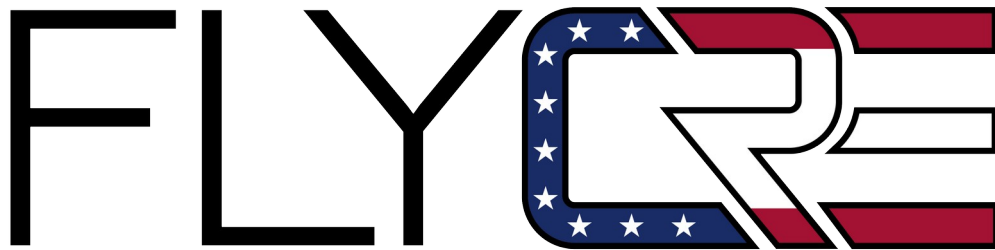


The Future of Roofing Documentation: Why Drones Are the New Industry Standard



A FlyCRE White Paper on Safety, Data Integrity, and Defensible Records

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Executive Summary

For most of the last century, the record of a roof's condition came from someone who climbed up and looked at it. That person took photos, wrote notes, and climbed back down. The record was only as good as their route, their camera, and their memory, and it was gathered at height, where a single misstep can be fatal. Falls are the leading cause of death in construction [1], and fall protection has been OSHA's most cited standard for 15 consecutive fiscal years through FY 2025 [2], and it topped OSHA's preliminary list of most cited hazards again for FY 2026 [24].

Drones address both the safety problem and the record problem. A pilot on the ground can now capture an entire roof in overlapping, georeferenced images, along with thermal and other sensor data, without anyone setting foot on the surface. The result is a dated record that can be captured the same way every time and compared over months and years.

That only matters if the record holds up. A roof record gets used by boards, adjusters, attorneys, and contractors who were not there when it was made. They need to know when it was captured, where, under what conditions, and whether anything has been changed since. They also need to know what the data can and cannot tell them.

This paper covers how aerial roof documentation is produced, the standards and rules that govern it, the published research on its limits, and what separates a defensible record from a folder of drone photos. It closes with a checklist any organization can use to evaluate an aerial documentation provider, including us.

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1. Introduction

A roof is a major building system that most owners rarely see in person. Most owners and managers see it only in photos, and most of those photos were taken by someone else for some other purpose: a roofer's estimate, an adjuster's claim file, a contractor's progress report. When a question comes up later about what the roof looked like before a storm, a leak, or a sale, those photos rarely line up. They were taken from different spots, at different times, with no common reference.

Aerial documentation fixes that by treating the roof as a mapped surface rather than a series of snapshots. The aircraft flies a planned pattern, the images are stitched into a single measured map, and every capture is tied to a date, a time, and a position on the earth. Fly the same plan again in six months and the two records can be laid side by side.

At FlyCRE, that is all we do. We capture, process, and deliver the record. We do not inspect, diagnose, repair, or survey. Interpretation belongs to the roofing contractor, engineer, adjuster, or attorney who uses the record. Keeping that line clear is part of what makes the record trustworthy.

2. Technical Overview

2.1 Data Precision and Reliability

Two kinds of precision apply to every aerial map, and they are often confused.

- **Resolution** is how much ground each pixel covers. Flying lower or using a sharper camera makes features easier to see.
- **Positional accuracy** is how close a point on the map is to its true location on the ground. Resolution does not establish it.

The American Society for Photogrammetry and Remote Sensing (ASPRS) made that distinction explicit in Edition 2 of its Positional Accuracy Standards, approved in August 2023. The standard reports accuracy as root mean square error measured against independent checkpoints, calls for at least 30 checkpoints for a full accuracy assessment, and no longer ties accuracy to ground sample distance, the ground area each pixel covers [3]. In plain terms, a provider can say a map was tested to meet a stated ASPRS accuracy only if it has been checked against independently surveyed checkpoints. A map that has not been tested that way can at most be described as produced to meet the standard, based on the provider's documented process [22].

That is why FlyCRE describes its measurements as approximate. They are intended for condition tracking and reference: comparing the size of an area between two dates, estimating a roof section, or locating a feature. They are not survey grade and are not certified by a licensed land surveyor. When a client needs survey grade results, that work belongs to a licensed surveyor under a separate agreement.

Where aerial documentation does excel is consistency. The table below compares the two ways of producing a roof record.

