details/F2016L00400

[48] CASA https://www.casa.gov.au/aircraft/standard-page/part-101-amendments-cutting-red-tape-remotely-piloted-aircraft

[49] CASA https://www.casa.gov.au/aircraft/standard-page/part-101-amendments-cutting-red-tape-remotely-piloted-aircraft

[50] Australian Government Federal Register of Legislation, *Civil Aviation Legislation Amendment (Part 101) Regulation 2016*, Explanatory Statement - https://www.legislation.gov.au/Details/F2016L00400/Explanatory%20Statement/Text

While these current amendments appear to exclude government-owned/public properties, LGIS is in discussions with CASA about whether the parameters of this provision will be extended to include government-owned properties.

Despite these upcoming amendments, LGIS strongly recommends that Councils ensure all staff flying RPA or external commercial operators hold a current Remote Pilot Licence. As reports in the media continue to grow on near misses, injury and death resulting from improper RPA use, this perpetuates our belief that RPA should not be treated as low risk equipment. Although the risk of death or serious injury is potentially lower than that of other workplace vehicles that require licences, the risk is still significant enough to require operators to be sufficiently trained and licensed.

In addition to licence requirements, Councils also need to mitigate risks associated with pilot/controller competency and fatigue. Pilots that are required to operate infrequently will need regular training activities to ensure competency and skills levels are maintained. On the other end of the scale, councils or contractors that have a large work schedule but only one pilot will need to have fatigue management procedures in place to mitigate associated risks.

2. Pilot operates under a commercial operator or Council with a CASA approved Operator's Certificate for the RPA and activity required

An Operator's Certificate is currently required for all commercial use of RPA. It requires CASA approval of the organisation's operating procedures to ensure that all appropriate controls are put in place and that the organisation has the right set of resources to do what it is intending to do. To certify, CASA requires an Operations Manual and supporting procedures to be submitted for approval, including:

- a risk assessment, specifying safety procedures and nominating key operations personnel, such as the Chief Pilot and Maintenance Controller and their responsibilities.
- proficiency requirements to keep RPA controllers abreast of industry developments and maintain competent in-field skills.
- a Flight and Maintenance Manual for each aircraft type that the operator is seeking approval for.
- a documented flight log for manual and automatic flight tests for each RPA type the operator is seeking approval for.
- details of any additional approvals required to fly within specific areas (ie, near aerodromes) or outside of standard flight requirements (ie, above 400 feet above ground level or out of the controller's line of sight).

The organisation may also be required to complete a series of interviews, RPA demonstrations and an inspection of facilities and maintenance activities. CASA may issue an Operator's Certificate if it is satisfied that the entity can conduct its RPA operations safely and documentation meets all of CASA's minimum requirements.[51] If required, the Operator's Certificate will have appropriate conditions imposed on it and may contain approval for unrestricted operations of a type described in the operator's Operations Manual.

As noted above, the amendments to CASR Part 101 will see the removal of the requirement for an Operator's Certificate for commercial operations involving a very small RPA (<2 kg). While this may reduce administrative costs and achieve process efficiencies for councils wanting to internally operate a very small RPA, it significantly increases a council's risk exposure and liability. As the amendments will remove the previous third-party endorsement of adherence to safe operating procedures that CASA's certification provided councils. To mitigate this risk, LGIS recommends that councils still implement the range of operation and maintenance procedures required by an Operator's Certificate to ensure operations are carried out safely. It is

[51] CASA (July 2002), p. 17.

further recommended that councils utilising external operators, require those operators to have a certified Operator's Certificate. Implementing these measures, will assist with mitigating a council's liability in the event of an incident as the council will be able to show what steps were taken to prevent the incident.

If a council is using an external commercial operator for its RPA activities, it should obtain copies of the above-mentioned CASA certificates/licences and confirm the details of certification on CASA's online database of Australian commercial operators to confirm the controller/pilot and operator are certified for the RPA use required. Alternatively, if an external uncertified operator is used for very small RPA operations post the release of the above-mentioned amendments, then the council should verify notification requirements have been met via CASA's online database. Otherwise, the legality of the imagery captured could come into question.[52]

3. **Pilot/commercial operator has demonstrated experience in piloting an RPA for the council's required use**

With so many operators existing in the market, it is vital that councils take the time to assess skills and choose the right operator for the job. As demonstrated in the case studies above, the required output will not be achieved if the operator does not have suitable experience in the field to know or possess the right platform, sensor and data processing software required to produce the desired output. Different jobs may require different suppliers and different technology options to achieve the best results.

