

Enterprise Drone Inspection: Picking the Right Platform

Volume 7

Public Safety: Crime & Accident Scene Documentation

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Prologue

The most forward-thinking public safety agencies are turning to drones to accelerate and improve their crime and accident scene documentation processes. With the growing number of public safety drone options on the market today, agencies face an ever-growing number of choices. The rise of autonomy offers an entirely new way to compare drones to each other. While the previous generation of manual drones were all equally limited to 2D waypoint or manual flight, autonomous drones can document complex scenes with entirely different flight paths. These closer, more adaptive flight patterns render the old ways of comparing drones to each other based on rudimentary camera specifications, like the number of megapixels, outdated.

This paper is the seventh volume of Skydio's eBook: Enterprise Drone Inspection: Picking the Right Platform, a collection of white papers that will help enterprise drone operators from various industries make more informed decisions when choosing their enterprise drones. In this installment, we use 3D model examples and rigorous camera benchmarking to help public safety officials understand the tradeoffs of various drone systems, and the impact those tradeoffs will have on the datasets their uncrewed aerial vehicles (UAVs) can generate.

We hope that this analysis will help your drone program make its decisions based on the quality of the drone's outputs, so that you know the end product you will be able to generate as you invest in your next drone system.

ABOUT THE AUTHORS



Alex Netto

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Alex Netto is an Associate Product Marketing Manager at Skydio. Prior to Skydio, Alex spent three years leading the demand generation team for Enterprise UAS. While at Enterprise UAS, Alex acquired hands-on experience on a wide variety of drone platforms and sensors, including DJI, FLIR, senseFly, and Autel. He also produced extensive drone use case content for DSLRpros.com and Dronefly.com. Alex has a bachelor's of science degree from the University of Oregon and is working on his Masters of Business Administration from California State University Northridge.



Guillaume Delepine

Senior Product Marketing Manager at Skydio

Guillaume Delepine is a Senior Product Marketing Manager at Skydio, the leading American drone manufacturer and world leader in autonomous flight. In his tenure at the company, he previously led Skydio's efforts to serve first responders as Public Safety lead. Then, as Enterprise Strategy Manager, Guillaume contributed to the fundraising, planning, and hiring process that led to Skydio's recent announcements of a Series D fundraise at a valuation of over \$1 billion USD, expanded roadmap, and growing executive team. Guillaume holds a BA from Princeton University, and took leave of the joint MPP/MBA program at Harvard University to join Skydio.



Russell Bondi

Image Quality Test Engineer at Skydio

Russell graduated from University California Santa Cruz with a major in Photography. He spent the majority of his time there working on digital photography from his weekend job at Skydive Hollister. His love for action sport photography and his understanding of subjective review led him to a career at GoPro, where he was the lead Image Quality Test Engineer on the Hero 6 and 7. His role was to uncover all image quality issues and help find the path to a fix. Working closely with ISP Tuning Engineers, as well as Firmware Engineers, to get products out the door in the best shape possible. When Russell is not working, he spends the majority of his time outdoors either surfing, mountain biking, skydiving, or snowboarding.

Crime & Accident Scene Documentation

Mapping and documenting accident crime scenes pose significant challenges to law enforcement officials. Traditionally, accident reconstructionists had been limited to simple photographs and measurements to document the scene. For car accidents, reconstructionists were unable to capture top down imagery that would show the relative positions of the cars in 3D space, this significantly limited the quality of the evidentiary data. Another side effect was the societal disruption of closed lanes during the lengthy process of evidence documentation.

Drones have amazing potential to solve many of these problems. However, manual drones cannot be trusted to fly up close to these kinds of accident scenes. The complex area around a car crash with street signs, other cars, people, vegetation, and structures is difficult for a manual drone operator to navigate near. So, to capture a car crash, a manual drone operator would have to maintain a long standoff distance from the scene, and rely on an expensive and delicate zoom camera to generate precision imagery from a high-altitude grid pattern. Even then, some of the sides of the cars would be obstructed due to the long stand off distance and other obstacles in the way such as trees, street signs, and barricade walls.



