PROJECT #90: EVALUATING THE EFFECTIVENESS OF ROOFING WORK INSPECTION USING REMOTELY PILOTED AIRCRAFT SYSTEMS

FINAL REPORT

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ABBREVIATIONS

AAM	Advanced Air Mobility
ABCB	Australian Building Codes Board
AEP	Annual Exceedance Probability
AGL	Above Ground Level
AI	Artificial Intelligence
ARI	Average Recurrence Interval
ARN	Aviation Reference Number
ASTM	American Society for Testing and Materials
AVCRM	Aviation Compliance and Risk Management System
BCR	Benefit–Cost Ratio
BIM	Building Information Modelling
BVLOS	Beyond Visual Line of Sight
CASA	Civil Aviation Safety Authority
CBA	Cost–Benefit Analysis
CRP	Chief Remote Pilot
ERSA	En Route Supplement Australia
EVLOS	Extended Visual Line of Sight
FPV	First Person View
IRR	Internal Rate of Return
JARUS	Joint Authorities for Rulemaking on Unmanned Systems
LiDAR	Light Detection and Ranging
MC	Maintenance Controller
NOTAM	Notice to Air Missions
NPV	Net Present Value
PCA	Plumbing Code of Australia
ReOC	Remotely Piloted Aircraft Operator’s Certificate
REPL	Remote Pilot Licence
RGB	Red, Green, Blue
RPAS	Remotely Piloted Aircraft Systems
SAIL	Specific Assurance and Integrity Level
SAM2	Segment Anything Model 2
SfM	Structure-from-Motion
SORA	Specific Operations Risk Assessment
VET	Vocational Education and Training
VMC	Visual Meteorological Conditions

EXECUTIVE SUMMARY

Moisture ingress and resultant water damage in buildings are linked to negative impacts on human health and amenity as well as building structural integrity and continue to be issues observed in Victorian residential buildings. Non-compliant roofing work is a key contributor to water ingress and frequently observed by building authorities in compliance monitoring of building and plumbing work. Roofing work is difficult to inspect using conventional 'in-person' approaches due to timing of site visits for regulatory inspections and safety considerations. The use of emerging technologies such as Remotely Piloted Aircraft Systems (RPAS), otherwise known as drones, to support inspections offers the potential to strengthen on-site quality assurance and regulatory oversight of roofing work, increase the rate at which non-compliant work is detected and rectified prior to occupancy, and inform the development of guidelines and training materials for practitioners for technology-assisted inspections.

To evaluate the thoroughness, accuracy and effectiveness of RPAS-assisted inspection of roofing work for residential buildings, the project methodology comprised several interrelated tasks, including an analysis of the regulatory landscape, stakeholder perspective mapping, cost-benefit analysis, field case studies, and an upscaling study. Based on this methodology, the project resulted in the following key findings:

- RPAS improve the accessibility, visual coverage, personnel safety, and speed of roofing inspections for residential buildings as compared with the conventional approach. Data collected by RPAS support planning, documentation, training, and development of artificial intelligence (AI) and remote inspection tools.
- RPAS-assisted inspections are permitted under the *Building Act*, noting though that mandatory inspections must be conducted 'in person' by the relevant building surveyor or their delegate on-site. This means that the relevant building surveyor or their delegate cannot rely *only* on photographs, videos and other evidence obtained through the use of a RPAS operated by persons not authorised under the Act.
- Federal, State, Territory and local government rules governing the use of RPAS combine to produce a complex and challenging regulatory space. The most pervasive and restrictive of these are the *Civil Aviation Safety Regulations 1998* (Cth) administered by the Civil Aviation Safety Authority (CASA).
- The CASA Regulations provide three pathways for RPAS use, with regulation complexity increasing with the weight of the RPAS. Common to all of them is for RPAS to be flown by CASA accredited or licensed pilots, and in accordance with CASA's Standard Operating Conditions or with a CASA authorisation.
- CASA's Standard Operating Conditions – in particular, that RPAS not fly over or near people (the 30m rule), not be flown in populous areas, and be kept within the pilot's visual line-of-sight – make compliant use of RPAS in support of building inspections in urban residential settings absent a CASA authorisation highly problematic. Greater scope exists to use RPAS in low density areas (i.e., regional / rural), and on greenfield development sites that can be vacated and controlled during RPAS operations.

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- Obtaining a CASA authorisation to fly RPAS (in particular RPAS weighing more than 250g) near or over people and beyond visual line of sight in populous area can be a complex, costly and time-consuming exercise. However, operating with a CASA authorisation offers several benefits, including greater safety assurance, flexibility to use larger and more complex RPAS, and enhanced professionalism, responsibility and legitimacy of operation.

- Stakeholder interviews show that RPAS are currently used mainly as a supplement to physical inspection, extending access and improving safety rather than replacing hands on assessment. Stakeholders reported benefits including reduced height risk, improved access to difficult roofs, clearer visual evidence, and broader consumer gains such as faster issue identification, fewer delays, reduced reliance on costly access methods, and earlier intervention for water ingress. Challenges reported by stakeholders include regulatory uncertainty, limited inspection-focused training, and gaps in workflow integration, pointing to a need for clearer guidance and support.

- The cost-benefit analysis indicates that RPAS-assisted inspections can result in avoided costs for homeowners, ranging from $1,472 (pre-occupancy) to $4,890 (post-occupancy). At the Victorian market scale of 61,260 new dwellings per year, RPAS-assisted inspections could prevent approximately $14.4 million in repair costs under pre-occupancy conditions and $47.9 million post-occupancy, based on a 16% observed rate of plumbing (stormwater) non-compliance.

Based on the above findings, the project makes the following recommendations:

- RPAS-assisted inspections have the potential to provide building practitioners, regulators, consumers and the public:

  - better monitoring of compliance with building and plumbing standards;

  - early identification and rectification of non-compliant building and plumbing work that would compromise the health and safety of persons who use buildings, and a building’s amenities, and environmental and energy efficiency;

  - more effective, efficient and safe work practices.

  These benefits promise greater compliance with building and plumbing standards, more cost-effective construction and maintenance of buildings, and a safer and more efficient and competitive building and plumbing industry.

- Organisations can engage CASA accredited or licensed pilots to employ RPAS weighing 2 kg or less in support of building inspections in low density settings and greenfield / development sites where compliance with CASA’s Standard Operating Conditions can be achieved.

- Organisations proposing to employ RPAS for ‘up-close building inspections’ in urban residential settings should ensure their RPAS are registered and pilots accredited or licensed with CASA, and apply to CASA for authorisation to fly over or near people in a populous area, and beyond the pilot’s visual line of sight (if needed). Applications should be for flights over and within the boundaries of the property (residential block) being inspected, which should be vacated for inspection purposes. Keeping flights within the boundaries of the property being inspected also should mitigate risks of trespass and privacy breaches.

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- Organisations proposing to employ RPAS routinely and at scale should consider applying for a ReOC.
- Given the limitations on the use of RPAS in high-density residential urban settings, and the time, cost and uncertainty involved in obtaining a CASA authorisation, a building inspection industry working group should be formed to engage CASA in a dialogue to assess the risks and rewards of using RPAS for up-close building inspections with a view to either: the grant of a general statutory authorisation or exemption; and/or regulatory reform, to facilitate the safe, effective and efficient use of RPAS for up-close building inspections.
- Organisations using RPAS should develop and implement a robust stakeholder communication plan to explain and demonstrate the value of using RPAS to assist with building inspections.
- Among the different RPAS-assisted inspection scenarios, the hybrid scenario, where RPAS is used for preliminary screening and difficult-to-reach areas and ladder for closer verification in safer places, is the recommended short-term implementation pathway. In the long term, remote image-based and automated AI-assisted remote inspection scenarios offer several advantages, including structured digital evidence, repeatability, audit trails, and capability for AI-assisted analytics. It is recommended that organisations using RPAS for roof inspection consider investing in the development of bespoke software tools for 3D visualisation of RPAS imagery and AI-assisted detection of non-compliance and defects to enable the digital transformation to these advanced inspection models.
- RPAS-assisted inspection should prioritise the segments with the highest value and risk, namely, two-storey dwellings, which present higher risk and more significant benefits in detecting non-compliance risks, and single-storey roofs where access, fragility, or safety risks are present.

1. INTRODUCTION

Water ingress and moisture damage are the most dominant building complaints. Prior studies have shown that over 30% of building disputes in Victoria are water-related, while non-compliant roofing and/or roof plumbing are among the most notable issues[1].

To ensure the integrity, safety and amenity of buildings and enforce compliance with statutory requirements, different building elements are inspected at different stages of construction. In Chapter 3, we classify these inspections into statutory inspections (being mandatory and compliance and assurance inspections provided for under State and Territory building legislation), and non-statutory inspections (conducted privately by builders, owners and insurance companies). Inspecting roofing and roof plumbing work using conventional methods present accessibility and safety challenges. The use of Remotely Piloted Aircraft Systems (RPAS) to support inspections of roofing offers the potential to strengthen on-site quality assurance of roofing work, regulatory oversight of roofing work, increase the rate at which non-compliant work is detected and rectified prior to occupancy, and inform the development of guidelines and training materials for practitioners for use of remotely piloted aircraft systems.

This aim of this project was to evaluate the thoroughness, accuracy, and effectiveness of using RPAS and 3D visualisation techniques for inspection of roofing work, analyse the costs and benefits, and map the regulatory landscape for wider implementation of RPAS-assisted inspections. Specifically, the project sought to answer the following questions:

- What elements of roofing work can and cannot be accurately inspected using RPAS?
- How and when could inspection of roofing work by RPAS be performed?
- Is a technology-assisted inspection of roofing work more thorough, accurate and effective than a conventional 'in-person' inspection?
- To what degree could emerging sensor and software technologies enhance a conventional 'in-person' inspection of roofing work?
- What are the costs, benefits and risks of RPAS-based inspection compared with conventional 'in person' inspections?
- What are the stakeholder perspectives on the use of RPAS-based inspection of roofing work?
- What factors must be considered for scaling up RPAS-based inspections?

To answer the research questions, the project methodology comprised the following interrelated tasks:

[1] Building and Plumbing Commission, VBA-DBDRV Moisture-related building disputes. 2024. Available at: https://www.vba.vic.gov.au/about/research/examining-moisture-related-disputes-in-victorian-residential-buildings

- An analysis of the regulatory landscape to understand the regulatory framework governing the use of RPAS for building inspections, identify the challenges of using RPAS in urban residential settings, and make recommendations for RPAS-assisted building inspections at scale in compliance with the current regulatory regime.
- A stakeholder perspective mapping to identify perceived benefits, challenges, and points of divergence across stakeholder groups with differing levels of RPAS experience and provide recommendations for context-appropriate integration of RPAS into roofing work inspection workflows, addressing regulatory compliance, workforce development, educational training, and consumer protection.
- A cost-benefit analysis to evaluate the net social and economic value of RPAS-assisted inspections, ensuring that resource allocation is evidence-based and delivers a clear return on public investment.
- Field case studies to evaluate the accuracy of RPAS-assisted inspections in detecting non-compliant roofing work and moisture/heat anomalies, assess the regulatory challenges of operating RPAS in residential settings, and explore the utility of advanced imaging tools enabling remote inspections.
- An upscaling study to analyse the organisational and financial requirements for scaling RPAS inspections, map diverse implementation pathways, and help organisations identify the most suitable adoption strategy based on their specific workload and technical maturity.

Figure 1 illustrates the overall methodological framework of the project. The following chapters describe the research tasks in detail.

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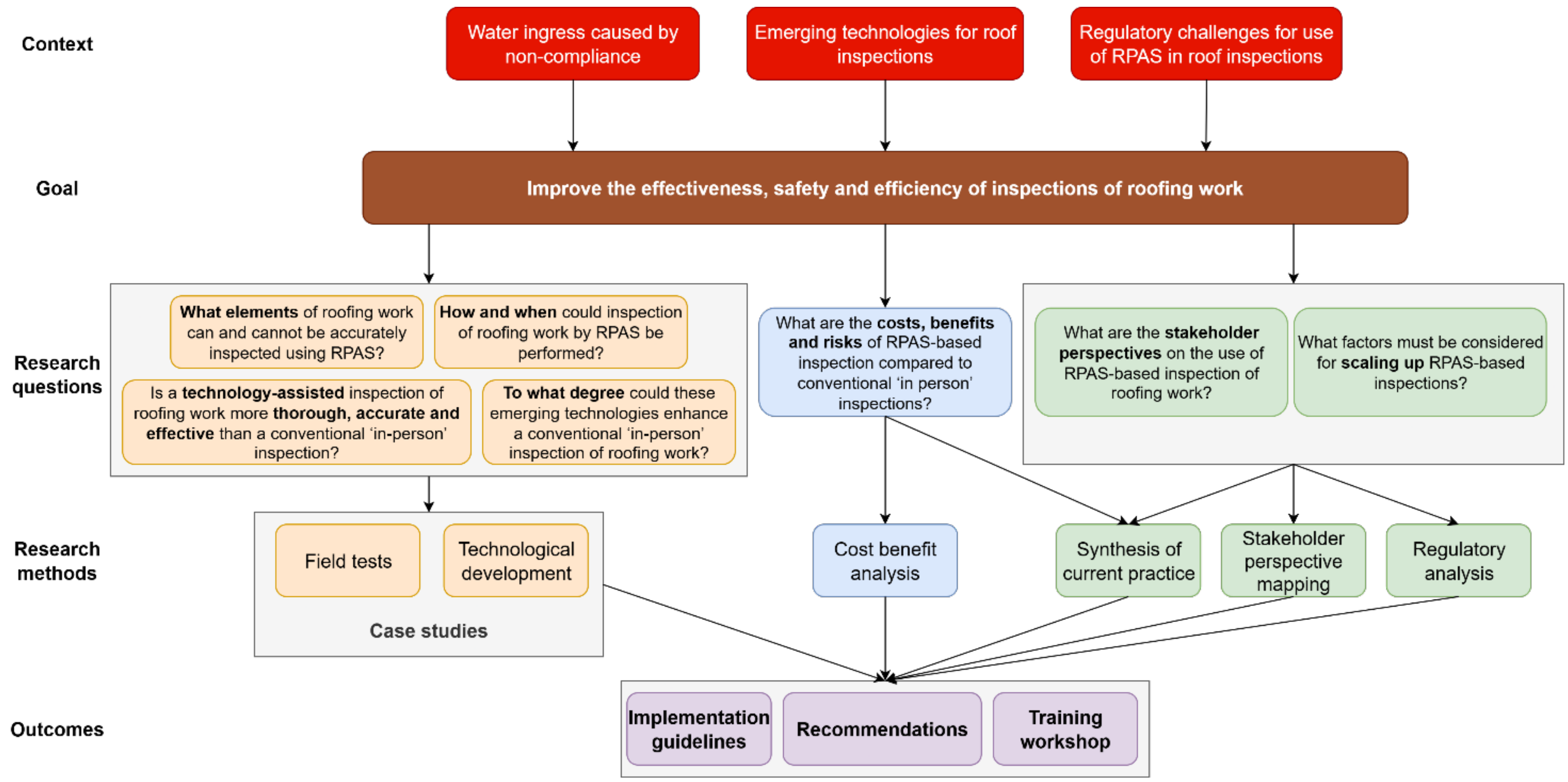

Figure 1: Methodological framework for RPAS-assisted inspection of roofing work

2. LITERATURE REVIEW

To assess the current state of RPAS-based roofing inspections, a literature review was conducted focusing on the operational scope of roofing work and compatible imaging technologies. This review establishes the fundamental components of roofing work and evaluates the imaging sensors applicable to assessing their condition.

2.1. Roofing (stormwater) work

2.1.1. Overview

The specifications and design requirements of the relevant roof components, including metal roofing sheets, roof tiles, flashings, capping, sarking, anti-ponding and roof plumbing systems (gutter, rainhead, sump), are governed by Australian standards, namely *SA HB 39:2015 Installation code for metal roof and wall cladding*[2], *AS/NZS 3500.3:2021 Plumbing and Drainage Standards*[3], *National Construction Code*[4] and *ABCB Housing Provisions Standard*[5]. This section summarises the regulatory definition and technical compliance context for roofing (stormwater) work and identifies the principal roof drainage components and detailing elements that typically require inspections to confirm compliance.

2.1.2. Definition of roofing (stormwater) work

Division 7 of the *Plumbing Regulations 2018*[6] defines roofing (stormwater) work as the construction, installation, replacement, repair, alteration, maintenance, testing, or commissioning of any roof covering or roof flashing, or any part of a roof drainage system involved in the collection or disposal of stormwater.

The scope includes:

- The connection of stormwater piping to below-ground stormwater drains or on-site retention tanks.
- Design work that is incidental to, or associated with, any of the aforementioned works.

Regulatory exclusions include:

- Cleaning, painting, or preparation work that does not involve connection, disconnection or alteration of drainage items.
- Work on roof coverings made of non-metallic tiles, timber, concrete, glass, bitumen, or slate.

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[2] Standards Australia, SA HB 39:2015 Installation code for metal roof and wall cladding. 2015. Available at: https://store.standards.org.au/product/sa-hb-39-2015
[3] Standards Australia, AS3500.3 Plumbing and Drainage Standards. 2025. Available at: https://store.standards.org.au/product/as-nzs-3500-3-2025
[4] Australian Building Codes Board, National Construction Code. 2025. Available at: https://ncc.abcb.gov.au/
[5] Australian Building Codes Board, Housing Provisions Standard. 2022. Available at: https://ncc.abcb.gov.au/system/files/ncc/ncc2022-abcb-housing-provisions.pdf
[6] *Plumbing Regulations 2018* (Vic). Available at: https://www.legislation.vic.gov.au/in-force/statutory-rules/plumbing-regulations-2018/009

- Membrane applications to roof coverings or flashings.
- Work on freestanding Class 10a buildings under 10 m², provided they do not require connection to a below-ground drain or retention tank.

2.1.3. Design criteria for roof drainage systems

Under *AS/NZS 3500.3:2021*, the design of roof drainage systems is based on meteorological criteria involving the Annual Exceedance Probability (AEP) and Average Recurrence Interval (ARI). Eaves gutters and associated vertical downpipes with overflow measures are designed to accommodate specific rainfall intensities by region, ensuring that the system can transfer stormwater to the point of connection. The *ABCB Housing Provisions Standard* provides Deemed-to-Satisfy Provisions for metal sheet roofing, gutters and downpipes, ensuring that the installation achieves the necessary weatherproofing and structural requirements.

In Victoria, a licensed or registered plumber carrying out roofing (stormwater) work must comply with the requirements of Victorian variation *VIC Part E3* in Schedule 10 to the *Plumbing Code of Australia (PCA)* and the standards set out in *Plumbing Regulations 2018*. The primary objective of these standards is to ensure that roof drainage systems are designed and installed to safeguard people and property from the adverse effects of stormwater.

2.1.4. Technical requirements and compliance inspection of roof components

A compliant roof drainage system for a residential building relies on the precise integration of metal sheet roofing, eaves gutters, and flashings. The inspection process in principle involves evaluating the integrity of these components based on material compatibility, hydraulic capacity, and the integrity of joints and fixings.

Material integrity and galvanic compatibility

Materials used in the manufacture and fitting of metal gutters and downpipes must conform to *AS/NZS 2179.1*[7]. A significant compliance factor involves the compatibility of materials in contact with runoff from the roof. For instance, the *ABCB Housing Provisions* specifies that no lead or copper materials can be used upstream from aluminium/zinc-coated or galvanised materials. Runoff from these metals can cause accelerated corrosion of downstream coatings. To prevent corrosion, the combined materials must be chemically compatible or separated by non-conducting gaskets to prevent direct contact.

Eaves gutter installation and support

Eaves gutters must be installed with a continuous fall toward the outlet to ensure effective drainage. According to *AS/NZS 3500.3*, support systems for eaves gutters manufactured from metals shall conform to *AS/NZS 2179.1*. These brackets must be securely attached to the building structure to prevent longitudinal movement. In terms of jointing, *SA HB 39* stipulates that joints must be lapped by a minimum of 25 mm in the direction of the flow, sealed with a neutral cure silicone sealant and mechanically fastened with rivets or bolts. These mechanical fixings are essential to maintain joint integrity despite the thermal expansion and contraction of the metal.

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[7] Standards Australia, AS/NZS 2179.1:1994. 1994. Available at https://www.standards.org.au/standards-catalogue/standard-details?designation=as-nzs-2179-1-1994

Overflow mechanisms and safety

To protect building interiors from flooding during extreme rainfall or downpipe blockages, eaves gutters must incorporate overflow measures. The *ABCB Housing Provisions* outline several acceptable overflow solutions, such as a front face weir with a minimum clear width of 200 mm and a minimum clear height of 20 mm. These provisions ensure an acceptable overflow capacity, typically ranging from 0.5 L/s to 1.2 L/s, depending on the configuration. It must also be ensured (e.g., by a licensed plumber) that these overflow paths remain unobstructed and discharge stormwater clear of the building.

Metal sheet roofing and weatherproofing flashings

Metal sheet roofing must be crest-fixed with self-drilling roof screws into the roof supports to provide structural stability and weatherproofing. *SA HB 39* requires that all self-drilling self-tapping roof screws are fastened on the crests of the roof covers. To prevent moisture ingress through capillary action, roofing sheets must incorporate an anti-capillary break at the side laps.

Flashings and cappings are critical for weatherproofing junctions and penetrations. Parapet cappings must be fixed at intervals not exceeding 500 mm and provided with a minimum fall of 3° across the width of the flashing to divert water back onto the roof coverings and prevent staining on the fascia. Transverse cappings should feature stop-ends to divert water effectively into the drainage system. Apron flashings and collar flashings for penetrations are securely fastened and sealed with flexible sealant to maintain a snug fit to the profile of the sheet.

Ultimately, a compliant roofing system is one where the meteorological design meets the physical reality of the installation. Mandatory and compliance inspections verify that the design and installation of roofing components adhere to the *Plumbing Regulations 2018,* thereby ensuring the structural integrity and safety of the building.

2.2. Imaging methods for roof inspections

2.2.1. Overview

This chapter presents a literature review of three types of advanced imaging systems with airborne feasibility for roof inspections, thus reducing the need of human operators physically accessing the roofs. This analysis provides a foundation for the subsequent case studies in this project.

2.2.2. Definition and technical understanding

RGB imaging

Ordinary digital cameras use an array of red, green, blue filters, called a Bayer filter array, to record the red, green, and blue wavelengths of visible light. The resulting image, often called an RGB image, contains three recorded values per pixel corresponding to the intensity of the red, green, and blue light. An RGB image is visualised as a colour image by mapping the recorded intensity for the red, green, and blue wavelengths to the brightness level of the red, green, and blue subpixels of the computer display. This will create a true-colour image visualisation, where the colours closely resemble those of the real scene. This is because the computer display emits red, green, and blue light in the same proportions that the human eye would perceive in the real scene.

Multispectral imaging

Multispectral imaging captures images across several narrow spectral bands, typically within 400–2500nm, generating a unique spectral signature for each pixel to identify material properties, such as asphalt or tiles. It employs pushbroom or frame sensors, enabling detailed analysis of surface characteristics (Adão et al., 2017; Khan et al., 2022). In the RPAS context, multispectral cameras, such as the BaySpec OCI-1000 (470–1000nm), are mounted on drones to perform non-destructive assessments of material degradation or corrosion. For roof inspections, this method is particularly valuable for identifying material types and detecting chemical changes in roofing components, like shingles, thereby supporting compliance with quality standards and facilitating regulatory checks.

Thermal imaging

Radiance-based thermal imaging, or infrared thermography, measures infrared radiation to detect temperature variations, visualised as color-coded images where warmer areas appear red and cooler areas blue. It includes passive methods, relying on ambient conditions, and active methods, using external stimuli for enhanced contrast (Garrido et al., 2022). When integrated with RPAS, thermal cameras, such as FLIR models, enable anomaly detection, including moisture ingress or insulation gaps, without physical access. In roof inspections, radiance-based thermal imaging excels for flat or low-slope roofs, identifying wet insulation or leaks through heat retention differences, particularly during post-sunset flights when temperature contrasts are most pronounced, making it a critical tool for rapid defect detection.

Fixed-baseline stereo imaging

Fixed-baseline stereo imaging utilises two cameras with a fixed separation, or baseline, to capture stereo images, which are processed via photogrammetry to create 3D models with accurate depth information. It leverages Structure-from-Motion (SfM) algorithms for high-resolution mapping (Colomina & Molina, 2014; Jiang et al., 2021). In RPAS applications, dual-camera systems are deployed on drones to generate detailed 3D reconstructions of structures. For roof inspections, this method produces precise geometric models, enabling structural assessments of features like cracks or slopes, which are essential for engineering evaluations and ensuring the integrity of roofing systems.

2.2.3. Comparative analysis of imaging methods

This section evaluates RGB, multispectral, thermal, and fixed-baseline cameras for RPAS in roof inspections, focusing on their advantages, disadvantages, accuracy, operational requirements, and suitability. The analysis draws on recent scientific literature to provide a robust foundation for stakeholders, including government authorities seeking regulatory compliance and practitioners aiming for operational efficiency. Each imaging method offers distinct capabilities, with trade-offs that inform their applicability to roofing contexts.

Advantages

Multispectral imaging excels in material analysis by capturing spectral data across narrow bands. Its ability to identify material composition, such as distinguishing asphalt from tiles with over 90% specificity, supports non-destructive compliance checks. It detects chemical changes, like corrosion in metal roofing, without physical sampling, and its high spectral resolution (2–10nm) reveals subtle defects, such as early shingle degradation, aiding preventive maintenance. Additionally, multispectral imaging operates reliably under varied lighting conditions, unlike standard RGB cameras, enhancing its versatility for roof inspections (Adão et al., 2017; Colomina & Molina, 2014; Khan et al., 2022; Tomita et al., 2022).

Radiance-based thermal imaging, or infrared thermography, is highly effective for detecting temperature-based anomalies. It scans up to 15,000 square feet per hour, reducing inspection time by 50% compared with manual methods, making it ideal for large commercial roofs. By eliminating the need for high-risk ladder access, it enhances safety, particularly for steep or fragile roofs. Radiance-based thermal imaging reliably identifies wet insulation with 90% sensitivity, addressing common issues like leaks, and aligns with ASTM C1153 standards, ensuring regulatory acceptance for compliance checks (Entrop & Vasenev, 2017; Garrido et al., 2022; Omar et al., 2021; Rakha & Gorodetsky, 2018).

Multiview RGB and fixed-baseline stereo imaging generate high-resolution 3D models, valuable for structural assessments. It achieves sub-centimetre-level precision in mapping roof geometry, such as slopes and cracks, and detects structural defects, like beam misalignments, critical for load-bearing roofs. Integration with Building Information Modelling (BIM) streamlines renovation planning, while its scalability allows efficient mapping of large industrial roofs, reducing fieldwork time by 30% (Al-Rawabdeh et al., 2020; Colomina & Molina, 2014; Jiang et al., 2021).

Disadvantages

Multispectral imaging faces significant barriers due to cost and complexity. Sensors, priced between $10,000 and $50,000, are prohibitive for smaller operators who might use RPAS for inspections. Data processing is intensive, generating terabytes per hour and requiring specialised software like ENVI, alongside high-performance computing. Heavy sensors (1–2 kg) reduce drone flight times to 15–20 minutes, limiting coverage. Radiometric calibration, sensitive to atmospheric conditions, further complicates inspections (Adão et al., 2017; Colomina & Molina, 2014; Khan et al., 2022).

Radiance-based thermal imaging is constrained by environmental and scope limitations. Accuracy suffers under solar radiation or cloudy conditions, necessitating post-sunset flights. It misses non-thermal defects, such as cracks, reducing its comprehensiveness. Frequent recalibration is required to maintain 90% accuracy, adding setup time. Active thermography, which enhances contrast using external heat sources, increases costs by approximately $5,000 or more (Entrop & Vasenev, 2017; Garrido et al., 2022; Omar et al., 2021; Rakha & Gorodetsky, 2018).

RGB and fixed-baseline stereo imaging involve photogrammetry processing for 3D scene reconstruction, which is a computationally intensive process and can take hours on a typical computer. The method requires photogrammetry expertise, limiting accessibility for untrained practitioners. It also fails to detect material-based defects, such as moisture, necessitating complementary sensors (Al-Rawabdeh et al., 2020; Colomina & Molina, 2014; Jiang et al., 2021).

Accuracy

Multispectral imaging offers high precision for material analysis, achieving 90–95% accuracy in classifying materials like concrete versus asphalt. It detects chemical defects, such as corrosion, with sub-pixel precision and maintains reliability across varied conditions, though calibration errors can reduce accuracy to 80%. Ground-truth comparisons confirm approximately 90% reliability for material degradation detection (Adão et al., 2017; Colomina & Molina, 2014; Khan et al., 2022).

Radiance-based thermal imaging is reliable for thermal anomalies, with 90% sensitivity for detecting wet insulation, validated by core sampling. It achieves 85–95% accuracy for heat leaks, adhering to ASTM C1153 standards. Active thermography, using controlled heating, reaches 92% defect detection rates. However, accuracy drops to 70% under cloudy conditions, highlighting the need for optimal timing (Entrop & Vasenev, 2017; Garrido et al., 2022; Omar et al., 2021; Rakha & Gorodetsky, 2018).

Fixed-baseline stereo imaging provides sub-centimetre accuracy for 3D roof models, validated against LiDAR, and detects cracks larger than 1mm with 95% reliability. It maintains 98% geometric fidelity across multiple flights, ensuring consistent models. However, its accuracy for non-geometric defects, such as moisture, is negligible, limiting its standalone use (Al-Rawabdeh et al., 2020; Colomina & Molina, 2014; Jiang et al., 2021).

Operational requirements

Multispectral imaging demands advanced resources. Spectral analysts are needed for data interpretation, and heavy drones, such as the DJI Matrice with over 5kg payload capacity, are required to carry 1–2kg sensors. Specialised software like ENVI, costing over $2,000 annually, is essential, and precise flight paths ensure uniform illumination, complicating logistics (Adão et al., 2017; Colomina & Molina, 2014; Khan et al., 2022).

Radiance-based thermal imaging is relatively accessible, requiring only 1–2 days of operator training. Lightweight cameras, such as the FLIR Vue (300g), are compatible with most drones. Nighttime flights optimise contrast, and periodic recalibration, taking approximately 10 minutes per setup, maintains accuracy (Entrop & Vasenev, 2017; Garrido et al., 2022; Omar et al., 2021; Rakha & Gorodetsky, 2018).

Fixed-baseline stereo imaging involves moderate complexity. GPS-stabilised drones ensure consistent baselines, while photogrammetry training, typically 1–2 weeks, is necessary. Software like Pix4D, costing over $3,000 annually, supports processing, and dual-camera setups add approximately 500g to the payload (Al-Rawabdeh et al., 2020; Colomina & Molina, 2014; Jiang et al., 2021).

Suitability for roof inspections

Multispectral imaging, though emerging, is specialised for material compliance, making it ideal for regulatory checks on roofing materials like shingles. However, its limited adoption in roof inspections necessitates pilot studies to validate its practical value (Adão et al., 2017; Colomina & Molina, 2014; Khan et al., 2022).

Radiance-based thermal imaging is suitable for detecting heat loss and moisture leaks. Its alignment with compliance standards ensures trust from authorities, and its versatility suits both residential and commercial roofs (Entrop & Vasenev, 2017; Garrido et al., 2022; Omar et al., 2021).

Fixed-baseline stereo imaging is suitable for structural and geometric analysis. RGB imaging can be integrated with radiance-based thermal imaging for comprehensive inspections in complex roofing projects (Al-Rawabdeh et al., 2020; Jiang et al., 2021).

Key takeaways

In conclusion, multispectral, thermal and fixed-baseline sensors are suitable for distinct aspects of roof inspections. While multispectral and fixed-baseline imaging methods are costly and require large RPAS, reducing their compatibility with the inspections of residential buildings, RGB and thermal imaging offer accuracy and feasibility for detecting moisture-related issues, which are relevant to the scope of the current project. Table 1 compares the different types of imaging methods for roofing work inspection.

Table 1: Summarised comparison of imaging methods

Criterion	RGB	Multispectral	Thermal	Fixed-Baseline
Suitability	True-colour visualisation	Material compliance	Moisture leaks	3D geometry
Limitation	Lack of spectral information	Costly ($10k–50k), data-heavy, heavy payload	Weather-bound, limited scope, calibration	Viewpoint-sensitive, processing-heavy
Accuracy	Cm-level geometric	90–95%, material-specific	85–95%, thermal defects	Sub-cm, geometric
Requirements	Ambient light	Large RPAS, specialised software	Basic training, nighttime, specialised software	Large RPAS, specialised software

2.2.4. Current applications in RPAS-based roof inspections

RGB cameras are the most common sensors mounted on RPAS. Radiance-based thermal imaging is widely adopted for the inspection of heat loss due to its operational simplicity and regulatory alignment with ASTM C1153-10 standards (ASTM, 2015). This method can potentially detect moisture ingress and insulation degradation without physical contact or destructive testing (Costanzo et al., 2014), especially for flat and low slope roofs (Kim et al., 2023). While multispectral imaging offers significant potential for advanced material characterisation and surface composition analysis in building inspections, its broader adoption in roof assessment remains limited due to factors such as system cost, the complexity of data acquisition and calibration, and a prevailing focus of research on applications like façade diagnostics, agricultural monitoring, or geological mapping rather than extensive roof-specific material verification (Zahiri et al., 2022; Yeum & Dyke, 2015). Fixed-baseline stereo imaging systems are highly effective for reconstructing 3D surface geometry, enabling the precise modelling of geometric deformations such as sagging or uplift in infrastructure (Chiu et al., 2017; Fathi et al., 2015). However, their utility is constrained when it comes to detecting non-geometric anomalies like water infiltration or material decay, which require radiometric or spectral contrast rather than spatial reconstruction.

The adoption of thermal imaging is driven by regulatory acceptance (ASTM C1153⍰10 2015), which standardises aerial infrared detection of subsurface moisture. Multispectral imaging shows promise for material compliance but is hindered by cost, complexity, and a lack of roof-specific studies, with most insights drawn from facade or mining applications. Fixed-baseline stereo imaging serves structural analysis but is constrained by technical demands and limited scope for non-geometric defects. Quantitative comparisons reveal significant disparities in RPAS-based roof inspection methods. Radiometric thermal imaging achieves high inspection rates with strong detection accuracy, making it highly efficient for large commercial buildings (BDG, n.d.; Chodura et al., 2025). In contrast, multispectral and fixed-baseline photogrammetry operate at slower rates and lack extensive roof-specific validation (Chodura et al., 2025; Mader et al., 2016).

2.3. Summary

The literature shows a greater number of studies supporting thermal methods on roofs, versus fewer studies addressing multispectral or stereo imaging in this context, highlighting a validation gap (Chodura et al., 2025). Key research gaps include the lack of large-scale trials, lack of studies on multi-sensor integration, and lack of standardised protocols tailored to roof inspection.

Hence, future research should emphasise multi-site case studies spanning flat, pitched, residential, and industrial roofs, to properly validate different imaging methods for wider industry adoption.

Table 2 summarises the current applications, adoption levels, performance metrics, and research gaps for each imaging method, providing a reference for stakeholders to assess their suitability for roof inspections.

Table 2: Current applications of imaging methods in RPAS-assisted roof inspections

Imaging Method	Current Applications	Adoption Level	Performance Metrics	Research Gaps
RGB	General inspection; 3D reconstruction	High	cm-level geometric accuracy	Automated detection of non-compliant work
Multispectral	Material characterisation; compliance checks for material types.	Low	~90% material classification accuracy; 85% specificity.	Large-scale roof trials.
Thermal	Moisture/insulation defect detection	High	85–95% accuracy; <10% false positives.	Pitched roof applications; multi-sensor integration.
Fixed-Baseline Stereo	3D reconstruction; structural assessments.	Moderate	Sub-cm geometric accuracy	Residential roof studies; standardised photogrammetry protocols.

3. REGULATORY LANDSCAPE

In this chapter we examine the legal and regulatory regime that applies to the use of Remotely Piloted Aircraft Systems (RPAS) for building inspection purposes, and propose a pathway for regulatory reform to facilitate their more effective and efficient (but continued safe) use. This chapter comprises five parts. In Part 1, we examine the regulatory landscape governing the use of RPAS for building inspections. This in turn comprises three sub-parts: (a) the building inspection regulatory framework; (b) the RPAS regulatory framework; and (c) other laws and regulations that impact or govern the use of RPAS. This examination reveals that it is the RPAS regulatory framework that imposes the greatest challenges to the use of RPAS in urban residential settings. In light of this, the chapter examines in Part 2 the experience of regulators implementing the RPAS regulatory framework (albeit in domains other than the building sector), and in Part 3 international comparators. Part 4 examines the admissibility in court of RPAS generated evidentiary material before concluding in Part 5, with recommended pathway forward. This pathway comprises both recommendations for RPAS use at scale in support of building inspections in compliance with the current regulatory regime, and proposals for regulatory reform to facilitate their more effective and efficient (but continued safe) use.

3.1. Regulatory context

3.1.1. Building inspection regulatory framework

The regulatory framework governing building inspections was examined in detail in Project #33 – Evaluation of emerging technologies for remote (virtual) inspections of building work (Project #33).[8] That report explained that most building regulation occurs at the State and Territory levels, and that while conceptually aligned, differences exist in their legal, regulatory and operational detail. The Project #33 report focused on Victoria; this report will do likewise.

Victoria's building system is primarily regulated through the *Building Act 1993* (Vic) (*Building Act*) and the *Building Regulations 2018* (Vic). The *Building Act* provides for two broad types of inspections:

1. Mandatory inspections; and
2. Compliance and assurance inspections.

In addition, there are non-statutory inspections. These might be conducted by a builder, owner or insurance company to determine compliance, or as part of a dispute resolution process. Each is examined below.

[8] Fang, Y., Khoshelham, K., Windholz, E., Ngo, T., Al-Azzawi, AB., Becker, S., Einizinab, S., Hu, S., Jiang, T., Mirzaei, K., Radanovic, M., & Sly, A. Evaluation of emerging technologies for remote inspections of building work: Final Report. Building 4.0 CRC. 2023. Available at: https://building4pointzero.org/projects/33-evaluation-of-emerging-technologies-for-remote-inspections-of-building-work/ (Project #33).

Mandatory inspections

What: Mandatory inspections are conducted of core components and stages of building works to ensure key structural, safety and amenity matters are achieved. In the case of a new building or an alteration to an existing building, the mandatory inspection stages are:[9]

a) before placing a footing;

b) before pouring an in-situ reinforced concrete member that is specified in the relevant building permit by the relevant building surveyor;

c) completion of framework;

d) inspection of fire and smoke resisting building elements as required under regulation 172; and

e) final, on completion of all building work,

and at other times and stages specified by the relevant building surveyor.