Whether evaluating the use of external or internal pilot capabilities for an RPA activity, LGIS recommends the following criteria is met (in addition to CASA certification/licence requirements mentioned above):[53]

- the pilot has demonstrated experience to support their ability to fly in the intended location.
- the pilot has demonstrated experience in capturing the required data, and
- the pilot has a knowledge of the operational area the RPA activity is supporting and can recognise what they are looking at, ie, asset fault or weed infestation.

With the approaching legislative amendments outlined above, councils may be enticed to use/purchase a very small RPA to avoid licence/certification requirements. If councils do go down this path, LGIS highly recommends that a thorough risk assessment and scoping activity is completed to ensure that:

1. the RPA is suitable for the required use (as most commercial operations generally required a RPAS with a MTOW greater than 2 kilograms to achieve the required accuracy).
2. risk mitigation procedures are put in place to ensure that staff flying the RPA are kept abreast of air safety and RPA use laws and regulations as they will still be required to fly within specified parameters, and
3. maintenance, operational and flight procedures are established and clearly documented to ensure safe operations.

As outlined above, despite this relaxation, LGIS recommends councils always take a risk-averse approach to RPA use and ensure all operators of RPA for council business are highly skilled in RPA use and licensed to mitigate any risk of damage. Taking this approach will also assist with minimising a council's liability for any resulting damage or injury. By upholding these requirements, councils can not only establish effective RPA operations but will further maintain safety levels and public trust in RPA use.

[52] Simon Holloway and Neville Plumb (October 2015), p. 5.
[53] Based on the advice and learnings provided by participants in the research for this report.

4.2 Legal parameters of RPA use

"With new technology comes new legal changes" but according to King and Company Solicitors, the potential legal challenges for local governments from RPA use are 'not insurmountable' and the many advantages and efficiencies the technology offers far outweighs the legal risks.[54]

The main legal issues to be considered when utilising RPA technology are: safety and liability for damage, privacy, and whether entry into the airspace above a property could expose councils to trespass or nuisance actions? In collaboration with LGAQ, LGIS has investigated these issues and sought legal advice from King and Company Solicitors. Findings are detailed below.

4.2.1 Safety and liability for damage

Under the *Civil Aviation Act*, the Civil Aviation Safety Authority (CASA) was established to develop and enforce the civil aviation safety standards. In 2002, CASA released *Part 101* of the *Civil Aviation Safety Regulations* to regulate RPA use. In addition to the CASA certification (mentioned above), the *Regulation* requires commercial RPA users to adhere to the following 'standard operating conditions' to ensure the safe operation of RPA:[55]

- operate the RPA no higher than 120 metres (400 feet) above ground level, in visual meteorological conditions, by day.
- operate the RPA within 'line of sight' of the pilot (not aided by binoculars or a telescope).
- not operate the RPA in a prohibited or restricted area or within 5.5 kilometres (three nautical miles) of an aerodrome boundary without special permission.
- not operated over an area where a fire, police or other public safety or emergency operation is being conducted without the approval of a person in charge of the operation.
- not operate an RPA over a populous area (defined as an area of sufficient density or where there is an unreasonable risk, caused from fault or failure, to life, safety or property of someone not involved in the RPA activity) and includes parks, beaches, sporting ovals and other public areas.
- not operate within 30 metres of a person who is not directly involved with its operation, and
- only operate one (1) RPA at a time.

Whether at fault or not, a breach of any of the above conditions by the RPA operator "constitutes an offense of strict liability" under the *Civil Liability Act*.[56] While adhering to CASA certification requirements and the standard operating conditions will contribute to reducing a council's liability, accidents can still happen. Plus, the airworthiness and technology used to control RPA during flights is still developing and the quality of such systems and platforms greatly differs amongst RPA providers.[57]

Whether using external or internal pilots, councils need to ensure that council's existing insurances include cover for any potential damage or harm caused to persons or property from RPA activity. And if using an external RPA operator, contract and insurance provisions should be in place to ensure liability for any damage rests with the operator (to the extent permitted by law).

[54] Advice provided by King and Co to LGAQ on 13 July 2015.
[55] House of Representatives Standing Committee on Social Policy and Legal Affairs (July 2014), p. 19.
[56] Advice provided by King and Co to LGAQ on 13 July 2015.
[57] House of Representatives Standing Committee on Social Policy and Legal Affairs (July 2014), p. 14.