Aspect	Handheld Roof Photography	Aerial Documentation
Coverage	Areas the photographer chose to walk and shoot	The full roof surface in overlapping images
Location of each image	Usually unrecorded or approximate	GPS position recorded in each image's metadata
Repeatability	Depends on the person and the day	The same flight plan can be flown each cycle
Output	Individual photos and notes	A single georeferenced map plus supporting layers
Personnel on the roof	One or more people at height	None for the documentation task
Measurements	Tape or estimate on site	Approximate measurements from the map, not survey grade

2.2 Multi-Sensor Capability

Every FlyCRE flight captures four data layers, delivered in this order:

- **Orthomosaic:** a single overhead map built from many overlapping images and corrected so it can be measured.
- **Thermal:** a record of the infrared energy coming off the roof surface at the time of capture.
- **Asset Visibility:** close views of rooftop equipment, penetrations, drains, and edges captured from a safe standoff distance.
- **Multispectral:** additional spectral bands recorded on every flight so records stay consistent across properties.

Thermal imagery deserves a closer look, because it is the layer most often oversold. A thermal camera records surface temperature differences, and those differences are shaped by many things besides what is under the membrane. Published research and the governing industry standard are consistent on this point:

- **Conditions matter.** ASTM C1153, the industry standard practice for locating wet roof insulation with infrared imaging, is built around nighttime imaging and sets out the meteorological conditions the survey depends on [4]. A study of drone thermography on buildings was flown on clear nights with a large difference between indoor and outdoor temperatures [5].
- **Reflections and viewing angle distort readings.** The same study found that clear sky reflected off rooftops reduced contrast in straight down images, and noted that emissivity, which controls how a surface reads on a thermal camera, drops at steep viewing angles [5].
- **Distance matters.** Building details were harder to make out, and temperature readings shifted more, at about 138 feet above the building than at about 72 feet [5].
- **Thermal imaging is not confirmation.** ASTM C1153 provides for verifying infrared findings with invasive test methods, and it does not identify the cause of moisture or its point of entry [4].

For that reason, FlyCRE treats thermal data strictly as a record. It shows how the roof surface read at a specific time under specific conditions. What those readings mean is a

question for a qualified professional, who may need to test on site before drawing any conclusion.

2.3 Workflow Integration

The record is delivered through FlyCRE Intelligence, our secure client platform. Each capture is dated and stored so it can be compared with earlier and later flights of the same property. Because the maps are georeferenced, they line up with each other and with other mapped data the client already keeps, such as parcel boundaries or site plans in a GIS.

The value builds over time. A single flight shows a moment. A series of flights shows a timeline, and a timeline gives the client's professionals what they need to answer the questions that come up later: when a condition first appeared, whether it changed, and what the roof looked like on a given date.

3. Regulatory Context

3.1 FAA Part 107 Compliance

Commercial drone flights in the United States are governed by 14 CFR Part 107. FlyCRE operates under it on every flight:

- **Certified pilots:** every remote pilot in command holds an FAA Remote Pilot Certificate [6].
- **Altitude and visibility:** flights stay at or below 400 feet above ground level, except when flown within a 400-foot radius of a structure and no higher than 400 feet above its top, and the aircraft stays within visual line of sight [6].
- **Airspace authorization:** near airports in controlled airspace, we request authorization through the FAA's LAANC system, which can approve requests in near real time when they fall at or below the altitudes shown on the FAA's UAS facility maps; requests above those altitudes, up to 400 feet, need further coordination with the FAA [7].
- **Remote ID:** aircraft broadcast identification as required by 14 CFR Part 89 [8].

3.2 OSHA and Cal/OSHA Alignment

Federal rules require employers to protect general industry workers on unprotected edges and around holes, including skylights, 4 feet or more above a lower level [20], and construction workers from falls of 6 feet or more to lower levels [9]. California requires protection for any employee who comes within 6 feet of a skylight, with a narrow exception for short, limited exposure tasks such as measuring or roof inspection, when rigging the protection would take as long as or longer than the task itself and adequate risk control is maintained [10]. The NIOSH Hierarchy of Controls ranks eliminating a hazard above every other control, because when the hazard is removed, no exposure can occur [11].

Capturing the roof record from the ground removes the fall exposure for that task. It does not change an employer's obligations when its employees still need roof access, such as for repairs. Our companion paper, *The Safety Advantage*, covers this in detail.