An officer can quickly deploy the Skydio 2 to produce a 3D model of the crash scene with a level of precision that can be attained of all areas of the accident, including the exact orientation and crumple zone of the vehicles. Source: Skydio.

For crime and accident scene reconstruction Skydio's Adaptive Mapping algorithms programmed into 3D Scan™ give the drone the ability to iteratively design a structure-specific 3D scanning path, and follow it with full obstacle avoidance engaged. As a result, the drone will fly this scanning path and can capture hundreds of images up close, from multiple angles, giving the accident investigators a holistic view of what happened. This ability to create a 3D digital twin provides the necessary context of vehicles in an accident that is hard or impossible to capture with a 2D flight pattern map or still photography. With 2D capture, the operator is creating a top down or satellite view of the scene, but fundamentally limits the amount of information collected by the reconstructionist. Being able to understand what is happening on the sides of the accident and to fully see the depth of the scene is where the real value of having a 3D model comes from. Being able to accomplish all this with minimal operator preparation and in record time to minimize the societal impact is where the unique value of Skydio 3D Scan is realized.

Mock Car Crash 3D Model

Below is an example 3D model of a mock car crash, generated with a Skydio 2 and Skydio 3D Scan. The photos are taken at 7.2 feet (2.2 meter) from the structure, providing a 0.927 millimeter ground sampling distance, and 422 photos total. In the selected shots, it is clear that the drone captures every angle of the car crash, especially the sides of all 3 cars, where manual drones cannot fly safely, because of the close proximity to the buildings on both sides of the street. As an accident report, this model would show the exact impact points and locations of even the smallest details on the car. The full model is on display on the Skydio Sketchfab Account, which can be accessed at the URL at this footnote. Further details on the model are listed below for reference.

Capture

Platform: Skydio 2

Date: April 13, 2021

Distance: 7.2 feet

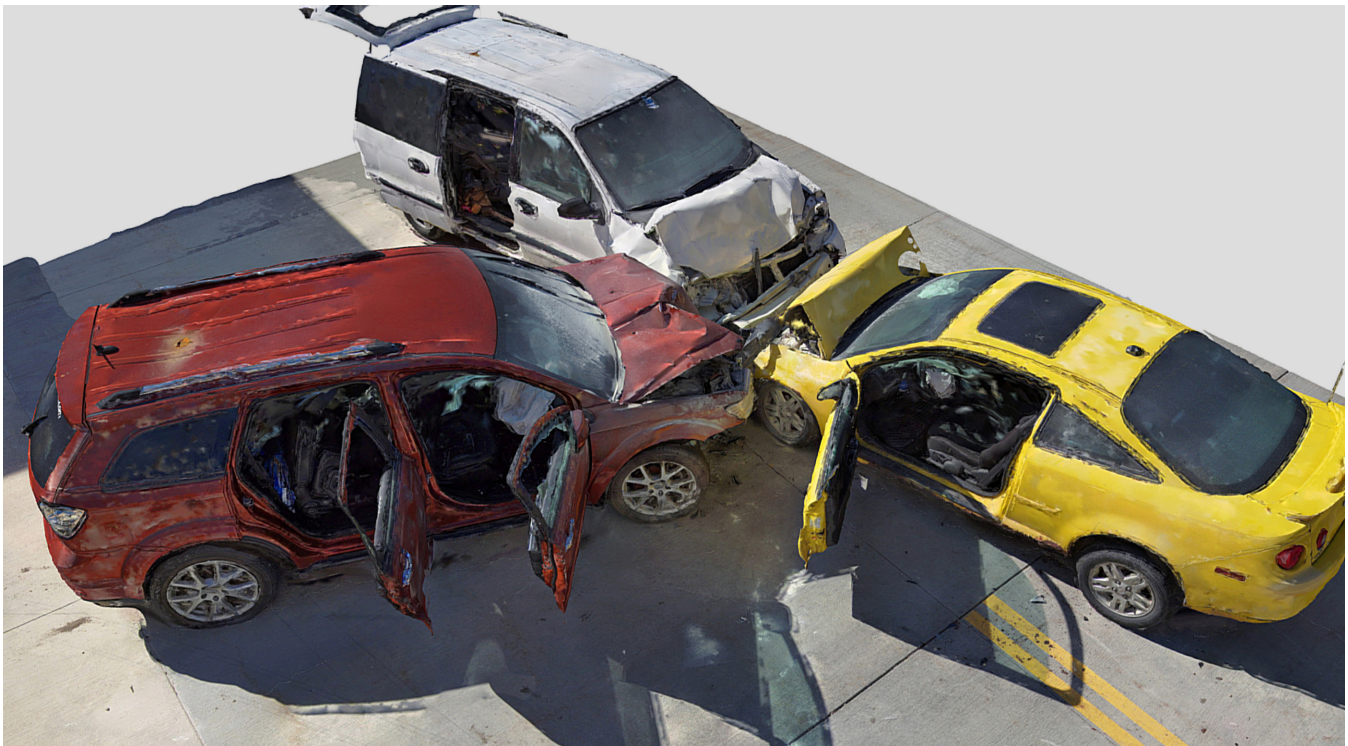
Ground Sampling Distance (GSD): 0.927 mm