In light of the unpredictability of RPA technology standards, the aim of the 'standard operating conditions' and stringent certification requirements on commercial users is to "segregate RPA operations from other airspace users."[58]CASA has advised that RPA technology is rapidly advancing with developments including reliable fail-safe and "detect and avoid" systems. As these developments become more widespread, CASA foresees a reduction in the need to segregate commercial RPA operations from other airspace users and may be open to approving more activities to operate outside of the standard operating conditions.

The above-mentioned amendments are the first stage of a comprehensive review that CASA is currently undertaking of the CASR and associated legislation. CASA has recognised the shortfalls of the current outdated regulatory provisions and CASA's intent is to rectify this and align Australia's RPA legislation with international regulatory frameworks and standards. Further to this, CASA is planning CASR Part 102 that will look into the regulatory framework and standards 'for BVLOS operations, operating in non-segregated airspace, and other complex operations including various degrees of automation.'[59]

CASA has recognised that it needs a regulatory framework that can quickly respond to changing market needs and requirements to effectively support a fast-moving technological field such as RPAS.[60] LGIS believes that local government needs to take a similar approach and ensure that any policy, procurement and operational decisions related to potential RPA use made now do not stifle future flexibility to adjust to this rapidly changing legislative and technological environment.

4.2.2 Privacy

Privacy issues from RPA use are possibly the legal issues of most concern to the community. However, if councils treat captured data similarly to all other personal data managed by councils, all potential issues should be mitigated. Additionally, proper community engagement on a council's RPA activities and privacy procedures should instil community confidence and address any concerns the community has.

Personal information collected from any RPA activity is subject to the obligations in the *Information Privacy Act (IP Act)* which stimulates the requirements for the collection, storage, use, handling and disclosure of personal information by Queensland Government agencies. RPA imagery captured by councils will also be public records, governed by the *Public Records Act.* While these are the two primary legal frameworks to be considered for managing personal information, unlawful RPA use by councils could also be actioned under the *Invasion of Privacy Act (Qld)* for privacy breaches relating to audio recordings of conversations and *Section 227A* of the *Criminal Code,* which applies to privacy breaches in both observations and audio recordings.

While council RPA activities are targeted at property issues, persons present on the property (whether privately or publicly owned) may be inadvertently captured by video footage and photographs. This imagery will contain personal information if the identity of an individual is apparent, can be reasonably ascertained or reveals information about an identifiable individual. For example, the data collected for Cairns Regional Council in the above-mentioned case study to inform pool registration and fencing compliance, contains personal information even though no people were captured in the imagery. The information that a pool owner has complied/not complied with their legislative obligations is classified as personal information pertaining to that individual and needs to be managed in accordance with the *IP Act*.

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[58] CASA (4 May 2015) *Remotely Piloted Aircraft Systems – An information paper for the Senate Standing Committee on Foreign Affairs and Trade –* file:///Users/puter/Downloads/CASA%20additional%20information%2011.5.15%20(1).pdf - p. 5.

[59] CASA (18 March 2015) https://www.casa.gov.au/standard-page/governing-use-rpas-%E2%80%93-safety-regulation

[60] CASA (18 March 2015)

Schedule 3 of the *IP Act* stipulates 11 Information Privacy Principles with which local governments must comply. The first principle being particularly relevant for RPA use, permits 'the collection of personal information by agencies only if that information directly relates to a function or activity of the agency, the collection is necessary to achieve that purpose and information is collected in a fair and lawful way.' In addition to this, the third principle requires that 'the collection of personal information does not constitute an unreasonable intrusion into domestic life of an individual'.

While an exemption to apply some of these principles exists for law enforcement purposes and councils may feel that other operational areas, such as, bridge or pest inspections have low privacy risks, it is highly recommended that councils carry out a Privacy Impact Assessment before utilising RPA for any activities.[61] Such as assessment will ensure all action taken to mitigate identified risks is documented and key stakeholders are engaged. This should not only prevent privacy issues from arising but will assist with minimising liability if an action does arise.

Going through such a process will also allow councils to establish mitigation procedures for risks to data security prior to data being received by council's secure IT systems. Depending on the RPA options being used, councils may need to consider risks associated with lost/stolen data from crashed RPA or wireless data transfers from an RPA being intercepted by data hackers. Thus again, highlighting the importance to select highly skilled pilots and tested RPA technology systems with demonstrated skills in managing these threats.