3.3 Records, Evidence, and Insurance

A roof record often ends up in a dispute: an insurance claim, a construction defect case, an HOA disagreement, or a sale that falls apart. When that happens, the question is not only what the record shows but whether it can be trusted.

Evidence rules now account for digital records, and they favor records made with a disciplined process:

- **Federal courts:** Since December 1, 2017, Federal Rules of Evidence 902(13) and 902(14) have allowed certain machine generated records and data copied from electronic devices to be authenticated by a written certification from a qualified person instead of live testimony, provided the other side receives reasonable written notice in advance. For copied data, the usual method is comparing hash values, a digital fingerprint of the file. These rules address authenticity only, and the other side can still challenge the evidence [12][23].
- **California courts:** Evidence Code section 1553 presumes that a printed copy of images stored on a digital medium accurately represents those images. If a party offers evidence that the printout is inaccurate or unreliable, the party offering it must prove its accuracy by a preponderance of the evidence [13]. The presumption covers the printout, not whether the original image is authentic or accurately depicts the scene.
- **Integrity checks:** NIST describes a hash algorithm such as SHA-256 as a way to detect whether a file has changed since its digest was generated [14].

None of this makes an image admissible on its own, and nothing in this paper is legal advice. It does show what attorneys and adjusters look for: a known capture date and location, an original file that can be shown to be unaltered, and a clear account of how the record was made. Those are the same things a disciplined documentation process produces.

4. Safety and Risk Management

4.1 Hazard Elimination

In 2024, falls, slips, and trips caused 389 of the 1,034 deaths in private-sector construction, and 95.9 percent of those were falls to a lower level [21]. A study of national fatality data from 1992 to 2009 found that falls from roofs accounted for about one third of construction fall deaths [15]. Every roof walk that can be replaced by a ground based flight is one fewer person exposed to that risk.

Flying carries its own risks, and we manage them the same way any aviation operation should: by planning for them before the aircraft leaves the ground.

4.2 Safety Management

The FAA describes a safety management system as four working parts [16]:

- **Safety policy:** leadership's commitment to safety and the structure to carry it out.
- **Safety risk management:** deciding whether new or changed risk controls are needed.
- **Safety assurance:** checking that controls keep working and finding new hazards.
- **Safety promotion:** training and communication that build a safety culture at every level.

FlyCRE's flight operations follow a written standard operating procedure that puts those ideas into practice in the field: aircraft and sensor checks before every flight, defined weather limits, briefed emergency landing areas, and a log of any anomaly so the lesson makes it back into the procedure. Pilots hold current FAA certification, and the company carries insurance for its operations.

5. Data Integrity, Security, and Privacy

A record is only as good as the trust people place in it. That trust rests on four things.

- **Capture time and position:** standard image metadata includes fields for the date and time an image was created and the latitude, longitude, and altitude of the camera [17]. FlyCRE records a GPS position for every image.
- **A stored history:** every capture is kept so it can be compared with later flights of the same property.
- **Restricted access:** FlyCRE Intelligence is encrypted and is not accessible to the public. Clients see their own properties.
- **Privacy:** we do not capture data of private residences or private property we are not hired to document, and our flights are planned at altitudes that avoid disrupting operations or residents.

Organizations that want more detail on our security and privacy controls can request our Security and Privacy Controls brief through the contact form at flycre.com.

6. Strategic and Operational Impact

The biggest change is not the camera. It is moving from a single snapshot to a timeline.

- **Baselines:** a record captured when a roof is new, repaired, or purchased gives every later record something to be measured against.
- **Change over time:** scheduled captures give the client's professionals what they need to determine when a condition appeared and whether it changed, which is often the question that matters most in a claim or dispute.
- **Shared reference:** owners, boards, contractors, and insurers can look at the same dated map instead of arguing over different sets of photos.
- **Portfolio consistency:** organizations with many buildings get records in the same format for every property.
- **Fewer people at height:** the documentation task stays on the ground, and roof access is reserved for the work that requires it.

None of this replaces the people who evaluate and repair roofs. It gives them a better starting point and a record that will still be there when someone asks about it years later.

7. Conclusion: From Risk to Record

Roof documentation used to mean sending someone up a ladder and trusting what they brought back. That approach put people at height and produced records that rarely matched from one visit to the next.