Overlap / Sidelap: 80 / 70%

Photos: 422

Flight Time: 18 min (approx. 1 battery)

Processing Package: Bentley ContextCapture



Skydio 3D Scan™ autonomously generates a custom data capture plan for the scene after the operator specifies the scan area. This helps the drone generate consistent, up-close imagery that maximizes photo quality with intelligent flight paths.

¹ View the 3D model of the Mock Car Crash here: <https://sketchfab.com/3d-models/car-crash-4a18c4cab3e14ebd8750adb8e8428d94>













In most crash scenarios, first responders need to focus on many things at once, including saving lives, clearing the site as fast as possible to minimize disruption, and documenting the scene of the incident. The pilot simply defines the area of interest (scanning volume) and Skydio 3D™ Scan makes the scene documentation process easy with adaptive mapping algorithms that pilot the drone to make a structure-specific 3D scanning path, and follow it with full obstacle avoidance engaged. This unique hardware and software combination gives first responders an easy to use tool that really makes a difference in the field.

Key requirements for Remote Asset Management

Resolution	~ 1mm
Photo Quality	Sufficient clarity for judicial review
Photo Location	80%/80% Overlap/Sidelap with full and redundant photo coverage
Relative and Absolute Accuracy	Only relative accuracy typically required

To better illustrate the impact of camera software, we conducted a study comparing the Skydio 2, DJI Phantom 4 Pro V2.0, and DJI Mavic 2 Pro, to understand which camera would generate the best results. Our test subject was a standard license plate, which can help first responders understand what level of detail they might be able to detect after conducting a crime or accident scene investigation. We took photos of the license plate from various equivalent standoff distances (how far the camera is from the subject) and at various ground sampling distances (how much area on the subject is covered by a single pixel), to see how the various cameras performed. A reconstructionist needing to get precise details would need to zoom into specific features, so here we have cropped all the photos to the same field of view to illustrate the cameras' performances at various GSDs. Here we present a comparison of photos at the same ground sampling distance, and further comparisons by standoff distance are available in Appendix 3.

Camera Performance on a License Plate

Ground Sampling Distance (mm/pixel)	Skydio 2	DJI Phantom 4 Pro V2.0	DJI Mavic 2 Pro
0.25 mm	0.59 meters from subject 	0.92 meters from subject 	1.05 meters from subject 
0.5 mm	1.19 meters from subject 	1.83 meters from subject 	2.10 meters from subject 
0.75 mm	1.78 meters from subject 	2.75 meters from subject 	3.16 meters from subject 
1 mm	2.37 meters from subject 	3.67 meters from subject 	4.21 meters from subject 