Finally, if a council outsources any aspect of its RPA activities it must ensure all reasonable steps are taken to bind the contractor to the requirements of the IP Act.[62]

4.2.3 Trespass and nuisance

Subdivision 3 of the *Local Government Act* confers a number of entry powers to authorised local government personnel to undertake required inspection, maintenance and enforcement activities on private and public land. The key operational areas identified in this report could require council officers to utilise these powers posing the question as to whether these entry powers extend to the operation of RPA or potentially expose councils to trespass and nuisance claims.

Entry powers are subject to the processes and requirements prescribed by the applicable legislation and if an authorised person, inspector or local government worker enters a property without having complied with these requirements, the respective council may be exposed to liability in an action for trespass. “If it is necessary to obtain owner permission to enter the land ‘on the ground’, it is no less necessary to obtain that permission to enter the owner’s airspace above the ground.”[63] If, however, a council has complied with permission/notification requirements or the power confers entry without permission, the use of an RPA as a tool to complete inspection work does not open councils to liability. “The powers to enter private property are readily adaptable to entering the owner’s airspace.”[64]

The owner’s airspace is defined by case law as the height “necessary for ordinary use and enjoyment of the land.” Given the sophistication of RPA technology, the circumstances in which it is necessary to bring the RPA into the owner’s airspace for an activity not covered by the legislative entry powers are likely to be few. However, when such circumstances arise, it is recommended to seek owner permission or if appropriate, obtain a warrant under *section 130* of the *Local Government Act*.

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[61] Office of the Information Commissioner (29 April 2013) *Privacy and drone technology – an introduction* - https://www.oic.qld.gov.au/guidelines/for-government/guidelines-privacy-principles/applying-the-privacy-principles/privacy-and-drone-technology

[62] *Chapter 2, Part 4 Information Privacy Act 2009.*

[63] Advice provided by King and Co to LGAQ on 13 July 2015.

[64] Advice provided by King and Co to LGAQ on 13 July 2015.

Irrespective of whether a council has entry powers to complete required surveillance, a nuisance claim may be available to a landowner if the RPA activity is found to be an "unreasonable interference with the use and enjoyment of land."[65] For example, 'constant' surveillance by flights over land might be considered a nuisance. Whether interference is "reasonable" is determined by factors, such as, the locality, duration, time of day, frequency and extent of the interference.

While the misuse of RPA technology may carry potential trespass and nuisance ramifications, "these need not be overstated."[66] A nuisance action generally requires tangible loss or damage, or anticipated tangible loss or damage. Differently, trespass is actionable without the necessity to prove material loss or damage. However, the aggrieved landowner will recover no more than nominal damages if they cannot show that the unauthorised entry has caused tangible loss.

As stated by King and Company Solicitors, 'what emerges from legislation and judicial authorities is that there is no need for panic or knee-jerk reaction from councils when considering trespass and nuisance liability. As with the use of any other technology, the application of common sense is key to safe and liability-free RPA usage.'

LGIS recommends the completion of a risk assessment process (including the assessment of privacy impacts) prior to the implementation of RPA activities. This will ensure all legislative requirements are met, key stakeholders are engaged and any required mitigation strategies are established minimising liability and risk to councils.

4.3 Specialised equipment to match required output

As already identified, RPA can be a cost-effective method of undertaking or supplementing council activities, however, without careful prior consideration and detailed scoping the outcomes can be disappointing. Whether choosing to outsource RPA activities or to develop internal capabilities, LGIS recommends that councils undertake a comprehensive scoping exercise to review the business processes the planned RPA activity is intended to support. Such a review needs to identify:

- what are the information requirements of the business processes in question?
- how is information currently collected, used, analysed, reported and stored?
- are there any opportunities to achieve efficiencies in these areas? Or are there any known limitations with the current processes?

When equipped with this knowledge a council can then make an informed decision on the best RPA platform, sensors (type and resolution), and data management solutions to meet its requirements. Councils may find that different platforms and sensors are best suited for meeting different information requirements and therefore, purchasing one type of RPA would not meet its needs. But rather, the council may find it more beneficial to access a variety of RPA services externally.