Roofing, stormwater and plumbing are not specifically identified for inspection at any of the mandatory inspection stages.

Who: The *Building Act* requires that mandatory inspections be conducted by the relevant building surveyor or their delegate.[10] The relevant building surveyor is the person appointed to assess, grant and ensure compliance with the building permit, and can be either a municipal building surveyor (employed by a local council) or a private building surveyor registered with the Victorian Building Authority (now trading as the Building and Plumbing Commission (BPC)).[11] Their delegate can be:

a) a person registered as a building surveyor or building inspector under Part 11 of the *Building Act* and whose registration authorises the carrying out of that inspection; or

b) in the case of a prescribed class of inspection, a person who is prescribed to carry out that type of inspection (which could be a civil engineer; mechanical engineer; electrical engineer; or fire safety engineer).

Importantly, the relevant building surveyor remains responsible for the proper inspection of the building works.[12] This imposes an obligation on the relevant building surveyor to

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[9] *Building Act 1993* (Vic) ss 34-35 (*Building Act)*; *Building Regulations 2018* (Vic) reg 167. Regulation 170 of the *Building Regulations 2018* (Vic) provides that the relevant building surveyor may omit a mandatory notification stage if they are not relevant to the building work.
[10] *Building Act* (n 9) section 35B.
[11] On 1 July 2025, the Victorian Building Authority commenced trading as the Building and Plumbing Commission. However, the legal entity remains the Victorian Building Authority. It is the regulator referred to in the *Building Act*, and in the *Building Legislation Amendment (Buyer Protections) Act 2025* (Vic) which consolidated in the Victorian Building Authority commenced trading as the Building and Plumbing Commission trading as the BPC, the Domestic Building Dispute Resolution Victoria (DBDRV), the domestic building insurance arm of the Victorian Managed Insurance Authority (VMIA), and conferred on the Victorian Building Authority enhanced enforcement powers. See Section 1.1.4 Reform Directions below.
[12] The case law that makes clear that notwithstanding any delegation, “the primary responsibility for inspection remains with the surveyor” and “it is not the duty to inspect, merely the act of inspection, which the surveyor is permitted to delegate”: *Toomey v Scolaro's Concrete Constructions Pty Ltd* (2001) 2 VSC 279, [236], [296]. And while Section 128 of the *Building Act* provides that the relevant building surveyor “is not

ensure the delegate has relevant and adequate experience, knowledge and skills to identify non-compliances with the *Building Act*, Regulations and building permit, and to put in place procedures to oversee the work of the delegate to ensure the inspections is being carried out appropriately and in accordance with the Act and Regulations.[13]

How: The *Building Act* requires that mandatory inspections be conducted "in person" - that is, on-site.[14] The legislation also arms the relevant building surveyor and their delegates with entry and other powers to conduct inspections. Section 228D of the *Building Act* deals specifically with power of entry for inspections required or authorised by the Act or Regulations. Relevantly for our purposes, section 228D(6) provides:

> An authorised person [which is defined in section 228(1) to include a relevant building surveyor or a person validly authorised by a relevant building surveyor] who exercises a power of entry of a building or land under this section may—
>
> (a) inspect the building or land and anything on the building or land; and
>
> (ab) for the purposes of an inspection under paragraph (a), cause any building work (including any building product or material) to be demolished, opened or cut into or tested if reasonably required to facilitate the inspection; and
>
> (b) take photographs (including video recordings) or make sketches of the building or land or the building work or plumbing work concerned; and
>
> (c) to the extent that it is reasonably necessary to determine compliance with this Act or the regulations, require a person to produce documents to the authorised person relating to building work or plumbing work or the work of a building practitioner or a plumber.[15]

However, as mandatory notification stage inspections must be carried out in person, the relevant building surveyor cannot conduct the mandatory inspection relying *only* on photographs, RPAS, video, declarations, or reports provided by a person who is not a registered building surveyor, inspector, or a prescribed person under section 35B of the *Building Act*.[16]

Also important is that the approval of building regulators is not required for the use by building surveyors or their delegates of inspection supporting technologies such as RPAS.

Compliance and assurance inspections

What: Compliance and assurance inspections are inspections expressly required or authorised by the Act to monitor, determine and, if necessary, enforce compliance with

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liable for anything done or omitted to be done in good faith in reliance on a certificate given by a registered building
practitioner", the courts have made clear the Section 128 statutory immunity is not available in circumstances where the relevant building surveyor adopts "an entirely 'hands off' approach to his (sic) … statutory and contractual obligations"; "blind disinterest is not good faith": *Toomey v Scolaro's Concrete Constructions Pty Ltd* (2001) 2 VSC 279, [283] – [284].

[13] Building and Plumbing Authority, Building Practice Note MI-01: Mandatory notification stages and inspection of building work. 28 June 2021. (now under review). Available at: https://www.vba.vic.gov.au/building/mi-01-mandatory-notifications-and-inspections-of-building-work. (Practice Note MI-01).

[14] *Building Act* (n 9) section 34. See the discussion in Project #33 (n 9) section 2.4.1.3.

[15] *Building Act* (n 9) section 228D(6).

[16] Practice Note MI-01 (n 13).

statutory requirements and to assure the safety of buildings and construction work. This includes inspections of plumbing work conducted pursuant to Part 12A of the *Building Act*. Plumbing work is defined to include (amongst other things) 'roofing (stormwater) work' which in turn is defined as 'the construction, installation, replacement, repair, alteration, maintenance, testing or commissioning of any roof covering or roof flashing, or any part of a roof drainage system involved in the collection or disposal of stormwater.' This includes, in addition to roofing and guttering, the downpipes and other piping connecting to a below-ground stormwater drain, or an on-site retention tank.[17] Plumbing work is regulated under the *Building Act* and *Plumbing Regulations 2018* (Vic). With few exceptions, plumbing work must be carried out by a person licensed or registered by the BPC for that class or type of work, and must comply with the *Plumbing Code of Australia* which is *Volume Three of the National Construction Code*.[18]

Who: Compliance and assurance inspections can be undertaken by a person authorised to conduct those inspections (referred to in the *Building Act* as an 'authorised person').[19] Authorised persons can include a BPC inspector, a municipal building surveyor (or a person validly authorised by a municipal building surveyor), persons authorised by Energy Safe Victoria, the Fire Rescue Commissioner and the Chief Officer of the Country Fire Authority, and in the case of inspections of plumbing work (including roofing (stormwater) work), a compliance auditor or plumbing inspector appointed under Part 12A of the *Building Act*.[20]

How: Unlike mandatory inspections, there is no requirement in the *Building Act* for these inspections to be carried out "in person". The *Building Act* does, however, provide authorised persons with entry and evidence gathering powers. Section 228D (discussed above) provides that the authorised person may take photographs (including video recordings) of the building, land and any building and plumbing work. In addition, section 228E contains an entry power for the purposes of monitoring for and determining whether the Act and regulations are being complied with or for assisting in the enforcement of the safety of buildings and of building and plumbing standards under the Act. Relevantly, section s 228E(3) states that an authorised person may enter and search a building or land under s 228E with the assistance of any person necessary to provide technical assistance to the authorised person; and section 228E(4)(f) specifies that an authorised person who enters and searches any building or land under s 228E may "make any still or moving image, audio recording or audiovisual recording".

Non-statutory inspections

What: Inspections also can be undertaken for non-statutory purposes. This could be at the initiation of an architect as part of the design process, a builder as part of its project management and monitoring functions, their client for quality assurance purposes, an insurance company as part of claim processing, or by any of these (and other) parties as part of a dispute resolution process.

Who: Non-statutory inspections can be carried out by any person, although in practice they tend to be carried out by registered building surveyors or inspectors, or by persons

[17] *Plumbing Regulations 2018* (Vic) regulation 25.
[18] Australian Building Codes Board, National Construction Code, Volume 3 - Plumbing Code of Australia – (2022). Available at: https://ncc.abcb.gov.au. (National Construction Code).
[19] *Building Act* (n 9) section 228D.
[20] Ibid section 228.

skilled in the subject-matter of the inspection (for example, a civil, mechanical, electrical or fire safety engineer; or a licensed or registered plumber of plumbing work).

How: There are no prescribed requirements for non-statutory inspections, with rights of entry and modes of inspection contractually negotiated.

Reform directions

Building regulation is an area that has been, and is likely to continue to be, the focus of reform. As the Project #33 report explained, the *Building Act* was amended in 2017 to significantly strengthen its regulatory oversight and enforcement mechanisms. This saw the introduction of the requirement for mandatory notification stage inspections to be conducted “in person”; the specification of the people to whom the inspection of building works may be delegated; and the strengthening of regulatory powers in support of stronger proactive compliance monitoring.

More recently, we have seen the passage of the *Building Legislation Amendment (Buyer Protections) Act 2025* (Vic) (*Amendment Act*) (and associated reforms) which saw the creation of the BPC and a number of reforms to strengthen confidence and integrity in and across the building and plumbing industry. Relevantly, the *Amendment Act* strengthens consumer protections by conferring on the BPC with new functions and powers simultaneously to better monitor, detect and enforce compliance with the State’s building and plumbing regulations, and to better support practitioners to comply with those regulations, in an effort to reduce the regulatory burden, and decrease the cost of, and increase the speed with which, residential housing in particular is constructed.

Project #33 also referred to a number of reports that called for regulatory reform to facilitate the use of remote, virtual and/or assistant-based inspections with the goal of improving the effective implementation of building and construction standards in the public interest, reducing costs and speeding up the construction of residential housing in particular.[21] This theme has continued in the Victorian Government’s Expert Panel on Building Reform Stage Two Report that, while not referring to RPAS specifically, recommends the adoption of new technologies, practices and products, refers specifically to the adoption of BIM (3D technology) and Digital Twin by industry and regulatory entities, and calls for amendments to the legislative framework to remove regulatory barriers that otherwise prevent the adoption of such new technologies, practices and products.[22]

What we can see from this brief discussion is that reform in the building regulatory sector seeks to strike a balance between effectiveness (strong oversight in the public interest to ensure buildings are safe, fit for purpose and free from defects) and efficiency (minimising the time, cost and regulatory burden in doing so). The strategic use of RPAS is well suited to striking this balance.

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[21] Project #33 (n 8) section 2.5.

[22] Victorian Government Building Reform Expert Panel, Building Reform: Paper Two. December 2023. Chapter 8 (Building maintenance, products and technologies). Available at: https://www.vic.gov.au/sites/default/files/2023-11/Expert-Panel%27s-Comprehensive-Review-of-Victoria%27s-Building-System-Stage-Two-Report-to-Government.pdf.

3.1.2. RPAS regulatory framework

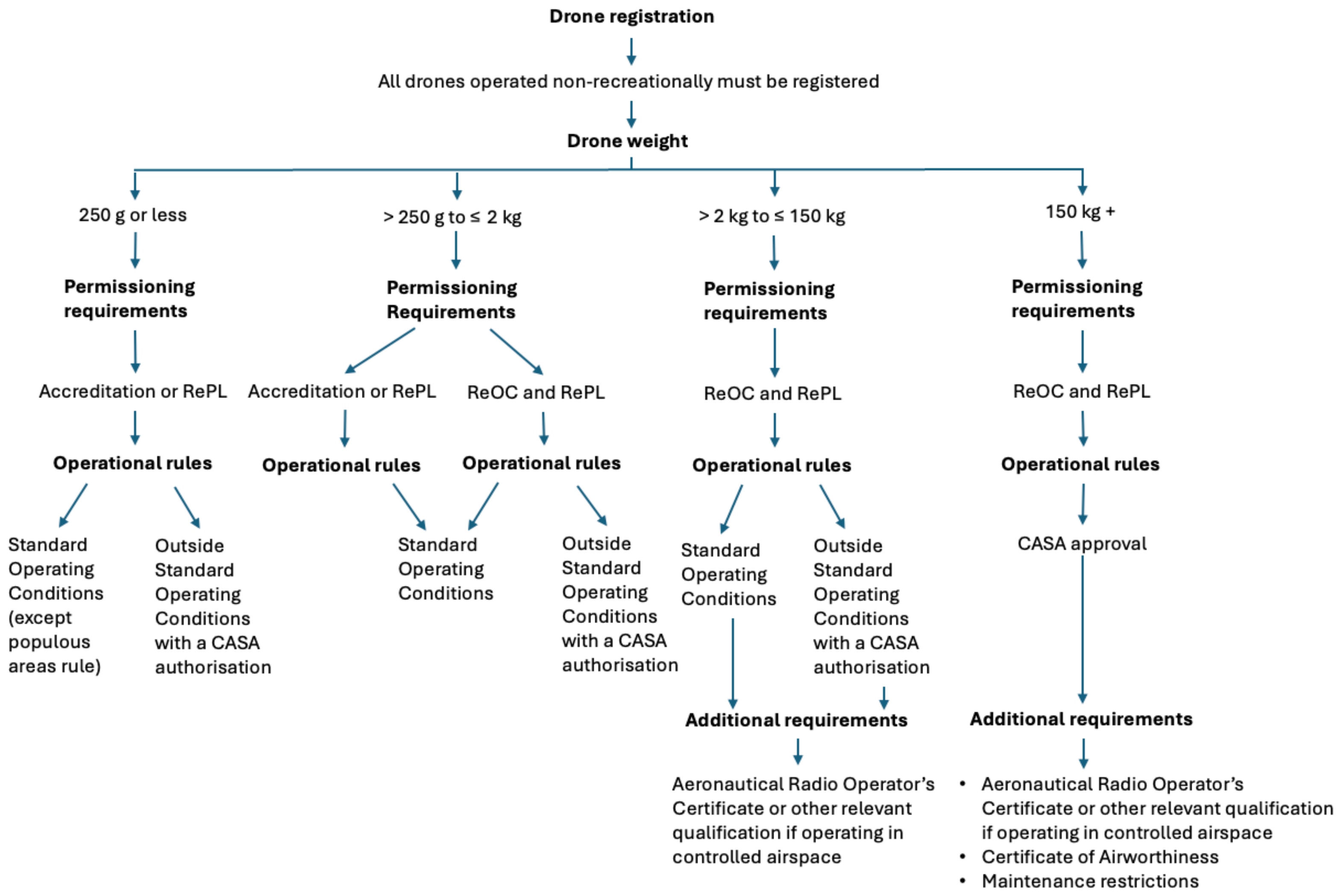
RPAS are primarily regulated under Part 101 of the *Civil Aviation Safety Regulations 1998* (Cth), which regulations are administered by the Civil Aviation Safety Authority (CASA).[23] In addition to the regulations themselves, there also is a range of legislative instruments (e.g., temporary management instructions, manuals of standards, exemptions, authorisations, and directions) which deal with more technical aspects. CASA also publishes a range of non-legislative instruments including guidance, handbooks, information sheets and checklists. Together, these instruments create a detailed and comprehensive permissioning and operational regulatory framework that attempts to balance widespread RPAS usage with safety, privacy and other relevant considerations.

Figure 2 provides a high-level summary of the CASA regulatory regime. As can be seen, RPAS weight is an important regulatory distinction, with RPAS weight calculated inclusive of all attachments such as cameras and sensors.[24] Many regulatory requirements are specific to weight categories. The focus of this section is on RPAS likely to be used for building inspection purposes, which excludes large heavy RPAS.

Another key distinction drawn in the regulations is between RPAS used for recreational purposes and those used for non-recreational purposes. CASA lists as an example of a non-recreational purpose “inspecting industrial equipment, construction sites or infrastructure”.[25] The focus of this section is on RPAS being used for non-recreational purposes.

Broadly speaking, RPAS regulations comprise an interrelated set of permissioning requirements and operational rules; interrelated in the sense that stricter permissioning requirements create pathways for more flexible operational rules. Each is examined below.

[23] State, territory and local government rules also apply to RPAS use, as do common law and legislative rules concerning trespass and privacy, for example. These are discussed in Section 3.1.3 below.
[24] *Civil Aviation Safety Regulations 1998* (Cth) regulation 101.022.
[25] CASA, Get or Renew Your Operator Accreditation. 11 October 2024. Available at: https://www.casa.gov.au/drones/operator-accreditation-certificate/get-or-renew-your-operator-accreditation.



Other operational categories irrelevant to building inspection (e.g., operations over the landholder's own land for no remuneration) have not been included.

Figure 2: Non-recreational RPAS use permissioning requirements and operational rules

Permissioning requirements

The *Civil Aviation Safety Regulations* impose three broad permissioning requirements on RPAS and those who use them:

- a requirement that the RPAS be registered
- a requirement that the pilot either be accredited or licensed
- certification of non-recreational users.

RPAS registration

All RPAS being used for non-recreational purposes must be registered regardless of the RPAS's weight.[26] Registration ends upon cancellation or, if it is not cancelled, automatically expires after 12 months.[27] This creates an annual obligation to renew RPAS registrations.

Registering a RPAS is a relatively quick and simple task.[28] It involves the following steps:

1. Sign in to or create a myCASA account using your Digital Identity.
2. Obtain an Aviation Reference Number (ARN) or link your existing ARN. An ARN is similar to a customer number. An ARN is necessary to obtain any permission (registration, accreditation, licence, certification or authorisation) from CASA. ARNs can be issued to both organisations (organisation ARN) and individuals (individual ARN). The only pre-requisite is that the party must be a legal entity. Organisation ARNs allow multiple people associated with the business to deal with CASA on its behalf. Individuals dealing with CASA on behalf of the business (including the person applying for an Organisation ARN) must also obtain an individual ARN.
3. Indicate whether the account is an individual or organisational account.
4. Apply to register the RPAS. The RPAS manufacturer and model can be selected from the drop-down menu. Alternatively, the manufacturer name, model, RPAS category and RPAS weight can be typed in manually. You must then enter the RPAS's serial number. A registration fee also may apply.

Pilot accreditation/licensing

Persons piloting RPAS for non-recreational purposes (which includes inspecting buildings) must either be accredited or hold a Remote Pilot Licence (RePL).[29] Accreditation and

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[26] *Civil Aviation Safety Regulations 1998* (Cth) regulations 47.015, 47.096A. The process for registering RPAS weighing more than 150 kg are subject to additional and more onerous permissioning requirements (see Division 47.C.1). RPAS weighing more than 150 kg must have a certificate of airworthiness or an experimental certificate: at regulations 101.046, 101.255; can only be operated with CASA approval: at regulation 101.275; and there are restrictions on how and by whom they are maintained: at regulations 101.260, 101.265.
[27] Ibid regulation 47.099.
[28] A helpful step-by-step guide to registering a RPAS can be found here: CASA, Register Your Drone. 11 October 2024. Available at: https://www.casa.gov.au/drones/drone-registration/register-your-drone.
[29] There may be other relevant permissioning requirements depending on the circumstances. For example, an operator must hold an Aeronautical Radio Operator's Certificate or other relevant qualification to fly RPAS

licensing are alternatives. A person with a RePL can fly RPAS that can be operated with an accreditation. However, a person with an accreditation cannot operate RPAS requiring a RePL.[30]

Whether you can pilot an RPAS with an accreditation or require a RePL depends on how much the RPAS weighs and where and how it will be flown.[31] For building inspections, an accreditation is a sufficient qualification if the RPAS weighs up to 2 kg and is operated pursuant to the Standard Operating Conditions detailed in 'Operational Rules' below.

Accreditation

Accreditations are available to persons piloting RPAS:[32]

- weighing 250 g or less
- weighing between 250 g and 2 kg that are being operated in Standard Operating Conditions (i.e., the RPAS is being operated in accordance with the general rules for flying RPAS detailed below, and not pursuant to any special approvals from CASA).
- weighing between 2 kg and 25 kg that are being operated in Standard Operating Conditions for specified or similar purposes (relevantly, aerial spotting and photography) over land owned or occupied by the owner of the RPAS, by the owner of the RPAS or a person piloting it on their behalf, and where no remuneration is payable to parties involved.

An accreditation is simpler to obtain than a licence.[33] There is no prescribed training required for accreditation. All that is required is for the applicant to have a myCASA account and ARN (see above), and to achieve a score of at least 85% on the CASA administered online RPAS accreditation quiz. There is no application fee for accreditations.

Accreditation expires upon the operator being granted a RePL, or after three years of being granted, whichever occurs sooner.[34] Accreditations can be renewed on CASA's website up to 30 days prior to expiration.

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weighing more than 2 kg in controlled airspace: *Civil Aviation Safety Regulations 1998* (Cth) regulation 101.285.

[30] CASA, Get Your Remote Pilot Licence. 11 October 2024. Available at: https://www.casa.gov.au/drones/get-your-operator-credentials/remote-pilot-licence.

[31] CASA, Advisory Circular 101-01 v6.0 Remotely Piloted Aircraft Systems – licensing and operations. May 2024. Page 18. Available at: https://www.casa.gov.au/sites/default/files/2022-09/advisory-circular-101-01-remotely-piloted-aircraft-systems-licensing-and-operations.pdf (Advisory Circular).

[32] *Civil Aviation Safety Regulations 1998* (Cth) regulation 101.237, regulation 101.252, subpart 101.FA.

[33] A helpful step-by-step guide to obtaining accreditation can be found here: CASA, Get or Renew Your Operator Accreditation. 11 October 2024. Available at: https://www.casa.gov.au/drones/get-your-operator-credentials/operator-accreditation.

[34] *Civil Aviation Safety Regulations 1998* (Cth) regulation 101.374G.

Licensing (RePL)

Persons operating a RPAS that is not eligible to be flown with an accreditation (see 'Accreditation' above) must hold a RePL.[35] Obtaining a RePL is more complicated than obtaining an accreditation.[36] It involves the following steps:[37]

1. Obtain an ARN.
2. Pass the required theory and practical training. CASA has a list of approved training providers that provide the training and assess applicants at the end. There also are mechanisms to have prior aviation experience recognised when applying for a RePL.
3. Apply for a remote pilot licence. This is done by the training provider on the applicant's behalf, after they pass both the theory and practical training components.

A RePL is specific to particular RPAS types and weights.[38] A RePL also does not expire.[39]

The cost of a RePL ranges from $1,350 to $3,500, depending on the training provider. This covers training, flight assessments, and mandatory CASA fees, with some packages also including an Aeronautical Radio Operator Certificate required for flying near airports and the like.

Certification of non-recreational users (ReOC)

A business, organisation or individual operating a RPAS for non-recreational purposes must obtain a Remotely Piloted Aircraft Operator's Certificate (ReOC) to operate the RPAS unless:

- an accreditation is sufficient to operate the RPAS; or
- the RPAS weighs between 25 kg and 150 kg and is operated in Standard Operating Conditions for one of the specified purposes (relevantly, aerial spotting and photography) or a similar purpose over land owned or occupied by the owner of the RPAS, by the owner of the RPAS or a person piloting it on their behalf with a RePL, and where no remuneration is payable to parties involved. The pilot must hold a RePL, however.[40]

Applying for a ReOC is technical, and comparatively more costly and time-consuming. Applicants are required to, amongst other things:

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[35] Ibid regulation 101.252.
[36] More information about how to obtain a RePL can be found at: CASA, Get Your Remote Pilot Licence. 11 October 2024. Available at: https://www.casa.gov.au/drones/get-your-operator-credentials/remote-pilot-licence.
[37] CASA, Get Your Remote Pilot Licence. 11 October 2024. Available at: https://www.casa.gov.au/drones/get-your-operator-credentials/remote-pilot-licence.
[38] RePL can be upgraded to allow the operator to fly RPAS in a higher weight class or different category. More information about how to upgrade a RePL can be found here: CASA, Upgrade Your Remote Pilot Licence. 11 October 2024. Available at: https://www.casa.gov.au/drones/remote-pilot-licence/upgrade-your-remote-pilot-licence.
[39] CASA, Get Your Remote Pilot Licence. 11 October 2024. Available at: https://www.casa.gov.au/drones/get-your-operator-credentials/remote-pilot-licence.
[40] *Civil Aviation Safety Regulations 1998* (Cth) division 101.F.4, regulation 101.270.

- create and appoint suitably qualified persons to various positions, including a Chief Remote Pilot and Maintenance Controller;
- develop detailed and bespoke operational procedures and manuals, which CASA must endorse; and
- ensure all pilots are licensed (RePL) and that they and all support personnel are trained on the relevant procedures and manuals.

Applicants also may be audited by CASA. The audit is a comprehensive review of procedures, documentation, and operational readiness, to ensure readiness to conduct RPAS operations safely. CASA also may ask to observe a RPAS flight to ensure that your team follows proper procedures.

And all of this is time consuming and costly. CASA advise that applications can take up to 70 business days to process, depending on the complexity of your operation and the thoroughness of the initial application.[41] Industry sources put the average processing time at between 3 and 6 months.[42] The cost of obtaining a ReOC involves a base CASA application fee (around $1,670 for the initial process, cheaper for renewals), and consultant fees for manuals and support. A review of providers reveals estimates for that support of between $1,600 and $3,000. This seems on the light side for a complex operations and organisation. In this regard, CASA states that a quote will be provided upon the application being received, which suggests that pricing is variable.[43]

The real cost, however, is in the staffing, ongoing training and administration. Operating under a ReOC involves having in place and maintaining a comprehensive Operations Manual (and supporting operational policies and procedures), induction and refresher training of pilots, and systems in place that enable the raising of a flight approval request for each flight, assessing it against CASA's Standard Operating Conditions (discussed in *Operational rules*), conducting a Job Safety (Risk) Assessment where it is not (or is otherwise required), and approving the flight (or not), and the maintenance of all associated records. Software exists to administer this process. It also can be done manually. Appendix A provides a Remote Piloted Aircraft Building Inspection Flight Approval Checklist designed to illustrate what the steps of the flight approval process might look like under a ReOC for an organisation employing RPAS to assist with building inspections.

One government department with a ReOC advised their annual budget was $0.5 million - which covers the wages of the Chief Remote Pilot and Maintenance Controller (CASA required positions of ReOC holders), and system costs (system fees, training, RPAS maintenance and any advice they may need). Importantly, this figure did not include the wages of the people who pilot the RPAS, or the costs of their remote pilot licences (RePL), which range from $1,350 to $3,500, covering training, flight assessments, and mandatory CASA fees, with some packages also including an Aeronautical Radio Operator Certificate required for flying near airports and the like.

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[41] CASA, Get Your ReOC. 11 October 2024. Available at: https://www.casa.gov.au/drones/remotely-piloted-aircraft-operators-certificate/get-your-reoc.
[42] See e.g. Flying Glass, 10 Essential Things to Know About Getting an ReOC. Available at: https://www.flyingglass.com.au/reoc-remote-operators-certificate/.
[43] CASA, Get Your ReOC. 11 October 2024. Available at: https://www.casa.gov.au/drones/remotely-piloted-aircraft-operators-certificate/get-your-reoc.

However, the benefit of a ReOC is that the bespoke procedures and manuals can include CASA endorsed authorisations and exemptions from otherwise applicable regulatory requirements, providing the flexibility to fly heavier RPAS and to operate outside the Standard Operating Conditions (that is, in urban residential settings). At the same time, they also can include additional regulatory requirements to mitigate risks specific to the ReOC holder.

Finally, an anomaly in the Regulations is that a sub-250 g RPAS cannot be operated under a ReOC. However, this does not mean that a ReOC holder cannot choose to apply the same organisational procedures to the use of sub-250 g RPAS as they do for RPAS that weigh more. What it does mean, however, is that authorisations or exemptions part of a ReOC will not automatically apply to a sub-250 g RPAS flown by the ReOC holder. Strictly speaking, the ReOC holder would have to apply for a separate authorisation or exemption for the sub-250 g RPAS flights, although it would be expected that they would be readily approved if that replicate the already approved ReOC conditions.

Operational rules

The *Civil Aviation Safety Regulations 1998* (Cth) and *CASA 20/25 – Operation of Certain Unmanned Aircraft and Rockets – Directions Instrument 2025* (Cth) impose general safety requirements and restrictions on the use of RPAS. The core or base rules are variably described by CASA as ‘Drone Safety Rules’ or ‘Standard Operating Conditions’. In this report, we will refer to them by the latter term.[44]

There are exceptions to some of the Standard Operating Conditions (e.g., for RPAS weighing less than 250 g). Authorisations and exemptions also can be obtained from CASA to operate outside of the Standard Operating Conditions. CASA accredited and licensed (RePL) pilots flying RPAS weighing 250 g or less can apply for these authorisations and exemptions without a ReOC. However, operators seeking authorisations and exemptions for RPAS heavier than than 250 g are required to hold a ReOC. These authorisations and exemptions can be hard coded into a ReOC (and the CASA endorsed operational procedures and manuals that are part of it), or can be applied for by a ReOC holder separately.

The scope of an authorisation or exemption will depend upon the particular rule and the perceived risk associated with an exemption from that rule. Authorisations and exemptions can be specific to a particular operation, to a geographic location, or more general applying to operations of a particular class (potentially inspection of Class 1 residential buildings).[45] Importantly CASA offers location-agnostic approvals, allowing RPAS to operate in different locations without site-specific permissions, provided they follow approved procedures (which would generally include site-specific risk assessments and implementing site-specific safety measures).

[44] ‘Standard Operating Conditions' is the terminology employed in this report and is used wholistically to refer to the operational rules for RPAS usage which themselves are variably described across different publications and to which the terms' 'Drone Safety Rules' and 'Standard Operating Conditions' are variably applied. The strict statutory definition can be found at *Civil Aviation Safety Regulations 1998* (Cth) regulation 101.238.
[45] As per the building classifications under the National Construction Code (n 18).

Standard Operating Conditions and Exemptions

The Standard Operating Conditions relevant to the use of RPAS for building inspection purposes are set out below, as are the key pathways available to obtain an authorisation or exemption from their application.

As a preliminary matter though, there are two important overarching obligations that apply in addition to the Standard Operating Conditions. First, is the **non-hazardous operation obligation** that RPAS not be operated in a manner which creates hazards for persons, property, or other aircraft.[46] Complying with this obligation may in practice require the RPAS pilot to adopt additional or more onerous procedures than those detailed below. Second, is the **no dropping or discharging of objects obligation** which (as its name suggests) prohibits dropping or discharging objects from RPAS if doing so would create a hazard to other aircraft, people, or property, with serious penalties for violations. A CASA approval or an exemption is required for such operations.[47]

One RPAS at a time; active oversight

RPAS pilots may only operate one RPAS at a time, and in a manner that allows for pilot intervention during all stages of the flight, unless the pilot has obtained CASA approval to do otherwise.[48] As a result, a pre-programmed flight conducted autonomously by a RPAS with no pilot supervision would only be possible if the operator applies for and receives CASA approval.

Must not fly near or above people (30 m / 15 m with consent)

RPAS cannot fly in the safety zone of persons that are not essential to its control and navigation. The safety zone is defined as a notional cylinder with a horizontal radius of 30 m from the person's position.[49] See Figure 3 (which is sourced from CASA's website).[50] CASA also interprets the rule expansively to apply to people inside and under structures (e.g., houses and bridges).[51]

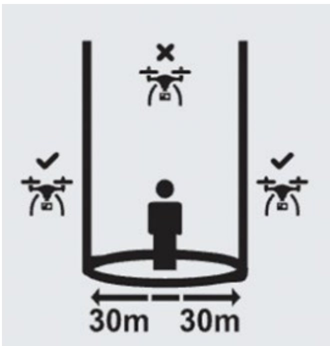

Figure 3: 30 m safety zone[52]

[46] *Civil Aviation Safety Regulations 1998* (Cth) regulation 101.055.
[47] Ibid regulation 101.090.
[48] Ibid regulation 101.097, 101.238, 101.300; *CASA 20/25 – Operation of Certain Unmanned Aircraft and Rockets – Directions Instrument 2025* (Cth) direction 8 ('*CASA 20/25*').
[49] *CASA 20/25* (n 48) direction 7.
[50] CASA, Drone Rules. Available at: https://www.casa.gov.au/knowyourdrone/drone-rules.
[51] Email from CASA to Elif Ives, 27 November 2025; *Civil Aviation Safety Regulations 1998* (Cth) regulation 101.245; *CASA 20/25* (n 49); CASA, RPAS Operations Over or Near People - 2024-01 (Temporary Management Instruction). April 2024. Available at: https://www.casa.gov.au/drones/flight-authorisations/flying-over-and-near-people.
[52] CASA, Drone Rules. Available at: https://www.casa.gov.au/knowyourdrone/drone-rules.

The practical consequences of this is that RPAS when flown must:

a) maintain a distance of at least 30 m from people that are not essential to its control and navigation, as measured from the person to the point on the ground directly below the RPAS; and

b) not fly at any altitude over a person unrelated to the RPAS's operation – with the no-fly zone conceptualised as a cylinder with a 30 m radius.[53]

CASA Regulations do not mandate the 30 m area to be cordoned off, for signage to be displayed, spotters / traffic controllers to be engaged, or for persons in the vicinity to be given advance notice of planned RPAS flights (although these are examples of good practice suggested by CASA). However, there must be some mechanism to provide the necessary confidence that the 30 m distance will be maintained which may involve one or more of these mechanisms.

There are a number of pathways by which RPAS can be flown closer than 30 m. These include:

<u>15 m from people with consent; no CASA approval required</u>: ReOC holders may operate RPAS closer than 30 m to a person, but not closer than 15 m where the person has provided consent.[54] The regulations do not expressly require the consent to be in writing. However, CASA's template Operations Manual for ReOC holders states that consents should be in writing, and this condition can be expected to attach to ReOCs generally. Therefore, details of it should be noted. As this is an exception to a Standard Operating Condition, a Job Safety (Risk) Assessment is required.

<u>CASA approval to operate near or over people</u>: ReOC holders can apply to CASA for authorisation to operate RPAS within 30 m of a person without their consent, or closer than 15 m to a person with their consent.[55] CASA has published a Temporary Management Instruction which sets out defined pathways in which it may approve applications to operate near or over people.

Proposed operations outside of the defined pathways are considered advanced operations and undergo a lengthier review process:[56]

- *Pathway 1*: operations in a controlled environment (being an area where no persons other than active participants and RPAS crew are permitted and that has access control to prevent third party entry) by a ReOC holder piloting a RPAS weighing 25 kg or less where active participants have provided written consent to

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[53] Email from CASA to Elif Ives, 27 November 2025; *Civil Aviation Safety Regulations 1998* (Cth) regulation 101.245; *CASA 20/25* (n 49); CASA, RPAS Operations Over or Near People - 2024-01 (Temporary Management Instruction). April 2024. Available at: https://www.casa.gov.au/sites/default/files/2024-04/temporary-management-instruction-2024-01-rpa-operations-over-near-people.pdf.
[54] *Civil Aviation Safety Regulations 1998* (Cth) regulation 101.245.
[55] *Civil Aviation Safety Regulations 1998* (Cth) regulation 101.245; *CASA 20/25* (n 49) direction 7. A helpful guide to applying for CASA approval can be found here: CASA, Fly over and Near People. 11 December 2025. Available at: https://www.casa.gov.au/drones/flight-authorisations/flying-over-and-near-people.
[56] CASA, RPAS Operations Over or Near People - 2024-01 (Temporary Management Instruction). April 2024. A link to this temporary management instruction which provides further detail on the pathways and the process for satisfying particular requirements (e.g. the process for obtaining consent) can be found here: https://www.casa.gov.au/sites/default/files/2024-04/temporary-management-instruction-2024-01-rpa-operations-over-near-people.pdf.

operations within 30 m. The requirements for written consent include a statement that the default distance is 30 m, that there may be serious risk of injury or fatality, and various emergency procedures and safety mitigators. This pathway only allows the pilot to operate over active participants. An active participant is defined as a "person who is participating directly in the activity to which the RPAS is operated".[57]

- *Pathway 2*: operations where the potential impact energy transfer is no greater than 15 joules, or 34 joules if informed consent is obtained. This is a relatively low threshold. Using Case Study 4 as an example, where the RPAS of 720 grams was flown at a height of approximately 20 m, the impact energy transfer of the RPAS in free fall from that height would be approximately 51-52 joules, much higher that the threshold. If, however, the RPAS was fitted with a parachute, then the impact energy transfer could be reduced to as low as 8 joules and below the threshold.[58]

- *Pathway 3*: RPAS operations with a final Specific Assurance and Integrity Level (SAIL) of not greater than 4, as assessed under the Joint Authorities for Rulemaking on Unmanned Systems (JARUS) Specific Operations Risk Assessment (SORA) methodology. SORA is a risk assessment framework. SAIL scores range from 1 to 6, and reflect the potential risks of the flight to persons on the ground and other airspace users. The assessment methodology is complex. It involves ground, air and containment assessments. It is possible up close building inspections could be conducted with a final SAIL not greater than 4, but this would require an operation/site specific assessment that is beyond the scope of this report, and an application to, and validation from, CASA.

CASA also has stated that "an application to operate closer than 30 m will include a rigorous risk assessment and implementation of mitigations assigned to each additional risk".[59] As a result, the process can take some time depending on the complexity of the operation being proposed. Some industry websites state the process can take up to 70 days.

Finally, it may be possible to get an approval to fly closer to non-essential persons that is not location specific so that ReOC holders do not need to apply for permission for every single operation. But the applicant would need to establish to CASA's satisfaction that each RPAS operation (in our case, each RPAS-assisted building inspection) is sufficiently similar to warrant a broader approval.[60]

Clear of populous areas

RPAS weighing more than 250 g must not be flown in a populous area without CASA approval.[61] 'Populous area' is defined as an "area that has a sufficient density of population for some aspect of the operation… to pose an unreasonable risk to life, safety or property of somebody [in the area unconnected with the operation]'.[62] Thus, while the CASA website lists as possible populous areas, residential areas, parks, beaches, roads, cars, footpaths, city areas, festivals, sporting events, and weddings,[63] whether a specific

[57] Ibid page 4.
[58] Calculations available on request.
[59] Advisory Circular (n 31) page 26.
[60] Email from CASA to Elif Ives, 13 October 2025.
[61] *Civil Aviation Safety Regulations 1998* (Cth) regulation 101.250.
[62] Ibid regulation 101.025.
[63] CASA, Flying in populous areas. 11 October 2024. Available at: https://www.casa.gov.au/drones/drone-rules/flying-populous-areas.

area is a populist area is a fact specific case by case determination dependent on the population density in the area at a particular time and the controls in place to guard against the risks of injury posed by the RPAS. Therefore, RPAS may operate over an area that would otherwise be considered ‘populated’ if the area is, for instance, cleared and cordoned off to maintain adequate distance (e.g., 30 m) between the RPAS and people.[64]

RPAS with CASA approval to fly in populated areas must maintain a sufficient height such that if their components fail, the RPAS will be able to clear the area. CASA approval (for RPAS with a certificate of airworthiness only) or a CASA exemption can be obtained to operate RPAS at lower altitudes if CASA is satisfied proper precautions will be taken to prevent the flight being dangerous to people and property.[65]

Finally, CASA recently introduced a general exemption entitling ReOC holders to fly RPAS weighing 250 g to 150 kg over populated areas if they have CASA approval to fly over or near people.[66]

Height restrictions

RPAS cannot be flown more than 122 m (400 ft AGL) above ground level without CASA approval.[67] Ground level is measured from the surface of the earth or water directly below the RPAS, as physically altered (e.g., measure from the bottom of a mining pit, not the natural surface). It excludes objects on the Earth’s surface (e.g., measure from the base and not the top of an apartment building).[68] ReOC holders can apply to CASA for approval to fly above 122 m, and additional height restrictions apply near airports and helipads (see below).