This figure compares the camera systems on the Skydio 2, DJI Phantom 4 Pro V2.0, and DJI Mavic 2 Pro drones, at four levels of ground sampling distance (GSD). The distance from the subject that corresponds to the GSD is unique to each camera and indicated in each cell. Photos are cropped to the same frame to enable comparisons of which camera generates fine detail. Note that drones were hand-carried for the study - while Skydio 2's trustworthy obstacle avoidance system enables up close flights, capturing imagery at short standoff distances is risky with DJI drones. Source: Skydio

The comparison above reveals several interesting insights that matter to teams looking to choose the right camera system for their inspection needs. It is important for customers to compare cameras at equivalent GSDs, because this can be controlled for by flying closer or farther away. So we control for GSD such that readers can gain insight on how the quality of the camera tuning will impact the photo outputs available to their teams. Our image quality team notes:



Skydio 2 photo taken at 0.75mm ground sampling distance



DJI Phantom 4 Pro V2.0 photo taken at 0.75mm ground sampling distance

Tone Mapping

Observe the area around the license plate, where the DJI cameras sacrifice detail to provide a brighter screen. In the Skydio photo, dirt and bird droppings on the trunk of the car are clearly visible, while the DJI cameras overexpose the white paint and lose all the detail (both the Mavic 2 Pro and the Phantom 4 Pro). In a crime or accident scene reconstruction, this can be the difference between detecting a critical piece of evidence, like a skid mark, and having an entire drone dataset thrown out of a trial because it didn't match a report from a point and shoot camera.

Watch for Over-sharpening

Observe the word "California" on the top of the license plates. The DJI photos pixelate this text more than the Skydio photos, even though these photos are taken at the same ground sample distance - meaning the pixelation has nothing to do with the size of the sensor or the distance of the camera from the subject. This is an over-sharpening artifact caused by the DJI drones not having enough contrast from the sensor, and trying to compensate with algorithmic sharpening. The result is that fine details may be invisible with the DJI cameras, even though the cameras do not lack for pixels.

Other than these slight differences, the photos are largely similar. Operators should note that even with a smaller sensor, the Skydio 2 can provide better photos.

Skydio Solutions for Public Safety

After reading the previous chapters, it is our hope that you feel more equipped to make a decision regarding your selection of drones. As you take this knowledge into the field to evaluate the available technologies, below is a concise summary of the components that make up the Skydio solution for public safety. Your Skydio sales and solutions engineering teams can help you determine which options are right for your program and make a plan to implement them.

Skydio 2+

An entry-level drone to introduce autonomy to public safety workflows. Features a 12MP camera, and six 4K color sensors used to support Skydio Autonomy enabling true 360° obstacle avoidance in every situation and up to 27 minutes of flight time. Backpack portable and easy-to-use, Skydio 2+ can be provided to any inspector to start taking advantage of aerial data.



Skydio 2+

Skydio X2E

Pairs the breakthrough Skydio Autonomy™ engine with a ruggedized airframe that features a color or optional dual color/thermal sensor, long-range operations, and extended battery life for up to 35 minute flight time. Core autonomy capabilities include **360° Obstacle Avoidance**, **Object and Scene Recognition**, and **Skydio Visual Navigator**.



Skydio X2E

Skydio Enterprise Controller

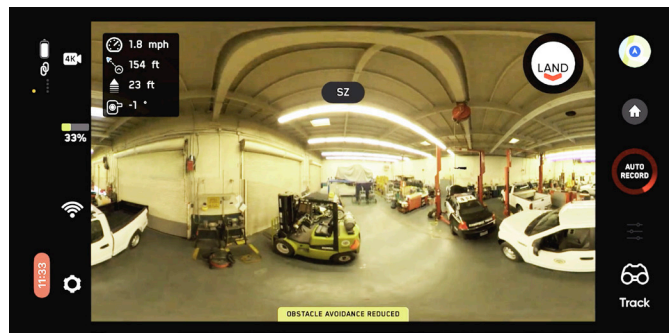
Ground control for X2E is enabled via the Skydio Enterprise Controller, which was designed from the ground up for pilots with demanding operating requirements. Ground control software is natively delivered via the Skydio Enterprise App.