For the councils with RPA use experience (interviewed for this report), few completed a review of business processes prior to purchasing or selecting an RPA supplier. Most utilised the RPA model recommended by a supplier for one activity and then tried to apply the same technology to other operational uses. While others simply purchased a cheaper model to 'see what it could do.' However, when interviewed by LGIS, most councils identified the shortcomings of their initial procurement as a learning to inform further RPA activity and recommended thoroughly scoping before selecting equipment.

[65] Advice provided by King and Co to LGAQ on 13 July 2015.
[66] Advice provided by King and Co to LGAQ on 13 July 2015.

Completing a review of its business processes allows a council to:

- prevent purchasing technology that under or over delivers on requirements. While the detriments of under-delivering on requirements are obvious, over delivering may lead to councils getting access to more data than staff or systems can handle. This may lead to data reports being too cumbersome to use and therefore, not properly utilised.
- make informed decisions to 'trade-off' between technology capabilities and outputs to get the best suited solution within budget constraints. For example, a fixed wing RPA model may be more expensive than a multi-rotor RPA but it may reduce time required for surveillance. Alternatively, the time spent using a multi-rotor RPA may be worth it if detailed data is required and the extra cost for high definition sensors suitable for a fixed-wing RPA are unaffordable. Completing such a 'trade-off' exercise will allow council officers to have a thorough understanding of the limitations of the system they are selecting so that they can then adjust business processes accordingly.
- better manage maintenance budgets as data reports can be targeted to specific requirements to identify 'hot spots' requiring action rather than reporting on all identified issues/defects.
- understand system requirements to ensure proper procedures are put in place prior to undertaking RPA activities to avoid rework later.

This exercise should also take into account any technological requirements identified in the previously mentioned risk assessment completed on a council's intended RPA activities. Depending on a council's appetite for legal risk, a council may consider investment in a certified/tested RPA with demonstrated fail-safe technology a priority.

Finally, the pace of development in the RPA industry is rapid. As identified at the beginning of this report, demands on local government service capabilities are also continually growing. While this report has identified the key operational areas currently relevant to RPA use, the future range of RPA applications and the innovation in supporting technology cannot be readily anticipated. Therefore, to continue to harness the full potential of this technology it will be necessary for councils to continually evolve and invest in skills and equipment. Thus, making the decision to purchase, lease or outsource RPA technology an important one requiring careful consideration.

4.4 Data infrastructure to support business needs

When considering RPA options, data infrastructure is often an afterthought for most council operational activities, however, is vital to the effectiveness of any RPAS. Along with RPA technology options, data management options need to be considered within the above-mentioned review of a council's business processes to scope the likely impact of intended RPA activities. Depending on whether council is using internal capabilities or outsourcing, data management considerations can include:

- how will data be transferred from the RPA to council?
- how will data be shared? Does the data have an administrator? Will the shared data be read only or can it be manipulated post-processing?
- does council need to receive all captured data or can data reports be tailored to reduce data transfer sizes?
- what data format is required?
- what data processing is required by council and does existing software have the required capabilities?
- do post-processing tools need to be purchased to automate analysis processes?
- does data need to be stored within council's IT systems or can council access data externally from a secure sever?
- can council's existing data systems handle the file sizes of required RPA data?
- how long does data need to be stored and how frequently does it need to be accessed?

Processing large file sizes received from RPA suppliers was an issue for many of the councils that took part in the investigations for this report. To work with RPA data, councils either needed to increase computing power or establish arrangements to access data from the RPA supplier's server. A 30 minute RPA survey can produce up to around one Terabyte of data. Thus, demonstrating that file transfers and data analysis can become cumbersome if appropriate consideration is not given to efficient data management solutions prior to undertaking RPA activities.

4.5 Community and stakeholder support

The final critical element to an RPAS running effectively is community and stakeholder engagement and support. Similar to data management, this area is not always given priority consideration. However, as identified by Neville Plumb, Palerang Council's Senior Environmental Officer, all of the above work can come undone and "a couple of complaints received by Councillors from the community can quickly result in a 'no drone' policy."[67]

Irrespective of whether an intended RPA activity will directly impact the community, councils should undertake community engagement activities to assist with educating and informing the community on RPA technology. As the technology is in its infancy and many members of the community have ill-informed perceptions on how the technology threatens their privacy, councils need to engage with the community prior to any intended RPA activities. This will avoid the community being shocked and feeling threatened when seeing an RPA completing council work.