Aerial documentation replaces it with something better on both counts. The pilot stays on the ground. The roof is captured the same way every time. Each image carries its date and position, and the whole record is stored so it can be compared, shared, and defended later.

The technology is not magic, and the research is clear about its limits, especially for thermal data. A provider that is honest about those limits, follows the rules that govern its flights, and keeps a clean line between documenting and interpreting is the one whose records will hold up.

That is the standard FlyCRE holds itself to. Documented Today, Defensible Tomorrow.

Appendix

A. Supporting Standards, Regulations, and References

- **14 CFR Part 107:** operating rules for small unmanned aircraft systems [6].
- **14 CFR Part 89:** Remote ID requirements for unmanned aircraft [8].
- **FAA LAANC:** automated airspace authorization for drone flights in controlled airspace [7].
- **OSHA 29 CFR 1910.28:** fall protection in general industry, including holes, skylights, and low-slope roofs [20].
- **OSHA 29 CFR 1926.501:** duty to have fall protection in construction [9].
- **Cal/OSHA Title 8, Section 3212:** floor openings, floor holes, skylights, and roofs [10].
- **ASPRS Positional Accuracy Standards for Digital Geospatial Data, Edition 2 (2023):** how map accuracy is tested and reported [3].
- **ASTM C1153:** standard practice for locating wet insulation in roofing systems using infrared imaging [4].
- **Federal Rules of Evidence 902(13) and 902(14):** self-authentication of machine generated records and copied electronic data [12].
- **California Evidence Code section 1553:** presumption of accuracy for printed images from digital media [13].
- **NIST FIPS 180-4:** the Secure Hash Standard, which includes SHA-256 [14].

B. Research Review: Aerial Thermography of Roofs and Buildings

The studies below are a starting point for anyone who wants to understand what aerial thermal data can and cannot support. They are summarized here, not endorsed, and readers should consult the full papers.

Mayer et al., Remote Sensing, 2023 [5]

- **What they did:** flew a drone with a thermal camera over buildings at two heights and two camera angles at night, plus close-range passes along the facades, and compared the results with ground based images.
- **What they found:** details were clearer and temperature readings more stable at about 72 feet above the building than at about 138 feet. Straight down images showed roofs well but suffered from sky reflections. Angled images captured both roofs and walls.
- **Why it matters:** flight height, camera angle, and weather all change what a thermal record shows. A record is only comparable to another record captured under similar conditions.

Entrop and Vasenev, Energy Procedia, 2017 [18]

- **What they did:** developed a step by step protocol for drone thermography of buildings through test flights and a literature review, then checked it on a final flight over solar panels and a building envelope.
- **Why it matters:** repeatable results depend on a written procedure, not on improvising each flight.

Rakha and Gorodetsky, Automation in Construction, 2018 [19]

- **What they did:** reviewed published uses of drones on existing buildings, including infrared energy audits and photogrammetric 3D modeling, then proposed standard procedures for drone energy audit flights and tested them on the Syracuse University campus.
- **What they concluded:** more experiments and replication are needed before such procedures can be standardized.
- **Why it matters:** the research community is still working toward standard procedures, so a provider should be able to show its own written procedure and apply it the same way every time.

ASTM C1153 [4]

- **What it covers:** the minimum conditions and procedures for using infrared imaging, from the ground or the air, to locate wet insulation in certain roofing systems, including verification with invasive test methods.
- **Why it matters:** even the standard written for this purpose treats infrared imaging as one step in a process that includes verification with invasive test methods.

C. Questions to Ask Any Aerial Documentation Provider

Use these questions to evaluate any provider, including FlyCRE. A provider whose records will hold up should be able to answer every one of them plainly.

- Do all of your pilots hold current FAA Remote Pilot Certificates, and will you show them?
- How do you get airspace authorization near airports?
- Are you insured for drone operations, and what does the policy cover?
- Does every image carry its capture date, time, and GPS position?
- Do you keep the original files, and can you show that a delivered file has not been altered since capture?
- Will the next capture of my property follow the same flight plan so the records can be compared?
- How do you describe the accuracy of your measurements, and have they been tested against surveyed checkpoints?
- Under what conditions do you capture thermal data, and do you record those conditions?
- Do you interpret the data, or do you leave interpretation to a licensed professional?
- Who can access my data, and how is it protected?
- Do you capture neighboring private property, and how do you avoid it?

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