Operations in prohibited and restricted areas and near airports / helicopter landing sites

The rules governing the flying of RPAS in prohibited and restricted areas, and near airports and helicopter landing sites, are (like much of CASA’s regulations) complex. This section focusses on the key rules potentially impacting the use of RPAS in support of building inspection activities.

Prohibited and restricted areas: Airspace can be prohibited or restricted for a number of reasons including: (1) public safety during emergencies like fires, rescue operations, or large public events like air shows; (2) national security; (3) environmental protection; (4) military operations; and (5) other potential air safety hazards. Approval from the authority controlling the area is necessary to operate RPAS in and over prohibited and restricted areas.[69] ReOC holders also can apply to CASA for permission to operate RPAS in some of these areas.[70]

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[64] Advisory Circular (n 31) pages 26—27.
[65] *Civil Aviation Safety Regulations 1998* (Cth) regulation 101.280.
[66] CASA, New Exemption to Streamline Applications for Drone Operations Over or Near People. 6 August 2024. Available at: https://www.casa.gov.au/about-us/news-media-releases-and-speeches/new-exemption-streamline-applications-drone-operations-over-or-near-people; *CASA EX45/24 — Operation of Remotely Piloted Aircraft Over Populous Area Exemption 2024* (Cth).
[67] *Civil Aviation Safety Regulations 1998* (Cth) regulation 101.085; *CASA 20/25* (n 49) direction 5.
[68] Advisory Circular (n 31) page 22.
[69] *Civil Aviation Safety Regulations 1998* (Cth) regulation 101.065; *CASA 20/25* (n 49) direction 6.
[70] Some of these approvals are automatic in the sense they operate as notifications triggering a disallowance mechanism: *CASA 66/24 — Operation of RPAS Within 3 Nautical Miles of a Controlled Aerodrome (CASA-Verified Drone Safety App) Instrument 2024* (Cth).

Controlled airspace other than an aerodrome:[71] RPAS can be operated below 122 m (400ft AGL) in controlled aerodrome other than airports without CASA approval. RPAS can only be operated above 122 m (400ft AGL) in areas designated by CASA in accordance with both air traffic control and CASA approval.[72] Pilots of RPAS weighing more than 2 kg must also hold further qualifications (e.g. an Aeronautical Radio Operator's Certificate) and maintain a listening watch and make broadcasts on the relevant frequencies.[73]

Aerodromes with an active air traffic control tower: Additional rules apply to flying near aerodromes with an active air traffic control tower, as illustrated in Figure 4.[74]

Thus, pilots cannot, without permission from the relevant air traffic control service fly:[75]

- within 5.5 km of airport. There is an exception for RPAS weighing 250 g or less, which can operate at heights up to 45 m outside the airport boundary.
- in the approach and departure path of a runway, which extends up to 7 km; and
- higher than 90 m between 7 km and 9.5 km of the approach and departure path of a runway.

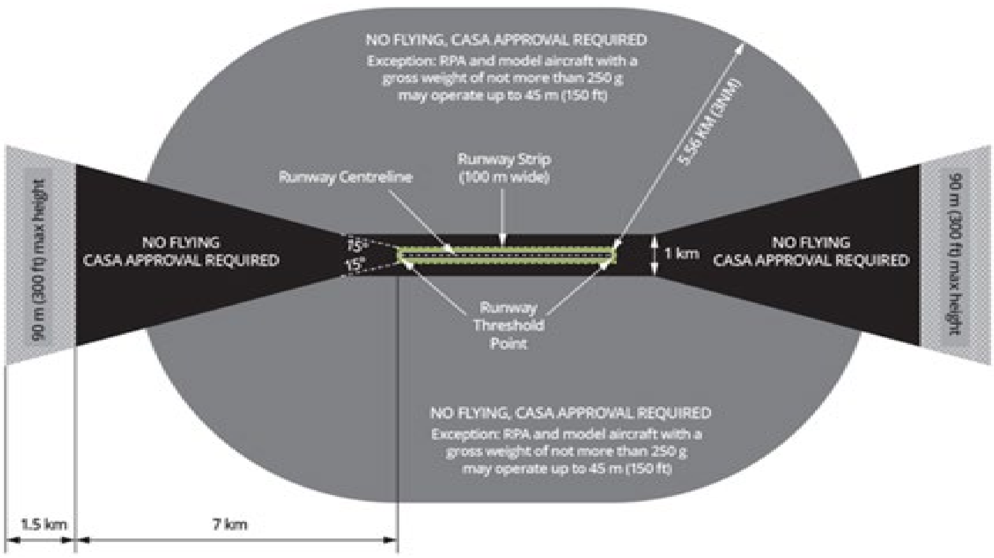

Figure 4: RPAS operational restrictions in a controlled aerodrome[76]

Important exceptions to operating in the no-fly zone for ReOC holders include: tethered operations conducted by ReOC holders; indoor operations; authorised operations; and eligible ReOC holders with automated airspace authorisations.[77]

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[71] Controlled airspace is "airspace of defined dimension within which an air traffic control service is provided to flights in accordance with the airspace classification": Advisory Circular (n 31) page 10.
[72] *Civil Aviation Safety Regulations 1998* (Cth) regulation 101.070.
[73] Ibid regulation 101.285.
[74] CASA, Flying Near Airports. 11 October 2024. Available at: https://www.casa.gov.au/drones/drone-rules/flying-near-airports.
[75] Ibid; *Civil Aviation Safety Regulations 1998* (Cth) regulations 101.075 – 101.080; *Part 101 (Unmanned Aircraft and Rockets) Manual of Standards 2019* (Cth) chapter 4 (*Part 101 MOS*).
[76] Ibid. CASA, Flying Near Airports. 11 October 2024. Available at: https://www.casa.gov.au/drones/drone-rules/flying-near-airports.
[77] *Part 101 MOS* (n 75) section 4.03.

Aerodromes without an air traffic control tower: RPAS can be operated near and within non-controlled aerodromes without an air traffic control tower provided that the RPAS is manoeuvred away from the no-fly zone (see Figure 5) and landed when the pilot becomes aware of other aircraft in the area.[78] There are limited circumstances in which ReOC holders can operate RPAS while an aircraft is in the area – notably, indoor operations, tethered operations and an operation using a RPAS weighing 250 g or less.[79]

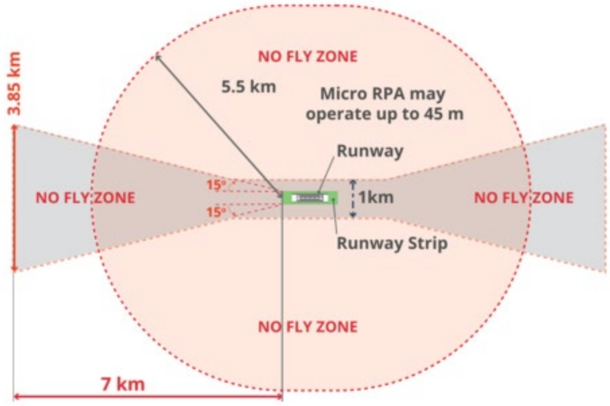

Figure 5: Operational restrictions in a non-controlled aerodrome while aircraft are in the area[80]

Helicopter landing sites: Pilots must maintain a distance of 1.4 km from helicopter landing sites when a helicopter is operating at the site, as illustrated in Figure 6. There are limited circumstances in which ReOC holders can operate RPAS while an aircraft is in the area – notably, indoor operations, tethered operations and an operation using a RPAS weighing 250 g or less.[81]

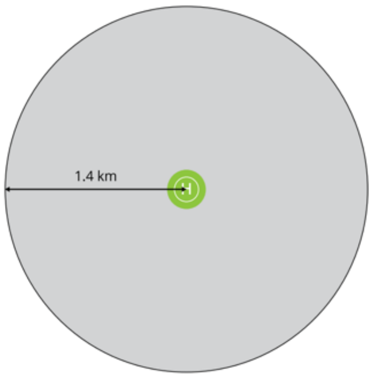

Figure 6: Operational restrictions at helicopter landing sites while aircraft are in the area[82]

[78] Ibid chapter 9; CASA, CASR Part 101 Mico and Excluded Remotely Piloted Aircraft Operations Plain English Guide Version 2.2. December 2024. Page 16. Available at: https://www.casa.gov.au/sites/default/files/2021-08/part-101-micro-excluded-rpa-operations-plain-english-guide-interactive.pdf (Micro and Excluded RPAS Plain English Guide).
[79] *Part 101 MOS* (n 75) chapter 9.
[80] Micro and Excluded RPAS Plain English Guide (n 78) page 17.
[81] *Part 101 MOS* (n 75) chapter 9.
[82] Ibid; Micro and Excluded RPAS Plain English Guide (n 78) page 18.

Finally, regardless of altitude or location, RPAS must not create an obstruction to aircraft that are taking off or landing at an airport and helicopter landing site.

Checking for prohibited, restricted and controlled airspace, and aerodromes: The location of prohibited, restricted and controlled areas can be checked in official publications such as ERSA (the En Route Supplement Australia, a publication containing information vital for planning a flight including information on all licensed aerodromes); and NOTAM (Notice to Air Missions, notices filed with an aviation authority to alert aircraft pilots of potential hazards along a flight route). CASA-verified RPAS safety apps also display prohibited and restricted areas, and should be consulted before flying a RPAS.[83] Note, however, that these apps are not an official source of information, and CASA recommends pilots reference official publications. Further, not all aerodromes are marked on aeronautical charts. CASA recommends "using satellite pictures or seek[ing] local knowledge to identify any nearby aerodromes."[84]

Weather conditions (operating in visual meteorological conditions (VMC))

RPAS cannot be flown in adverse weather conditions that would pose a hazard to the location, persons, property, or other aircraft.[85] Whether certain weather conditions pose such a risk will depend on the particular RPAS and local circumstances. Further, RPAS can only be flown at night, through cloud or fog or in non-VMC conditions in accordance with either air traffic control directions or CASA approval, which approval can be included in a ReOC's CASA endorsed Operations Manual.[86]

Flying RPAS beyond the operator's and/or observer's visual line of sight

Generally, the person controlling the RPAS must keep the RPAS within their naked eye line-of-sight at all times during the flight.[87] A RPAS is flown within the operator's naked eye line-of-sight if "the person can continually see, orient and navigate the aircraft to meet the person's separation and collision avoidance responsibilities, with or without corrective lenses, but without the use of binoculars, a telescope or other similar device".[88] It necessitates that the operator's view of the RPAS is not obstructed by any objects (e.g. buildings) during the flight.

ReOC holders can apply to CASA for approval to conduct either extended visual line of sight operations (EVLOS) or beyond visual line of sight operations (BVLOS). The ReOC holder must have a comprehensive set of documented practices and procedures for BVLOS and EVLOS operations.[89]

Extended visual line of sight operations (EVLOS): EVLOS operations involve trained observer(s) that maintain constant situational awareness of the RPAS's surroundings and keep it within their visual line of sight or know its exact location. The maximum distance that the observer can be away from the RPAS is 1,500 m, and minimum visibility

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[83] A link to a list of CASA-verified done safety applications that can be used to check the locations of prohibited and restricted operating areas, controlled airspaces and aerodromes can be found here: CASA, Drone Safety Apps. Available at: https://www.casa.gov.au/knowyourdrone/drone-safety-apps.
[84] Advisory Circular (n 31) page 22.
[85] *Civil Aviation Safety Regulations 1998* (Cth) regulation 101.055.
[86] Ibid regulation 101.095; see also *CASA 01/17 – Approval – Operations of RPAS at night 2023* (Cth).
[87] *Civil Aviation Safety Regulations 1998* (Cth) regulation 101.073.
[88] Ibid regulations 101.073, 101.300.
[89] *Part 101 MOS* (n 77) section 5.05.

standards apply.[90] “There are two classes of EVLOS operations: Class 1, which requires the remote pilot and observer to be co-located, and Class 2, which permits the pilot and observer(s) to be separated.”[91] Operator’s seeking to conduct EVLOs operations must: (a) hold a ReOC or be a member of the personnel of a ReOC holder; (b) hold a RePL; (c) obtain an instrument of approval from CASA; and (d) train the remote pilot and observer(s) and perform proficiency checks in accordance with the ReOC holder’s documented practices and procedures.[92]

Beyond visual line of sight operations (BVLOS): BVLOS is an operational category in which neither the remote pilot nor any observer has direct visual sight of the RPAS. Operator’s seeking to fly RPAS BVLOS must: (a) hold a ReOC or be a member of the personnel of a ReOC holder; (b) hold a RePL and have either themselves passed, or be working under an individual that has passed, the Instrument Rating or BVLOS exam; and (c) obtain CASA approval to operate beyond their visual line of sight. This requires applicants to prepare and submit a SORA risk assessment, amongst other documentation. Operations with a risk classification of SORA SAIL III or higher will require advanced operations approval.[93]

“BVLOS operations are not routinely permitted.”[94] Each application to CASA for BVLOS operations is assessed individually, and the process to obtain permission to conduct BVLOS operations can be lengthy. CASA practice has been to limit BVLOs approvals to specific operations necessitating new applications for each operation. However, CASA has recently commenced trialling a set of approval pathways for BVLOS operations to alleviate some of the regulatory burden.[95] The pathways, which are available to ReOC holders conducting operations with RPAS weighing 25 kg or less, are set out in Table 3.

Note that CASA’s Broad Area BVLOS Operations – 2025-03 (Temporary Management Instruction) also imposes other miscellaneous requirements and restrictions on pilots operating under these pathways (e.g. operating below 400ft, a certain distance from aerodromes).

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[90] Ibid chapter 5; in particular, section 5.11.
[91] Advisory Circular (n 31) page 27.
[92] *Part 101 MOS* (n 75) chapter 5. The following website provides a useful guide to applying for and varying EVLOS flight approvals: CASA, Extended Visual Line-of-Sight Operations. 11 October 2024. Available at: https://www.casa.gov.au/drones/flight-authorisations/extended-visual-line-sight-operations.
[93] *CASA EX51/24 – Remotely Piloted Aircraft Operations Beyond Visual Line of Sight Exemption 2024* (Cth); CASA, Advanced Operations. 31 July 2025. Available at: https://www.casa.gov.au/drones/flight-authorisations/advanced-operations.
[94] Advisory Circular (n 31) page 28.
[95] Trial for 12 months commencing 13 October 2025: CASA, New Trial Pathways for BVLOS Approvals. 19 September 2025. Available at: https://www.casa.gov.au/about-us/news-media-releases-and-speeches/new-trial-pathways-bvlos-approvals; CASA, Broad Area Beyond Visual Line-of-Sight. 11 December 2025. Available at: https://www.casa.gov.au/drones/flight-authorisation-trials/broad-area-beyond-visual-line-sight.

Table 3: Approval Pathways for BVLOS Operations[96]

	Pathway A		Pathway B	
	A1 – sparsely populated	**A2 – suburban**	**A3 – lightly populated**	**A4 – sparsely populated**
RPAS characteristics	< 1 m in size < 25 m s^{-1} maximum airspeed	< 1 m in size < 25 m s^{-1} maximum airspeed	1 to 3 m in size < 35 m s^{-1} maximum airspeed	1 to 3 m in size < 35 m s^{-1} maximum airspeed
Population density	< 500 people km^{-2}	< 2,500 people km^{-2}	< 50 people km^{-2}	< 250 people km^{-2}
Required mitigations	Sheltered structure* or PFRS**	Sheltered structure* and PFRS**	Sheltered structure* or PFRS**	Sheltered structure* and PFRS**

* **Sheltered structure** – more than 90% of non-active personnel are reasonably likely to be within a structure that the RPAS cannot penetrate.
** **PFRS** - A parachute recovery system that ensures the energy transfer upon collision with a person is less than 80 joules.

The Authorisation Process: Complexity, Time and Cost

As noted above, mechanisms exist to obtain authorisations to operate outside the Standard Operating Conditions that would provide the flexibility to employ drones to undertake up-close building inspections in urban residential settings. However, the process can be complex, time consuming and costly.

Obtaining an authorisation permitting what CASA refer to as 'close proximity' (closer than 30 m) and beyond visual line of sight operations requires detailed submissions containing risk and safety assessments of the proposed operations and corresponding risk management and operational processes and procedures. The complexity of this process varies with the complexity of the proposed operations, and often is an interactive exercise involving multiple conversations and drafts before CASA is satisfied both of the robustness of the risk management process, and of the operator's capability and capacity to operate in accordance with it.

The time to obtain an authorisation varies with the complexity of the proposed operation and its assessment. The CASA website advises applicants to allow at least three months for most authorisations and several months for beyond visual line of sight authorisations, with long lead times between applying for an authorisation and the application being assigned to an inspector for review and assessment.

And it is during this lead between application and assignment to an inspector, that applicants are provided with an estimate of the regulatory service fee for processing the application. The regulatory service fee is CASA's estimate of its costs of processing the application, applying an hourly rate of between $100 and $190 per hour depending on the

[96] Table is based on CASA, Broad Area BVLOS Operations – 2025-03 (Temporary Management Instruction). September 2025. Available at: https://www.casa.gov.au/drones/flight-authorisation-trials/broad-area-beyond-visual-line-sight. See Hover UAV, Self Assessed Borad Area BVLOS Drone Approvals. 22 September 2025. Available at: https://hoveruav.com.au/resource-centre/self-assessed-broad-area-bvlos-RPAS-approvals/.

nature and complexity of the work (most technical work is done at a rate of $160 per hour).[97] Payment of the fee must be received before work assessing the application will commence. Applicants with applications that prove to be more complex than originally anticipated can be asked to pay additional fees; and applicants with less complex applications receiving refunds.

There also are a number of private providers that will prepare the necessary documentation for CASA approval, assist in communication between the applicant and CASA throughout the approval process, and train the applicant organisation on how to operate compliantly with any authorisations. They quote fees of between $3,490 and $4,955 for 'fly near' operations, with a corresponding CASA regulatory service fee of $2,640 (which suggests about 16.5 hours work on CASA's part).

Record keeping

Record keeping requirements are detailed in *Part 101 (Unmanned Aircraft and Rockets) Manual of Standards 2019* (Cth) (*Part 101 MOS*) and vary according to the type of permission that the operator has to fly RPAS (i.e. a ReOC, RePL and/or an accreditation), the RPAS's weight and the particular circumstances of the operation.[98] The most comprehensive record keeping requirements apply to ReOC holders, and are outlined in division 10.2 of *Part 101 MOS*. Fewer (if any) requirements apply to RPAS pilots that are not operating under a ReOC (see division 10.3 *Part 101 MOS*). This includes RPAS operations involving RPAS that weigh: (1) 250 g or less; or (2) between 250 g and 2kg and are being operated in accordance with the Standard Operating Conditions detailed above (i.e., it has no special exemptions from CASA). But even in situations where RPAS operators are under no or limited record keeping obligations, good practice suggests they should keep an operational log that records:

- the nature and purpose of the flying operation;
- information identifying the RPAS, including the type, model and unique identification mark;
- the dates and times of the operation;
- the places from which and over which the RPAS flew;
- any consents obtained;
- the heights at which the RPAS was flown.

Reform directions

To understand how RPAS regulation might evolve in the future, we examined CASA's *RPAS and AAM Strategic Regulatory Roadmap 2024*, which was most recently updated in November 2025. We also interviewed CASA's National Manager, Emerging Technologies and Regulatory Change.

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[97] See CASA, 'Fees and Charges' 8 December 2025. Available at: https://www.casa.gov.au/about-us/reporting-and-accountability/service-standards-fees-and-statistics/fees-and-charges#CostRecoveryImplementationStatement

[98] A summary of the records that need to be kept can be found here: CASA, Record Keeping. 11 October 2024. Available at: https://www.casa.gov.au/drones/remotely-piloted-aircraft-operators-certificate/record-keeping.

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CASA explained that its initial approach to the regulation of RPAS was precautionary in nature due to the absence of information on RPAS risks and its statutory responsibility for treating safety as the highest priority. CASA also noted that the social licence to use RPAS was not uniformly established. However, experience has shown there is no significant evidence that RPAS operating according to existing risk mitigation strategies pose an unacceptable threat to people or other aircraft. This has seen CASA recently enable a wider range of use cases. At the same time however, CASA is conscious that with the easing of regulations may come increase scale of use, and that increased scale of use may lead to increased risk.

CASA expects RPAS use to be increasingly enabled over coming years, and in particular for the easing of operational rules applying to some classes of RPAS (e.g., RPAS under 250 g; RPAS with parachutes and enclosed blades). This is consistent with CASA's *RPAS and AAM Strategic Regulatory Roadmap 2024* that identifies nine areas where CASA expects increased use of RPAS. Relevantly, one of those is:

> 4. **Inspections and imaging** – using RPAS to capture imaging for information, research or data-gathering purposes. This may include the use of photography, the use of LIDAR or other sensors or analysis.

The roadmap also emphasises that driving the evolution of its regulatory cycle is the need to decrease the regulatory burden and resources required for oversight, increase regulatory consistently and efficacy, while simultaneously increasing safety assurance.

CASA's aim is to accommodate (without compromising safety) the anticipated greater demand to use RPAS for non-recreational purposes by:

- clarifying existing regulations;
- introducing new regulations and amending existing ones to keep pace with advances in RPAS technology (including increasing levels of automation in RPAS);
- giving RPAS users access to more (and lower-level) airspace, with more complex operations like EVLOS and BVLOS becoming commonplace; and
- streamlining approvals for more complex operations.

Permissioning (licensing) is likely to remain the mainstay of future regulation, with the use of licence (RePL) / operating certificate (ReOC) terms and conditions to mitigate many risks of RPAS use. This is the approach currently employed in the grant of ReOCs, where the ReOC may both incorporate authorisations and exemptions (from otherwise applicable regulatory requirements) and conditions (additional regulatory requirements to mitigate risks specific to the ReOC holder).

How this may evolve in the context of building inspections is not specifically addressed in CASA's Roadmap. However, CASA stated that it is open to engagement with stakeholders to assess and enable use of RPAS for up-close building inspections in appropriately safe circumstances. CASA's preference is for engagement to be broad based and not with individual agencies – recognition that the risk to safety does not change according to who is using the RPAS.

Finally, CASA's RPAS and AAM Strategic Regulatory Roadmap states that any changes to the regulatory framework will be informed by international standards and developments in like-minded countries. In this regard, see the discussion of international comparators in Section 3.3.

3.1.3. Other laws and regulations

In addition to the building inspection and CASA RPAS regulatory frameworks, there are a range of other laws and regulations that impact or govern the use of RPAS. These are summarised below.

Noise

All RPAS are required to abide by the *Air Navigation (Aircraft Noise) Regulations* 2018 (Cth).[99] Generally, RPAS being used for non-recreational purposes (which includes inspecting construction sites) must obtain noise approval unless:[100]

- the RPAS weighs 250 g or less; or
- the RPAS complies with the Standard Operating Conditions.

RPAS operators can check whether they are they are eligible for an exemption or automatic noise approval using this self-assessment application form: https://www.RPAS.gov.au/RPAS-noise-approval. Based on the answers provided in the self-assessment, the activity might be automatically exempt from requiring approval, granted an automatic approval or the applicant might be required to complete a full application. A full application is required if the activities undertaken by the RPAS operator are considered to pose a high risk of causing significant noise impacts to the community. RPAS used for most construction inspections are unlikely to require a full application; a possible exception being inspections of complex or large construction sites located in densely populated or sensitive areas.

Privacy

RPAS operators also must comply with relevant Federal, State and Territory privacy laws. These laws deal with the collection, storage, access to, and dissemination of personal and private information. At the Federal level, the *Privacy Act 1988* (Cth) and the Australian Privacy Principles apply to Australian government agencies; private sector businesses with an annual turnover of more than $3,000,000; and private sector businesses providing services under a contract with the Australian Government (regardless of turnover). And in Victoria, the *Privacy and Data Protection Act 2014 (Vic)* apply to Victorian public sector organisations and private entities acting on their behalf.

Also relevant are surveillance laws. For example, under the *Surveillance Devices Act 1999* (Vic), a person must not knowingly observe or record a private activity of another person without that person's consent.[101] Private activity means an activity carried on in circumstances that indicate that the parties desire it to be observed only by themselves and in a location in which they can reasonably expect that it might not be observed by others. It does not include activities carried on outside a building. Accordingly, care should

[99] RPAS operators also may be subject to applicable local noise abatement requirements.
[100] Federal Department of Infrastructure, Transport, Regional Development, Communications, Sport and the Arts, Drone Noise Approval. Available at: https://www.drones.gov.au/drone-noise-approval; *Air Navigation (Aircraft Noise) Regulations 2018* (Cth) regulation 6(2A).
[101] *Surveillance Devices Act 1999* (Vic) section 7.

be taken to ensure people located inside in a neighbouring house or apartment are not captured in the inspection recordings. While the *Surveillance Devices Act* does not apply to recording people walking outside a building or when engaging in 'public' activities, care also should be taken to minimise the likelihood of those persons being recorded.

A detailed examination of these Acts is beyond the scope of this paper. Nor are the Acts RPAS specific. With this in mind, the Federal Department of Infrastructure, Transport, Regional Development, Communications, Sport and the Arts also has issued a set of RPAS Privacy Guidelines.[102]

Two core principles to guide RPAS-assisted building inspections can be drawn from them:

- Personal information (including the likenesses of people not involved with the RPAS operation) should not be collected. The personal information most likely to be collected during roof inspections is a likeness of an individual from which they are identifiable. To minimise the risk of this occurring, care should be taken to ensure RPAS are flown in a manner that cameras attached to them face into the property the subject of the inspection.
- If personal information (including likenesses) is accidently collected, reasonable steps must be taken to permanently de-identify the personal information, destroy the personal information, or protect it from misuse. In the case of roofing inspections, this may require the immediate destruction or de-deification of persons whose likeness has accidentally been captured.

Trespass and nuisance

Operating a RPAS over private property may amount to trespass if it is at an unreasonable height that interferes with owner's ordinary use and enjoyment of their land, and occurs without the owner's permission.[103] It is a question of fact in each particular circumstance as to whether or not a trespass or nuisance has occurred and would depend on, among other things, the manner with which the owner of the property uses and enjoys their land, and the height and length of the intrusion.[104]

RPAS use also could constitute a nuisance if it amounts to a substantial and unreasonable interference with a person's use or enjoyment of their land.[105] This could include the noise of a RPAS that is flown adjacent to but not directly above the person's land, although compliance with the *Air Navigation (Aircraft Noise) Regulations* 2018 (discussed above) would appear to be a complete defence to any such claim.

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[102] Federal Department of Infrastructure, Transport, Regional Development, Communications, Sport and the Arts, Privacy Policy. Available at: https://www.drones.gov.au/drone-rules/privacy-policy.

[103] *LJP Investments Pty Ltd v Howard Chia Investments Pty Ltd (*1989) 24 NSWLR 490, 495. See also s 30 of the *Wrongs Act 1958* (Vic) which provides: 'No action shall lie in respect of trespass or nuisance by reason only of the flight of an aircraft over any property at a height above the ground which having regard to the wind the weather and all the circumstances is reasonable, or the ordinary incidents of such flight, so long as the provisions of the Air Navigation Regulations are duly complied with.'

[104] *LJP Investments Pty Ltd v Howard Chia Investments Pty Ltd* (1989) 24 NSWLR 490, 495; *Lord Bernstein v Skyviews and General Ltd* [1978] 1 QB 479, 489. See also *Bocardo SA v Star Energy UK Onshore Ltd* [2010] 3 ER 975, [984]–[993].

[105] *Civil Law (Wrongs) Act 2002* (ACT) ch 9; *Defamation Act 2005* (NSW); *Defamation Act 2006* (NT); *Defamation Act 2005* (SA); *Defamation Act 2005* (Qld) 2005; *Defamation Act 2005* (Tas); *Defamation Act 2005* (Vic); *Defamation Act 2005* (WA).

To avoid the risk of trespass and nuisance, every effort should be made to keep the RPAS flight within the boundaries of the property being inspected, and avoid flying over adjacent properties.

State, territory and local law

In addition to the requirements listed above, there are state, territory and local rules for RPAS use. While the specific restrictions vary between state, territories, and local government areas, permission is generally required to operate over sensitive, riskier or more crowded areas (e.g., state and national parks, national monuments, government buildings, beaches and municipal parks and reserves). As a result, most are unlikely to be relevant to the use of RPAS to inspect buildings with the result that a detailed examination of them is outside the scope of this paper.[106] Having said that, there are two restrictions worthy of specific mention. First, permission is required to operate within 120 m of correctional facilities, such areas in effect constituting a prohibited or restricted area.[107] And second, RPAS can only be operated within 45 m of powerlines and cables with the permission of the relevant electricity supplier. There is an exception for sub 2 kg RPAS which can be operated up to 3 m from an aerial line supported by poles or 6 m of an aerial line supported by towers.[108]

A Remote Piloted Aircraft Building Inspection Flight Approval Checklist

Appendix A is a draft generic template of a Remote Piloted Aircraft Building Inspection Flight Approval Checklist focussed on the use of RPAS to assist with building inspections. The Checklist is based on the template Flight Record in the CASA RPAS Sample Operations Manual, to which other relevant legal requirements in the Victorian Building Act and Regulations, state, territory and local laws, and the common law, have been added. The content of the Checklist may vary according to any authorisations, exemptions and conditions obtained by the organisation. And notwithstanding it is drafted for a ReOC holder, it is suitable for use by non-ReOC holders (with minor modification).

The Checklist reflects a manual system. Organisations using RPAs at scale employ the Aviation Compliance and Risk Management System (AVCRM). The AVCRM system is an online aviation management system for RPA operations. The AVCRM system provides operational planning, job safety assessment, aviation map information, approvals, document storage, inventory, defect logging, incident reporting, pilot qualification management, weather, regulatory information and compliance monitoring for subscribers.

3.2. Regulator experience with the regulatory environment

As noted above, the *Civil Aviation Safety Regulations 1998* (Cth) are very strict, making the use of RPAS in support of building inspections in urban residential settings highly problematic. Obtaining a ReOC can provide much needed flexibility in implementing the Regulations, but can impose significant costs and administration burdens. It is therefore

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[106] These restrictions can be transient and may change frequently. Many are catalogued at Federal Department of Infrastructure, Transport, Regional Development, Communications, Sport and the Arts, 'State and Territory Rules' webpage, available at https://www.drones.gov.au/drone-rules/state-and-territory-rules. A map showing local RPAS rules for parks and corrections institutions across Australia can be found at the Department's 'Local Drone Map Is Live!' webpage, available at https://www.drones.gov.au/news-and-announcements/local-drone-rule-map-live.

[107] See e.g., *Corrections Legislation Miscellaneous Amendment Act 2017* (Vic). Applies to prisons, residential facilities and youth justice facilities. Permission is required from the prison governor, officer in charge, or law enforcement agency, as appropriate.

[108] *Electricity Safety (General) Regulations 2019* (Vic) regulation 604.

instructive to look at the experience of other regulators implementing the Regulations (albeit in other domains), and private actors doing so in the building and construction sector (See Chapter 4 Stakeholder Perspective Mapping).

Interviews were conducted with the Chief Remote Pilots of three regulators employing RPAS in support of their regulatory activities. The three regulators interviewed all hold a ReOC with CASA. Two employ RPAS at scale in support of their monitoring, compliance and enforcement activities; one uses RPAS comparatively sparingly to assist with incident investigation. And while they operate in different regulatory fields, there is a similarity in their experiences and perspectives.

All three regulators acknowledged their position as government agencies dictates that they operate strictly in accordance with the law, and described themselves variably as prudent, very conservative, and risk averse.

Purpose

The interviewed regulators used RPAS for three purposes:

- **Monitoring** – to monitor for changes in the areas for which they have regulatory responsibility (e.g., environment; land management; forestry; threatened species; fire prevention preparation).
- **Detecting non-compliance** – to detect instances of non-compliance (e.g., waste storage; animal welfare; wildlife and fire preparation offences; misuse use of public land).
- **Investigations and enforcement** – investigation of incidents and suspected breaches; gathering evidence for enforcement actions.[109]

Drivers

The following drivers/benefits were identified:

- Safety – minimise exposure to unsafe conditions.
- Effectiveness – enhance accuracy; improve quality of evidence to support decision-making; improve detection of non-compliant activities.
- Efficiency – cover a much larger area in a shorter period of time, which produces time savings. One regulator did note that the time saving may not be as great as what might be thought given: (1) the officer must still attend the site [none employ fully remote / automated inspections]; and (2) the regulatory burden of preparing a flight plan; getting it approved; reviewing, transferring and storing records and data.
- Environmental benefits – using RPAS compared with fixed aircraft.

[109] None of the regulators interviewed expressed issues or concerns with the admissibility of evidence gathered through the use of RPAS, save that one regulator reported there having been some challenges to the accuracy of models produced with the data (as opposed to its mode of procurement). Those instances have required expert evidence to explain to the court how the models are produced and to attest to their accuracy, with the result that the challenges were dismissed, and the admissibility of the models and the data upon which they were based was upheld.

Barriers

The following barriers were identified:

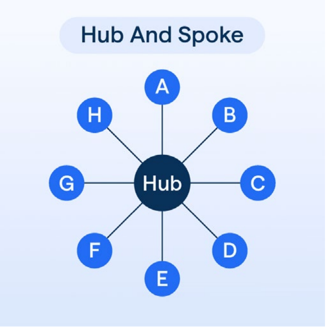
- Regulatory constraints – CASA regulations, specifically those limiting the ability to fly near and over people, line of sight requirements and airspace restrictions were identified as significant barriers to greater and more effective use of RPAS. All three regulators stated they do not use RPAS in urban residential areas for these reasons.
- Regulatory complexity – the complexity of the regulation was raised separately from the constraints it imposes, and which increases the cost of compliance. Having said that, those interviewed acknowledge CASA's responsiveness and recent efforts to ease the regulatory burden.
- Privacy / noise issues – these too can impact where and when RPAS may be flown.
- Attitudes of those being inspected – the higher likelihood of non-compliances being detected through the use of RPAS can lead to a higher rate of confrontation with those whose properties / activities are being incepted.

Types of RPAS

Across the regulators interviewed, the lightest RPAS were approximately 280 g, and carried a photographic/video camera. The heaviest RPAS was 15.5 kg. It could carry a variety of cameras (normal, thermal and ground penetrating), as well as gas detection payloads and water sampling equipment.

All regulators expressed a desire to move to lighter micro (sub 250 g) RPAS, but noted the anomaly in the CASA regulations that micro-RPAS could not be used under their ReOC.

Organisational set-up



Two regulators use RPAS at scale (80 and 30 licensed pilots each).[110] Those regulators employ a 'hub and spoke' organisational model, with a central function (hub) managing, approving, monitoring, training and setting policy for RPAS use, with pilots conducting operational activities located in regional offices and locations (nodes), connecting to and seeking approvals form the hub through a central management system (spokes). Both regulators employ the Aviation Compliance and Risk Management (AVCRM) Software.[111] The AVCRM system enables the pilot to create a flight plan (there is a Job Safety (Risk) Assessment for every flight), send it to the Chief Remote Pilot for approval, and for the Chief Remote Pilot to check it is compliant with the organisation's ReOC, CASA regulations and the organisation's own policies and guidelines, and to approve it. The AVCRM then keeps a record of every flight in compliance with CASA regulations and any requirements of the ReOC.

[110] The other regulator has a small centralised team of 4-5 pilots and conduct between 10 to 15 flights per annum.

[111] AVCRM, RPAS Manager. Available at: https://avcrm.net/RPAS/. The regulator not employing RPAS at scale do not use AVCRM due to their small scale.

The hub comprises the Chief Remote Pilot (CRP) and Maintenance Controller (MC), the minimum positions required of a ReOC holder. One regulator also had a dedicated team of 3 licensed operators in the hub for more complex operations.

The licensed pilots in the regional offices/locations are staff of the regulator.[112] They are a mix of authorised officers, scientific researchers, incident coordinators and other positions, for whom being a pilot is an adjunct to (a tool to assist them to perform) their primary role (cf. the primary role). For one regulator, pilots in the nodes are restricted by policy to flying exclusively in the sub 2 kg category taking photos and videos only, with more complex operations undertaken by the central dedicated team (located in the hub).

Pilots are accredited/licensed through external providers, with internally delivered regulator specific training in accordance with the ReOC. The comprises induction training prior to starting operations, training on the specific RPAS proposed to be used to confirm their ability to control and use the RPAS's features, training for non-Standard Operating Conditions approved by CASA (e.g., at night; extended visual line of sight), and refresher training.

One regulator said their annual budget is approx. $0.5 million per annum – which covers the wages of the CRP and Maintenance Controller (CASA required positions of ReOC holders), and system costs (AVCRM fees, training, RPAS maintenance and any advice they may need). This does not include the wages of the people who pilot the RPAS in regional offices and locations, for whom flying the RPAS is only part (and not a major part) of their roles.

All regulators interviewed did not report any industrial issues with the use of RPAS in support of their activities.

3.3. International comparators

CASA's *RPAS and AAM Strategic Regulatory Roadmap 2024* states that CASA will seek to align its regulations with those of like-minded countries. It is therefore instructive to examine the regulatory regimes of other countries. The countries chosen for this exercise are New Zealand, the United Kingdom, the United States of America, Canada and Singapore. The first four jurisdictions were selected because of their similar urban settings; Singapore was selected because of its comparatively more developed use of RPAS for building inspections in high density urban settings.

There are important similarities across all jurisdictions. First, like Australia, their regulatory regimes seek to strike an appropriate reward-risk balance – seeking to facilitate RPAS use for commercial and recreational purposes while ensuring safety, privacy and other risks associated with their use are appropriately mitigated. Second, and again like Australia, they seek to strike this balance through a mix of interrelated permissioning requirements and operational rules; interrelated in the sense that stricter permissioning requirements often allow for more flexible operational rules. Third, with the exception of New Zealand, their regulatory regimes are complex and highly technical (again, like Australia). And fourth, their RPAS regulations are evolving rapidly, a product of both the speed of technological change and changing risk appetites.

[112] One regulator reported having commenced RPAS operations using a panel of external providers but that proved unsuccessful because of costs and flexibility issues.

There also are important differences: some are substantive and reflect different regulatory risk appetites and different criteria employed to categorise RPAS and RPAS use; others are procedural; and others still reflect different terminology. These differences make direct comparisons difficult. Indeed, such a detailed examination is beyond the scope of this report. For this reason, this section adopts a high-level perspective focusing on key differences that might shed light on how Australia's regulatory regime might evolve and/or provide the basis for an application or exemption from existing regulatory requirements.