Skydio Enterprise Controller

Skydio Autonomy Enterprise

Delivers the professional flight experience required to meet the challenges of the most complex missions and environments. Leverage AI-pilot assistance capabilities to maximize your situational awareness and achieve ultimate flight control in obstacle-dense environments. Key features of this package include **360 Superzoom™**, **Close Proximity Obstacle Avoidance**, **Vertical View**, and **Visual Return to Home**.



Skydio Autonomy Enterprise

Skydio 3D Scan™

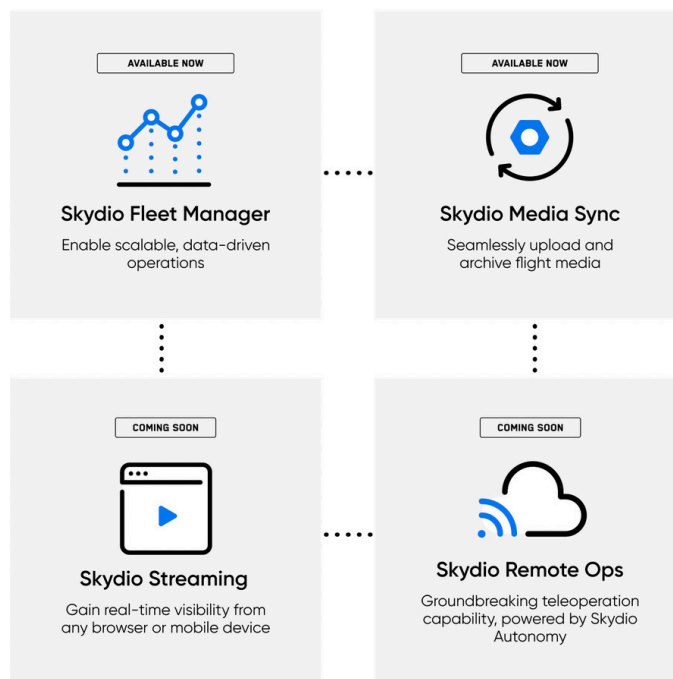
The first-of-its-kind adaptive scanning software built on top of Skydio Autonomy. 3D Scan allows the drone to automate the data capture process needed to generate 3D models with comprehensive coverage and ultra-high resolution, so that crews can perform higher quality scans in less time and with minimal pilot training.



Skydio 3D Scan

Skydio Cloud

Skydio Cloud serves as a foundation for autonomous connected flight operations as well as API-based integrations with our partner ecosystem. It includes Skydio Fleet Manager and Skydio Media Sync, which help distributed fleets manage their operations and data more effectively than they can with spreadsheets and SD cards. Skydio Streaming and Remote Ops are both coming soon, and allow for real-time monitoring and execution of drone operations through the cloud.



Skydio Academy

Delivered online, or in-person, in both self-paced and instructor-led configurations, Skydio Academy provides flexible options for your pilots to achieve the **Skydio Professional Operator (SPO)** and **Skydio Expert Operator (SEO)** certifications that can help a program manager manage and track core competencies across a distributed pilot fleet.



Skydio Professional Operator (SPO)

Certifies **foundational knowledge** about Skydio aircraft, preflight, launch, flight skills, landing, postflight, maintenance, and troubleshooting.



Skydio Expert Operator (SEO)

(requires Skydio Professional Pilot certification)

Certified **real-life flight skills** to safely and efficiently operate Skydio aircraft and software. As an SEO, you will be ready to take flight with complete confidence.

Conclusion and Looking Ahead

The data captured is the most important output of a drone for scene documentation and producing a useful dataset can help a drone program scale within a larger public safety organization. Therefore, we encourage drone operators to work with their downstream colleagues to make sure that the drones they purchase can produce sufficient datasets to meet the precision requirements. The tools in this white paper can help operators look beyond the specifications of the hardware, and instead focus on the outputs the system can generate. Choosing in this way can greatly improve an organization's chance of success.

In the next installment of this eBook, we will be taking a deep dive using similar analytic techniques, on how not to evaluate inspection drones. Stay tuned for the next volume!



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