Community engagement activities could include a combination of public notices / announcements, letterbox drops or consultation sessions. To be effective, the activities should explain:

- the intended RPA use
- the benefits from the use and what this will mean for the community
- procedures in place to protect the community's privacy and safety, and
- details of the planned RPA activities.

Engaging with the community to gather feedback on other RPA use opportunities could also assist with building community support for the technology.

Engagement activities should include both internal and external stakeholders to ensure consistent messages are being shared about council's RPA activities and should include:

- residential and business customers
- relevant community and industry interest groups
- council staff and councillors
- relevant government departments and members of Parliament.

5 Risk-averse and cost-effective access to RPA services

Despite a number of successful trials across Queensland, few councils have taken the steps to establish RPA activities within their ongoing operations. LGIS investigated this further to identify the barriers preventing councils from progressing their RPA use and then considered options to assist councils to overcome the identified barriers.

[67] Simon Holloway and Neville Plumb (October 2015), p. 3.

5.1 Barriers to establish ongoing RPA services

5.1.1 Cost

Based on the feedback from councils involved in this report, the primary barrier preventing the uptake of the technology appears to be cost (see Table 5 below for high-level cost estimates). Also, as the benefits of the technology are not widely understood amongst different council operational areas, officers involved in the initial RPA trial work found it difficult to justify the expense to service only one area of council.

5.1.2 Choosing the most suitable delivery model

When considering the costs associated with ongoing use of RPA technology, council officers are faced with the decision to build internal RPA capabilities or outsource service requirements to external RPA suppliers. As detailed in Table 5, both options come with their own set of benefits and limitations. Councils may at first consider that the purchase and in-house operation of RPA is the most cost-effective approach. However, as detailed above the operation of RPA and the information they provide is not without risk, including safety, legislative, reputational and financial. Plus, as it is unlikely that councils would purchase a fleet of RPA, purchasing one type of RPA could restrict their ability to evolve with the market and adjust technology options to suit specific requirements. Thus, limiting the benefits and efficiencies available.

When undertaking an assessment of the two different delivery models, council needs to consider the whole of life costs in addition to an assessment of non-financial risks and benefits. Councils need to recognise that with internal capability comes significant responsibility to manage and mitigate risks, plus maintain certification, equipment and staff proficiency. While councils will still play the leading role in any outsourced RPA activities, outsourcing RPA services has the potential to reduce many of the risks discussed above by contractually transferring the risk to the RPA supplier.

Table 5 – High-level summary of benefits and limitations for RPA delivery options

	In-house capability		**Provision by external suppliers**	
Service attributes	***Benefits***	***Limitations***	***Benefits***	***Limitations***
Access	Flexible use as needed.	Infrequent use can result in poor maintenance of technology and skill proficiency. Potential start-up delays associated with CASA approval (if required).	No costs or issues resulting from lag time between jobs.	Use dependent on supplier availability.
Ability to meet Council's information requirements		Limited to capabilities of purchased technology and staff knowledge.	Ability to access current market response to information requirements.	
Cost[68]	Potentially a cost-effective option if equipment is utilised regularly.	Significant upfront cost. Platform: $30k to $100k (depending on requirements). Payload and associated software: $1-$75k (depending on requirements).	Less significant cost with daily usage ranging from $2k to $5k (depending on job requirements). Plus no ongoing	Costs can become expensive for regular activities.

[68] Cost estimates are based on information gathered from the market sounding process for RPAS best suited for the key operational areas and are provided as estimates only.

		Plus estimated 20% ongoing maintenance cost. Staff training ranging from $2k to $5k depending on location and requirements. Plus ongoing training and administrative costs.	maintenance costs.	
Certification requirements	Council is in control of certification requirements.	Council is responsible for associated costs (up to $10k plus ongoing costs[69]), documentation, training and maintenance of certification requirements. Plus, liable for any breaches of legislative requirements. Potential CASA delays in approving certification.	Council can pass on liability to the supplier (to the extent permitted by law).	Outside of contract parameters, council has limited control over supplier procedures and quality.
Service quality	Council has full control of flight activities and associated data management.	Council performance is linked to their level of technological and staffing investment. Also, council is 100% liable for any issues/damage caused from the RPA activities.	Council can pass on liability to the supplier (to the extent permitted by law).	Outside of contract parameters, council has limited control over supplier procedures and quality.