3.3.1. Permissioning requirements

RPAS registration and Remote ID

There is a global trend towards relaxation of permissioning requirements for lighter drones, including registration requirements (e.g. see Canada,[113] Singapore,[114] and the United Kingdom[115]). However, more generally for all drones, international regulators are increasingly becoming more interested in where and how RPAS are being operated, with the United Kingdom,[116] the United States of America [117] and Singapore[118] having mandated Remote ID broadcasting for all or particular types of drones.

In New Zealand, only Operator's Certificate holders (roughly equivalent to a ReOC) may – if directed to do so – be required to register their RPAS.[119]

Pilot accreditation and licensing

Accreditation and/or licensing is central to each of the selected jurisdictions' regulatory regimes. Most jurisdictions (like Australia) require minimal or no qualifications to operate sub-250 g RPAS (e.g., New Zealand,[120] the United Kingdom[121] and Canada[122]). In contrast, a Remote Pilot Certificate is required to operate all sub-25 kg RPAS in the United States of America, [123] and all commercial pilots in Singapore are required to hold the

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[113] Transport Canada, Registering Your Drone: Overview. 1 April 2025. Available at: https://tc.canada.ca/en/aviation/drone-safety/registering-your-drone.
[114] Civil Aviation Authority of Singapore, Unmanned Aircraft Regulatory Requirements. Available at: https://www.caas.gov.sg/public-passengers/unmanned-aircraft/ua-regulatory-requirements.
[115] UK Civil Aviation Authority, Registering to Fly Drones and Model Aircraft. Available at: https://www.caa.co.uk/drones/getting-started-with-drones-and-model-aircraft/registering-to-fly-drones-and-model-aircraft.
[116] UK Civil Aviation Authority, Remote ID (RID). Available at: https://www.caa.co.uk/drones/moving-on-to-more-advanced-flying/remote-id-rid.
[117] Federal Aviation Administration, Remote Identification of Drones. 19 March 2025. Available at: https://www.faa.gov/uas/getting_started/remote_id.
[118] Civil Aviation Authority of Singapore, UA Remote Identification. Available at: https://www.caas.gov.sg/public-passengers/unmanned-aircraft/ua-regulatory-requirements/ua-remote-identification.
[119] *Civil Aviation Rules 2023* (NZ) rules 101.5, 102.15.
[120] Civil Aviation Authority of New Zealand, Your Drone Questions Answered. Available at: https://www.aviation.govt.nz/drones/your-drone-questions-answered.
[121] UK Civil Aviation Authority, Registering to Fly Drones and Model Aircraft. Available at: https://www.caa.co.uk/drones/getting-started-with-drones-and-model-aircraft/registering-to-fly-drones-and-model-aircraft.
[122] Transport Canada, Drone operation Categories and Pilot Certificates: Microdrones. 4 September 2025. Available at: https://tc.canada.ca/en/aviation/drone-safety/learn-rules-you-fly-your-drone/drone-operation-categories-pilot-certificates/microdrones.
[123] Federal Aviation Administration, Certified Remote Pilots Including Commercial Operators. 25 March 2025. Available at: https://www.faa.gov/uas/commercial_operators.

equivalent of a licence, ReOC and specific operational approval regardless of the RPAS's weight.[124]

Some jurisdictions operate a tiered system of accreditation/licensing dependent on the RPAS's weight and operational circumstances (e.g., the United Kingdom and Canada); whereas others operate a more uniform system that is largely independent of weight (e.g., New Zealand and the United States of America). For example, New Zealand pilots are only required to hold a licence if flying within 4 km of an aerodrome,[125] and an Operator's Certificate if the RPAS is heavier than 25 kg[126] or otherwise operated outside New Zealand's standard rules.[127] In contrast, in the United Kingdom, separate qualifications exist for operating 50 m from, 30 m from, and infrequently over, uninvolved persons.[128]

Certification of non-recreational users and waivers/approvals for complex operations

All jurisdictions have more advanced, complex permissioning requirements to conduct certain kinds of riskier operations. A pre-requisite to conducting such operations in all the jurisdictions examined is a detailed operational procedure and risk management framework. What this specifically entails, however, varies significantly between jurisdictions.

For example, in the United States of America, although pilots need only obtain a waiver for complex operations and there is no exact equivalent of a ReOC, a comprehensive operational and risk management framework is required to be submitted for that waiver.[129]

By contrast, the United Kingdom has various categories of complex operations with varying requirements, including – at the most basic level and most relevant for roof inspections – a PDRA01 authorisation. A PDRA01 is somewhat equivalent to a ReOC in that holders must have an operations manual, prepare risk assessments and keep operational records. However, interestingly, PDRA01s applications now work on a self-declaration and audit mechanism.[130]

New Zealand's permissioning requirements are the most similar to Australia's, requiring an Operator's Certificate (equivalent to a ReOC) and approval to operate outside of New Zealand's standard RPAS rules.[131] Although structurally similar to Australian and New Zealand requirements, Singapore is more restrictive in that an Operator's Permit

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[124] Civil Aviation Authority of Singapore, Unmanned Aircraft Regulatory Requirements. Available at: https://www.caas.gov.sg/public-passengers/unmanned-aircraft/ua-regulatory-requirements.

[125] *Civil Aviation Rules 2023* (NZ) rule 101.205; *Civil Aviation (Operation of Unmanned Aircraft, Control Line Model Aircraft and Free Flight Model Aircraft) Transport Instrument 2025* (NZ) (*CATI 101-1*).

[126] *Civil Aviation Rules 2023* (NZ) rule 101.215.

[127] Civil Aviation Authority of New Zealand, Intro to Part 102 Certification for Unmanned Aircraft. Available at: https://www.aviation.govt.nz/drones/regulations/part-102-certification-for-drones.

[128] UK Civil Aviation Authority, Introduction to More Advanced Flying. Available at: https://www.caa.co.uk/drones/moving-on-to-more-advanced-flying/introduction-to-more-advanced-flying

[129] Federal Aviation Administration, Part 107 Waivers. 15 January 2026. Available at: https://www.faa.gov/uas/commercial_operators/part_107_waivers.

[130] UK Civil Aviation Authority, PDRA01 Overview. Available at: https://www.caa.co.uk/drones/specific-category/pdra01-operational-authorisation/pdra01-overview.

[131] Civil Aviation Authority of New Zealand, Intro to Part 102 Certification for Unmanned Aircraft. Available at: https://www.aviation.govt.nz/drones/regulations/part-102-certification-for-drones.

(equivalent to a ReOC) and flight specific approvals are required for all non-recreational operations.[132]

3.3.2. Operational rules

All jurisdictions with the exception of Singapore (where each commercial operation or sets of commercial operations requires specific approval from the relevant authority) have a set of operational rules which, like Australia's Standard Operating Rules, permit RPAS operations without additional approvals. All jurisdictions also provide mechanisms for obtaining authorisations or exemptions to operate outside the standard operating rules. The standard operating rules, and the mechanisms for obtaining authorisations or exemptions from them, vary (sometimes significantly) between jurisdictions. Discussed below are the operational rules in the selected jurisdictions most relevant to RPAS-assisted building inspections that differ notably from those in Australia.

Note, some regulators recognise that operations in the immediate vicinity of/around vertical objects (e.g. buildings) pose a lower risk and are relaxing various operational rules accordingly e.g. in New Zealand, operations near aerodromes and in controlled airspace without approval,[133] and BVLOS operations in Canada.[134]

Flying near or over people

Pilots in Canada, the United States of America and the United Kingdom with the requisite qualifications can conduct certain, more complex operations (e.g., flying over uninvolved persons) without specific approval from the relevant authority if they abide by particular conditions (one of which usually relates to the weight of the RPAS).[135] Of particular interest is the rule in the United Kingdom permitting RPAS to be flown over persons so long as this is kept to a minimum with a PDRA01, noting roof inspections are an example of a PDRA01 operation.[136] New Zealand operators can only fly over people with their consent.[137]

Flying over other people's property

In the United Kingdom, additional qualifications are required to operate RPAS heavier than 250 g (or heavier than 900 g with a UK1 class mark) within 150 m from residential, recreational, commercial and industrial sites, and within 50 m of individual residential

[132] Civil Aviation Authority of Singapore, Unmanned Aircraft Regulatory Requirements. Available at: https://www.caas.gov.sg/public-passengers/unmanned-aircraft/ua-regulatory-requirements.
[133] *CATI 101-1* (n 125).
[134] Transport Canada, Drone Operation Categories and Pilot Certificates: Advanced Operations. 4 November 2025. Available at: https://tc.canada.ca/en/aviation/drone-safety/learn-rules-you-fly-your-drone/drone-operation-categories-pilot-certificates/advanced-operations.
[135] Canada: Transport Canada, Drone Operation Categories and Pilot Certificates: Advanced Operations. 4 September 2025, available at: https://tc.canada.ca/en/aviation/drone-safety/learn-rules-you-fly-your-drone/drone-operation-categories-pilot-certificates/advanced-operations. USA: *Operation of Small Unmanned Aircraft Systems Over People*, 14 CFR Parts 11, 21, 43, and 107 (2021), available at https://www.faa.gov/sites/faa.gov/files/2021-08/OOP_Final%20Rule.pdf. UK: UK Civil Aviation Authority, Introduction to More Advanced Flying, available at https://www.caa.co.uk/drones/moving-on-to-more-advanced-flying/introduction-to-more-advanced-flying.
[136] UK Civil Aviation Authority, PDRA01 Overview. Available at: https://www.caa.co.uk/drones/specific-category/pdra01-operational-authorisation/pdra01-overview.
[137] Civil Aviation Authority of New Zealand, Flying Your Drone Safely'. Available at: https://www.aviation.govt.nz/drones/flying-your-drone-safely; *Civil Aviation Rules 2023* (NZ) r 101.207(a).

buildings.[138] In New Zealand, operators must have the landowner's permission to fly over their land, including in public areas.[139]

Beyond visual line of sight

Pilots in New Zealand,[140] the United Kingdom,[141] the United States of America,[142] and Canada[143] with the relevant qualifications are able to conduct some form of beyond visual line of sight operations without specific approval. For instance, first person view (FPV) operations where an observer but not the pilot maintains visual line sight of the RPAS can be conducted by suitably qualified pilots without specific approval in all of these jurisdictions.

3.3.3. Conclusion

Notwithstanding differences in the regulatory approach to RPAS use in the selected countries, the following directional trends can be discerned (although how they are achieved varies from jurisdiction to jurisdiction):

- RPAS laws in most jurisdictions are evolving to allow suitably qualified pilots greater operational discretion to undertake more novel (riskier) operations without specific regulator approval;
- greater scope for suitably qualified pilots flying lighter RPAS to fly over and near people;
- greater scope for suitably qualified pilots flying lighter RPAS to fly beyond visual line of sight.

3.4. Admissibility of RPAS generated evidentiary material

Another question that often arises concerning the use of RPAS generally and in the context of their use in support of regulatory activities in particular, is the admissibility of material generated by, through or with their assistance. In this section we examine, first, the admissibility of photographs and videos taken by a camera being flown by a RPAS; second, the admissibility of computer-models generated from those photographs and videos; and third, the discretion of a court to refuse to admit evidence improperly obtained.

3.4.1. Admissibility of photographs and videos

Photographs and videos are 'documents' as defined in the Dictionary to the Uniform Evidence Act[144] and, as such, can be tendered as evidence of their contents in

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138 UK Civil Aviation Authority, Introduction to More Advanced Flying. Available at: https://www.caa.co.uk/drones/moving-on-to-more-advanced-flying/introduction-to-more-advanced-flying
139 *Civil Aviation Rules 2023* (NZ) rule 101.207(a).
140 *CATI 101-1* (n 125).
141 UK Civil Aviation Authority, First Person View. Available at: https://www.caa.co.uk/drones/moving-on-to-more-advanced-flying/first-person-view-fpv.
142 Federal Aviation Administration, Small Unmanned Aircraft (UAS) Regulations Part 107. 6 October 2020. Available at: https://www.faa.gov/newsroom/small-unmanned-aircraft-systems-uas-regulations-part-107.
143 Transport Canada, Drone Operation Categories and Pilot Certificates: Advanced Operations. 4 September 2025. Available at: https://tc.canada.ca/en/aviation/drone-safety/learn-rules-you-fly-your-drone/drone-operation-categories-pilot-certificates/advanced-operations.
144 The Uniform Evidence Act (UEA) is a system of harmonised evidence laws in Australia, primarily based on the *Evidence Act 1995* (Cth), that aims for consistent rules across federal and state courts in participating jurisdictions. In Victoria, the uniform Evidence Act is enacted in the *Evidence Act 2008* (Vic).

accordance with s 48 of the Act. Its admissibility then is subject to it meeting two basic requirements:

- Relevance: that it has probative value; that it either supports or undermines the truth of any point at issue in the legal proceedings; and
- Authenticity: that it is a fair and accurate representation of what it purportedly depicts. This, in turn, can require proof of the efficacy and capacity of the recording equipment and in some cases, that it has not been tampered with. Proof of some of these elements are supported by presumptions in the Evidence Act. Most relevantly there is a rebuttable presumption of the working accuracy of scientific and technical instruments, which makes photographs and video recording prima facie evidence of the facts recorded.[145] (These presumptions are discussed in more detail in the next section.)

3.4.2. Computer-generated models

The Uniform Evidence Act contains a number of provisions facilitating proof of electronic evidence. Sections 146–147 facilitate proof of ‘evidence produced by processes, machines and other devices’ and are intended, among other things, to facilitate the admission of computer-produced evidence. Section 146 applies to a document or thing produced wholly or partly by a device or process and which is tendered as evidence of a particular outcome produced by that device or process. Section 147 applies to documents produced by processes, machines and other devices in the course of business. They then provide that if it is reasonably open to find that the device or process is of a kind that, if properly used, ordinarily produces that outcome, it is presumed (unless evidence sufficient to raise doubt about the presumption is adduced) that, in producing the document or thing on the occasion in question, the device or process produced that outcome. The Act gives as an example, that it would not be necessary to call evidence to prove that a photocopier normally produced complete copies of documents and that it was working properly when it was used to photocopy a document tendered as evidence.

At common law a photocopier is an example of what courts have termed a ‘notorious’ class of instruments, being instruments in respect of which courts will take judicial notice of their trustworthiness. Other examples include speedometers, thermometers and clocks.[146] If an instrument or device is not in this class (such as a purpose specific computer model), then expert evidence may be required to establish that the instrument or device ‘is of a scientific or technical character’ and that when properly operated will produce output (a document or thing) that is accurate.[147]

In this regard, one of the regulators using RPAS interviewed for the purposes of this project, advised they have had challenges to the accuracy of 3D surveys produced from data generated from cameras and other instruments attached to a RPAS, and that with the assistance of evidence from the experts who produced the surveys, the challenges were dismissed and the survey admitted as evidence.

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[145] Ss 146-147 Evidence Act. See also the discussion in John Anderson, *Uniform Evidence Act: Text and Essential Cases* (The Federation Press, 4th ed., 2012) [3.600]-[3.610], [7.290]-[7.300].
[146] See e.g., *Porter v Kolodzeil* [1962] VR 75; *Allen v Broome* [2003] TASSC 38; Gorham v Brice [1902] 18 TLR 42; *Thompson v Kovacs* [1959] VR 229.
[147] *Porter v Kolodzeil* [1962] VR 75, 79.

3.4.3. Exclusion of improperly or illegally obtained evidence

The final question to be considered in this section is the consequences should the evidence be obtained improperly or illegally, as might be the case if the RPAS is flown in breach of CASA or other legal requirements. This is covered by section 138 of the Uniform Evidence Act. It provides that evidence obtained improperly or in contravention of an Australian law 'is not to be admitted unless the desirability of admitting the evidence outweighs the undesirability of admitting [improperly or illegally obtained] evidence'. In applying section 138, the party seeking to exclude the evidence bears the onus of establishing that the evidence was improperly or illegally obtained. If this is established, the onus then shifts to the party seeking admission of the evidence to satisfy the court that the desirability of admitting the evidence outweighs the undesirability of admitting it, given the manner in which it was obtained.

Section 138 does not define 'improperly' obtained evidence. However, section 138(3) provides a non-exhaustive list of the factors a court may take into account in conducting the balancing exercise specified in s 138(1). These include:

a) the probative value of the evidence;
b) the importance of the evidence in the proceeding;
c) the nature of the subject-matter of the proceeding;
d) the gravity of the impropriety or contravention;
e) whether the impropriety or contravention was deliberate or reckless;
f) whether the impropriety or contravention was contrary to or inconsistent with a right of a person recognised by the International Covenant on Civil and Political Rights;
g) whether any other proceeding (whether or not in a court) has been or is likely to be taken in relation to the impropriety or contravention; and
h) the difficulty (if any) of obtaining the evidence without impropriety or contravention of an Australian law.

These provisions highlight the importance of complying with all applicable laws and regulations.

3.5. Summary

As can be seen, there are various Federal, State, Territory and local government rules and regulations governing the use of RPAS in Australia that combined, produce a complex and challenging regulatory space. The most pervasive and restrictive of these are the *Civil Aviation Safety Regulations 1998* (Cth) administered by CASA. These rules make the use of RPAS in support of building inspections in high-density urban residential settings highly problematic. Greater scope exists to use RPAS in low density areas (i.e., regional / rural), and on greenfield development sites that can be vacated and controlled during RPAS operations.

Scope exists to obtain authorisations and exemptions from some of the stricter regulatory requirements. Some of these authorisations and exemptions are available to accredited pilots; all are available to licensed pilots (RePL) and organisations that have obtained a ReOC. Obtaining a ReOC is comparatively more costly and time-consuming. Applicants are required to, amongst other things: create and appoint suitably qualified persons to various positions, including a Chief Remote Pilot and Maintenance Controller; develop detailed and bespoke operational procedures and manuals, which CASA must endorse; and ensure all pilots are licensed (RePL) and that they and all support personnel are trained on the relevant procedures and manuals. Operating in accordance with a ReOC also requires the Chief Remote Pilot to approve all flights.

The time, cost and greater administration involved in applying for and operating according to RePLs and ReOCs more exacting requirements can be significant. However, so too are the benefits, including the greater safety assurance they provide, the flexibility they afford to use (and to expand to use) larger and more complex RPAS, and the professionalism and heightened responsibility they demonstrate and legitimacy they confer. For this reason, we recommend organisations proposing to employ RPAS for 'up-close building inspections' at scale apply for a Remotely Piloted Aircraft Operators Certificate (ReOC) with authorisations and exemptions to enable their safe, effective and efficient use at scale for this purpose. At a minimum this should include the ability to fly near or above people (i.e., exemption from the 30 m / 15 m rule) and authority to conduct EVLOS/BVLOS operations over and within the boundaries of property (residential blocks) that have been vacated for inspection purposes.

In the interim (or potentially as a precursor learning exercise to applying for a ReOC), organisations can engage accredited or licensed pilots to trial RPAS use in support of building inspections in low density settings and greenfield / development sites where compliance with CASA's Standard Operating Conditions can be achieved.

Finally, a building inspection industry working group should be formed to engage CASA in a dialogue to assess the risks and rewards of using RPAS for up-close building inspections with a view to either:

- the grant of a general statutory authorisation or exemption; and/or
- regulatory reform,

to facilitate the safe, effective and efficient use of RPAS for up-close building inspections.

Applications for authorisations, exemptions or regulatory reform to enable the safe, effective and efficient use of RPAS for 'up-close building inspections' should at a minimum seek:

- the ability to fly near or above people (i.e., exemption from the 30 m / 15 m rule); and
- authority to conduct EVLOS / BVLOS operations,

over and within the boundaries of property (residential blocks) that have been vacated for inspection purposes.

This can (and should) be done contemporaneously with individual organisational applications for ReOCs. While CASA has expressed a preference for industry-based consultations, CASA's 'regulatory cycle' for normalising novel operations often begins with individual exemptions that drive policy development.[148]

[148] See the regulatory cycle diagram on page 9 of CASA's RPAS and AAM Strategic Regulatory Roadmap 2024, available at https://www.casa.gov.au/resources-and-education/publications/corporate-publications/rpas-and-aam-strategic-regulatory-roadmap#Roadmapupdates

4. STAKEHOLDER PERSPECTIVE MAPPING

4.1 Overview

RPAS are increasingly being considered as a digital inspection tool in building and infrastructure assessment practices (Mirzabeigi et al., 2025; Panigati et al., 2025). In the residential and commercial construction context, ongoing difficulties associated with roof access, safety, and the changing form of housing have prompted both private actors, such as builders, insurers, and independent inspection firms and public-sector bodies, including regulators and government agencies, to explore how RPAS might be incorporated into existing roof inspection practices (Macêdo et al., 2021).

Despite this growing interest, the role of RPAS in roofing work inspections continues to evolve and is shaped by how different stakeholders perceive its suitability, legitimacy, and place within established inspection and regulatory frameworks (Charlesraj & Rakshith, 2020). Stakeholder perspectives are therefore central to examining how RPAS is interpreted and positioned within inspection, regulatory, training and organisational decision-making contexts. Variations in professional roles, institutional responsibilities, and levels of direct exposure to RPAS technology can result in differing expectations and interpretations of RPAS use. Examining these perspectives provides an essential foundation for understanding how RPAS is currently positioned within the sector and how its future use may be shaped.

The aim of this chapter is to map and analyse stakeholder perspectives on the use of RPAS for roofing work inspections, drawing on insights from a broad range of industry, regulatory, policy, training, and service stakeholders. This chapter focuses to identify perceived benefits, challenges, and points of divergence across stakeholder groups with differing levels of RPAS experience and organisational roles. In addition, the chapter explicitly explores education and training considerations, including current training practices, workforce capability gaps, and design principles for integrating RPAS-related competencies into vocational and professional training pathways. By systematically examining these perspectives, the chapter seeks to inform evidence-based recommendations for the responsible, effective, and context-appropriate integration of RPAS into roofing work inspection workflows, addressing regulatory compliance, implementation feasibility, workforce capability development, education and training alignment, and consumer protection.

4.2 Data collection and analysis methods

This phase of the study adopted a qualitative research approach based on semi-structured interviews to capture stakeholder perspectives on the use of RPAS in roofing work inspections. Participants were purposively recruited to represent a broad range of stakeholder groups relevant to RPAS adoption, including regulators, inspectors, managers, training providers, RPAS service providers, professional bodies, builders, and independent practitioners. Selection criteria were designed to capture variation in professional role, institutional responsibility, and level of exposure to RPAS, ensuring inclusion of participants with direct operational experience, indirect or observational exposure, and no prior hands-on use of RPAS technology. Table 4 shows the demographics of the participants.

Table 4: Demographics of the participants

Demographic Factor	Categories		Number of Interviewees (n)
Interviewee Role	Inspectors	Regulatory inspectors	4
		Private inspectors	1
	Management / Leadership	Inspectorate managers	2
	Regulators (Non-inspector roles)	Investigations / Compliance & enforcement	2
		Dispute resolution / Building assessment	2
		Technical authority / Policy & governance	2
	Professional bodies		2
	Industry (builders / contractors)		2
	Training providers		4
	RPAS service providers		3
Years of Experience	Less than 6 years		3
	6–10 years		6
	11–20 years		9
	21-30 years		4
	31+ years		2
Gender	Male		23
	Female		1
RPAS Experience	Direct Operational Experience		14
	Indirect Experience		8
	No Experience		2

In Table 4, the "Inspectors" category includes both inspectors working within a regulatory inspectorate (n = 4) and one independent private inspector (n = 1). Within the regulatory inspectorate, inspectors operate across three inspection streams: preventive (proactive identification of non-compliance), audit and surveillance (targeted compliance monitoring), and specialist inspections (complex or high-risk building monitoring). Inspectorate managers supervise inspection teams and coordinate the planning and delivery of regulatory inspection programs. In contrast, the category "Regulators (non-inspector roles)" refers to regulatory personnel engaged in investigations, dispute resolution, technical authority, and policy or governance functions rather than routine field inspections.

Interviews followed a semi-structured protocol to enable consistency across participants while allowing flexibility to explore role-specific and context-sensitive insights. The interview protocol was reviewed for consistency with the project's ethical approval (MUHREC Project ID: 47223). Interviews were conducted online via a video conferencing software, typically lasting between 45 and 60 minutes, and employed open-ended questions to encourage detailed reflection. The interview questions were designed to elicit participants' views on the current status, perceived benefits, and challenges associated with RPAS use in roofing work inspections, while the interviews with training providers additionally focused on the existing training landscape, gaps, and recommendations for future training development in the area. Data were analysed using thematic analysis methods to systematically code, organise, and compare large volumes of qualitative data across stakeholder groups. NVivo, a qualitative analysis software, was employed to enhance analytical rigour by facilitating transparent code development, efficient retrieval of coded data, and structured comparison of themes across professional roles and experience levels (Zamawe, 2015). Representative quotations were selected to support interpretation and strengthen the credibility and transparency of the findings.

4.3 Key findings

This section presents the findings from interviews, highlighting stakeholder perspectives on the use of RPAS for roofing work inspections. The analysis identifies the current landscape, key benefits, and challenges of RPAS usage for roofing work inspection. Differences in views across stakeholder groups with varying levels of RPAS experience are explored, providing insights into areas of convergence and divergence that inform recommendations for responsible and effective RPAS integration.

4.3.1 Current landscape of RPAS usage for roofing work inspection

Current RPAS use in roofing work inspections remains uneven and context-dependent across the sector. While drones are increasingly recognised as a useful support tool, particularly for improving safety and access in complex, high-risk, or large-scale assets, their application is not yet routine or standardised. In practice, RPAS is most commonly used for preliminary visual scoping and access-restricted assessments, with outputs typically limited to high-resolution imagery rather than fully integrated analytical or reporting workflows. Participants broadly positioned RPAS as a complementary tool that improves reach and safety, but emphasised that routine adoption depends on inspection-specific regulatory confidence (clearer understanding of how RPAS operations can comply with existing aviation regulatory framework and inspection legislation in residential settings, and how RPAS-generated imagery may be used as evidentiary material (Sections 3.1.2 and 3.4), workflow integration, and workforce capability, including clearer training pathways and guidance for residential operating environments.

4.3.2 Benefits of RPAS usage for roofing work inspection

Improved access to hard-to-reach roof areas

One of the most consistently identified benefits of RPAS use was improved access to roof areas that are difficult, costly, or unsafe to inspect using conventional methods. Participants emphasised that many contemporary residential roofs, particularly double-storey dwellings, flat roofs, box gutters, and townhouses, are effectively inaccessible without scaffolding, harness systems, or specialist access trades. RPAS were therefore viewed as enabling visual access without physical roof entry, addressing a long-standing inspection constraint. This benefit was recognised by approximately three-quarters of participants, with particularly strong consensus among regulators and inspectors involved in audit, surveillance, and compliance activities.

Interviewees with direct operational RPAS experience described RPAS as a practical response to "no-access" outcomes that would otherwise result in incomplete inspections. Regulators noted that RPAS imagery allows inspections to proceed where physical access is not feasible, with one participant explaining that on multi-storey roofs "you've just got no chance without a drone", whereas RPAS allow inspectors to "fly it up, take a picture, and bring it back down". Another inspector similarly observed that RPAS use provides "more than enough information to make determinations in the majority of cases" where roof access is unavailable.

Stakeholders without direct operational RPAS experience also acknowledged the access advantage of RPAS but tended to frame it in more conceptual terms. To maximise this benefit, participants recommended formally embedding RPAS as an initial access tool within inspection workflows, where drones are first used to obtain visual information and assess roof conditions to determine whether the physical roof access is required, particularly for multi-storey and high-risk roofs, while retaining targeted physical access only where necessary.

Improved safety for inspectors and workers

RPAS were seen as reducing the need for inspectors to physically access roofs, thereby lowering the risk of falls and serious injury by a large majority of participants across regulatory, industry, and professional roles. This safety benefit was acknowledged not only by participants with direct RPAS experience, but also by those without operational exposure, indicating broad agreement on its importance.

Participants with regulatory and policy responsibilities strongly framed RPAS as a safety intervention rather than merely an efficiency tool. One senior regulator described RPAS as "a really good safety tool," noting significant improvements in occupational health and safety in practice. Similarly, a builder reinforced this view, emphasising that "avoiding roof access directly mitigates the potential for injury or even death associated with traditional inspections".

Some participants raised secondary safety considerations related to RPAS operation itself, such as managing bystanders and launch locations in suburban environments. For example, one regulator noted that when operating RPAS in residential areas, "you'd have to have some sort of signage to say that a drones in use… and if someone were to enter that zone, then we would have to bring the RPAS down for the safety considerations" However, these concerns were generally viewed as manageable through procedures and training and did not diminish the perceived safety value of RPAS compared with physical roof access. Stakeholders recommended explicitly positioning RPAS within organisational safety policies and training frameworks and prioritising their use in situations where roof access poses heightened risk, particularly on multi-storey and steep roofs.

High-quality visual data and improved visibility

High-quality visual data was identified as a major benefit of RPAS use, recognised by a clear majority of participants (approximately two-thirds of interviewees, with 9 files and 18 coded references). Stakeholders emphasised that RPAS provide close-range, high-resolution imagery that exceeds what is typically achievable from ground-based observation or existing remote imaging tools. This improved visibility was seen as particularly important for identifying visible defects, assessing drainage elements, and understanding roof conditions in context, especially where physical access is limited.

Participants with regulatory and inspection responsibilities consistently highlighted the value of image clarity for supporting inspection judgments. One senior regulator noted that “while satellite imagery is useful for some purposes, it is nowhere near the detail you can see with a RPAS,” explaining that RPAS allow inspectors to “get down close enough to see whether there is a sump, an overflow provision and a primary outlet”. Similarly, another regulator observed that in many compliance assessments, non-compliant plumbing elements such as missing drainage provisions are “generally visibly obvious, and that even without precise measurement, clear imagery can be sufficient to support a determination”.

However, there was some divergence in how visual accuracy was interpreted across roles. Participants with direct operational RPAS experience tended to emphasise that RPAS imagery provides sufficient accuracy for identifying clear non-compliances, even if it does not replace detailed physical measurement. As one regulator explained, “we’re not measuring 400 versus 410… but 400 versus 200 is a very big difference, and that level of accuracy can easily be obtained from a drone”. In contrast, participants with indirect experience or no experience were more cautious, stressing that the usefulness of visual data depends on image quality and documentation, with one inspector noting that “as long as it’s a clear photograph that shows the defect, we can base our findings on that but that ambiguity would limit evidentiary value in legal scenarios” Several stakeholders from regulatory inspection and other regulatory roles noted that post-processing and annotation tools could further enhance the interpretability of RPAS imagery, particularly when used to support regulatory decisions or dispute resolution processes.

In some specific inspection contexts, participants also noted that image clarity may be affected by roof material and lighting conditions. Reflective or visually uniform surfaces, such as metal sheeting or glossy tiles, were reported to reduce defect visibility under strong sunlight or variable exposure, requiring careful camera control. As one respondent noted, “you’re dealing with shiny roofs… exposures hide all the defects,” highlighting the importance of operator skill in managing lighting and image capture.

Pre-inspection screening and initial assessment

The use of RPAS as a pre-inspection screening tool was identified as a notable benefit by approximately half of the interviewees, with stronger emphasis among regulators and inspectors managing high inspection volumes. Participants described RPAS as enabling a rapid initial assessment of roof conditions, allowing inspectors to determine whether further physical access, specialist trades, or follow-up inspections were necessary. This capability was seen as particularly valuable in contexts where inspection resources are limited and where unnecessary site access can introduce avoidable costs, delays, or safety risks, as per the participants.

Participants with direct RPAS experience emphasised the operational value of screening prior to committing to physical inspections. One inspector explained that RPAS allow inspectors to “have a quick look first and then decide whether it’s actually worth going any further,” noting that in many cases issues can be ruled out early without the need for roof access. Similarly, an inspector involved in specialist inspections observed that RPAS can help identify whether a complaint “is actually roof-related or something else altogether,” improving prioritisation and reducing unnecessary escalation to more complex or high-risk inspection processes.

Stakeholders without direct RPAS experience also recognised the potential of RPAS for initial assessment but tended to frame it as a decision-support mechanism rather than a replacement for inspection activities. These participants stressed that RPAS screening should inform, rather than substitute for, professional judgement, particularly in regulatory and insurance contexts where evidentiary thresholds apply. Participants recommended formally integrating RPAS into inspection decision pathways, enabling RPAS-based screening outcomes to be documented and used to justify subsequent inspection actions, including targeted physical access or closure of low-risk cases.

Time and cost efficiency

Time and cost efficiency were identified as an important benefit of RPAS use by a majority of participants, particularly among regulators, independent inspectors, and service providers responsible for managing inspection workloads and resources. In cases where roof access is deemed necessary, some participants noted that using RPAS could provide efficiency gains by having fewer personnel on site, shorter inspection durations, and avoidance of repeat visits. This was seen as especially relevant for multi-storey residential buildings, where conventional inspections often involve significant time and cost associated with scaffolding or specialist access arrangements. While this section reports perceived efficiency gains qualitatively from participant viewpoints, Chapter 5 evaluates these efficiencies quantitatively through scenario modelling and comparative cost/time analysis of RPAS-enabled and conventional inspections.

Participants with direct operational RPAS experience provided concrete examples of these efficiencies. One service provider explained that “what would normally take multiple people and several hours can be done by one person with a drone in a fraction of the time,” particularly for double-storey roofs where access constraints are significant. Similarly, a regulator involved in surveillance activities noted that RPAS-assisted inspections allow teams to “get through a lot more sites in a day” by reducing setup and access time.

However, perceptions differed regarding the consistency of these efficiency gains. Some participants cautioned that time savings could be offset by post-flight data processing, image review, and reporting requirements if workflows are not well integrated. As one inspector observed, “the flying part is quick, but you still have to download, review, and document everything properly,” which can reduce overall efficiency if not managed carefully. Participants without direct RPAS experience were more likely to raise these concerns, emphasising that efficiency benefits depend on how RPAS are embedded within existing inspection and reporting systems. Conversely, participants with more advanced RPAS workflows noted that efficiency gains were significantly enhanced when drone operations were integrated with automated reporting or asset management platforms. One participant explained that “on the back end, data consolidation is a big one… clients really find use in being able to automate output rather than drown in Excel spreadsheets," highlighting the role of software integration in realising time and cost benefits beyond the flight itself. Several participants with direct operational RPAS experience emphasised that efficiency gains are greatest when inspectors are trained to operate RPAS themselves, thereby seamlessly integrating RPAS use into routine inspection workflows. In contrast, participants without direct RPAS experience tended to favour external operators or small specialist RPAS teams, viewing this model as a way to manage training and compliance demands and thereby improving efficiency.

Compliance verification and follow-up inspections

The use of RPAS to support compliance verification and follow-up inspections was identified as a key benefit by a substantial proportion of participants. They noted that RPAS imagery enables visual confirmation of rectification works and post-completion conditions without requiring repeat physical roof access, which is often impractical or unsafe.

Participants with regulatory and inspection responsibilities emphasised that RPAS are especially valuable during follow-up stages, where the objective is to verify whether identified non-compliances have been addressed. One regulator explained that RPAS allow inspectors to confirm rectification remotely, stating that "if the issue was visible before, and it's visible now that it's been fixed, that's sufficient for us". Similarly, an inspector involved in surveillance activities noted that RPAS imagery reduces reliance on self-reported rectification, allowing inspectors to "see it for ourselves without having to go back up on the roof".

However, some divergence was evident regarding the evidentiary limits of RPAS-based verification. Participants without direct RPAS experience tended to emphasise that RPAS imagery should be treated as supplementary evidence rather than a full substitute for physical inspection, particularly where concealed elements or precise measurements are required. As one investigation team leader noted, "it works well when the issue is visible, but if it's hidden or borderline, you still need someone on the roof." In this context, stakeholders recommended formally recognising RPAS imagery as acceptable supporting visible evidence for rectification, while clearly defining the circumstances under which physical re-inspection remains necessary.

Client/consumer outcomes and satisfaction

Improved client and consumer outcomes were identified as an important benefit of RPAS use by a moderate proportion of participants (11 out of 24 participants- 46%), with the strongest emphasis from regulators and inspectors. Participants highlighted that RPAS-assisted inspections can reduce delays, costs, and uncertainty for homeowners, particularly in situations involving water ingress, post-handover defects, or access-restricted roofs. This benefit was framed less in terms of inspection efficiency and more in terms of consumer protection, peace of mind, and reduced exposure to ongoing damage.

Several participants noted that conventional access constraints often leave consumers with limited and costly options, such as erecting full scaffolding or engaging private inspectors willing to take on elevated risk. One specialist inspector observed that consumers are frequently advised to spend "$3,000 to $5,000 to put up scaffold around their entire house just so we can inspect it," which many are unwilling or unable to do, whereas RPAS offer a more proportionate and accessible alternative. Others emphasised that delays in access can directly worsen occupant outcomes, with one participant noting that while waiting for access arrangements, “the leak is ongoing, that damage is ongoing” which affects the safety and the comfort of occupants.

Participants also highlighted that RPAS can support earlier detection and faster resolution of roofing issues, particularly water ingress, which has direct implications for occupant health, comfort, and amenity. One Builder noted that RPAS imagery allows responsibility to be established quickly, stating, “with drone images we can show the roof plumber: ‘Here’s the photo, it’s your fault, go fix it,’” leading to rectification within days rather than weeks. Policy-making stakeholders further linked this capability to broader consumer benefits, noting that “water damage is the leading cause of residential building insurance claims and that drone-supported inspections can play a role in reducing claim frequency and severity by enabling earlier intervention”. Some participants also observed emerging consumer-led uses of RPAS, with homeowners increasingly conducting their own roof checks or presenting RPAS footage during inspections. While this was viewed positively in terms of awareness and engagement, participants stressed that professional interpretation remains essential to ensure that appropriate conclusions are drawn.

Other identified benefits of RPAS use

Whole-of-roof visibility was noted by several participants as a supplementary benefit, with RPAS enabling inspectors to view roof systems holistically rather than as isolated components. This broader visual context was seen as particularly useful for understanding drainage layouts, identifying interactions between roof elements, and recognising patterns of debris accumulation or water flow that may not be apparent from partial or ground-based views.

Preventive monitoring and early issue identification was also highlighted, particularly by regulators and inspectors, who noted that RPAS can support periodic checks of roof condition and maintenance status. Some participants observed that both professionals and homeowners are increasingly using RPAS to monitor roofs proactively, enabling issues such as blocked gutters or displaced components to be identified before they escalate into more serious defects.

4.3.3 Challenges of RPAS usage for roofing work inspection

Regulatory uncertainty and compliance complexity

Regulatory uncertainty and compliance complexity emerged as the most significant and widely cited challenges affecting the use of RPAS for roofing work inspections. This challenge was raised by the majority of participants across stakeholder groups, particularly regulators, inspectors, professional bodies, and managers, and was consistently identified as a key barrier to the routine and scalable deployment of RPAS in residential environments. Rather than reflecting a single regulatory obstacle, participants described a layered and intersecting set of aviation, privacy, inspection, and organisational compliance requirements that together create operational uncertainty and risk aversion. The regulatory requirements underlying these concerns are detailed in Section 3.1.2, which outlines the relevant operational rules governing RPAS use in proximity to people.