5.1.3 Procurement

After deciding on whether to build internal capabilities or outsource, the procurement process is another hurdle for council officers to overcome to establish RPA services. Procurement of equipment or third party suppliers can be an involved process. Due to the relatively high costs associated with purchasing RPA equipment, it may require a full procurement process in accordance with the *Local Government Act*. This process in itself can be expensive and time consuming. The market for equipment and service suppliers can be hard to navigate in terms of establishing reputation and understanding the vast array and difficult to compare range of RPA technology options available.

The above barriers are not new to a significant purchase decision and with time these barriers will be overcome as councils become more educated on RPA use and benefits; legislative and legal requirements may become less cumbersome; and, RPA technology may reduce in cost. However, the sooner councils overcome these barriers the sooner they can:

- achieve greater cost savings
- promptly reduce safety risks, and
- promptly enhance council service capabilities to better respond to increasing community, environmental and regulatory demands.

5.2 A *gateway service* to transition local government to innovative technology

The benefits available to local government from RPA technology are too significant and widespread not too capitalize on (a) the significant savings from bulk procurement and (b)

[69] Based on the current costs associated with CASA certification of one operator and two pilots. Costs are provided as estimates only.

providing councils with the full range and benefits available from RPA technology now. LGIS recommends the implementation of a local government-wide *gateway service* to provide councils with the support and confidence required to remove all perceived hurdles and barriers when establishing ongoing and successful RPA operations.

5.2.1 Reduce costs

In the first instance, the *gateway service* will address the primary barrier to ongoing RPA use – costs – by combining council purchasing power and engaging with RPA providers as a collaborative group. As identified throughout this report, many councils are still in the concept/investigatory phases of their RPA procurement. They are, therefore, not yet locked into supplier contracts or purchases and can still consider other procurement options. It is uncommon for a service to be so widely beneficial amongst councils at the same time that a number of councils (especially, within the same region) are investigating procuring that service. This not only presents a unique opportunity for cost savings from sharing the costs across a number of councils but, with the RPA market still in its infancy, also gives councils a stronger presence within the market. Thus, allowing them to tailor the products and services being delivered to better meet councils' requirements.

What is being proposed is not a straight forward bulk procurement activity but rather a local government-wide service delivery model where greater cost efficiencies would be achieved from a greater purchasing power and efficient scheduling of RPA activities. While the economies of scale cost savings are obvious, a scheduling program with effective quality control procedures is additionally required to ensure RPA activities are properly scoped, timely scheduled and efficiently carried out to achieve further cost reductions.

5.2.2 Efficient access to a range of suppliers

The *gateway service* will additionally remove the procurement hurdles for councils and provide convenient and efficient access to a range of suppliers to meet different RPA requirements. As identified above, different RPA activities can have different system requirements. Therefore, it can be ineffective for councils to purchase/access one RPA solution. But at the same time, it can be too costly for one council to access the services of a range of RPA suppliers in light of work requirements being irregular and infrequent. The provision of a *gateway service* can provide councils with the best of both options – the flexibility of a range of RPA services to meet their requirements at a reduced cost.

5.2.3 Risk mitigation and quality control

A *gateway service* will also bring critical quality controls to the RPA market at such a delicate time for development. As highlighted in the Parliament inquiry, "Eyes in the Sky", regulators are taking a cautious approach to regulating RPA use to ensure that development is not stifled.[70] This could quickly change if significant safety or privacy issues arise due to poorly managed RPA activities and therefore, highlights the importance for all within the industry to ensure their activities are carried out to the highest of standards.

A centrally-managed *gateway service* has the capability to establish and apply consistent quality control procedures across all scheduled RPA activities. Such a system would also allow learnings from each RPA activity to be invested back into the development of management procedures, thus providing councils access to high quality outcomes without the risk and effort required to manage internal RPA capabilities.

Similar to the introduction of smart-phone and tablet technology, the benefits from RPA use are council-wide and require a holistic management approach to effectively transition all council

[70] House of Representatives Standing Committee on Social Policy and Legal Affairs (July 2014), p 31.

operations to the new technology. Such an effort can be overwhelming for councils where resources are limited, therefore LGIS is recommending a *gateway service* to ensure councils of all sizes can still reap the full benefits available from RPA technology. Table 6 below, details the centrally coordinated support that would be available to councils through a *gateway service* to assist with reviewing and adjusting business processes across a number of council operational to enable ongoing RPA use.