A dominant perception among participants, especially those without direct RPAS operational experience, was that aviation regulations, particularly CASA requirements, significantly constrain RPAS use in dense suburban settings. The 30-metre separation rule was repeatedly described as difficult to operationalise in practice, given the proximity of neighbouring properties and the unpredictability of bystander movement. As one manager explained, “maintaining a 30-metre distance from many people… typically we’re inspecting things in suburbs with houses close together… if the neighbour comes outside, we're going to be within 30 m" a view that also reflected uncertainty about how the separation rule is interpreted in practice, including misconceptions about its applicability based on whether people are indoors or outdoors when in fact the requirement applies irrespective of location. Similarly, a senior plumbing inspector noted that while mitigation measures such as signage could be used, "we can only advise people, we can't force them… and if they were to enter that zone, then we would have to bring the drone down," creating practical limits on inspection continuity. These concerns were often intertwined with anxieties about legal exposure and organisational liability.

Related concerns were also raised about the perceived inflexibility of CASA's altitude and proximity restrictions in low-risk inspection contexts, particularly for low-altitude roofing inspections where the likelihood of airspace conflict is minimal. Participants suggested that a more context-sensitive interpretation of these requirements could improve operational efficiency without compromising safety. This perspective is consistent with international regulatory approaches discussed in Section 3.3.2, where some aviation authorities recognise reduced risk when RPAS operate in close proximity to vertical structures and have accordingly relaxed certain operational constraints.

Privacy considerations further compounded regulatory uncertainty, particularly for government agencies. Multiple participants raised concerns about incidental capture of adjacent properties during RPAS operations, framing this as both a legal and reputational risk. One senior regulatory officer questioned whether it was "safe and appropriate for us as a government agency to have a viewing position of adjoining properties which might be occupied," highlighting heightened scrutiny applied to public-sector RPAS use. Participants also noted that even where formal permission was obtained through building management or owners' corporations, individual residents were not always aware that inspections were taking place, increasing the potential for complaints or misunderstandings. Others cited real-world neighbour complaints and social conflict, noting that even compliant operations could trigger public concern or misunderstanding, thereby discouraging use.

Beyond aviation and privacy constraints discussed above and in Section 3.2, participants also identified inspection legislation as a structural constraint. One participant from a professional body and senior regulators (3 participants) emphasised that mandatory statutory inspections must be conducted "in person", limiting the formal role RPAS can play in compliance decision-making. As one regulator stated, "if there's a mandatory inspection required, it obligates the statutory building surveyor to do that work in the first person… you can't necessarily say that 'a drone inspection' is in the first person". This view reflects the legislative requirements outlined in Section 3.1.1 on mandatory inspections, particularly the obligation for in-person inspection by the relevant building surveyor. In this context, RPAS was considered the most suitable tool to support statutory inspections, providing high-quality visual evidence that complements in-person inspection duties rather than serving as a standalone substitute, consistent with the regulatory requirements discussed in Sections 3.1.1 and 3.1.2.

Importantly, participants with direct RPAS experience tended to interpret regulatory constraints differently. Experienced users acknowledged limitations such as no-fly zones near airports and controlled airspace, but emphasised that many perceived barriers stem from conservative interpretation rather than absolute prohibition. One technical services officer noted that while "regulatory burden" exists in populated areas, emerging solutions such as micro-RPAS could "get around a lot of that," suggesting scope for adaptive compliance strategies. This divergence highlights how familiarity with RPAS regulations and operational practice shapes perceptions of feasibility.

Several stakeholders also pointed to organisational constraints as a distinct but related issue. Even where licensing and training had been completed, the absence of internal policies and endorsed procedures was reported to prevent RPAS use. One participant explained that despite organisational investment, "policy and procedure hasn't been developed to get the drones in the air… so we were told to slow down until everything comes in line," effectively stalling implementation. Participants noted that this issue was particularly pronounced in government agencies, where internal procedures must align with strict regulatory and compliance obligations before RPAS can be deployed. As a result, regulators were perceived as having less operational flexibility than private operators, who may adopt new technologies more rapidly.

To address these regulatory challenges, participants consistently called for clearer, inspection-specific guidance on compliant RPAS use, particularly tailored to residential contexts. Suggested measures included clearer alignment between aviation rules and inspection legislation, sector-endorsed operational frameworks, explicit treatment of privacy and public engagement protocols, and the development of internal organisational policies that enable, rather than inhibit, compliant RPAS use. Collectively, participants emphasised that reducing regulatory ambiguity is essential not only for legal compliance, but also for building organisational confidence and public trust in RPAS-assisted roofing work inspections.

Training, licensing, and workforce capability gaps

Training and workforce capability limitations were identified as a major challenge influencing the practical uptake of RPAS for roofing work inspections, closely linked to regulatory complexity but distinct in its operational implications. This issue was raised by a substantial proportion of participants across stakeholder groups who noted that while interest in RPAS use is growing, the skills, confidence, and capacity required to operate RPAS safely and compliantly are unevenly distributed across the workforce.

A dominant perception among inspectors and operational managers was that current licensing and training requirements present a significant barrier, particularly for experienced inspectors later in their careers. Several participants described the CASA certification process as demanding and poorly aligned with the specific task of roofing work inspection. One inspector commented that "the test is really hard… it's not really about flying a drone for inspections, it's about flying planes and helicopters," adding that for older inspectors "it's just not worth bothering". This perception was echoed by others who felt that training pathways were overly generic and insufficiently tailored to inspection-focused operations, discouraging uptake even where organisational support existed.

Participants with direct operational RPAS experience acknowledged the importance of formal training and licensing but argued that the issue lies less in the capability itself and more in how training is structured and supported. Experienced operators noted that, once trained, inspectors could effectively integrate RPAS into routine workflows, but emphasised that insufficient opportunities for practice and inconsistent organisational backing often undermine confidence. One manager observed that "we've got trained people and licensed operators, but they don't fly often enough to stay comfortable," resulting in underutilisation despite investment in skills development.

A clear divergence emerged between stakeholders who favoured upskilling inspectors as dual inspector–pilots and those who advocated for specialist or hybrid models. Participants with direct operational RPAS experience tended to support inspector-operated RPAS, citing efficiency and workflow integration, whereas those without experience expressed concern about added workload, liability, and skill dilution. As one non-operational manager stated, “you’re asking inspectors to be inspectors, pilots, and risk managers all at once,” suggesting that specialist RPAS operators or small dedicated teams may be more appropriate in some organisational contexts.

Stakeholders from professional bodies further highlighted the absence of inspection-specific RPAS curricula as a structural gap. Participants noted that existing training programs focus primarily on aviation compliance rather than inspection outcomes, evidentiary standards, or integration with regulatory decision-making. This misalignment was seen as limiting the relevance of training and contributing to inconsistent competence across practitioners.

To mitigate these challenges, participants recommended developing tailored training pathways focused on RPAS-assisted inspection, including modular licensing options, refresher training, and supervised operational exposure. Several stakeholders also emphasised the need for organisational strategies that support skill retention, such as regular flying opportunities, mentoring arrangements, and clear role definitions.

Evidentiary and measurement limitations

Evidentiary reliability and measurement capability were widely identified as key limitations of RPAS use in roofing work inspections, particularly in regulatory, compliance, and dispute-resolution contexts. A majority of regulators and inspectors noted that while RPAS. are effective for visual identification of defects, they cannot reliably capture precise measurements required for certain compliance decisions, such as box-gutter depth, sump capacity, flashing laps, or falls. As one inspector explained, “sometimes you really need to physically measure the depth of sumps and outlets the drone can’t do that,” especially where small dimensional differences determine compliance.

Participants also highlighted the inability of RPAS to detect concealed defects beneath roof coverings or within assemblies. One experienced inspector noted that “the RPAS might show the top of a valley and it all looks good, but underneath it might not be compliant and you can’t see that with a drone,” limiting the evidentiary completeness of RPAS-only inspections.

A clear divergence emerged between compliance-focused stakeholders and operational users regarding how RPAS-based evidence should be used, rather than whether it is acceptable. Regulators and dispute-resolution professionals emphasised evidentiary defensibility, particularly in contested or legal contexts, with one participant noting that “as a witness in court, I wouldn’t rely on a drone image alone.. someone will ask if you physically measured it.” However, these stakeholders did not dismiss RPAS measurements entirely; several acknowledged that precise physical measurement is not always required, especially where discrepancies are large, with one regulator explaining that “we’re not measuring 400 versus 410… but 400 versus 200 is a very big difference, and that level of accuracy can easily be obtained from a drone.” In contrast, inspectors with hands-on RPAS experience adopted a more practice-oriented perspective, focusing on timely identification and rectification of non-compliance rather than legal contestability. These participants argued that visual evidence is often sufficient to support compliance action, particularly where standards rely on observable conditions rather than marginal tolerances. As one inspector explained, “whether it’s holding 5 mm of water or 20 mm doesn’t really matter the standard says it shouldn’t hold water at all,” framing RPAS imagery as adequate for enforcement in routine inspection contexts. While these views reflect stakeholder caution about evidentiary defensibility, the legal framework discussed in Section 3.4.1 explains that photographs and video recordings including those captured by RPAS are recognised as documentary evidence under the Uniform Evidence Act and may be admissible in legal proceedings where relevance and authenticity are established. In this sense, some concerns expressed by participants appear to reflect uncertainty about evidentiary expectations rather than a strict legal prohibition on the use of RPAS-derived imagery.

To address these limitations, participants consistently recommended using RPAS as a complementary tool rather than a replacement for physical inspection, combining RPAS imagery with targeted on-site measurements where required.

Operational constraints in residential settings

Operational constraints associated with conducting RPAS inspections in residential environments were frequently raised by participants and represent a significant challenge to routine deployment. These constraints were most strongly emphasised by regulators, inspectors, and managers working in dense suburban contexts, where physical space, surrounding activity, and environmental conditions complicate RPAS operations.

A dominant concern related to the practicality of operating RPAS in confined suburban environments characterised by narrow lot boundaries, adjacent dwellings, overhead powerlines, street trees, and pedestrian and vehicle traffic. Several inspectors noted that safe launch and recovery locations are often limited, particularly where buildings occupy most of the site footprint. One participant explained that “with two- or three-storey buildings in suburbs, you’ve got power lines, trees, traffic. Sometimes the only place you can launch is the public street,” creating operational and safety challenges.

Weather sensitivity was also identified as a practical limitation, particularly wind conditions common in exposed residential areas. Participants with direct operational RPAS experience noted that even moderate wind can reduce flight stability and image quality, sometimes necessitating rescheduling inspections. As one inspector observed, “weather would be the biggest one… if it’s quite windy, we can’t do it using a drone and we have to reorganise the audit,” undermining the perceived time efficiency of RPAS in certain circumstances.

Managing bystanders and neighbours was identified as a practical challenge in residential settings, where unexpected movement can disrupt RPAS operations. As one inspector noted, “we can only advise people, we can’t force them… if they enter that zone, then we have to bring the drone down.”

A divergence in perspective was evident between experienced RPAS users and those without direct RPAS experience. Operational users tended to view these constraints as manageable through planning, signage, and procedural controls, often describing them as part of normal site risk management. In contrast, participants with no experience perceived residential constraints as a more significant barrier, expressing concern that cumulative operational issues could reduce efficiency and increase liability.

To address these constraints, participants recommended clearer operational guidelines tailored to residential settings, including site assessment protocols, weather thresholds, and communication strategies for occupants and neighbours. They further suggested that smaller or micro-RPAS could partially mitigate space and proximity challenges.

Data processing and workflow integration

Data processing and workflow integration were commonly identified as practical challenges that hinder routine use of RPAS for roofing work inspections. While participants generally agreed that RPAS flights are relatively quick to conduct, many emphasised that the time and effort required after flight reviewing imagery, selecting relevant evidence, annotating defects, and incorporating outputs into formal inspection reports (post processing) can disrupt established workflows.

A dominant perception among operational and regulatory participants was that RPAS use can increase administrative workload if not supported by appropriate systems and processes. Several inspectors noted that “getting the images is the easy part,” whereas post-flight tasks require substantial desk-based work, particularly where evidence must meet compliance or enforcement standards. One manager described RPAS data as “hitting the desk of the inspector, adding that without workflow redesign it can feel like adding another layer of red tape” to already demanding reporting requirements. These concerns were particularly pronounced in government settings, where documentation and auditability are critical.

Participants also highlighted limitations in current software and data interpretation tools. Although high-resolution imagery was widely valued, several stakeholders noted that existing platforms do not always support efficient measurement, annotation, or direct integration with regulatory reporting systems. As one participant explained, “there isn’t a lot of software to do the data interpretation… it’s a complex problem,” particularly when inspectors must translate visual information into formal compliance determinations.

A divergence in perspective emerged between participants with direct RPAS experience and those without. Experienced users tended to view data processing challenges as transitional and manageable through training, standardised templates, and improved software tools. In contrast, participants without operational RPAS experience perceived data handling as a significant barrier, expressing concern that RPAS would add to workloads rather than streamline inspections.

Organisational and cultural resistance

Organisational and cultural resistance emerged as a significant non-technical challenge affecting the uptake of RPAS in roofing work inspections. Participants perceived that even where RPAS are available and staff are trained, their use is often constrained by internal risk cultures, governance processes, and uncertainty around organisational responsibility. This issue was raised most frequently by regulators, senior inspectors, and managers working within public-sector and regulatory organisations.

Clear differences were observed between public- and private-sector perspectives. Government participants emphasised that they operate under stricter compliance, accountability, and reputational constraints, which limit their ability to trial or adapt new technologies informally. As one professional body representative explained, “private operators can choose when to cut a regulatory corner… government agencies don’t have that discretion…we have to get permission first.” In contrast, private inspectors and service providers described greater flexibility to experiment with RPAS within their own risk envelopes, often integrating RPAS more rapidly where they perceived clear operational value.

Cultural resistance at the individual level was also noted, particularly among some experienced inspectors accustomed to traditional, hands-on inspection practices. Participants suggested that uncertainty sometimes stemmed from concerns about professional identity, increased workload, or fear of being required to take on additional roles, such as becoming a RPAS pilot. However, several interviewees noted that resistance often diminished once inspectors observed the practical benefits of RPAS in reducing physical risk and improving access.

To address organisational and cultural resistance, participants emphasised the importance of leadership endorsement, clear internal policies, and role clarity around RPAS use. Formalising procedures and explicitly positioning RPAS as a complementary tool rather than a replacement for professional judgement were seen as critical steps in legitimising RPAS use and supporting broader organisational acceptance.

Privacy and public perception

Privacy concerns and public perception were frequently identified as contextual challenges influencing the acceptability of RPAS use in residential roofing work inspections. Participants across stakeholder groups noted that RPAS can trigger discomfort or suspicion among occupants and neighbours, particularly in dense suburban environments where flight paths may pass near adjacent properties. Several interviewees expressed concern that RPAS operations could be perceived as intrusive or as a form of surveillance, especially when operated by government agencies. One participant observed that members of the public may be uneasy with “the idea of a government organisation getting up in the sky and looking into people’s backyards,” highlighting the sensitivity of RPAS use in residential contexts.

Real-world experiences of neighbour complaints and social conflict were also reported, with some participants describing situations where RPAS inspections caused anxiety or confrontation between neighbours and homeowners. These concerns were closely linked to broader issues of trust, transparency, and consent, rather than to technical capability alone. While participants generally viewed privacy risks as manageable, they emphasised the need for clear communication, visible identification, and consistent operational protocols to maintain public confidence.

Overall, stakeholders agreed that addressing privacy and public perception is essential for the broader acceptance of RPAS in residential inspections, particularly for government-led applications, and should be treated as a social and governance issue alongside technical and regulatory considerations.

4.3.4 Education and training

Current landscape of RPAS exposure in VET

The interview findings with training providers indicate that drone-related training for roofing work inspection contexts is currently informal, inconsistent, and largely educator-driven, rather than being embedded within accredited vocational education and training (VET) packages. While standalone RPAS qualifications exist for CASA certification, participants consistently noted that these are not translated into systematic inclusion within plumbing, building, or inspection training programs. As a result, exposure to drones in VET depends on individual educators’ interest and capability rather than being a standardised component of workforce preparation. One training provider explained that “at this stage, it’s predominantly based on the interest of the people delivering the content… because it’s not in the training package to use drones," highlighting the structural dependence on discretionary teaching practices.

Training design considerations

There was a strong consensus on practical design principles for introducing drone training in the context of roofing work inspections. Participants consistently favoured incremental and embedded approaches, rather than standalone or optional courses, arguing that embedding drones within existing units and assessments would normalise them as a routine professional tool. One educator stated, "if you don't want it to be a choice, and you want it to be a tool that they use, then you have to embed it." Many recommended starting with awareness-focused activities such as demonstrations, short in-class exercises, or safety planning applications that use RPAS imagery to identify roof hazards, access constraints, and work-at-heights risks prior to physical roof access before progressing to more advanced operational skills. Micro-credentials and short courses were viewed as complementary pathways for motivated learners and professionals, but not a substitute for core integration. Importantly, participants emphasised that sustained uptake would ultimately depend on alignment between training packages, industry practice, and regulatory expectations. As one respondent observed, when regulators restrict physical roof access for safety reasons, "the only other way of doing it is to fly a drone… that's when you'll get people starting to use the tech and be much more eager to adopt the trainings."

Barriers to training content development and implementation

Beyond formal licensing requirements, participants identified multiple barriers that constrain the development of workforce capability in drone-enabled roofing work inspections. A key issue was curriculum overcrowding, with existing VET programs are already perceived as very full, making the addition of new content challenging without increasing workload for both educators and students. Compounding this were staffing constraints, as effective delivery requires educators who are simultaneously trade-qualified, educator-qualified, and competent in RPAS operation and regulatory compliance. As one respondent noted, "you've got to be qualified in the profession, and you've got to be qualified as an educator as well," describing a narrow and difficult-to-source skill set. Regulatory compliance further added complexity, with any training needing to satisfy both VET governance requirements and CASA aviation rules. Participants also emphasised that limited and uneven industry uptake of drones reduces student demand, reinforcing a cycle in which training providers are reluctant to invest in content that may not attract enrolments. As one provider reflected, "we can teach it, we can develop content… but if the industry's not going to use it, no-one's going to do the course."

4.4 Discussion

Patterns across roles and experience levels

As per the interview results, clear patterns emerged between operational inspectors and managerial, administrative, and regulatory stakeholders, as well as between participants with and without direct RPAS experience. Inspectors with hands-on RPAS use tended to adopt a pragmatic, task-oriented perspective, viewing RPAS as a practical extension of existing inspection tools, particularly for access-constrained roofs, preliminary screening, and visual confirmation of rectification. These participants were generally comfortable with RPAS providing sufficient evidence for many compliance decisions, particularly where precise physical measurement was not possible, provided that the defect or non-compliance was visually evident. In contrast, managers, administrators, and dispute-resolution professionals, especially those without direct RPAS experience, were more likely to frame RPAS use through the lens of organisational risk, legal defensibility, and procedural compliance. Their concerns were less about whether RPAS could technically capture useful information and more about how RPAS outputs would withstand formal scrutiny, court processes, and internal accountability requirements. This divergence reflects not resistance to technology, but differences in professional responsibility: inspectors are primarily accountable for identifying issues on site, while managers and regulators must also consider downstream legal, reputational, and governance implications.

Experience with RPAS further shaped perceptions. Participants without operational RPAS experience were more likely to overestimate regulatory constraints and understate operational flexibility, whereas experienced users demonstrated a more nuanced understanding of what is permissible, workable, and proportionate in practice.

Perceived vs actual regulatory constraints

A significant finding was the gap between perceived CASA restrictions and actual regulatory requirements. Many participants, particularly those without direct RPAS experience, misinterpreted CASA requirements as effectively prohibiting RPAS use in dense residential environments, citing concerns such as the 30-m separation requirement (as stated in Section 3.2), neighbour movement, and privacy risks. However, as outlined in Section 3.2, the CASA framework consists of a set of operational conditions such as maintaining separation from persons not involved in the operation and keeping the aircraft within the pilot’s visual line of sight rather than a blanket prohibition on RPAS use in residential areas. These perceptions often led to a precautionary stance where RPAS use was avoided altogether to minimise organisational liability. Similar misinterpretations were also evident regarding evidentiary requirements, where some participants assumed that drone imagery would not be accepted in legal contexts. However, as discussed in Chapter 3 (Section 3.4.1), photographs and video recordings may constitute admissible evidence where standard evidentiary conditions are met.

The persistence of regulatory misperceptions among stakeholders therefore points to a training and awareness gap, rather than an impossible regulatory barrier. Addressing this gap is critical to avoiding overly cautious interpretations that unnecessarily limit RPAS uptake.

Preferences on RPAS inspection models

A key contribution of this study is clarifying that RPAS-enabled inspections do not require a single, fixed operational model. The findings instead support three viable implementation models. These operational models reflect different workforce configurations through which the inspection scenarios analysed in the cost-benefit assessment (Chapter 5) may be implemented. The Inspector + Pilot and Inspector with Pilot models most closely align with the Eye-in-the-Sky (B1) and Hybrid (B2) inspection options, where RPAS is operated on-site during the inspection. In contrast, the Small Specialised Team model aligns with the Remote Image-Based Inspection (C1) scenario, where imagery is captured by a dedicated RPAS team and subsequently reviewed by inspectors off-site.

Inspector + Pilot model

The same individual conducts the inspection and operates the drone. This model aligns with experienced inspectors’ preference for seamless workflow integration and maximises time and cost efficiency. However, it also concentrates training, licensing, and workload demands on a single role, which some participants viewed as unsustainable without organisational support.

Inspector with Pilot model

A dedicated or semi-dedicated pilot supports inspectors on site, sometimes with a spotter. This model was favoured by stakeholders concerned about compliance complexity and public safety, particularly in government contexts, but involves higher coordination and staffing costs.

Small Specialised Team model

In this model, a small number of dedicated, highly qualified drone pilots (e.g., two to three personnel) operate as a specialist RPAS unit within or across organisations. These teams are deployed to sites where roof access is particularly constrained or high-risk, capturing imagery that is subsequently reviewed by inspectors off-site. This approach reduces the training and licensing burden on the wider inspection workforce, supports efficient use of specialist expertise, and challenges the assumption that inspectors must always be physically present or act as pilots themselves.

Mapping interview themes onto these models shows that many perceived challenges, such as training burden or workflow disruption, are model-specific rather than inherent to RPAS use. Making these alternatives explicit is therefore critical for informed decision-making.

Contradictory perceptions and evidentiary sufficiency

The findings also highlight a constructive divergence rather than simple disagreement regarding evidentiary standards. Compliance-focused stakeholders emphasised court defensibility, yet several acknowledged that absolute precision is not always required, particularly where standards are binary or condition-based. Operational inspectors, meanwhile, prioritised timely identification and rectification over marginal measurement accuracy. This suggests that the debate is not about whether RPAS data is acceptable, but when it is sufficient and for what purpose: screening, enforcement, dispute resolution, or litigation. These distinctions align with the evidentiary considerations discussed in Section 3.4, which examines the admissibility and use of RPAS-generated material across different regulatory and legal contexts.

Cascading impacts and broader implications

RPAS usage has cascading impacts across the inspection system. Overly conservative interpretations of RPAS use can lead to delayed or incomplete inspections, increased reliance on costly access methods such as scaffolding, and prolonged exposure of occupants to unresolved defects such as water ingress. In practice, this shifts risk and cost away from inspection bodies and onto consumers, who may face extended periods of damage, higher remediation costs, or limited options for independent verification. Conversely, where RPAS are well integrated into inspection workflows, stakeholders reported improved inspection coverage, earlier identification of defects, and reduced reliance on high-risk access methods. These outcomes generate broader benefits beyond inspectors themselves, including enhanced consumer protection, reduced insurance claims associated with water damage, and improved public safety through fewer work-at-height activities, highlighting the system-wide implications of how RPAS adoption is framed and operationalised.

4.5 Summary

This study demonstrates that RPAS should be understood and implemented as a complementary inspection tool rather than a replacement for physical roof inspection. Across stakeholder groups, RPAS were consistently viewed as most effective when used to extend inspection reach, improve safety, and support decision-making in situations where conventional access is constrained or disproportionate, while targeted physical inspection remains essential for concealed elements, precise measurement, and mandatory statutory requirements.

Key benefits identified include improved access to hard-to-reach roofs, significant reductions in work-at-height safety risks, enhanced visual evidence for defect identification, and improved efficiency through pre-inspection screening and follow-up verification. Stakeholders also highlighted broader consumer benefits, including faster issue identification, reduced inspection delays, lower reliance on costly access methods, and earlier intervention for water ingress and related defects. Collectively, these benefits position RPAS as a valuable enabler of safer, more proportionate, and more responsive roofing work inspection practices.

However, the findings also identify several challenges that must be addressed for responsible implementation. Regulatory uncertainty, particularly misinterpretation of CASA requirements and privacy obligations, emerged as the most significant barrier, alongside gaps in inspection-specific training, evidentiary clarity, workflow integration, and organisational readiness. Importantly, these challenges were not framed as reasons to avoid RPAS use, but as conditions requiring clearer guidance, policy alignment, and institutional support. Without such measures, overly conservative interpretations risk undermining the very safety, efficiency, and consumer protection benefits that RPAS can deliver.

In conclusion, RPAS offer substantial value to roofing work inspections when integrated thoughtfully and proportionately. Their effective use depends not on replacing established inspection practices, but on augmenting professional judgement, improving safety, and expanding inspection capability within clearly defined regulatory, organisational, and evidentiary boundaries.

5. COST-BENEFIT ANALYSIS

5.1 Overview

This chapter provides a Cost–Benefit Analysis (CBA) of RPAS-assisted scenario-based deployment for conventional residential roofs and roof-related plumbing inspection. CBA is a tool to analyse the economic, financial value, and social benefits of a proposed investment by comparing the total expected costs against total expected benefits. This can inform investment decisions to allocate resources efficiently and ensure that public interventions deliver net social gains. According to the *Victorian Guide to Regulation Toolkit 2* (DTF, 2014), CBA plays a central role in regulatory impact assessments, helping to determine whether a regulatory proposal will improve overall community welfare.

Roofing and plumbing inspections are less effective when inspectors face detection and safety challenges due to constraints in physical roof access. While RPAS are commercially mature, competitively priced, and technically capable of routine deployment, their role in improving inspection outcomes has not yet been assessed within a formal cost-benefit framework at a regulatory scale.

CBA relies on quantitative metrics to support investment decision-making and option appraisal:

- **Benefit–Cost Ratio (BCR):** The BCR expresses the ratio of the present value of benefits to the present value of costs. A value greater than one indicates that benefits exceed costs (Commonwealth of Australia, 2006).
- **Cost-effectiveness analysis:** Used when outcomes are broadly equivalent across scenarios, this metric allows comparison based on relative efficiency and unit cost.
- **Net Present Value (NPV):** NPV measures the difference between the present value of benefits and costs, providing an absolute indication of an option's economic contribution (DTF, 2013).
- **Internal Rate of Return (IRR):** IRR identifies the discount rate at which the NPV equals zero and indicates the investment's expected rate of return (New Zealand Treasury, 2015).

Together, these metrics support systematic comparison of alternative scenarios and enable the ranking of investments based on economic efficiency and risk-adjusted value (Commonwealth of Australia, 2016).

5.2 Problem statement and objective of CBA

Roof inspection practice becomes less effective when inspectors cannot safely obtain direct line of sight access to the roof. This is most acute in multi-storey and otherwise constrained inspection contexts, where conventional inspection often relies on ground-based or indirect proxy observation. The result is weaker evidence base for compliance decisions, greater uncertainty in defect identification, and a higher risk that defects remain undetected until later stages, when rectification is more disruptive and costly. The problem is therefore not simply inspection cost; it is the combined effect of reduced detection capability, personal safety exposure, downstream rework and dispute costs, and potential health costs for building occupants which can arise from living in a damp/mouldy building, and the broader psychological impact.

This chapter focuses on inspection contexts where roof elements are inspected as part of proactive compliance activity. The evidence base is useful for comparing methods within a regulatory oversight context, but it should not be presented as a random sample of the entire housing stock. That distinction is important because the analysed proactive program is risk targeted. The analytical purpose here is therefore comparative: to test whether RPAS-assisted inspection offers better value than conventional approaches under typical regulator conditions, especially where roof access is restricted.

The assessed scenarios were designed to test which RPAS-assisted inspection approaches best achieve four practical objectives:

- improve inspection coverage and detection of non-compliance risks where direct access is constrained,
- reduce inspector exposure to working-at-height risk,
- maintain or improve regulatory defensibility of inspection outcomes, and
- do so at an acceptable cost and with a feasible implementation pathway.

5.3 Definitions, CBA base case and alternative scenarios, and analysis methods

A pragmatic mixed-methods approach was used, drawing on an inspection dataset representing approximately 12–13% of annual new dwellings, semi-structured interviews with current RPAS adopters (see Chapter 4), and document analysis supported by a literature review focusing on empirical data[149]. The dataset provides statistically robust evidence for comparing inspection methods within a regulatory oversight context[150], though it should not be interpreted as a random sample of all new homes. In addition, case studies and experiments (See Chapter 6) were adopted to measure inspection time, validate roof plumbing checklist outcomes, and assess the cost and risk-adjusted benefits of RPAS-based applications for roof inspections.

The analysis followed the Victorian Department of Treasury and Finance (2014) guidelines for cost-benefit analysis. The inspection method was assessed using six scenarios, which were grouped into three distinct categories:

- Conventional (A1 with ladder and A2 without ladder)
- RPAS-assisted (B1 eye-in-the-sky and B2 hybrid)
- Remote inspection (C1 image-based and C2 AI-assisted).

Table 5 summarises the assessed inspection scenarios.

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[149] Australian Building Codes Board, Building Confidence Report – A case for intervention. 2021. Available at: https://www.abcb.gov.au/resource/report/building-confidence-report-case-intervention
[150] Building and Plumbing Commission, BPC PIP Inspections by BCA Class. 2025.

Table 5: Inspection scenarios considered for CBA

Inspection scenario	Short description	Best suited to	Indicative coverage and detection logic	Inspection method	Indicative time
A1 Conventional Inspection with ladder	Conventional inspection with ladder	Single-storey / safe access	Direct visual inspection where safe access exists	Visual inspection, tactile verification (fixings, seals), measurements	45 min
A2 Conventional Inspection without ladder	Conventional proxy inspection without ladder	Multi-storey / unsafe access	Limited observation from ground/interior/neighbouring vantage points	Ground-level observation (gutters, eaves), internal inspection (ceiling, attic), binoculars	30 min
B1 Eye-in-the-Sky Inspection	RPAS-only visual inspection	Constrained roofs where no physical access needed	High roof coverage through overhead/perimeter imagery	Overhead and perimeter flight, visual inspection through livestream imagery, post-flight review	29 min
B2 Hybrid Inspection	Hybrid RPAS + selective ladder verification	Constrained roofs where some physical confirmation remains useful	High coverage plus targeted physical verification	RPAS flight to identify areas of concern followed by inspector physically accessing those areas for verification	49 min
C1 Remote Image-Based Inspection	Remote image-based inspection	Workflow standardisation / digital review	High coverage through image capture and remote review	RPAS flight followed by inspector review of acquired imagery	35 min
C2 Automated AI-assisted Remote Inspection	AI-assisted remote inspection	Future-state automated support	High coverage with automated flagging plus human validation	RPAS flight followed by automated AI analysis of acquired imagery and inspector review of AI-flagged areas	25 min

Definition of conventional inspection scenarios

A1 – Conventional inspection with ladder. This scenario is commonly used for single-storey Class 1a buildings and, where safe access is possible, double-storey buildings. The inspector uses a ladder to physically access the roof for visual inspection, tactile verification (fixings, seals) and physical measurements. This allows a coverage of 70–85% of roof area subject to the availability of safe access points (Rakha and Gorodetsky, 2018).

A2 – Conventional inspection without ladder. This scenario applies to double-storey and higher single-story buildings, where direct access and conventional inspection with ladder is not feasible. In this scenario, the inspection is carried out through proxy evaluation, based on indications from other inspected elements. Inspector assesses the roof from the ground level, interior, or neighbouring vantage points (proxy evaluation). The method includes also ground observation (gutters, eaves), internal inspection (ceiling, attic), binoculars and other devices to gain sight. The coverage is 10–30% of roof area with limited visibility.

For the CBA, we assume that scenario A2 achieves 60% detection rate relative to A1. This is justified by the fact that proxy evaluation may result in missed defects not visible from ground/interior, whereas direct access enables detection by observation (Rakha et al. 2018).

Definition of RPAS-assisted inspection scenarios

B1 – Eye-in-the-Sky inspection provides a comprehensive aerial view of the roof using RPAS. It allows the inspector to view the roof through the RPAS camera and assess the roof condition without physical access, improving coverage and safety. The method uses lightweight RPAS (< 2 kg) and involves overhead and perimeter flight, 4K video and imagery capture, and post-flight review. This allows coverage of 95–100% of roof area. The detection rate is assumed to be 130% of the A1 baseline, representing a 30% improvement (Silveira et al. 2021). The total inspection time is estimated at 30 minutes, comprising 10 minutes of flight time and 20 minutes of review, rounded up from case studies.

B2 – Hybrid inspection combines the traditional conventional inspection using ladder with RPAS-assisted observation. The RPAS is used for preliminary screening and difficult-to-reach areas, while the ladder inspection allows for closer verification in safer places, balancing accuracy and efficiency. The scenario uses lightweight RPAS (as B1) together conventional inspection (as A1), with the RPAS flight identifying areas of concern followed by inspector physically accesses those areas for verification. This allows coverage of 95-100% of the roof area through RPAS and targeted physical verification 20-30% increasing confidence level of the inspection. The detection rate is estimated as 140% of the A1 baseline, resulting in 40% improvement (Silveira et al 2021). The total inspection time measured in the cases and used for the estimate are 45 minutes, comprising of 10 minutes flight time, 20 minutes reviewing and visually inspecting and 15 minutes targeted physical inspection.

Definition of remote inspection scenarios

C1 – Remote image-based inspection involves fully remote inspections conducted through captured photos and videos. Inspectors review the imagery off-site to identify potential issues, relying on professional judgment rather than automated analysis. This scenario is attractive for future analytics, defect trend monitoring, and personnel training. The method uses RPAS (as B1), together with cloud storage and 3D modelling software. It involves an RPAS flight, undertaken on-site, e.g., by a contractor, followed by imagery upload and review by the remote inspector. This allows coverage of 95-100% of roof area. The detection rate is assumed to be 120% of the A1 baseline, representing a 20% improvement, which is lower than B1 due to the absence of on-site context. The total inspection time is estimated at 35 minutes, comprising 10 minutes of flight time and 25 minutes of remote review, including 3D model generation.

C2 – Automated AI-assisted remote inspection uses artificial intelligence to automatically process captured images or videos to detect potential defects or non-compliance risks. Inspectors then validate the AI-generated findings to ensure reliability and accuracy. This scenario is also attractive for analytics, defect monitoring, personnel training, and full automation. The method uses RPAS (as C1), together with visualisation and AI defect detection software, which is not yet maturely available and was programmed for this project. It involves an RPAS flight, followed by automated AI analysis and inspector review of the AI-flagged areas. This allows coverage of 95-100% of roof area. The detection rate is assumed to be 135% of the A1 baseline, representing a 35% improvement through AI complimenting human assessment. The total inspection time is estimated at 25 minutes, comprising 10 minutes of flight time and 15 minutes of AI review and validation. It must be noted that the accuracy of AI may be limited (assumed 80%) depending on the quality and adequacy of the images (which requires the RPAS pilot to have inspection knowledge for the type of roof). Thus, verification by a human operator remains essential.

5.4 Results

5.4.1 Cost Assessment of Inspection Scenarios

This section presents the results of the cost-benefit analysis and compares the assessed inspection scenarios on a common economic basis. The analysis focuses on the relative net value of each scenario under the central case, with particular attention to Net Present Value (NPV) and Benefit–Cost Ratio (BCR).

The economic analysis is based on recorded inspection data which spans 2023–24 and comprises 7,750 proactive building and plumbing inspections in Victoria, equivalent to around 12–13% of the 61,260 new homes constructed during the period. Of these, 881 building inspections and 1,100 plumbing inspections were undertaken at the lock-up, completion, and final stages. Approximately 50% of the relevant building inspections and 90% of the relevant plumbing inspections involved conventional roof and plumbing inspection for buildings, equivalent to about 440 building inspections and 990 plumbing inspections. On this basis, the annual inspection demand relevant to this analysis is estimated at 1,232 inspections. Of the 1,232 inspections, 670 relate to single-storey dwellings and 562 to two-storey dwellings.

RPAS deployment is also constrained by CASA's 30 m rule (15 m with consent – see Section 3.1.2). Under a strict interpretation, a 15 m clearance radius implies that a rectangular land parcel must have an area of at least 900 m^2 to fully contain the clearance envelope. In practice, this is a conservative estimate because most land parcels have road frontage, enabling the RPAS crew to secure the area and maintain the required safety distance from people. On this basis, we assume that only parcels under 500 m^2 are unsuitable for standard RPAS deployment. Land and Housing Supply Indicators[151] suggest that approximately 27% of new developments are built on parcels of 500 m^2 or smaller. Accordingly, standard RPAS use is assumed to be feasible for around 73% of relevant inspection tasks. This gives rise to two deployment cases in the economic analysis: a two-storey-only case of 410 deployable inspections per year (73% of 562 two-storey inspections), and a broader combined deployment case of 592 deployable inspections per year, comprising 410 two-storey plus 182 selective high-risk single-storey inspections.

The results for the assessed scenarios are summarised in Table 6 for multi-storey inspections and Table 7 for combined multi-storey and targeted high-risk single-storey inspections. In both cases, the comparison is made across four inspection scenarios (B1,

[151] Land and Housing Supply Indicators. Available at: https://www.abs.gov.au/statistics/industry/building-and-construction/land-and-housing-supply-indicators/latest-release

B2, C1, and C2) and three operating models: RPAS sub-250 g, RPAS sub-2 kg, and ReOC RPAS sub-2 kg.

Table 6: RPAS deployment in multi-storey inspections only. Assumed deployment volume: 410 inspections/year

Inspection scenario	Platform / model	Annual cost ($)	Annual benefit ($)	Net annual benefit ($)	NPV ($)	BCR	Payback (months)
B1 Eye-in-the-Sky inspection	RPAS sub-250 g	38,523	131,469	92,946	$724,236	3.2	2.9
	RPAS sub-2 kg	43,022	131,469	88,447	$672,453	2.9	4.7
	ReOC RPAS sub-2 kg	576,216	131,469	-444,747	-$3,652,221	0.2	-0.9
B2 Hybrid inspection	RPAS sub-250 g	50,550	92,400	41,851	$309,806	1.8	6.5
	RPAS sub-2 kg	55,049	92,400	37,351	$258,023	1.6	11.1
	ReOC RPAS sub-2 kg	588,242	92,400	-495,842	-$4,066,651	0.2	-0.8
C1 Remote image-based inspection	RPAS sub-250 g	45,253	136,297	91,044	$708,807	2.9	3.0
	RPAS sub-2 kg	49,753	136,297	86,544	$657,024	2.6	4.8
	ReOC RPAS sub-2 kg	580,878	136,297	-444,581	-$3,650,876	0.2	-0.9
C2 AI-assisted remote inspection	RPAS sub-250 g	39,240	138,228	98,988	$773,245	3.4	2.8
	RPAS sub-2 kg	43,739	138,228	94,489	$721,462	3.0	4.4
	ReOC RPAS sub-2 kg	574,865	138,228	-436,636	-$3,586,438	0.2	-0.9

Table 7: Combined multi-storey and selective high-risk single-storey deployment. Assumed deployment volume: 592 inspections/year (410 multi-storey + 182 selective high-risk single-storey inspections)

Inspection scenario	RPAS/ RePL+ReOC	Annual cost ($)	Annual benefit ($)	Net annual benefit ($)	NPV ($)	BCR	Payback (months)
B1 Eye-in-the-Sky inspection	RPAS sub-250 g	47,257	185,542	138,285	$1,091,976	3.8	2.0
	RPAS sub-2 kg	51,630	185,542	133,912	$1,041,215	3.4	3.1
	ReOC RPAS sub-2 kg	593,338	185,542	-407,797	-$3,352,523	0.3	-1.0
B2 Hybrid inspection	RPAS sub-250 g	64,622	129,130	64,508	$493,581	1.9	6.5
	RPAS sub-2 kg	68,996	129,130	60,135	$442,819	1.8	11.1
	ReOC RPAS sub-2 kg	610,704	129,130	-481,573	-$3,950,919	0.2	-0.8
C1 Remote image-based inspection	RPAS sub-250 g	55,634	192,513	136,879	$1,080,571	2.9	3.0
	RPAS sub-2 kg	60,008	192,513	132,505	$1,029,809	2.6	4.8
	ReOC RPAS sub-2 kg	601,716	192,513	-409,203	-$3,363,929	0.2	-0.9
C2	RPAS sub-250 g	46,952	195,302	148,350	$1,173,613	3.4	2.8
	RPAS sub-2 kg	51,325	195,302	143,977	$1,122,851	3.0	4.4

AI-assisted remote inspection	ReOC RPAS sub-2 kg	593,033	195,302	-397,732	-$3,270,887	0.2	-0.9

The results should be interpreted in light of several practical considerations: operational and workflow considerations, technology readiness, and RPAS platform choice.

- **Relative performance of RPAS-assisted inspection scenarios:** The economic metrics indicate that C2 produced the strongest performance overall, followed by B1 and C1. These three scenarios all performed strongly and the performance differences between them are relatively small as compared with the much larger performance gap between the scenarios utilising sub-250g RPAS and those requiring ReOC.

- **Operational and workflow considerations:** Under the assumptions applied (see Appendix B), scenarios B1, C1, and C2 all represent economically attractive RPAS-assisted approaches, with the choice between them depending not only on modelled NPV and BCR, but also on operational preference, technology readiness, and workflow fit. During the case studies, B2 appeared to be the inspector-preferred scenario (see Chapter 6) despite somewhat lower economic returns, as it combines RPAS screening with selective physical verification, which is more closely aligned with current inspection practices and professional judgement.

- **Technology readiness:** While C2 performed strongly, these results should be interpreted with caution, as its practical implementation is currently limited by low technology readiness. This scenario was evaluated using custom-made open-source tools developed specifically for this project; consequently, it does not yet constitute a commercially mature or widely accessible inspection solution.

- **RPAS platform choice:** The choice of RPAS platform is a key determinant of economic performance. Across both deployment cases, sub-250 g platforms consistently outperform sub-2 kg platforms on cost-effectiveness because their lower capital and operating costs improve NPV, BCR, and payback outcomes. The sub-2 kg platform may still offer operational advantages, including better wind resistance, longer flight times, and higher-quality imagery. Yet, these advantages come at a cost premium and do not improve the economic case under the assumptions applied here.

- **ReOC operating model:** The results indicate that a full ReOC operating model is not cost-effective at the inspection volumes assessed in this chapter. Under the current assumptions, all ReOC scenarios remain below a BCR of 1 and produce a negative NPV in both the multi-storey-only deployment case and the combined multi-storey plus targeted single-storey deployment case. On a linear extrapolation of the current model outputs, ReOC becomes economically viable only at substantially higher annual flight volumes (see Appendix B). For the hybrid inspection scenario B2, which was preferred by the inspectors during the case studies, the ReOC operating model would require approximately 1,992 annual flights to reach a BCR above 1 and approximately 2,018 annual flights to achieve a positive NPV. Accordingly, while B2 appears to be the most operationally credible near-term pathway from an inspector's perspective, a dedicated ReOC model would only become economically justified at much higher annual utilisation than the inspection volumes assessed here.

The base case is defined by the current conventional practice under two access conditions. A1 represents conventional roof and plumbing inspection for buildings where safe physical access is possible, typically for single-storey dwellings and some accessible two-storey cases. A2 represents conventional inspection where direct access is not feasible and assessment relies on proxy observation from the ground, interior, or neighbouring vantage points. The practical distinction between A1 and A2 is therefore not primarily non-compliance risk, but whether inspectors can obtain a direct line of sight safely through conventional means. On this basis, RPAS deployment is directed to the inspection contexts where line of sight is constrained, and ladder-related fall risk is highest. In practice, this applies most clearly to two-storey and higher dwellings and to the subset of single-storey dwellings that inspectors identified as inaccessible under normal ladder-based conditions. These are the cases in which RPAS can remove the need for unsafe physical access while improving visual coverage.

At the operational level, assuming a team of eight full-time licensed inspectors, the task of 410-592 inspections per year translates to 51-74 RPAS flights per inspector per year. The larger number of RPAS deployments for the combined multi-storey and high-risk single-storey dwellings improves the economic case, while ensuring that the inspectors obtain line of sight without unsafe physical access to identify non-compliance roofing work.

5.4.2 Key cost and benefit drivers

The economic ranking of the scenarios is driven by a small number of underlying cost and benefit drivers, principally labour time, detection performance, platform cost, and the regulatory operating model, as shown in Table 8. On the cost side, the main drivers are labour inputs, RPAS amortisation, insurance, software, and any licensing or ReOC overhead. On the benefit side, the results are driven by higher defect detection rates and the avoided escalation from pre-occupancy to post-occupancy rectification cost. Taken together, these drivers explain why RPAS-assisted scenarios perform favourably relative to conventional constrained inspection, and why lower-cost operating models outperform ReOC-based deployment under the assumptions applied.

Table 8: Key economic drivers of scenario results

Driver	Why it matters	Main effect on results
Labour time per inspection	Determines direct operating cost	Penalises B2, favours B1/C2
Detection rate	Determines avoided defect cost	Favours C1/C2
Damage cost avoided	Converts detection into benefit	Supports all RPAS options
RPAS platform cost	Changes annualised equipment cost	Favours sub-250 g
ReOC overhead	Adds large fixed annual cost	Makes ReOC cases uneconomic

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Cost drivers

- Inspection labour time is a primary cost driver. Scenario costs vary materially according to total inspection time, including setup, execution, and review[152] (See Appendix B).
- Platform cost affects the annualised cost per inspection. Sub-250 g RPAS platforms have lower capital and amortisation costs than sub-2 kg platforms (See Appendix B).
- Software, insurance, and maintenance add modest but recurring operating costs across RPAS-assisted scenarios (See Appendix B).
- Training and licensing costs are relevant for RPAS deployment, but they are relatively small compared with labour and regulatory overheads when spread across annual inspection volumes (See Appendix B).
- ReOC overhead is the largest structural cost driver where certified operations are assumed. At the inspection volumes assessed, this fixed annual overhead materially weakens the economic case (See Appendix B).

Benefit drivers

- Detection performance is the principal benefit driver. Higher detection rates increase the likelihood that non-compliance risks are identified before occupancy.
- Avoided damage cost underpins the monetised benefit. The analysis is based on the difference between weighted pre-occupancy and post-occupancy rectification costs.
- Line of sight and coverage are central to the benefit logic. RPAS-assisted scenarios improve visual access in cases where conventional roof inspection for buildings is constrained.
- Safety benefit is concentrated in cases where RPAS removes the need for unsafe physical access, particularly in two-storey and inaccessible single-storey contexts.
- Deployment scale affects economic performance. As the number of deployable inspections increases, fixed equipment and training costs are spread across a larger inspection base, improving NPV and BCR.

Structural assumptions

- Base case definition: A1 represents conventional roof inspection for buildings where safe physical access is possible, while A2 represents conventional inspection under constrained access using proxy observation.
- Detection rates: The model assumes detection rates of 70% for A1, 60% for A2, 90% for B1, 92% for B2, 95% for C1, and 97% for C2 (See Appendix B).
- Damage-cost basis: Damage rectification costs are appraised at $1,472 pre-occupancy and $4,890 post-occupancy, with the benefit derived from avoiding

[152] The state of the public sector in Victoria 2016-2017. https://www.vpsc.vic.gov.au/wp-content/uploads/2018/02/State-of-the-Public-Sector-In-Victoria-2016-2017-Final-Web-version-ISSN-2204-9096.pdf

escalation to later-stage rectification. These estimates are the weighted average of rectification costs with the weights representing the likelihood of different damage severities (See Appendix B).

- Safety assumptions: Conventional ladder inspection is assumed to carry a 0.5% serious fall-injury risk, RPAS-only scenarios 0%, and hybrid inspection 0.2%, with an average serious injury cost of $50,000[153, 154].
- Deployment constraint: RPAS use is assumed feasible for 73% of the relevant inspection tasks after excluding land parcels of 500 m^2 or smaller [155].
- Deployment cases: The results are modelled for a multi-storey-only case of 410 inspections per year and a combined case of 592 inspections per year, comprising 410 multi-storey and 182 selectively targeted inaccessible or high-risk single-storey inspections.
- Evaluation horizon and discounting: NPV and BCR are calculated over 10 years using a 4% and 7% discount rate in the reported scenario tables.
- Operating models: The analysis distinguishes between RePL-based RPAS deployment and ReOC-based deployment. ReOC overhead is treated as a fixed structural cost and materially weakens the economic case at the inspection volumes assessed.
- Technology maturity: C2 should be interpreted cautiously, as the AI-assisted scenario was tested using open-source tools developed for this project and does not yet represent a commercially mature inspection product.

Table 9 and Table 10 compare the Net Present Value (NPV) results at the reported 4% discount rate and the Victorian Treasury central case discount rate of 7% over a 10-year evaluation horizon. Lower discounting strengthens the economic case for all non-ReOC RPAS deployment models, because future net benefits are discounted less heavily. However, this does not change the relative ranking of the scenarios. Across both deployment cases, C2 remains the strongest modelled economic option, followed by B1, and C1, while all ReOC-based models continue to produce negative NPVs.

[153] Work Safe Victoria. 2024. Available at: https://www.worksafe.vic.gov.au/news/2024-02/prevention-focus-deaths-and-injuries-construction-falls
[154] Victoria Government Gazette. Available at: Workcover-insurance-industry-rates-and-industry-claims-cost-rates-2025-06.pdf
[155] Land and Housing Supply Indicators. Available at: https://www.abs.gov.au/statistics/industry/building-and-construction/land-and-housing-supply-indicators/latest-release

Table 9: Comparison of NPV at 4% and 7% discount rates, multi-storey-only deployment, assumed deployment volume: 410 inspections/year

Inspection scenario	Platform / organisational form	NPV (10 years, 4%)	NPV (10 years, 7%)
B1 Eye-in-the-Sky inspection	RPAS sub-250 g	$724,236	$623,176
	RPAS sub-2 kg	$672,453	$576,285
	ReOC RPAS sub-2 kg	-$3,652,221	-$3,168,650
B2 Hybrid inspection	RPAS sub-250 g	$309,806	$264,302
	RPAS sub-2 kg	$258,023	$217,411
	ReOC RPAS sub-2 kg	-$4,066,651	-$3,527,524
C1 Remote image-based inspection	RPAS sub-250 g	$708,807	$609,816
	RPAS sub-2 kg	$657,024	$562,925
	ReOC RPAS sub-2 kg	-$3,650,876	-$3,167,485
C2 AI-assisted remote inspection	RPAS sub-250 g	$773,245	$665,616
	RPAS sub-2 kg	$721,462	$618,725
	ReOC RPAS sub-2 kg	-$3,586,438	-$3,111,686

Table 10: Comparison of NPV at 4% and 7% discount rates, combined multi-storey and selective high-risk single-storey deployment, assumed deployment volume: 592 inspections/year

Inspection scenario	Platform / organisational form	NPV (10 years, 4%)	NPV (10 years, 7%)
B1 Eye-in-the-Sky inspection	RPAS sub-250 g	$1,091,976	$941,620
	RPAS sub-2 kg	$1,041,215	$895,613
	ReOC RPAS sub-2 kg	-$3,352,523	-$2,909,128
B2 Hybrid inspection	RPAS sub-250 g	$493,581	$423,441
	RPAS sub-2 kg	$442,819	$377,435
	ReOC RPAS sub-2 kg	-$3,950,919	-$3,427,307
C1 Remote image-based inspection	RPAS sub-250 g	$1,080,571	$931,743
	RPAS sub-2 kg	$1,029,809	$885,737
	ReOC RPAS sub-2 kg	-$3,363,929	-$2,919,005
C2 AI-assisted remote inspection	RPAS sub-250 g	$1,173,613	$1,012,312
	RPAS sub-2 kg	$1,122,851	$966,306
	ReOC RPAS sub-2 kg	-$3,270,887	-$2,838,435

These results should be interpreted in light of uncertainty around a small number of key assumptions. The most important sources of sensitivity in this analysis are deployment scale, platform choice, regulatory operating model, and technology maturity.

Deployment scale

- The results improve materially as the deployable inspection base increases from the multi-storey-only case of 410 inspections per year to the combined case of 592 inspections per year.
- This reflects the spreading of fixed equipment, training, and operating costs across a larger inspection base.
- The combined deployment case therefore produces higher NPVs, stronger BCRs, and shorter payback periods than the multi-storey-only case across the non-ReOC RPAS options.

Platform choice

- The results are sensitive to RPAS platform cost, across both deployment cases, sub-250 g RPAS generally outperforms sub-2 kg RPAS on NPV, BCR, and payback. This indicates that lower capital and operating cost materially strengthens the economic case, even where the sub-2 kg platform may offer operational advantages such as greater wind resistance, longer flight time, and improved imagery.

Regulatory operating model

- The results are highly sensitive to whether RPAS deployment is undertaken under a RePL-based model or a full ReOC model.
- Under the inspection volumes assessed, all ReOC scenarios produce negative NPVs and BCRs below 1.
- This indicates that the fixed annual ReOC overhead is the single largest factor weakening the economic case.
- On this basis, ReOC deployment is not cost-effective for the inspection task assessed here unless utilisation increases substantially.

Technology maturity

- The central-case ranking is also sensitive to implementation maturity.
- Although C2 produces the strongest modelled economic performance, it was tested using open-source tools developed for this project and does not yet represent a commercially mature inspection product.
- The practical interpretation of the results should therefore distinguish between modelled economic potential and current deployability.

The relative ranking of the non-ReOC RPAS scenarios remains favourable across the assessed deployment cases. C2 produces the strongest modelled economic result, with C1 and B1 also performing strongly and relatively closely. However, the practical choice of the scenario remains sensitive not only to economic assumptions, but also to implementation readiness, workflow fit, and organisational implementation model.

5.4.3 Implementation considerations

The preferred scenario in practice is not determined by economic performance alone. Feedback from the inspectors involved in the field case studies (See Chapter 6) indicated that B2 (Hybrid) was the preferred operational model because it combines RPAS-enabled screening with selective physical verification in ambiguous or safety-sensitive areas. This makes B2 more consistent with current inspection workflow, professional judgement, and confidence in final assessment, even though it does not produce the highest modelled return.

The choice of RPAS platform is also material. Although sub-250 g platforms produce the strongest economic outcomes, because their lower capital and operating costs improve NPV, BCR, and payback performance, sub-2 kg platforms offer operational advantages such as greater wind resistance, longer flight endurance, and improved imagery.

While the results suggest that ReOC-based deployment is not justified for the inspection tasks at the annual volumes assessed, with substantially higher annual utilisation ReOC-based deployment becomes economically viable.

A further implementation consideration concerns technology maturity. Although C2 produces the strongest modelled economic outcome, its viability hinges on the availability of commercially mature software. Its results should therefore be interpreted as indicating potential future value rather than an immediately deployable market-ready solution. By contrast, B2 is more credible as a near-term operational pathway because it aligns more closely with current inspection practice and does not depend on immature automation capability.

Taken together, the results suggest a distinction between economic optimum and practical near-term preference. On the modelled results, C2 performs best, followed by C1 and B1. In implementation terms, however, B2 appears to be the most operationally credible near-term pathway, while sub-250 g RPAS provides the most cost-effective platform choice. Broader and better-targeted deployment improves the economic case further and strengthens the proactive inspection team’s capacity to obtain line of sight without unsafe physical access and to identify non-compliance before faulty building product and defective work reach consumers.

5.4.4 Limitations and interpretation

The results should be interpreted considering several limitations in the underlying evidence and modelling assumptions.

- The analysis is based on recorded inspection activity undertaken by a proactive inspection team and is intended to represent the regulatory inspection task.
- RPAS deployment is limited by CASA’s Standard Operating Conditions and site-level constraints. The model assumes that approximately 73% of the relevant inspection task is deployable under standard conditions. Results are therefore sensitive to the actual proportion of sites at which RPAS can be used in practice.
- The benefit estimates are driven by assumed detection-rate differences between scenarios and by the assumed difference between pre-occupancy and post-occupancy rectification costs. These assumptions are informed by interviews, case evidence, and literature, but they remain model-based estimates rather than directly

observed program-wide outcomes. Safety benefits are similarly based on assumed differences in ladder-related injury exposure across inspection modes.

- The C2 scenario should be interpreted cautiously. It was tested using open-source tools developed for this project and does not yet represent a commercially mature or widely available inspection product. Its results therefore indicate potential future value rather than immediate market-ready deployment.
- The ReOC cost assumption is based on interview evidence from one regulator-scale operating context and should be interpreted as indicative rather than universally applicable. The economic performance of ReOC scenarios is therefore sensitive to both organisational scale and the operational base across which fixed overhead is allocated.

5.5 Summary

This chapter appraises the cost-effectiveness of RPAS-assisted deployment options for conventional roof inspections for buildings where safe physical access and direct line of sight are constrained. The analysis was based on recorded inspection data from a proactive inspection team and examined both economic performance and practical implementation considerations.

The results indicate that RPAS-assisted inspection improves the inspection task in three main ways.

- It strengthens line of sight and visual coverage in cases where conventional inspection would otherwise rely on proxy observation.
- It reduces ladder-related fall risk by removing or limiting the need for unsafe physical roof access.
- It improves the likelihood that non-compliance is identified before faulty building product and defective work reach consumers, thereby reducing downstream rectification and dispute costs.

Across the modelled scenarios, C2 (AI-assisted remote inspection) produced the strongest economic performance, followed by B1 (Eye-in-the-sky inspection) and C1 (Remote image-based inspection). However, these three options all performed strongly and relatively closely under the non-ReOC operating models. B2 (Hybrid inspection) produced somewhat lower economic returns, but feedback from the inspector who were involved in the case studies (See Chapter 6) indicated that this inspection scenario is the preferred operational model because it combines RPAS screening with selective physical verification and therefore aligns more closely with the current inspection workflow and professional judgement.

Platform choice also materially affected the results. Sub-250 g RPAS consistently produced the strongest economic outcomes because lower capital and operating costs improved NPV, BCR, and payback performance. Sub-2 kg RPAS remained economically positive under the non-ReOC cases but performed less strongly because of higher equipment cost. Their practical value lies more in operational capability than in superior cost-effectiveness.

The analysis also shows that deployment scope matters. The broader combined deployment case produced stronger results than the multi-storey-only case because fixed equipment, training, and operating costs were spread across a larger inspection base. This suggests that the value of RPAS increases when deployment is directed to those inspection contexts where direct line of sight is constrained, and safety risk is highest.

The results support a targeted and staged deployment pathway:

- Stage 1: prioritise two-storey and other access-constrained inspections where the safety and line-of-sight benefits are greatest.
- Stage 2: extend deployment to selected inaccessible single-storey cases where conventional ladder-based access is limited or unsafe.
- Stage 3: consider broader deployment only where regulatory constraints, site conditions, and operating model permit.

At the level of practical impact, the modelling indicates that earlier non-compliance and defect identification can avoid substantial downstream repair costs. Based on the weighted damage assumptions applied in this chapter, the difference between pre-occupancy and post-occupancy rectification costs is material, and RPAS-assisted inspections can generate per-inspection benefits in the order of several hundred dollars, depending on scenario and inspection context. At a broader consumer level, the cost-benefit analysis indicates that earlier detection has the potential to avoid repair costs escalating from approximately $1,472 at pre-occupancy to $4,890 at post-occupancy for the weighted defect profile used in the model. This means the principal value of RPAS deployment is not only operational efficiency, but also reducing the likelihood that non-compliance and defects remain undetected until they impose higher costs on homeowners and the wider system.

By contrast, a dedicated ReOC operating model was not economically justified at the annual inspection volumes assessed. All ReOC scenarios produced a negative NPV and a BCR below 1, indicating that the fixed annual overhead is too high relative to the deployable inspection task under the assumptions used in this chapter.

RPAS-assisted inspection offers a credible means of strengthening proactive inspection capability and consumer protection in constrained inspection contexts. In modelled economic terms, C2 (AI-assisted remote inspection) performs best. In practical near-term terms, B2 (Hybrid inspection) appears to be the most operationally credible pathway. Taken together, the results support RPAS deployment as a targeted tool for improving line of sight, reducing safety exposure, and preventing faulty building product and defective work from reaching the market and harming consumers.

6. FIELD CASE STUDIES

6.1 Overview

This chapter presents the four completed case studies which compare different approaches to residential building roof inspections. While in practice statutory (mandatory and compliance and assurance inspections) and non-statutory inspections are carried out at different stages of construction or post-occupancy (see Section 3.1.1), the case studies reported in this chapter focus on plumbing compliance on completion of all building work. The methodology to conduct these inspections follow the scenarios defined in Section 5.3, namely conventional in-person inspections with (A1) and without ladder (A2), RPAS as eye-in-the-sky inspections (B1), and remote inspection enabled by advanced imaging tools including web-based visualisation of the captured imagery and video (C1) and AI-assisted detection (C2).

Data collection and in-person inspections were performed at the study sites in these case studies. Case studies 1, 2 and 4 include post-field-work interviews with the participating plumbing inspectors to analyse the inspection outcomes. Case study 3 is focused on the evaluation of thermal imaging for detecting moisture and heat anomalies on roofs. In addition, case study 4 places emphasis on the regulatory challenges of operating RPAS in residential settings and studies the advanced imaging tools developed in this research to explore off-site inspections.

6.2 Comparative methodology

Case studies 1, 2 and 4 involved operating an RPAS to inspect the subject buildings and collect imagery data. These case studies were conducted on greenfield development sites in controlled environments clear of unrelated personnel. The RPAS was solely controlled by a pilot with a RePL affiliated with a university under the CASA education exemption[156].

The inspection approaches studied in the case studies are detailed below.

6.2.1. Conventional inspection

Each of case studies 1, 2 and 4 enlisted the participation of two BPC plumbing inspectors. In case studies 1 and 2, the first inspector performed a conventional roof inspection which would typically occur near completion of the building project and before an occupancy certificate is issued. During this inspection, roof components such as roofing sheets and roof plumbing systems were examined and measured against relevant standards, including *AS/NZS 3500 Plumbing and Drainage Standards*, to verify compliance. Then, rectification of non-compliance is required and enforcement action is taken where necessary.

The inspector was responsible for deciding how the inspection would be conducted. This included determining whether to physically access the roof, selecting appropriate tools, and identifying which items should be measured based on their professional experience.

[156] Civil Aviation Safety Authority, Drones for education. 2024. Available at https://www.casa.gov.au/drones/drone-rules/drones-education

For example, an inspector might access the eaves gutter of a single-storey Class 1 residential building using a securely placed ladder. Measurements such as the gutter size and gradient could then be taken using tools like a tape measure and a digital level.

However, safe roof access is not always possible. In situations such as a double-storey building without secure scaffolding, the inspector would instead conduct the inspection from ground level. This approach severely limits visibility of the roof and prevents the collection of numerical measurements.

Any potential non-compliance with regulations and standards identified during the inspection, along with their severity, was recorded for later comparison.

6.2.2. RPAS as eye-in-the-sky inspection

In case studies 1, 2 and 4, an RPAS-assisted inspection was conducted through collaboration between the second inspector and a licensed RPAS pilot. The RPAS used in these case studies was a DJI Air 3 in the *very small* weight classification as defined by CASA[157], weighing 720 g (Figure 7). It was equipped with a wide-angle camera and a medium telephoto camera capable of producing high-resolution RGB images and videos, as well as safety features including high-accuracy Global Navigation Satellite System (GNSS) and a vision-based collision avoidance system.

Figure 7: DJI Air 3 with RGB cameras

The pilot was responsible for the manoeuvring of the RPAS following the inspector's instructions, who was directing the operation to inspect the roof components of interest through the video displayed on the wireless controller transmitted from the cameras onboard of the RPAS. Potential non-compliance, especially those that were not formally assessed in the first stage due to access constraints, were identified and recorded.

6.2.3. Advanced imaging

In the final stage of each on-site inspection, the RPAS embarked on an automated flight following pre-configured flight paths, in order to collect high-resolution images and videos of the assessed roof. Various heights and angles were utilised to ensure a full coverage of the roof. The collected data was then used to explore advanced imaging tools to aid the inspections, namely 3D modelling, an image-based roof inspection application and AI-assisted fault detection tools.

6.2.4. Interviews and comparison

After the conclusion of the on-site inspection in each case study, an interview was held involving the researchers and inspectors who participated in the case studies. Questionnaires and checklists were completed collectively to reflect on the experience of

[157] Civil Aviation Safety Authority, Drone weight categories and requirements. 2024. Available at: https://www.casa.gov.au/drones/operator-accreditation-certificate/drone-weight-categories-and-requirements

the three field stages and compare their outcomes, including time taken, items inspected, roof coverage, measurement accuracy and ease of action.

6.2.5. Infrared imaging

Case study 3 did not adopt the aforementioned methodology as its objective was to assess to what extent thermal imaging can detect moisture ingress or heat leakage on roof components. A bespoke roof structure was constructed with several induced moisture and heat anomalies. An uncooled infrared thermal camera (Figure 8) was used to obtain images with pixels representing relative temperature readings, which were then processed and analysed to identify the issues.

Figure 8: DJI Zenmuse XT2 thermal camera

6.2.6. Regulatory challenges of RPAS operations

The case studies revealed the challenges of RPAS-assisted roofing work inspections in compliance with RPAS operational rules set out by CASA, state authorities and local councils. In case studies 1 and 2, the RPAS pilot was affiliated with a university and utilised the CASA education exemption to conduct the on-site inspections without needing a ReOC accreditation. Standard Operating Conditions were followed to the best of the researchers' abilities. However, collecting suitable data for remote inspection scenarios necessitated a brief breach of line-of-sight operational rule. This highlighted the complexity and difficulty of complying with CASA's Standard Operating Conditions. Therefore, in case study 4, a simulated exemption-free procedure was followed to evaluate the regulatory challenges from the planning to the execution of ReOC-governed RPAS flights for roofing work inspections. The Remotely Piloted Aircraft Building Inspection Flight Approval Checklist in Appendix A was used to complete the pre-flight planning and checks that would typically be approved by a Chief Remote Pilot under the ReOC, while the Standard Operating Conditions were strictly enforced on site.

6.3 Data collection and processing

Recently completed Class 1a buildings in southeastern Melbourne were provided for case studies 1, 2 and 4 (Figure 9), all installed with corrugated metal roofing sheets and eaves gutters. As outlined in Table 11, the building for case study 2 was single-storey, while the other two were double-storey. This led to significantly different outcomes from the conventional inspections, which will be discussed in the results.

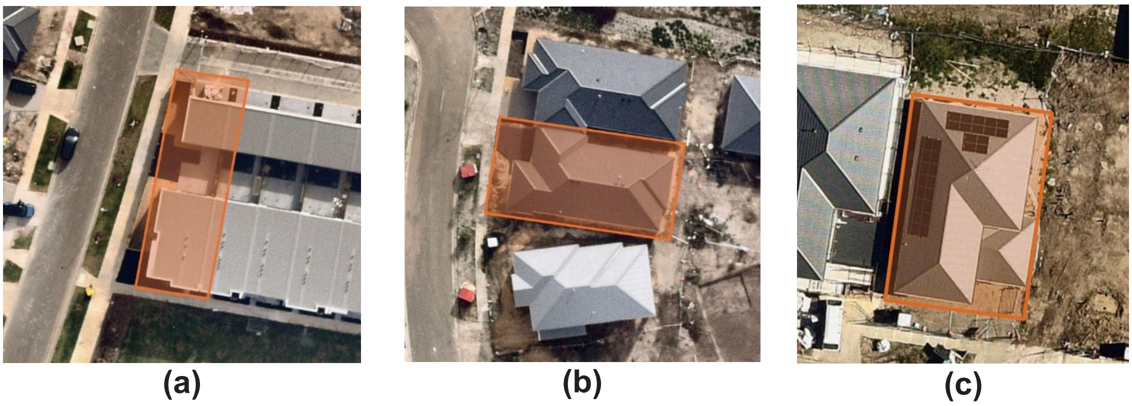


Figure 9: Sites used for case studies 1 (a), 2 (b) and 4 (c)

Table 11: Site details of case studies 1, 2 and 4

Case study	Building type	Date
1	Class 1a, double-storey	01/04/2025
2	Class 1a, single-storey	28/05/2025
4	Class 1a, double-storey	28//11/2025

6.3.1. Case study 1

The field activities in case study 1 took place at 11AM, 01 April 2025. The inspection subject was a double-storey residential building with a separate garage (Figure 10). Due to the lack of secure scaffolding, the inspector was unable to gain direct access to the roof and the conventional inspection was conducted on the ground level at a distance from the building (i.e., inspection scenario A2 as defined in Section 5.3). By visually assessing the subject from multiple angles, the inspector was able to qualitatively check the gradient of the gutters and the pitch of the roof sheets. The process took approximately 10 minutes and no non-compliance risks were identified by the inspector.

Figure 10: Subject building for case study 1

In the second stage, the DJI Air 3 RPAS was used as an *eye-in-the-sky* (i.e., inspection scenario B1). The second inspector instructed the pilot to focus the RPAS on various roof components and inspected them remotely using the real-time camera view transmission on the wireless controller. Due to the full coverage of the roof, more categories of items were inspected using this approach than the previous, including flashings, capping, penetrations, rivets, the interior of the eaves gutters, stains and debris. Minor risks such as stains and slight roof sheet bending were discovered. However, measurements of lengths and gradients were not possible as the RPAS used did not have the capability of real-time measuring. This stage of the field activities took approximately 10 minutes as well. Note that this did not include the time that would be required for pre-flight planning or clearing the site before take-off as case study 1 was conducted under the education exemption and on a greenfield development site without human interference.

A second RPAS flight was carried out in an automated manner following a fixed flight path. The RPAS automatically collected 221 48MP images of the roof at the heights of 5 m and 10 m, respectively. Around 30% of the images were taken near the boundaries of the building with the camera pitched at an angle of 45°, while the rest were taken directly above the roof. The collected images were used for 3D modelling using the photogrammetry software Agisoft Metashape in order to perform both visual inspections and numerical measurements (i.e., inspection scenario C1).

The RPAS in the second flight was briefly operating beyond the line of sight of the pilot, which was in breach of the Standard Operating Conditions. This was avoided in subsequent case studies but presented the challenge of complying with the regulations while utilising the modern features of RPAS.

6.3.2. Case study 2

Case study 2 began at 11AM, 28 May 2025 at a single-storey building site, where the roof was deemed safe to access by the inspectors (Figure 11). During the conventional inspection, the inspector set up a ladder and a gutter protector at six chosen locations around the building to maximise visual coverage of the roof (A1). Where appropriate, the dimensions of roof components, the gradient of the gutters were measured using a hand-held measurement device (Figure 12). Probing by hand was also employed by the inspector to assess whether certain components, e.g., screws, flashings, were fastened. The inspector identified that parts of the eaves gutters had debris inside and were not installed at sufficient gradients, as demonstrated by non-compliant gradient angles measured with a digital level and the accumulation of stormwater in such gutters. The procedure took approximately 45 minutes, although it is noteworthy that nearly 40% of the time was devoted to the inspector explaining the process to the case study observers.

Figure 11: Subject building for case study 2

Figure 12: Inspector performing gutter gradient measurement in case study 2

The RPAS-assisted inspection (B1) was carried out under the same practice as that in case study 1 (Figure 13). While providing full coverage of the roof and close-up views of the entire gutters, this operation confirmed the conclusions of the conventional inspection within 10 minutes. In addition, 57 images of the roof were collected using the RPAS for post-processed advanced imaging inspections (C1).

Figure 13: RPAS in operation in case study 2

6.3.3. Case study 3

The literature review in Chapter 2 identified thermal imaging as a promising option to detect moisture and heat anomalies. In case study 3, this was investigated by using an uncooled infrared camera attached to the RPAS on a bespoke roof structure made to simulate a real-life roof with different materials (Figure 14). As shown in Figure 15, two different types of roofing materials, namely tin sheets and terracotta tiles, were installed on the roof and tested to evaluate the efficacy of thermal imaging. First, a heater was used to generate heat under the exposed timber frame for 15 minutes before infrared images were taken from above. Water was then introduced on and beneath the metal sheets, tiles and plasterboards to simulate excess moisture and assess whether it can be identified using the thermal camera attached to the RPAS. Note that the RPAS was not piloted throughout this case study and was only used to power and control the thermal camera.

Figure 14: Roof structure used in case study 3

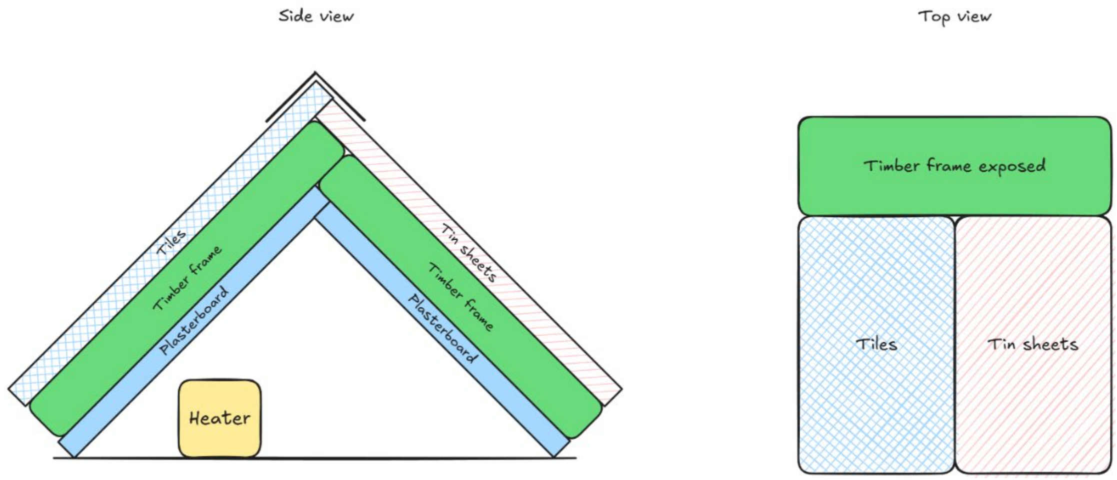


Figure 15: Design of the roof structure used in case study 3

6.3.4. Case study 4

Prior to the field activity of case study 4, a rigorous procedure was followed from the planning stage to simulate a commercial flight adhering to all RPAS operational rules as specified in Section 3.1.2. Every effort was made to comply with CASA's Standard Operating Conditions. The site chosen was on a greenfield development site, and the flight was conducted at the end of the work day when the site had largely been vacated. Nonetheless, the RPAS team asked the last remaining workers to move away from the inspection site to ensure the required distance between drone and persons was maintained. The flight was also operated such that the pilot maintained visual line-of-sight at all times. The flight record template developed in this project (Appendix A) was used to perform pre-flight checks including weather and airspace activities to ensure that the RPAS would be operated in suitable conditions without interfering with other aircrafts.

The experiment took place at 4PM, 28 November 2025 at a double-storey building site (Figure 16). Due to workers present on the neighbouring site at the beginning of the activity, which would have rendered the RPAS flight non-compliant by breaching the 30-metre rule, the research team waited for 30 minutes before the take-off of the RPAS to wait for workers on the neighbouring site to finish the work and depart that site. This highlights the difficulty of complying with CASA flight rules during a roof inspection. An eye-in-the-sky inspection (B1) was performed by the pilot and an inspector of the metal roof which took approximately seven minutes. Due to the lack of physical access to the roof, no numerical measurements were taken in this activity. Using the high-resolution camera attached to the RPAS, 109 images of the roof were then taken to be used for the development of advanced imaging tools, which were evaluated later through online conferencing by a second independent inspector who was not involved in the on-site inspection.

Three inspection scenarios based on advanced imaging were explored after the collected data were processed, namely web-based image and video inspection (C1), and AI-assisted detection of non-compliance risks (C2). The inspector was given the same video recorded during the eye-in-the-sky inspection to review, with the ability to pause and rewind as compared with the on-site operation. The web-based tool provided the capabilities of zooming in/out and measuring on the images taken by the RPAS. Lastly, the

Segment Anything 2 (SAM2)[158] AI model was employed to produce several short videos with automatically detected non-compliance risks, which were verified by the inspector.

Figure 16: RPAS in operation in case study 4

6.4 Results and findings

By consolidating the results obtained from the on-site inspections and the interviews of the case studies, different roof inspection approaches were evaluated and compared in terms of the coverage of roof components, operational efficiency and safety. The findings from the thermal imaging assessment and the experimental advanced imaging tools are also presented in this section.

6.4.1. Roof component coverage

The capabilities of the tested methods were assessed in terms of the roof components requiring compliance checks according to the standards, as demonstrated in Table 12, where:

- ✓ represents ideal inspection quality,
- ○ indicates limited accessibility, visibility or quality, and
- ✕ indicates that the category is impossible to be inspected by the corresponding method.