Table 6 – Benefits available from a local government-wide gateway service

Service element	***Benefits***
Procurement	▪ Thorough evaluation of suppliers. ▪ Consistent procurement and contract documentation across all councils and suppliers. ▪ Thorough scoping of council requirements. ▪ Ongoing market research to ensure that councils have access to the latest RPA suppliers and technology best suited to their requirements.
Pre-activity scoping	▪ Assistance with reviewing business processes to identify and plan for RPA activities. ▪ Assistance with risk and privacy impact assessments and development of mitigation strategies.
RPA access	▪ Efficient booking and scheduling system. ▪ Access to a range of suppliers to allow council to select the supplier/technology best suited to their requirements.
Data management	▪ Customised and consistent reporting. ▪ Access to secure offsite data storage to avoid large data file transfers. ▪ Assistance with development of data requirements to inform work flow procedures. ▪ Coordination of data sharing to enhance the performance of RPA post-processing software.
Quality assurance	▪ Verification of suppliers' required CASA certifications and adherence to approved operational procedures. ▪ Quality checks to ensure all risk mitigation and quality control procedures are followed. ▪ Continual enhancement of operational and safety procedures utilising learnings from completed activities.
Stakeholder engagement	▪ Coordination of RPA activities that spread across council borders. ▪ Coordination of funding for related research projects. ▪ Assistance with the development of communication activities to educate/inform communities on planned RPA activities.

6 Concluding summary

This report demonstrates a clear business case for councils to integrate RPA technology throughout their operations. There are unquestionable benefits available from using the technology that can significantly enhance councils' service capabilities.

LGIS has identified immediate cost savings are available from using RPA for the following operations:

- Maintenance asset condition inspections, such as bridge inspections
- Planning and development surveillance
- Landfill and quarry volumetric assessments and other geospatial mapping activities
- Pest control application

- Compliance surveillance.

As minimal effort is required to translate the activities that RPA are currently performing in other industries to these council operations, cost savings are very easy to achieve once set-up and procurement challenges are overcome. The use of RPA for these operations will also significantly reduce the time required to complete activities and immediately reduce safety risks.

Further to this, there are short to long-term cost savings available from using RPA for the following operations:

- Disaster surveillance
- Pest and weed mapping and monitoring
- Automated road condition assessments.

Use of RPA in these areas require more time to establish and develop the technology and software requirements to automate detection of defects, pests and areas of operational interest. These operational activities could also significantly benefit from broad-scale (BVLOS) RPA data capture which would require time to obtain CASA approval. These developments will significantly reduce labour intensive processes, freeing up human resources, plus achieve a level of accuracy currently unachievable with conventional methods.

Despite the significant benefits available, councils have a number of barriers preventing them from being early adopters of the technology. As highlighted within the report, five critical elements are required to ensure councils are not exposed to safety, legal and reputational risk from their RPA activities:

1. Highly skilled and certified pilot
2. Understanding of the legal parameters of RPA use
3. Specialised equipment to match the required output
4. Data infrastructure to support business reporting, analysis and storage needs
5. Community and stakeholder support.

Council resources are already stretched and finding additional resources and time to invest in establishing these elements is overwhelming and too cumbersome for many councils. Achieving cost-effective, efficient access to effective RPA services is paramount to the success of councils integrating this technology within their operations.

The benefits to local government are widespread and too significant to delay. Therefore, LGIS recommends a local government-wide *gateway service* that will not only provide councils with economies of scale cost savings and the support required to remove all perceived hurdles and barriers to establishing ongoing RPA operations. But will further achieve a stronger presence for local government within the RPA market. This will allow councils to inform the direction of the RPA market through expected quality standards plus provide an innovative agenda for RPAS, technology and future applications within council services – achieving a better outcome for all.

The proposed service will also provide councils with the flexibility of a range of RPA services to meet their requirements at a reduced cost. Such an initiative will ensure RPA activities are properly scoped, timely scheduled and efficiently carried out to achieve further cost reductions and high quality outcomes without the risk and effort required to manage internal RPA capabilities.

LGIS is experienced in designing and delivery gateway and change management services to local government. This experience includes assisting councils with transitioning council operations and their communities to new technology or to align with new regulatory requirements. Delivering such services involved research and development, state/regional procurement, extensive stakeholder engagement, supplier management, logistic management, quality assurance, marketing and data and information technology management. LGIS believes this experience makes it well-suited to coordinate the delivery of the proposed RPA *gateway*

service across interested councils. LGIS proposes to investigate the development of this initiative further with LGAQ and Queensland local government.