The results indicate that the conventional inspection approach alone is not suitable for multi-storey buildings as the inspectors often conduct the inspection on the ground level with poor visibility of the roof and no accessibility to the roof components due to the lack of safe roof access (inspection scenario A2). Only the materials of some components, the gradient of the gutters and the pitch of the roof can be visually judged with low accuracy, provided that there is visual line-of-sight to these items.

In comparison, the conventional inspection provides direct access to most of the roof components requiring attention on a single-storey residential building (inspection scenario A1), assuming that the roof can be safely reached by an inspector using a ladder. Notably,

[158] https://sam2.metademolab.com/

the materials of roof components such as screws and rivets, as well as their fastening can be assessed in this approach since hand probing is available, except for items that are out of reach. Nevertheless, the experiments have shown that the lengthy process of setting up a ladder securely and the limited visual coverage of the roof on the ladder in this approach significantly increase the overall inspection duration and limit the number of inspections that can be completed on a given schedule.

Table 12: Categorised performance evaluation of the tested roof inspection scenarios. ✓: ideal inspection quality. ○: limited accessibility, visibility or quality. ✕: the category is impossible to be inspected by the corresponding method

Inspection scenario	Roof coverage	Materials	Roof pitch	Gutter gradient	Flashing & capping	Screws & rivets	Insulation & sarking	Water ponding	Debris
A1 **Conventional inspection with ladder**	○	✓	✓	✓	✓	○	○	✓	✓
A2 **Conventional inspection without ladder**	○	○	○	○	✕	✕	✕	✕	✕
B1 **Eye-in-the-sky inspection**	✓	✓	○	○	○	○	✕	✓	✓
C1/C2 **Remote inspection using images and/or AI assistance**	✓	✓	✓	✓	○	○	✕	✓	✓

Using an RPAS as an eye-in-the-sky (B1) to assist the roof inspections offers several benefits. It allows the inspectors to visually inspect roof components on the surface from the sides of, and above the roof. Figure 17 shows instances of potential non-compliance risks in case studies 1 and 2 that could not be detected through conventional inspections without safe roof access.

In addition, RPAS as eye-in-the-sky (B1) provides more flexible view angles to assess potential roof plumbing concerns with higher certainty than the conventional approach. For instance, Figure 18(a) shows a joining of flashings on the subject building used in case study 2, which was a non-compliance risk identified by the inspector that could not be confirmed as it was out of reach even with the help of a ladder. However, the RPAS later provided a birds-eye-view which verified that the flashing was effectively sealed, as shown by Figure 18(b).

(a) (b) (c)

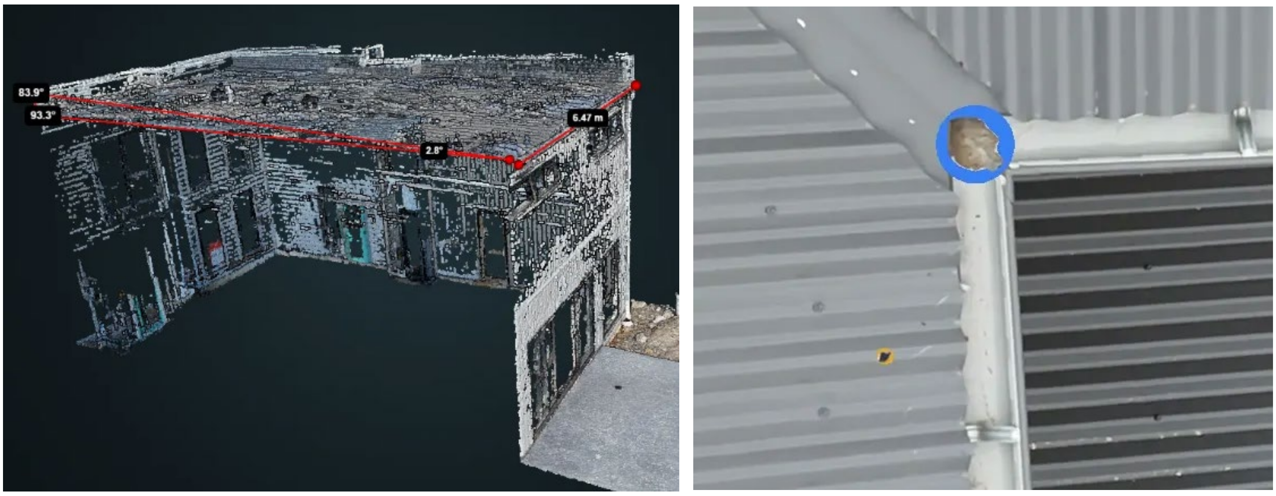
Figure 17: Roof plumbing issues found in case studies 1 and 2: (a) stains left on flashing and/or metal roof sheets by rain, (b) bending or damage to metal roof sheet, (c) water ponding in gutters due to insufficient gradients

(a) (b)

Figure 18: A flashing concern identified in case study 2: (a) point of interest viewed from the ground level, (b) the same point viewed with an RPAS from above

On the other hand, the case studies revealed drawbacks of roof inspections using RPAS as eye-in-the-sky (B1), namely the lack of physical contact, visibility under the metal roof sheeting and measuring capability. It is not possible to confirm the integrity of flashings, capping, screws and rivets without physical probing. Insulation and sarking layers could not be inspected as these were installed below the roofing sheets. Although visual assessment is possible from the side of the building, precise measurements cannot be conducted for the roof pitch and gutter gradient using consumer-grade RPAS in small form factors. Nevertheless, RPAS can achieve a full visual inspection of roofing work in a significantly reduced amount of time on site, as compared with that of conventional inspections with a ladder (A1).

Finally, the high-resolution images taken by RPAS on site offer post-processed options providing better image clarity, measuring ability, off-site inspection and opportunities of AI-assistance. The 3D reconstructed models of the buildings enable numerical measurements of objects such as inter-rivet distances and the roof pitch, as demonstrated in Figure 19(a), filling the gap that consumer-grade RPAS is incapable of real-time measurement. With the help of state-of-the-art AI tools to perform tasks such as image segmentation and object detection, non-compliance risks, e.g., roof and gutter sheet damage as shown in Figure 19(b), can be automatically identified for the inspector to verify. As shown in Table 12, inspections based on advanced imaging provide full coverage of the roof and high inspection quality in more categories than the eye-in-the-sky (B1) alternative, except only those that require physical probing or are hidden under the surface. The advanced imaging inspection options explored in this project are more systematically tested in case study 4 and detailed in Section 6.4.4.



(a) **(b)**

Figure 19: Examples of advanced imaging options. (a) 3D roof model with measurements reconstructed from high-resolution images. (b) potential non-compliance risks of roof sheet and gutter damage identified by AI detection tool

6.4.2. Efficiency and safety

While a conventional in-person inspection can directly access more roof components than the RPAS as eye-in-the-sky approach for single-storey residential buildings, it is more time-intensive and has more safety concerns for personnel in comparison. In case study 2, where the two inspection approaches yielded similar results, the conventional in-person inspection required up to four times more time to complete, of which a large proportion could be attributed to the assembly of the ladder. Also, the inspector had partial visibility of roof components such as the gutters at each ladder setup. Rigorously inspecting the entirety of the roof would have necessitated even more ladder locations and a longer duration. By contrast, the RPAS-assisted inspection enabled the inspector to view the whole roof, including all the gutters, within 10 minutes.

Moreover, ladder use is a major contributor to injuries during roof inspections, highlighting the safety risks associated with conventional access methods. This was demonstrated in the field activities, during which the ladder required an additional operator to hold steady when it was positioned on soft soil. The use of RPAS would reduce safety risks for inspectors by decreasing the number of ladder setups required. Therefore, an optimised workflow for inspecting the roof of a single-storey building is suggested with two stages, essentially the B2 hybrid inspection scenario: 1) a preliminary scanning of the roof with an RPAS as eye-in-the-sky to identify points of interest with non-compliance risks warranting further physical inspection; 2) in-person inspections using a ladder at only the points of interest where the in-person inspection with a ladder can be conducted safely.

6.4.3. Thermal imaging

The thermal camera in case study 3 was used to assess the ability of RPAS-carried thermal cameras to detect anomalies related to moisture and heat leakage. The collected thermal images were normalised to highlight pixels with significantly high or low thermal values. The results demonstrate that while thermal imaging can clearly reveal heat leakage through gaps in the roof structure, it is less effective to show surface moisture on the roof. More importantly, it cannot be used to identify any moisture ingress beneath roof covering.

As shown in Figure 20, the simulated heat leakage through the gaps in the timber frame is apparent on a normalised thermal image, with significantly high relative temperatures being represented as the dark red colour. A histogram was also plotted with a best-fit probability density function (PDF) to evaluate whether such anomalies could be numerically identified, which shows that the thermal values can also be fitted to a normal distribution, with pixel values corresponding with the heat signature falling outside of the 95% confidence interval, suggesting that it is an anomaly requiring attention.

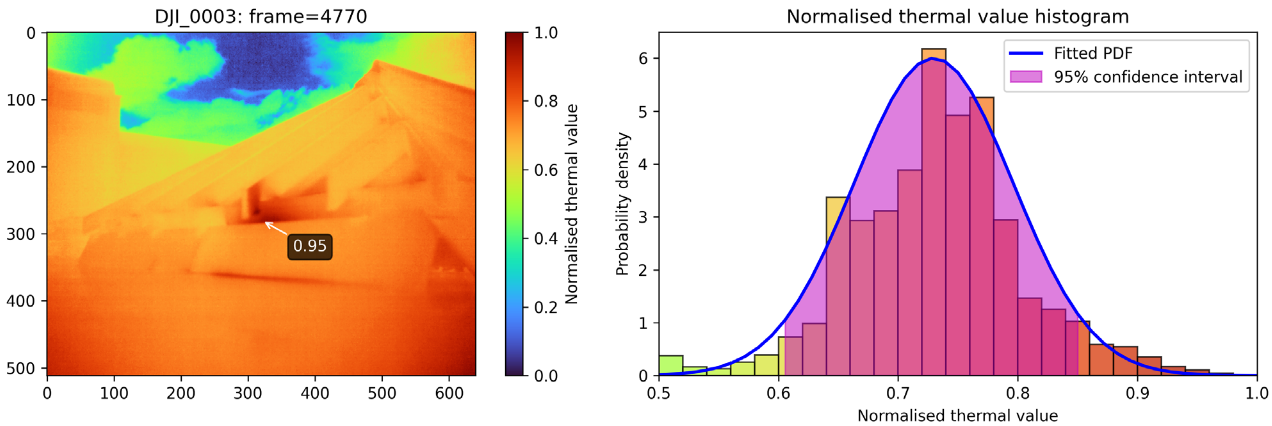


Figure 20: Normalised thermal values and histogram of heat leakage

Water introduced on the surface of roof covering materials including metal sheets and terracotta tiles, on the other hand, was more difficult to visualise using thermal imaging. Figure 21 shows that the pixels affected by induced moisture, represented by the deep blue colour, have only slightly lower values than the others and cannot be easily isolated.

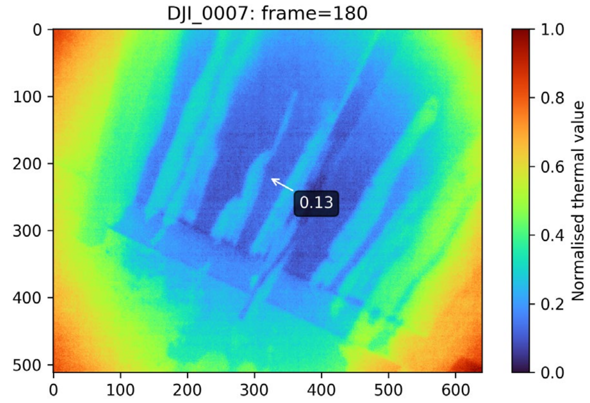


Figure 21: Normalised thermal values of moisture on roof surface

The experiment demonstrated that moisture beneath roof covering was not able to be detected by a thermal camera. Figure 22 is of the roof structure with a large quantity of water introduced between the metal sheets and the plasterboards underneath. No moisture footprint can be identified from the image as different parts of the metal sheets show similar thermal values.

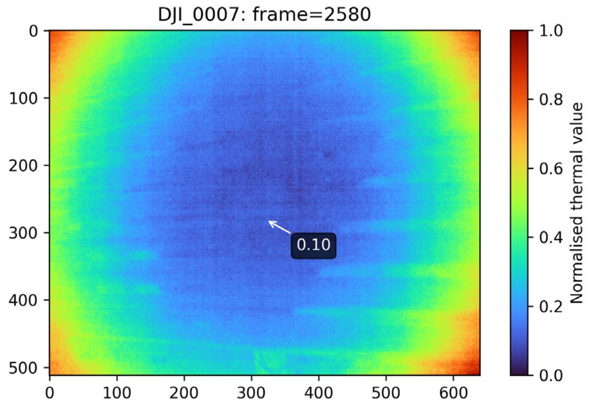


Figure 22: Normalised thermal values of moisture beneath roof covering

6.4.4. Advanced imaging options

Aerial images were collected from the RPAS flights in case studies 1, 2 and 4 for the reconstruction of 3D models of the subject buildings. The objective was to create a semi-automated workflow, in which data collection and model reconstruction are performed with minimal human supervision, enabling inspectors to perform visual inspections and numerical measurements remotely. Based on the images and videos collected on site, as well as the 3D model reconstructions, three types of advanced imaging tools were developed and tested in case study 4, as shown in Figure 23.

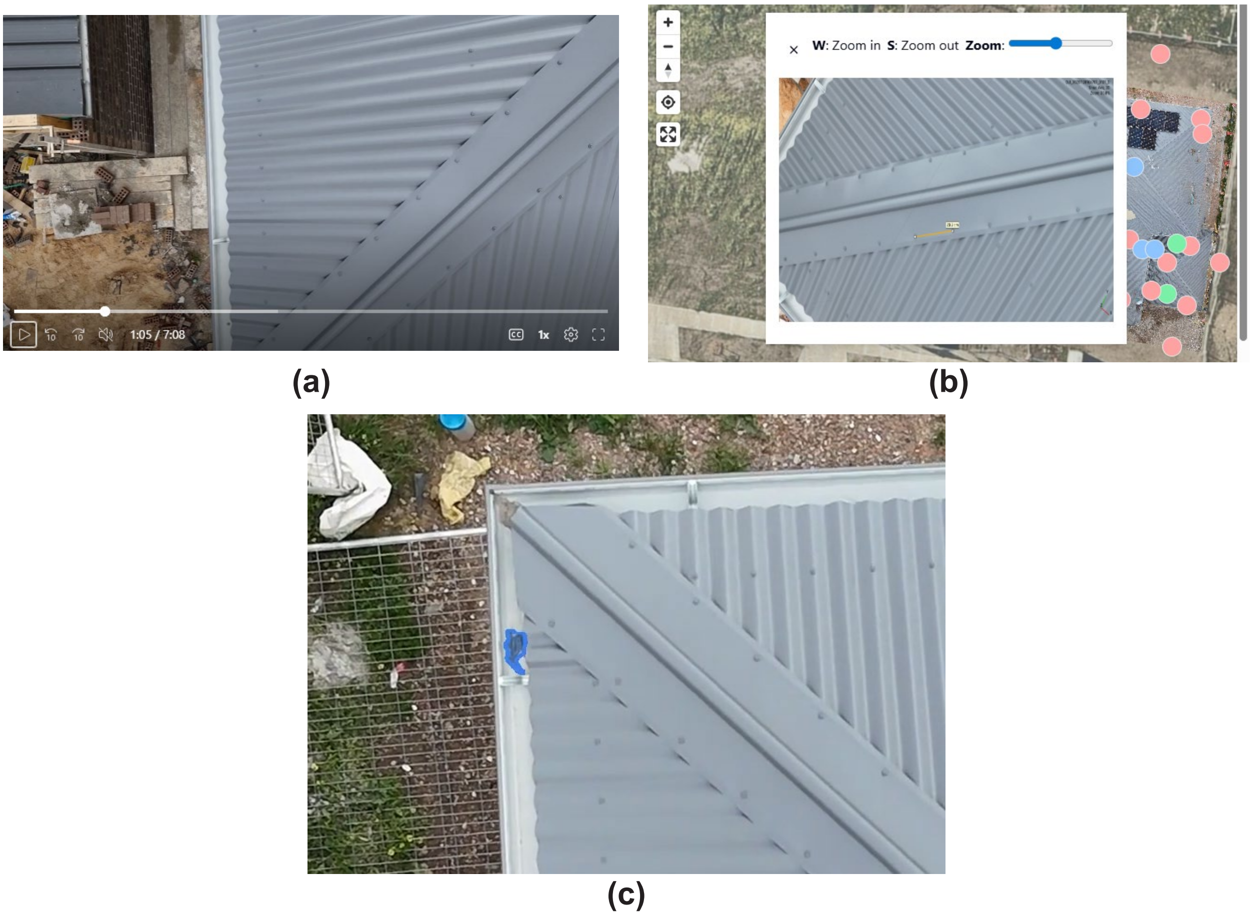


Figure 23: Examples of advanced imaging inspection tools (a) Tool A: video inspection, (b) Tool B: web-based image inspection, (c) Tool C: AI-assisted anomaly detection

Despite the video (Tool A) providing the identical view of the roof available to the on-site inspector performing the eye-in-the-sky inspection, who identified no apparent non-compliance, the second inspector identified several non-compliance risks, such as residual water in the gutter suggesting insufficient gutter gradient and damages to the roof sheets. This is due to the ability to pause and replay the video, as well as the good visibility on a computer monitor, comparing with the smaller RPAS controller screen affected by glare on site.

The web-based inspection tool (Tool B) combines high-resolution images collected by the RPAS and the 3D reconstruction of the building to allow for detailed visual inspections and measurements. The inspector was able to confirm the non-compliance risks identified using the previous tool (Tool A) with the ability to retain annotated images as documented evidence. The measurements based on the 3D model also filled the gap that measurements, e.g., distances between rivets, could not be checked due to the lack of physical access to the roof.

Finally, the SAM2 AI model (Tool C) successfully identified and tracked non-compliance risks such as water in the gutter, foreign object in the gutter and damages to the roof sheets within the video recorded by the RPAS. This helped the inspector to be quickly presented with potential issues within seconds.

6.5. Summary

The case studies presented in this section provided useful insights into the effectiveness and efficiency of RPAS-assisted roof inspection. Overall, RPAS as eye-in-the-sky (B1) provides a comprehensive view that enables inspectors to assess roof components more effectively, efficiently, and safely than conventional inspection methods. The advanced imaging tools require expert knowledge on RPAS piloting and 3D modelling, but they have the potential to increase the work efficiency of inspectors by performing quick preliminary scans using data collected from multiple sites. The video and image data can also be retained for documentation purposes for inspected buildings. Moreover, they can serve as effective training resources for the next generation of inspectors by way of off-site, scenario-based learning.

7. ROADMAP FOR UPSCALING

7.1. Overview

This section presents a decision-support roadmap for upscaling Remotely Piloted Aircraft Systems (RPAS) for roof inspection. It begins by outlining what is included in the roadmap and the underlying assumptions, before presenting the upscaling roadmap itself. The section also explains how cost and organisational change are assessed. Overall, it is intended to support organisations implementing RPAS-enabled roof inspection to make informed choices about adoption and scale-up, and to clarify the implications of those choices in terms of cost and organisational change.

The section does not recommend a single "best" configuration. Instead, it outlines the key differences and practical considerations across inspection configurations so organisations can assess which approach best aligns with their current capabilities, inspection volumes, and operating environment. In doing so, it maps alternative implementation pathways, recognising that suitable choices will vary by organisational context.

7.2. Inspection scenarios

In this roadmap, inspection scenarios refer to the different technical ways in which RPAS technology can be used to support roof inspection. We draw on the four inspection scenarios identified in the cost–benefit analysis, which are introduced and defined in Section 5.3. These inspection scenarios are:

1. eye-in-the-sky inspection (B1)
2. hybrid inspection (B2)
3. remote image-based inspection (C1)
4. AI-assisted remote inspection (C2).

7.3. Operational models

Operational models describe the organisational structure through which RPAS-enabled roof inspection is delivered. They specify how an organisation arranges roles and responsibilities to support roof inspection and how this structure is coordinated in day-to-day delivery. Four operational models emerged from the interviews (Section 4.4):

I. **Some inspectors are pilots**. This refers to an arrangement in which only a subset of inspectors is trained and certified to operate RPAS.

II. **All inspectors are pilots**. This refers to a workforce wide approach in which all inspectors are trained and certified.

III. **Dedicated pilot team**. This refers to establishing a specialised internal team whose members are both pilots and inspectors. The team undertakes data collection, roof assessment, and reporting, and operates as a distinct service function within the organisation.

IV. **Externalised pilot services**. This refers to outsourcing RPAS operations to an external specialist provider, with the organisation purchasing RPAS data collection as a service.

7.4. Assumptions

Two assumptions underpin the roadmap.

Assumption 1: Sub 2 kg RPAS

The roadmap is developed on the basis that RPAS operations use sub 2 kg RPAS. This aligns with Section 5.4, which identifies sub 250 g and sub 2 kg platforms as the practical adoption pathway for typical inspection businesses. It is also supported by Section 5.4, which indicates that platforms exceeding 2 kg represent a step change in cost and compliance requirements, while the additional payload capacity and other associated industrial capabilities are not necessary for routine roof inspections. The case study testing reported in Section 6.3 suggests that sub 2 kg RPAS are sufficient to detect the majority of roof defects. On this basis, the roadmap assumes the use of sub 2 kg RPAS.

Assumption 2: ReOC based operation is pursued

For simplicity, the roadmap assumes a ReOC-based operating arrangement as the long-term direction. This is reasonable because ReOC enables bespoke organisational procedures that can incorporate CASA-endorsed authorisations and exemptions from otherwise applicable regulatory requirements. While organisations may not hold the relevant approvals immediately, the roadmap assumes they will progressively work towards a common compliance baseline (ReOC + RePL) so configurations can be assessed consistently. Although ReOC involves higher upfront cost, it also indicates it supports the full benefits of RPAS deployment and that the effective overhead can be reduced when scaling across more inspection categories and higher volumes.

7.5. Roadmap for upscaling

The roadmap is presented as a matrix in Table 13. The columns represent inspection scenarios, and the rows represent operational models. Each matrix entry represents a unique combination of an inspection scenario and an operational model. In this report, each entry is referred to as an inspection configuration.

The roadmap evaluates every unique combination with inspection scenarios and operational models based on its cost and organisational change. Cost refers to the investment and spends associated with RPASs, digital infrastructure, training and certificates (e.g., obtaining and maintaining a ReOC), and outsourced services costs (if applicable). Organisational change refers to the extent of change involved in workflow and governance structure in comparison to conventional inspection, including integration between data collection and analysis, and coordination across organisational boundaries.

Table 13: Roadmap for upscaling RPAS-assisted building inspections

		Inspection Scenarios			
		B1 **Eye-in-The-Sky**	**B2** **Hybrid Inspection**	**C1** **Remote Image-Based Inspection**	**C2** **AI-assisted Remote Inspection**
Operational Models	**Some Inspectors are Pilots**	Cost: Low Organisational Change: Medium-Low Benefits: Medium Flight frequency: Medium	Cost: Medium-Low Organisational Change: Medium-Low Benefits: Medium-High Flight frequency: Medium	Cost: Medium-high Organisational Change: Medium Benefits: High Flight frequency: Medium-High	Cost: Medium-High Organisational Change: Medium Benefits: High Flight frequency: Medium-High
	All Inspectors are Pilots	Cost: Medium-Low Organisational Change: Medium-Low Benefits: Medium Flight frequency: Medium	Cost: Medium Organisational Change: Medium Benefits: Medium-High Flight frequency: Medium	Cost: Medium-High Organisational Change: Medium-High Benefits: High Flight frequency: Medium-High	Cost: High Organisational Change: High Benefits: High Flight frequency: Medium-High
	Dedicated Pilot Team	Cost: Medium-Low Organisational Change: Medium-Low Benefits: Medium Flight frequency: Medium	Cost: Medium Organisational Change: Medium Benefits: Medium-High Flight frequency: Medium	Cost: Medium-High Organisational Change: Medium Benefits: High Flight frequency: Medium-High	Cost: Medium-High Organisational Change: Medium-High Benefits: High Flight frequency: Medium-High
	Externalised Pilot Services	Cost: Medium Organisational Change: Medium Benefits: Medium Flight frequency: Medium	Cost: Medium Organisational Change: Medium Benefits: Medium-High Flight frequency: Medium	Cost: Medium-High Organisational Change: Medium-High Benefits: High Flight frequency: Medium-High	Cost: Medium-High Organisational Change: Medium-High Benefits: High Flight frequency: Medium-High

7.5.1. Cost assessment criteria

In this analysis, cost refers to the organisation’s overall cost implications for implementing and operating each inspection configuration. It reflects both set-up costs and ongoing operating costs. The cost rating therefore indicates the relative level of investment and expenditure an organisation should expect for each inspection configuration. Cost is assessed across five components: (1) RPAS related costs, (2) digital infrastructure, (3) training and certification, (4) per-job fees for externalised pilot services (where relevant), and (5) benefit–cost ratio (BCR).

First, RPAS related costs mainly consist of the purchase and other minor costs such as insurance and parachute (when needed). These costs tend to increase when piloting capability is expanded across more inspectors, because having more staff able to fly usually leads to higher utilisation and a need for greater equipment availability. Where pilot services are externalised, RPAS purchase and maintenance costs shift largely to the service provider rather than the organisation. However, externalising piloting does not remove the organisation's need to invest in certain digital systems, such as data storage, remote inspection platforms, and reporting systems.

Second, digital infrastructure costs reflect the software and systems needed to enable RPAS supported inspection. These typically include pre-flight tools (e.g., risk management software and flight path planning) and post-flight tools (e.g., data storage, remote inspection platforms, 3D modelling for off-site measurement, and AI-assisted remote inspection detection if applicable). Moving from eye-in-the-sky (B1) to AI-assisted remote inspection (C2) increases the number and complexity of these tools and therefore increases cost.

Third, training and certification costs include obtaining licences (ReOC and RePL), as well as ongoing and onboarding training. Formal licensing training is typically delivered through external, approved training providers, so these costs increase with the number of staff requiring qualification. Once an organisation operates under a ReOC, it will usually have a Chief Remote Pilot who can support internal onboarding and recurrent training, particularly around organisation specific standard operating procedures (SOPs). Training costs also increase with the complexity of the tasks and the standard required. For example, training for basic flight operations is typically less intensive than training to use a remote inspection platform, and (where applicable) use AI tools to support roof assessment.

Fourth, where pilot services are externalised, internal RPAS and pilot training costs are replaced by a per-job (or per-hour) service fee. Service pricing, market rate and fees vary by provider, location, and scope of work. In general, higher data collection requirements increase unit cost: a quick roof scan is more likely to be cheaper than evidence-grade capture following standardised protocols (e.g., defined heights, certain angles, and quality thresholds). Where pilots are expected to exercise inspection-relevant judgement during image capture, service pricing is also likely to be higher.

Fifth, different inspection scenarios generate different levels and types of value. Therefore, in addition to estimating implementation cost, we also consider the benefit-cost ratio (BCR) to reflect the relationship between expected benefits and the associated costs. Including BCR ensures that comparisons across all inspection scenarios account for different value propositions, rather than treating all scenarios as equivalent in benefit and differing only in cost.

7.5.2. Organisational change assessment criteria

Organisational change refers to: (1) the degree of adjustment required relative to the conventional inspection methods and (2) the integration effort required across roles and organisations.

First, we evaluate how much the inspection workflow needs to change when implementing RPAS. The workflow typically includes flight planning, data collection, data analysis, data storage, and reporting, and how many SOPs must be revised to support consistent delivery. For eye-in-the-sky inspection (B1), changes are mainly concentrated in flight planning, data collection, and basic reporting, because the captured data is typically reviewed using existing inspection judgement with limited additional digital processing. By contrast, remote (C1) and AI-assisted (C2) inspection scenarios place greater demands on downstream analysis workflows (for example, structured review processes, quality assurance, and digital tools that support remote assessment and analytics). As a result, these scenarios require stricter SOPs and more substantial adjustments.

Second, we consider the integration effort required across roles (pilots and inspectors), and organisational boundaries (external company and roof inspection company). In the inspection scenarios where only some inspectors operate as pilots, or where a dedicated pilot team is established, the organisation must manage the interface or boundary objects with more efforts. For example, this includes handover routines, data quality assurance and feedback loop between on-site data capture and off-site analysis. Where pilot services are externalised, these interface requirements extend across organisations and typically require more explicit coordination mechanisms (e.g., scheduling and access arrangement, capture and deliverable standards).

The organisational change ratings above focus on the operational and governance adjustments required to implement RPAS-enabled inspection, such as workflow redesign, SOP revision, and interface coordination. These factors are included because the extent of workflow change and the effort required to manage interfaces vary across inspection scenarios and operational models.

By contrast, factors that are more contingent on the adopting organisation’s internal conditions are not captured explicitly, as this roadmap is intended to be applicable across different organisations. Accordingly, the ratings do not quantify broader change management effort, such as stakeholder engagement, internal communications, cultural change and adoption support, or temporary productivity impacts during transition.

7.6. Assessment of each inspection configuration

7.6.1. Eye-in-the-sky Inspection (B1)

Benefits: Medium

Eye-in-the-sky inspection provides provide benefit by supporting more informed inspection decision-making early in the workflow. A comprehensive overhead view of the roof helps identify non-compliance risk locations, and guides whether and where physical access is needed. The benefit is therefore mainly in improved visibility and better targeting of subsequent in-person inspection effort, rather than producing evidence-grade outputs.

Flight frequency: Medium

Eye-in-the-sky inspection is likely to be used routinely for many jobs where an overhead view of the roof materially improves inspection planning and on-site decision-making, but it is not necessarily applied to every roof inspected as a default. In practice, organisations may prioritise it for roofs that are more complex, higher risk, or where access is uncertain.

Cost-Benefit Analysis: High BCR

The cost–benefit analysis indicates that eye-in-the-sky inspection delivers strong value for money. The value comes from improving roof assessment through a comprehensive overhead view of the roof: hovering above the roof and using zoomed imagery increases visibility of roof condition and potential risk areas. In this scenario, avoiding the use of ladder also delivers safety benefit. At the same time, the cost base remains relatively low because this inspection scenario does not introduce the major cost drivers (e.g., remote inspection platforms, SfM/3D modelling, or AI-enabled detection of non-compliance risks). As a result, an uplift in inspection benefit is achieved without heavy investment in advanced digital infrastructure. The BCR may vary slightly across operating models because the cost base changes: it is likely to be higher where piloting capability is limited to a subset of inspectors or concentrated in a dedicated team, and lower where workforce-wide pilot training is required or where external service fees are high.

I. Eye-in-the-sky inspection (B1) where some inspectors are pilots

Cost: Low; Organisational change: Medium-Low

Cost is assessed as low because this scenario does not yet introduce the major cost drivers that will dominate later configurations, such as AI-enabled non-compliance risk detection, SfM/3D modelling, remote inspection platforms, or workforce-wide pilot training. The primary incremental costs are operational rather than technological: more time is required on-site for a comprehensive overhead view of the roof, and additional time is spent interpreting imagery. Training and competency requirements increase, particularly for assessing roof condition and producing basic reporting outputs. However, post-flight handling remains only slightly heavier, and “eye-in-the-sky” capture is operationally simple (hovering above the roof with limited manoeuvrings rather than complex angle/overlap requirements), which keeps both software and equipment demands minimal.

Organisational change is medium-low because eye-in-the-sky inspection utilise RPAS for decision support that influences how inspections are planned and conducted, without requiring substantial changes to roles or governance, e.g., guiding where physical access to the roof may be needed, highlighting potential risk areas, and shaping the focus of subsequent in person inspections. This increases the need for light standardisation in SOPs, such as basic guidance on flight height and minimum views, but the complexity of SOPs remains limited due to straightforward image capture requirements. A further driver of change is the handover risk created by having only some inspectors as pilots: unclear expectations can lead to coordination failures between those collecting imagery and those interpreting it, requiring modest integration routines like request/feedback loops and occasional re-flight triggers.

II. Eye-in-the-sky inspection (B1) where all inspectors are pilots

Cost: Medium-Low; Organisational change: Medium-Low

Cost is medium-low because the technical scope remains simple, with no AI analytics, SfM/3D modelling, or dedicated remote inspection platform. The main cost uplift comes from scaling pilot training and certification to the entire inspection workforce, including ongoing training and onboarding. RPAS procurement may also increase to support day-to-day utilisation and operational flexibility across teams. The additional cost is primarily workforce capability rather than software intensity.

Organisational change is medium-low, a shift in governance emphasis compared with the “some inspectors are pilots” scenario. Eye-in-the-sky still requires light SOP standardisation because outputs inform decision-making, but reliability is secured differently. Instead of focusing on ensuring the accuracy and reliability of a small subset of pilots and managing handovers, the governance structure must adapt towards workforce-wide consistency management. This involves clearer common standards for capture and reporting, periodic calibration, and continuous training across the workforce to reduce variability in how inspectors interpret overhead imagery and document screening insights.

III. Eye-in-the-sky inspection (B1) with dedicated pilot team

Cost: Medium-Low; Organisational change: Medium-Low

Cost remains medium-low, sitting between the “some inspectors are pilots” and “all inspectors are pilots” modes. The inspection software and digital infrastructure are unchanged, and equipment requirements are similar due to straightforward capture tasks. What shifts is the distribution of training and operational effort: pilot capability is concentrated in a small team, reducing training and costs compared with training everyone.

Organisational change is assessed as medium-low because the core eye-in-the-sky workflow does not change relative to the previous case. The key difference is structural. With a dedicated pilot team, the main coordination requirement is to establish a clear internal interface. Such as how requests are raised, how flights are scheduled, and how results are handed over. Once established, the pilot team operates as a self-contained unit with higher efficiency, with fewer integration demands across the wider organisation. In that sense, the governance emphasis stays focused on maintaining the reliability of the dedicated team’s practice, rather than managing handovers across multiple individuals or calibrating the whole workforce.

IV. Eye-in-the-sky inspection (B1) with externalised pilot services

Cost: Medium (volume- and price-dependent); Organisational change: Medium

Cost is medium because outsourcing shifts the cost structure rather than simply reducing it. The organisation avoids purchasing and maintaining RPAS, and no need to train and certify pilots. Instead, it pays an external provider on a per-job basis. For eye-in-the-sky inspections, this fee is typically higher because data collection requirements are more demanding and pilots must apply inspection-relevant judgement to ensure imagery supports roof assessment. Which means the pilots need to apply inspection-relevant judgement to ensure the imagery supports roof assessment. Over time, the economics will depend on inspection volume and prices. Economics will depend on inspection volume and prices: high and steady volume can accumulate fees quickly, while variable volume makes outsourcing attractive. As RPAS inspection services become more common and standardised, market pricing may fall, shifting this assessment.

Organisational change is medium. The organisation must now manage an inter-organisational interface. This includes scheduling and site access arrangements, agreed data capture and deliverable standards, and a basic quality assurance loop to handle unsatisfied results. These coordination routines are more formal than internal models, yet contained because responsibility for flight operations sits outside the organisation, and internal process changes mainly integrate external outputs into existing planning and inspection routines.

7.6.2. Hybrid Inspection (B2)

Benefits: Medium-High

Hybrid inspection combines RPAS inspection with on-site verification, which improves detection confidence beyond eye-in-the-sky alone. The RPAS captures overview and targeted checking of high-risk areas, while ladder inspection enables closer verification where uncertainty remains. The main benefit is therefore improved inspection effectiveness through complementary modes.

Flight frequency: Medium

Hybrid inspection is likely to be applied selectively rather than routinely. It is most suitable for complex or higher-risk jobs where the additional time on site is justified by the uplift in coverage and verification. For simpler roofs, organisations are likely to rely on lighter configurations to avoid unnecessary site time.

Cost-Benefit Analysis: Medium BCR

The cost–benefit analysis suggests that hybrid inspection provides solid value, but it is less cost efficient than eye-in-the-sky and remote inspection. The benefits come from combining RPAS coverage with ladder-based verification. This improves confidence in identification of non-compliance risks on complex roofs. However, the inspection remains labour intensive on site. RPAS activity is added rather than substituted. Time on site increases. Ladder access also reintroduces safety risk. These factors reduce overall efficiency. As a result, the BCR is medium. The BCR can vary across operating models. It will usually be higher when only some inspectors are pilots or when a dedicated pilot team is used. It may reduce when all inspectors are trained as pilots. It may also reduce when external service fees are high.

I. Hybrid inspection (B2) where some inspectors are pilots

Cost: Medium-low; Organisational change: Medium-Low

Cost is medium-low because hybrid inspection increases time on site. Inspectors use the RPAS to obtain an overview and check difficult-to-reach areas, then move to ladder inspection to verify uncertainties and inspect specific locations more closely. This combined approach raises labour input compared with eye-in-the-sky alone. However, the digital infrastructure remains light. Hybrid inspection does not require a remote inspection system, and it does not introduce AI detection or SfM/3D modelling at this stage. Training costs also remain contained because only some inspectors are pilots.

Organisational change is medium-low because the core inspection practice stays anchored in conventional on-site work. The RPAS is integrated as an aid rather than a substitute, so accountability and evidence expectations remain largely unchanged. The main adjustments are procedural: light SOP standardisation for when RPAS observation is sufficient and when ladder verification is triggered.

II. Hybrid inspection (B2) where all inspectors are pilots

Cost: Medium; Organisational change: Medium

Cost increases to medium because the main change is scale. Pilot training and certification extend to the whole inspection workforce, including ongoing currency and onboarding for new staff. To support routine use in day-to-day operations, the organisation is also likely to increase RPAS availability so that “RPAS + ladder” work can be carried out without bottlenecks. The digital infrastructure remains broadly similar to the previous inspection scenarios, with no remote inspection system and no AI/SfM modelling software at this stage. So the cost uplift is driven mainly by training and equipment capacity rather than new software categories.

Organisational change moves to medium because the governance requirement shifts. Compared with having only some inspectors as pilots, the organisation must secure workforce-wide consistency in how RPAS observations are combined with ladder verification and how findings are documented. This typically requires clearer SOP standardisation (particularly around triggers for ladder inspection and minimum expectations for capture and reporting), alongside periodic calibration and refresher training to reduce variation in practice across the workforce.

III. Hybrid inspection (B2) with dedicated pilot team

Cost: Medium; Organisational change: Medium

Cost is medium. Relative to “hybrid inspection with some inspectors are pilots”, the digital infrastructure and on-site work pattern are similar. The inspection remains largely conducted on site, with the RPAS used to support coverage and ladder inspection used for verification. However, under a dedicated pilot team operating model, training and certification are concentrated in a small team rather than spread across the full workforce, so training and RPAS costs sit between the “some inspectors” and “all inspectors” models. Because hybrid work still involves both RPAS and ladder activity, time on site remains a material cost component regardless of who flies, which keeps the overall cost above medium-low.

Organisational change is medium because the dedicated pilot team model requires a more deliberate operating arrangement to avoid underutilisation and ad hoc deployment. Beyond establishing a standard interface for requesting and scheduling the team, the key shift is the need for an evaluation mechanism that identifies which jobs are suitable for the dedicated team’s hybrid approach. This screening step allows work to be directed systematically. Rather than blending the team into the general workforce and using RPAS only when needed, the efficiency of the planning and executing will increase. In practice, this introduces additional coordination and governance around selection criteria for deciding which jobs/sites should be allocated to the dedicated team, and how those jobs are scheduled and dispatched.

IV. Hybrid inspection (B2) with externalised pilot services

Cost: Medium; Organisational change: Medium

Cost is medium because outsourcing removes the need for the inspection organisation to purchase and maintain RPAS and to train and certify pilots. Importantly, it can also avoid the need for the organisation to obtain and maintain a ReOC for these operations, because the external provider typically conducts the flights under their own ReOC and assumes responsibility for compliant flight operations and aviation risk management. Instead, the organisation pays a per-job (or per-hour) service fee. In hybrid inspection, the external pilot does not need the more specialised “roof inspection” judgement associated with eye-in-the-sky remote assessment, because the inspector is on site and retains responsibility for interpretation and verification. As a result, outsourced cost is driven mainly by labour hours and mobilisation rather than specialist analytics or advanced software. That said, cost remains sensitive to inspection volume and market rates, particularly once travel time, minimum call-out charges, and rescheduling are factored in.

Organisational change is medium. Hybrid inspection requires the pilot and inspector to be on site at the same time and to work in close coordination: inspectors direct where to fly and what to zoom in on, while pilots manage safe and compliant flight operations. Externalising the pilot function makes scheduling and on-site inspection more difficult because two parties must align availability and access. It also creates a practical coordination gap: inspectors may not understand RPAS capabilities and constraints, and external pilots may not understand inspection priorities and cues, so real-time collaboration can be inefficient and prone to misunderstanding. In practice, these interface frictions can erode the intended efficiency gains of hybrid inspection and increase the likelihood of prolonged site visits, which is why this operating model is typically a poor fit for the hybrid scenario.

7.6.3. Remote Image-Based Inspection (C1)

Benefits: High

Remote Image-Based inspection delivers higher quality and evidence level documentation. It enables more systematic coverage of the roof, generates reusable photos and videos that can be reviewed off site. A further benefit is that roof assessment can be decoupled from site attendance. Data capture occurs on site, while assessment and reporting can be completed remotely, which supports more flexible resourcing and improved consistency.

Flight frequency: Medium-High

Remote Image-Based inspection typically requires at least one structured flight per job because the imagery becomes part of the formal evidence. As a result, flight frequency will be higher than other configurations where RPAS are used primarily for screening. In practice, the frequency will depend on how broadly organisations adopt remote image-based inspection as a default method, but each remote inspection case requires evidence-grade capture rather than ad hoc flying.

Cost-Benefit Analysis: High BCR

The cost - benefit analysis indicates that remote Image-Based inspection delivers strong value for money. The benefits are high because the scenario produces evidence grade documentation that supports off-site assessment and reporting. It improves traceability and auditability. It also reduces the need for repeated site access and ladder based inspection. These factors lift safety and consistency. The cost base increases due to the need for digital systems and more structured data capture. However, these costs are offset by the value of reusable inspection evidence. As a result, the BCR is high. The BCR can vary across operating models. It will usually be higher when piloting capability is limited to some inspectors or concentrated in a dedicated team. It may reduce when all inspectors are trained as pilots. It may also reduce when external service fees are high or when providers cannot reliably meet evidence-grade capture requirements.

I. Remote image-based inspection (C1) where some inspectors are pilots

Cost: Medium-High; Organisational change: Medium

Cost is medium because remote image-based inspection introduces a step up in capability. The organisation needs a remote inspection platform and stronger visualisation and reporting tools, with more robust data storage and access arrangements than earlier scenarios. Where off-site measurement is required, 3D modelling capability may also be introduced. Training requirements increase on both sides: pilots must follow more refined, evidence grade data collection practices, while off-site inspectors need training in image based roof assessment and reporting based on formal evidence. In addition, work shifts from site time to office time.

Organisational change is medium because the governance structure must adapt to a split workflow in which one group collects the data and another analyses it. This separation can reduce efficiency if responsibility and accountability are not managed carefully. The organisation needs clear rules for who is accountable for data sufficiency, who signs off the inspection outcome, and how exceptions are handled when imagery is ambiguous. To support this governance arrangement, a stricter SOP is required for data collection (coverage, angles, and minimum quality), alongside a continuous feedback loop between off-site inspectors and pilots so that learning from analysis is translated into improved capture practice. Finally, the model formalises separated skill sets: pilots require flying competence and sufficient inspection awareness to capture what is needed, while inspectors deepen their image-based assessment capability without needing piloting knowledge.

II. Remote image-based inspection (C1) where all inspectors are pilots

Cost: Medium-High; Organisational change: Medium-High

Cost is medium-high because the remote image-based inspection skills remains the same while pilot training and certification are expanded to the whole workforce. This increases both upfront and ongoing training requirements (including continuous training and onboarding), and it typically requires additional RPAS capacity to support routine use without bottlenecks. The increase in cost is driven mainly by people and equipment scale rather than introducing a new software category comparing with previous operational model.

Organisational change is medium-high because the governance structure must operate at workforce scale. Responsibility and accountability remain shaped by the split workflow of data collection and analysis. This split workflow must be managed by stricter SOPs regarding the data coverage, angles, and quality. Compared with having only some inspectors as pilots, the organisation must now secure workforce wide consistency in both capture practice and remote inspection. That typically requires more formal calibration routines, stronger quality assurance, and a maintained feedback loop.

III. Remote image-based inspection (C1) with dedicated team

Cost: Medium-High; Organisational change: Medium

Cost is medium-high because the remote image-based inspection capability is still required. Regardless of the number of pilots and inspectors, the organisation needs the inspection platform and associated visualisation and reporting tools, data storage, and 3D modelling software. These systems are materially more demanding than in earlier inspection scenarios and therefore sit towards the higher end of the cost scale. Compared with “all inspectors are pilots”, cost can be lower on the people side because training and certification are concentrated in a small, dedicated team, and RPAS capacity does not need to be scaled across the whole workforce. However, the software requirements remain largely unchanged, keeping the overall cost at medium-high.

Organisational change is medium because the dedicated team model can simplify governance once the interface is established. The workflow is still split: on-site data collection by pilots and off-site assessment by inspectors. So responsibility and accountability must be supported by stricter SOPs. The difference from the “all inspectors are pilots” model is that consistency management becomes more focused: instead of calibrating the whole workforce, the organisation concentrates on the reliability of one team’s capture practice. With a stable internal interface (requesting, scheduling, handover), the dedicated team can operate as a relatively contained service function with increased efficiency, reducing the breadth of organisational change even though the underlying governance requirements remain.

IV. Remote image-based inspection (C1) with externalised pilot service

Cost: Medium-High; Organisational change: Medium-High

Cost is medium-high because outsourcing removes RPAS purchase and pilot training, but it does not remove the cost drivers associated with remote image-based inspection as a service. The organisation still needs to train inspectors in image-based roof assessment and reporting, and it will still incur costs for the remote image-based inspection platform, data storage, visualisation, and 3D modelling to support off-site measurement. In addition, purchasing remote inspection capture as an external service is typically expensive in the current market because remote image-based inspection places higher requirements on data coverage and quality. Given the present maturity of specialist providers, pricing can be high and hard to negotiate. Over time, this may soften as the market standardises, but under current conditions it is reasonable to place cost at the higher end.

Organisational change is medium-high because the governance structure and interface management become formal, but they remain only to the inspection function rather than redesign of the whole organisational procedure. The key challenge is the pilot–inspector interface across organisational boundaries, since the inspection service is externalised. Remote image-based inspection relies on tight alignment between what inspectors need to see and what pilots capture. This requires iterative refinement of coverage based on off-site review. When services are externalised, sustaining this continuous feedback loop is harder: the external provider has limited incentive to invest in fine-tuning data collection. As a result, the organisation must compensate through clearer deliverable standards, stronger contractual mechanisms, and more deliberate communication routines to avoid misalignment and re-work.

7.6.4. AI-assisted Remote Inspection (C2)

Benefits: High

AI-assisted remote inspection builds on the benefits of remote inspection by accelerating the roof assessment process. As suggested in Section 5.4, on-site time savings could be offset by post-flight data processing. AI-enabled software can help inspectors increase efficiency by prioritising areas of concern, highlighting non-compliance risks, and summarising repeated non-compliance patterns across jobs. Over time, this creates a stronger foundation for monitoring non-compliance trends and more systematic decision support. These benefits are longer term and contingent on tool availability, and they should be interpreted in light of the current limited commercial maturity of AI software for the detection of non-compliance risks. As explained in Section 5.4, AI software for inspection scenario C2 is not yet commercially available.

Flight frequency: Medium-High

Flight frequency is broadly similar to remote inspection because each AI-assisted case still requires at least one evidence-grade capture flight. However, AI-enabled workflows place greater emphasis on consistent capture patterns to support analytics performance. In practice, this implies more structured and repeatable data collection (for example, standard views) and, where automated flight planning is used, more standardised flight routines to produce comparable datasets across inspections.

Cost-Benefit Analysis: High BCR

The cost-benefit analysis indicates that AI-assisted remote inspection delivers strong value for money. The benefits are high because the scenario produces evidence grade documentation eliminating the need for repeated site access and ladder-based inspection. The cost base increases due to the need for digital systems and specialised software. However, these costs are offset by the value of reusable inspection evidence. As a result, the BCR is high, with the caveat that commercially mature AI software is not currently available.

I. AI-assisted remote inspection (C2) where some inspectors are pilots

Cost: Medium-High; Organisational change: Medium

Cost is medium-high because AI-assisted remote inspection requires more software than image-based remote inspection. In addition to the remote inspection platform, storage, visualisation and reporting, the organisation introduces AI detection of non-compliance risks and analytics, and may also adopt automated flight planning to standardise image capture. This system also requires tuning and maintenance to perform reliable. Importantly, AI software tools for the detection of non-compliance risks are not yet commercially mature. Training requirements also increase: pilots must capture data in ways that suit AI processing, and inspectors must be able to validate AI outputs rather than relying on judgement alone. Currently, organisational change is medium because the governance structure must accommodate the AI - human workflow. Responsibility and accountability become more explicit: AI can propose findings, but inspectors remain responsible for validation and sign -off. This requires stricter SOPs for how AI outputs are reviewed and documented.

II. AI-assisted remote inspection (C2) where all inspectors are pilots

Cost: High; Organisational change: High

Cost is high because the organisation combines the most software-intensive inspection mode with workforce-wide capability. AI analytics and automated flight planning add substantial digital investment, and scaling pilot training and certification across al inspectors increases both initial and ongoing training load. Additional RPAS capacity is typically required to support routine use across teams, and the operating burden grows because both capture practice and AI-enabled review must be supported across the whole workforce. At present, AI tools for non-compliance detection are not commercially mature. Organisational change is high because governance and consistency management must operate at full scale. The organisation must standardise capture practices to support reliable AI processing, while also maintaining consistent human validation and reporting across inspectors. Accountability arrangements need to be specific (such as what can AIdetect, what inspectors must verify), supported by structured calibration routines, quality assurance, and a maintained feedback loop linking data capture, off-site roof assessment, and model fine tuning.

III. AI-assisted remote inspection (C2) with dedicated pilot team

Cost: Medium-High; Organisational change: Medium-High

Cost is medium-high because the majority of the inspection software still needs to be implemented and maintained (automated flight path planning, remote inspection platform, and data storage solution). However, compared with training all inspectors as pilots, concentrating pilot capability in a dedicated team can lower training and equipment costs. This operational model provides a more realistic pathway given that AI software for detecting con-compliance risks is not yet commercially mature. Organisations may therefore choose to develop their own AI tools, rather than relying on off-the-shelf solutions. More investment is required for internal development, adaptation, or co-development with vendors. Organisational change is medium-high because the model places the pilot team at the centre of both operational delivery and AI performance improvement. The governance structure must support a tighter coupling between data capture and analysis. A dedicated team with combined inspection and piloting knowledge is well positioned to drive the efficiency (Section 5.4). They are able to use the off-site validation outcomes to refined data capture SOPs, and working with the AI analysis tools through iterative tuning. That learning loop raises organisational effort above "medium", but it is focused within a bounded group rather than dispersed across the whole workforce.

IV. AI-assisted remote inspection (C2) with externalised pilot services

Cost: Medium-High; Organisational change: Medium-High

Cost is medium-high because outsourcing removes internal RPAS purchase and pilot training, but the AI-assisted system costs remain and service pricing is typically higher where evidence-grade, AI-suitable datasets are required. Inspectors still require training to validate AI outputs and produce reports, and service fees can increase due to stricter capture requirements. At present, AI tools for detecting non-compliance are not commercially mature, which means genuinely AI-enabled external services may be limited in availability and may carry higher costs associated with bespoke integration and iterative refinement. Organisational change is medium-high, but the configuration is generally not recommended because the most critical interface sits across organisational boundaries. AI-assisted inspection depends on tight alignment between capture routines and analytics performance, and it often requires iterative refinement based on validation outcomes. When pilots are external, sustaining this feedback loop is difficult: the external provider has limited incentive to adapt practice beyond contract terms. In practice, this can lead to repeated false detections, and slow learning cycles, which undermines the value of AI-enabled inspection.

7.7. Summary

In summary, the optimal pathway for scaling up RPAS-assisted inspections depends on the chosen inspection scenario and operational model, balanced against the organisation's capabilities, inspection volume, operating environment, and capacity for change. While the more accessible eye-in-the-sky inspection scenario (B1) with inspectors as pilots can be scaled with lower costs and organisational change, the more advanced AI-assisted remote inspection scenario (C2) with externalised pilot services would involve higher costs and more extensive organisational change.

8. CONCLUSIONS AND RECOMMENDATIONS

8.1. Conclusions

This project evaluated the effectiveness of RPAS and advanced imaging techniques for the inspection of roofing work to support or enhance conventional in-person inspections. From the literature review, regulatory study, perspective stakeholder mapping, cost-benefit analysis, field case studies and upscaling study the following key conclusions are drawn:

- RPAS improve the accessibility, visual coverage, personnel safety, and speed of roofing inspections for residential buildings as compared with the conventional approach. Data collected by RPAS support planning, documentation, training, and development of artificial intelligence (AI) and remote inspection tools (Chapter 2).
- Federal, State, Territory and local government rules and regulations make the use of RPAS in support of building inspections in high-density urban residential settings highly problematic, with the rules that RPAS not fly over or near people (the 30 m / 15 m rule with consent) and be kept within the pilot's visual line-of-sight being the most restrictive. Greater scope exists to use RPAS in low density areas (i.e., regional / rural), and on greenfield development sites that can be vacated and controlled during RPAS operations (Chapter 3).
- Scope exists to obtain authorisations and exemptions from some of the stricter CASA's regulatory requirements. Some of these authorisations and exemptions are available to accredited pilots; all are available to licensed pilots (RePL) and organisations that have obtained a Remotely Piloted Aircraft Operator's Certificate (ReOC). Obtaining and operating in accordance with a ReOC is comparatively more costly and time-consuming. However, operating with a ReOC offers several benefits, including greater safety assurance, flexibility to use larger and more complex RPAS, and enhanced professionalism, responsibility, and legitimacy of the operation (Chapter 3).
- Several organisations (regulatory as well as private businesses) use RPAS as a supplement to physical inspection, extending access and improving safety rather than replacing hands on assessment. RPAS reduce the safety risks associated with roof access, improve access to difficult roofs, provide clearer visual evidence, and offer broader consumer gains such as faster issue identification, fewer delays, reduced reliance on costly access methods, and earlier intervention for water ingress (Chapter 4).
- The cost-benefit analysis demonstrated significant benefit to cost ratios (BCR) for RPAS-assisted inspection scenarios. The higher accuracy of RPAS-assisted inspection in detecting roof defects and non-compliance risks can result in avoided costs for homeowners, ranging from $1,472 (pre-occupancy) to $4,890 (post-occupancy). At the Victorian market scale of 61,260 new dwellings per year, RPAS-assisted inspections could prevent approximately $14.4 million in repair costs under pre-occupancy conditions and $47.9 million post-occupancy, based on a 16% observed rate of plumbing (stormwater) non-compliance (Chapter 5).

- Among RPAS-assisted inspection scenarios, the hybrid scenario, where RPAS is used for preliminary screening and difficult-to-reach areas and ladder for closer verification in safer places (Scenario B2 – see Section 5.3), offers the best accuracy and efficiency at the current level of technology. While remote and AI-assisted inspection scenarios (Scenarios C1 and C2 respectively) demonstrated a significant potential for the automation of inspection operations, these require the development of bespoke software tools for effective visualisation of RPAS imagery enabling 3D measurements as well as reliable AI tools for automated identification of defects and non-compliances (Chapter 6).
- The best implementation pathway to scale up RPAS-assisted inspections varies by organisation. It depends on the chosen inspection scenario and operational model, as well as the organisation's capabilities, inspection volumes, operating environment, and capacity for change (Chapter 7).

Based on the research findings, the following answers are provided for the research questions:

What elements of roofing work can and cannot be accurately inspected using RPAS? The field case studies demonstrated that RPAS provide increased visibility for all elements of roofing work which are visually inspected. Roofing elements that require measurement such as roof pitch and gutter gradient can be remotely inspected using RPAS imagery after post processing (Scenario C1 – see Section 5.3). Roofing elements that are not directly visible or require physical probing, such as insulations and sarking, cannot be inspected using RPAS.

How and when could inspection of roofing work by RPAS be performed? At the current level of technology, and due to the lack of bespoke software tools for effective visualisation of RPAS imagery enabling 3D measurements, the hybrid scenario, where RPAS is used for preliminary screening and difficult-to-reach areas and ladder for closer verification in safer places (Scenario B2 – see Section 5.3), offers the best accuracy and efficiency. RPAS-assisted inspection is best performed at the completion of the construction and pre-occupancy, as it can identify non-compliance risk and defects early. However, it can also be used during the construction for quality assurance, and post-occupancy for defect detection and maintenance.

Is a technology-assisted inspection of roofing work more thorough, accurate and effective than a conventional 'in-person' inspection? The field case studies demonstrated that RPAS-assisted inspection significantly enhances the accuracy of detecting non-compliant roofing work and defects as compared with the conventional in-person inspection.

To what degree could emerging sensor and software technologies enhance a conventional 'in-person' inspection of roofing work? Using RGB imagery captured by RPAS enhances the in-person inspection by allowing the inspector to view the difficult-to-access parts of the roof. Thermal imagery proved effective for detecting heat loss but less so for moisture ingress. Software tools for 3D visualisation of RPAS imagery and AI models for automated defect detection can further enhance the efficiency of the inspection operations.

What are the costs, benefits and risks of RPAS-based inspection compared with conventional 'in person' inspections? RPAS-assisted inspections reduce ladder-related safety risks, increase the likelihood of detecting non-compliant roofing work, and outperform conventional in-person methods in terms of economic return. Specifically, AI-assisted remote inspection (Scenario C2 – see Section 5.3), remote image-based inspection (C1), and eye-in-the-sky inspection (B1) perform strongly and relatively closely under the non-ReOC operating models. For double-storey buildings, where access challenges amplify the comparative advantage of RPAS, these scenarios achieve benefit-to-cost ratios (BCR) ranging from 2.6 to 3.4. Hybrid inspection (Scenario B2) produces somewhat lower economic returns, but feedback from the inspectors involved in the case studies indicate that it is the preferred operational model because it combines RPAS screening with selective physical verification, which aligns closely with the current inspection workflow. A dedicated ReOC operating model is only justified economically for high volumes of annual inspection tasks. Overall, RPAS-assisted inspections present a compelling, evidence-based pathway for modernising building and plumbing oversight by increasing the likelihood of detecting non-compliant roofing work. This enhances the regulatory return on investment, ensuring limited inspection resources yield maximum compliance impact across the housing sector.

What are the stakeholder perspectives on the use of RPAS-based inspection of roofing work? Stakeholder interviews show that RPAS are currently used mainly as a supplement to physical inspection, extending access and improving safety rather than replacing hands on assessment. Stakeholders reported benefits including reduced height risk, improved access to difficult roofs, clearer visual evidence, and broader consumer gains such as faster issue identification, fewer delays, reduced reliance on costly access methods, and earlier intervention for water ingress. Challenges reported by stakeholders include uncertainty around RPAS regulations, limited inspection-focused training, and gaps in workflow integration, pointing to a need for clearer guidance and support.

What factors must be considered for scaling up RPAS-based inspections? The upscaling study identified several factors that must be considered for scaling up RPAS-based inspections. These include the inspection scenario, operational model, cost, and organisational changes in the workflow and governance structure. The best pathway for scaling up RPAS inspections depends on the chosen inspection scenario and operational model, as well as the organisation's capabilities, inspection volumes, operating environment, and capacity for change.

8.2. Recommendations

Building upon the findings and answers to the research questions, the project makes the following recommendations:

- RPAS-assisted inspections have the potential to provide building practitioners, regulators, and consumers:
    - better monitoring of compliance with building and plumbing standards;
    - early identification and rectification of non-compliance and defects that would compromise the health and safety of persons who use buildings, and a building’s amenities, and environmental and energy efficiency;
    - more effective, efficient and safe work practices.

  Combined with in-person inspections, these benefits provide greater compliance with building and plumbing standards, more cost-effective construction and maintenance of buildings, and a safer and more efficient and competitive building and plumbing industry.

- Organisations proposing to employ RPAS for building inspections at scale should:
    - apply for a Remotely Piloted Aircraft Operators Certificate (ReOC);
    - as part of (or separately to) the ReOC application, apply for authorisations and exemptions to enable safe, effective and efficient RPAS use for building inspections at scale. At a minimum this should include the ability to fly near or above people (i.e., exemption from the 30 m / 15 m rule) and authority to conduct extended/beyond visual line-of-sight operations over and within the boundaries of property (residential blocks) that have been vacated for inspection purposes.
    - conduct all RPAS operations in accordance with their ReOC and CASA approved RPAS Operations Manual; and
    - engage pilots who hold a Remote Pilots Licence (RePL).
- Organisations using RPAS should develop and implement a robust stakeholder communication plan to explain and demonstrate the value of using RPAS to assist with building inspections.
- A building inspection industry working group be formed to engage CASA in a dialogue to assess the risks and rewards of using RPAS for up-close building inspections with a view to either:
    - the grant of a general statutory authorisation or exemption; and/or
    - regulatory reform

  to enable the safe, effective and efficient use of RPAS for building inspections.
- Among the different RPAS-assisted inspection scenarios, the hybrid inspection (Scenario B2) is the recommended short-term implementation pathway. The hybrid inspection scenario uses RPAS for preliminary screening and difficult-to-reach areas, supplemented by ladder inspections for closer verification where it is safe to do so.
- In the long term, remote image-based and automated AI-assisted remote inspection scenarios (C1 and C2) offer several advantages, including structured digital evidence, standardised detection systems, repeatability, audit trails, capability for AI-assisted analytics, and provision of digital material for training courses. It is recommended that organisations using RPAS for roof inspection consider investing in the development of bespoke software tools for 3D visualisation of RPAS imagery and AI-assisted detection of non-compliance and defects to enable the digital transformation to these advanced inspection models.
- RPAS-assisted inspection should prioritise the segments with the highest value and risk:
    - Two-storey dwellings, which present higher risk and more significant benefits in detecting non-compliance risks;
    - Single-storey roofs where access, fragility, or safety risks are present.

8.3. Limitations and future research

The findings of this research are context-specific and should be interpreted within the regulatory, organisational, and residential construction settings examined in this project. Factors such as aviation regulation, statutory inspection requirements, organisational governance, housing density, and workforce capability may differ across jurisdictions, building types, and institutional settings. Consequently, the transferability of the findings and proposed implementation approaches to other contexts should be considered with caution.

The cost–benefit analysis is scenario-based and relies on a set of assumptions regarding inspection volumes, RPAS deployment feasibility, detection rates, inspection time, rectification costs, safety benefits, equipment costs, and regulatory operating requirements. While these assumptions were informed by available inspection data, field case studies, stakeholder input, literature, and relevant policy guidance, they should be interpreted as indicative rather than as directly observed outcomes from a large-scale operational RPAS inspection program. Further research is required to validate detection performance, false-positive and false-negative rates, actual rectification costs, and realised safety outcomes across a larger and more diverse set of inspections.

The AI-assisted remote inspection scenario (C2) is based on tools that are not yet commercially mature or widely deployed at scale. Future research should assess the reliability, cost, workflow implications, and regulatory acceptability of commercially mature 3D visualisation and AI-assisted defect-detection tools under real operational conditions.

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APPENDIX

A. Remotely Piloted Aircraft Building Inspection Flight Approval Checklist

Appendix A is a draft generic template of a Remotely Piloted Aircraft Building Inspection Flight Approval Checklist focussed on the use of RPAS to assist with building inspections.

A.1. Deciding to use RPAS to assist with a building inspection?

The principle that should govern this decision is that the person who is responsible and accountable at law for the conduct of the inspection should make that decision.

- In the case of mandatory inspections, that person is the relevant building surveyor;
- In the case of compliance and assurance inspections, it is the person authorised by the legislation to conduct the inspection;
- And in non-statutory inspections (such as might be caried out by a builder, owner or insurance company), the person with the contractual right to initiate and determine the scope and nature of the inspection.

A.2. Which RPAS should be used?

The choice of RPAS should take into account payload, sensor type, range, and utility and feasibility for particular sites and inspection elements.

Also need to ensure minimum regulatory (legal and operational) requirements in the following areas:

- data precision standards;
- IP licensing to enable regulatory oversight and data exchange;
- compatibility and interoperability requirements;
- data provenience, management and retention (auditable; etc to ensure admissibility in enforcement proceedings);
- privacy protection, data security and cybersecurity.

A.3. Who should operate the RPAS?

The pilot could be a building surveyor / plumbing or roofing inspector / third party assessor also trained in the use of drones, or a commercial / specialist drone pilot retained by a building surveyor / plumbing or roofing inspector / third party assessor to assist with an inspection.

Importantly, whoever is chosen to pilot the RPAS must be accredited or licensed with CASA, and must be competent to conduct the inspection. They need to have:

- the RPAS flying knowledge and skills to operate the RPAS safely, effectively and in compliance with all regulatory requirements – the importance of this increases with the complexity of the site, and with the sophistication, size and weight of the RPAS being employed; and

- the building and technical knowledge to capture the imagery necessary to achieve the inspection objectives.

A simple example to illustrate – the use of a video recording to facilitate a building inspection. The pilot would need to know:[159]

- what features are important to capture and why;
- when and how to take a wide pan to facilitate a broader assessment of the site, and when to zoom into specific elements;
- the correct flight paths and angles to accurately capture required features;
- the correct settings for fixed image and video cameras such as exposure levels, focussing and depth of field and focal length;
- techniques such as incorporating scale elements to calibrate perceived size and proportions.

Added to this is a third requirement: independence. The person operating the technology should be sufficiently independent of the persons whose work is being inspected. In the case of regulatory inspections (mandatory and compliance and assurance), construction personnel, plumbers and other persons whose work is the subject of inspection should not be piloting the RPAS or otherwise participating in the inspection in a manner that could create perceptions of a conflict of interest.

Deciding whether a person:

1. has the building and technical knowledge commensurate with the nature of the inspection being conducted;
2. has the technical skills, knowledge, and competence (and in some cases (e.g., RPAS) licence) to use the technology for the purpose of the inspection; and
3. is sufficiently independent of the persons whose work is being inspected,

should be made by the person who decides to conduct the remote inspection (see Section A.1. above; indeed, it is part of the one decision).

[159] Australian Institute of Architects, Response to Victorian Building Authority Guideline for the Conduct of Non-mandatory Remote Video Inspections (RVIs) 1st Edition August 2020.

A.4. Personnel, Site and Inspection Details

This checklist is based on the template Flight Record in the CASA RPA Sample Operations Manual, to which other relevant legal requirements in the Victorian Building Act and Regulations, state, territory and local laws, and the common law, have been added. The content of the Checklist may vary according to any authorisations, exemptions and conditions obtained by the organisation, and notwithstanding it is drafted for a ReOC holder, it is suitable for use by non-ReOC holders (with minor modification).

The Checklist reflects a manual system. Organisations using RPAS at scale employ the Aviation Compliance and Risk Management System (AVCRM). The AVCRM system is an online aviation management system for RPAS operations. The AVCRM system provides operational planning, job safety assessment, aviation map information, approvals, document storage, inventory, defect logging, incident reporting, pilot qualification management, weather, regulatory information and compliance monitoring for subscribers.

Name / position of commissioning person:		
Name and ARN of pilot:		
Name and ARN of ReOc Holder:		
Site address:		
Proposed date of inspection:		
Building inspection / drone flight task overview:		
Other parties to the inspection and their role:		
Site conditions / safety assessment		
Consent to enter and record, if required (yes / no, and details)[160]		
Has the drone pilot been briefed on the purpose and nature of the inspection and the aerial data required to be captured?		☐
Does the drone pilot have the skills, knowledge and experience to conduct the RPA assisted inspection?[161]		☐

[160] In the case of mandatory and compliance and assurance inspections, it is a statutory right to enter and record. In non-statutory inspections, the right needs to be obtained contractually.

[161] The pilot not only must be accredited or licensed with CASA, they also must be competent to conduct the inspection. They need to have the RPA flying knowledge and skills and the building and technical knowledge to capture the specified aerial data safely, effectively, and in compliance with all regulatory requirements and in satisfaction of the inspection objectives.

A.5. Drone Flight Requirements

A.5.1 Pre-flight Operations overview and preliminary assessment

Operation identifier:	
Name and ARN[162] of pilot:	**See above.**
Name and ARN of ReOC:	**See above.**
Drone flight task overview:	**See above.**
Location: **Recovery Location:** **Launch Location**	
Proposed date(s) and time(s):	
Proposed RPAS type/model(s) and registration details:	
Maximum height planned:	__________ **m AGL**
Preliminary assessment:	

Against Standard Operating Conditions:

	YES	NO
30 m from people can be maintained	☐	☐
Must not fly above people (30 m cylinder)	☐	☐
Clear of populous area	☐	☐
Below 122 m / 400 ft AGL	☐	☐
Outside of an active restricted area	☐	☐
Outside of the no-fly zone of a towered airport	☐	☐
Outside of the no-fly area during a relevant event	☐	☐
Operating in day VMC (visual meteorological conditions)	☐	☐
Operating VLOS (visual line of sight)	☐	☐
Not near active emergency operations	☐	☐
RPA weight 2 kg or less	☐	☐
Against Other Requirements:		
Noise approval not required (or obtained if required)	☐	☐
Keep within the boundaries of the property	☐	☐
Minimise risk of filming people in adjacent properties	☐	☐
3 m from standard pole power lines / 6 m from tower lines	☐	☐

If answered YES to ALL the above, complete below and submit to Chief Remote Pilot for authorisation: (Go to Section 2.3)

If answered NO to ANY of the above, complete the Job Safety Assessment (Go to Section 2.2).

[162] Aviation Reference Number issued by CASA

A.5.2 Job safety assessment

Map of operating area showing launch and landing locations and any relevant hazard

Airspace class(es) and height(s)		Maximum operating height	m AGL
PRD (prohibited, restricted and danger areas)		Maximum operating altitude	m AMSL
Nearby aerodromes (include location, distance, type)			
Aeronautical radio frequencies			

VLOS	☐	EVLOS	☐	BVLOS	☐	DAY	☐	NIGHT	☐

Airspace hazards and mitigations

Ground hazards and mitigations (people, obstacles, interference, etc.)

Do the special operating procedures in the CASA approved Operations Manual adequately mitigate all hazards? (circle applicable)	YES	NO
If NO, detail unmitigated hazards		

Preliminary assessment / JSA accurate (circle applicable)	YES	NO
If NO, record changes here		
Additional operating restrictions/limitations		
Identification of official authorisation obtained (if applicable)		

A.5.3 Authorisation

Flight authorisation Approved (circle applicable)	YES		NO
Chief Remote Pilot:	ARN:	Sign:	Date:
Registered Pilot:	ARN:	Sign:	Date:

A.5.4 Flight log

Part A

Remote Pilot to complete before commencing operations.

Remote Pilot	Observer/crew	
Weather (confirm that conditions meet manufacturer limitations)		
Consents (e.g., to fly within 15 m of people)		
Onsite validation of planning documentation completed	RP initials:	

Detail any omissions and errors in planning document here

Part B

Remote Pilot to complete at the conclusion of operations.

Was the operation conducted in accordance with Section 2?	YES	NO
If NO, record changes here		

General comments

B. Cost-Benefit Calculations

Appendix B describes the assumptions and calculations involved in the cost-benefit analysis.

B.1. Overview of parameters and assumptions applied

Parameter	Assumption Applied	Rationale / Treasury Alignment
Evaluation Horizon	10 years	Consistent with Treasury guidance that the analysis period should reflect the economic life of the decision or capability rather than individual assets. Appropriate for regulatory service delivery interventions.
Discount Rate (Central Case)	4% (real)	Victorian DTF central case discount rate for regulatory and service delivery contexts with evaluation periods exceeding one year.
Discount Rate (Sensitivity)	7% (real)	Applied as a sensitivity test to reflect higher opportunity cost and uncertainty, consistent with medium-risk public sector investments.
Annual Inspection Volume	7,750 inspections for buildings	Reflects typical annual proactive inspection activity of a large building regulator. Forms the program-level unit of analysis.
Roof Inspection Share	1,232 (15.8%) conventional roof inspections	Proportion of inspections involving conventional roof inspection for Class 1a dwellings, based on recent regulator data.
Multi-Storey Share	~40% of conventional roof inspections	Reflects observed inspection mix and higher-risk inspection context.
RPAS Equipment Lifespan	2–3 years	Based on manufacturer guidance and operational experience; equipment replaced at end of useful life.
Training Costs	Initial training in Year 1; refresher training every 3 years at 20% of initial cost	Reflects skills maintenance requirements without assuming full retraining cycles.
Cost Growth	2.5% p.a. (CPI)	Standard real-cost escalation assumption for labour and equipment.
Productivity Improvement	1% p.a. efficiency gain	Captures learning-by-doing effects and operational optimisation over time.
Insurance Premiums	Baseline rates for ladder inspections; reduced premiums for RPAS scenarios	Reflects lower injury exposure associated with reduced working-at-height risk.
Residual Value	Not included in base case; indicative 20–30% residual value at Year 10	Conservative treatment; exclusion biases results against RPAS scenarios. Inclusion would marginally improve NPV.

B.2. Overview of assumption category for inspection scenarios

Assumption Category	A1* (Conv., single-storey)	A2* (Conv., multi-storey, proxy)	B1** (RPAS-assisted)	B2** (RPAS + ladder)	C1** (Remote with RPAS imagery)	C2** (Remote + AI automation)
Discount Rate (4% / 7%)	✓	✓	✓	✓	✓	✓
10-Year Horizon	✓	✓	✓	✓	✓	✓
Inspection Volume Assumption	✓	✓	✓	✓	✓	✓
Roof Inspection Share	✓	✓	✓	✓	✓	✓
RPAS Equipment Costs	–	–	✓	✓	✓	✓
RPAS Replacement Cycle	–	–	✓	✓	✓	✓
Training & Refresher Costs	–	–	✓	✓	✓	✓
Productivity Improvement (1% p.a.)	–	–	✓	✓	✓	✓
Insurance Premium Reduction	–	–	✓	✓	✓	✓
Residual Value Sensitivity	–	–	✓	✓	✓	✓
Regulatory Flight Constraint (27%)***	–	✓	✓	✓	✓	✓

* Scenarios A1 and A2 represent the baseline, with no RPAS-specific capital, training, or productivity assumptions applied.

** Scenarios B and C inherit all base program assumptions plus RPAS-specific cost, risk, and productivity parameters.

*** Regulatory airspace constraints are applied to all RPAS-assisted scenarios through reduced deployable site counts.

B.3. NPV and BCR calculations

Example Case: Multi-Storey Buildings

Note: All dollar values are rounded to the nearest integer.

Assumptions:

- Inspection scenario: Hybrid (B2)
- Number of inspections/year where RPAS deployment is feasible: 410 (73% of 562)
- Conventional defect detection rate: 80%
- Hybrid defect detection rate: 93%
- Defect rate: 16%
- Defect rectification cost: $4,890 (See B.4.)
- Time span: 10 years
- Discount rate: 7%

Cost calculations:

- Initial capital (large organisation): $32,800 (8x RPAS + Accessories)
- Residual value (Year 10): $9,840 (30% of replacement cost)
- Cost per inspection: $150
- Annual cost = 410 inspections × $150 = $61,500

Benefit calculations:

- Detection benefit = (Hybrid detection rate – Conventional detection rate) × Defect rate × Defect rectification cost = (93% - 80%) × 16% × $4,890 = $100 per inspection
- Safety benefit = (Ladder fall rate – Hybrid fall rate) × Injury cost = (0.5% - 0.2%) × $50,000 = $150 per inspection
- Total benefit per inspection = $100 + $150 = $250
- Annual Benefit = 410 inspections × $250 = $102,400

NPV Calculations:

- Annuity Factor (7%, 10 years) = 7.0236
- PV(Benefits) = $102,400 × 7.0236 = $719,212
- PV(Costs) = $61,500 × 7.0236 = $431,950
- NPV = PV(Benefits) - PV(Costs) - Initial capital + Residual value
  = $719,212 - $431,950 - $32,800 + $9,840 = $264,302

BCR:

- BCR = PV(Benefits) ÷ [PV(Costs) + Initial capital – Residual value]
  = $719,212 ÷ ($431,950 + $32,800 - $9,840) = 1.6

Victorian DTF Assessment: STRONG (BCR 1.5-2.0 threshold)

B.4. Defect rectification cost estimation

Severity	Cost * (Pre Occ.)	Cost * (Post Occ.)	Proportion **	Weighted *** (Pre occ.)	Weighted *** (Post Occ.)
Small	$550	$1,500	64%	$352	$960
Moderate	$2,000	$5,500	26%	$520	$1,430
Major	$6,000	$25,000	10%	$600	$2,500
TOTAL			100%	$1,472	$4,890

* Cost values are estimates based on commercial prices for different types of roof repairs.

** Proportions are estimated based on a likelihood of 20%, 8%, and 3% for small, moderate, and major defects respectively.

*** Weighted costs are calculated by applying proportions to their respective costs.

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