Skydio

EBook

Enterprise Drone Inspection: Picking the Right Platform

Volume 2

High-Precision Construction Management: How to Get Decision-Quality Data From Your Drone Program

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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.

Brian Richman

Senior Product Manager at Skydio

Brian Richman is an Enterprise Product Manager at Skydio with almost 10 years of experience in drones. Brian works on realizing Skydio's vision for automated drone inspection and mapping by enabling levels of safety, precision, and data quality beyond what even the best drone pilots in the world are capable of. Before Skydio, Brian was the product lead for Airware's Mobile business unit, launching a pioneering end-to-end commercial drone configuration and flight software. Brian is also a former R&D team lead for the RQ-23 Tigershark program, with 700+ combined flight hours as a pilot, payload operator, and mission commander.

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.

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Prologue

With the growing number of enterprise drone options on the market today, operators face an ever-growing number of choices. Critically, 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 perform inspection missions 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 second 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 construction organizations understand the tradeoffs of various drone systems, and the impact those tradeoffs will have on the datasets their program 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.

Data Quality Requirements for Key Use Cases

Different inspection programs are likely to have different data quality requirements. The true requirements for a dataset come from the consumer of the data—whoever needs to receive an inspection report and either certify approval or take corrective action. To provide context as operators assess the level of quality that will be required to scale their drone inspection programs, we have assembled key requirements from anonymized sets of customers in the various industries that have adopted drones for inspection.

Skydio's Solutions Engineering team works with drone programs day in and day out to understand and document their requirements and make sure our customers end up with the best possible drone operations. They have been instrumental in helping to document the requirements that are typical for various industries. While this list is not exhaustive, the industries this eBook will focus most on are:

Industry	Typical Use Cases	Asset to Scan	Artifacts to detect	Common Precision Requirement (GSD)
Construction	**Primary:** Progress Assessments **Additional:** • Inventory management (Volumetrics) • Site Survey	Construction sites, equipment inspections	Asset damage, misalignment vs. tolerance across subcontractors	Up to 1 cm
Focus of this volume				
Transportation	**Primary:** Bridge Inspection **Additional:** • Inventory management (Volumetrics) • Road grading & survey	Bridges, Roads, Railroad Tracks	Cracks and delamination in concrete, bolts, nuts, connection points in weight bearing areas	Sub-millimeter to 5 mm
Utilities	**Primary:** Transmission & distribution inspection **Additional:** Long linear inspection for wildfire risk	Power plants, Transmission Lines, Oil Pipelines	Rust and loose bolts	Up to 0.5 cm (Primarily photos, not models)

Industry	Typical Use Cases	Asset to Scan	Artifacts to detect	Common Precision Requirement (GSD)
Telecom	**Primary:** Digital Twins for Remote Management	Cell Towers	Labels on antenna arrays, antenna orientation, structure damage	< 2 mm
Insurance	**Primary:** Roof Inspection	Homes	Hail damage	< 1 mm
First Responder	**Primary:** Collision scene reconstruction **Additional:** Crime/ Arson investigation	Crime or accident scenes	Crumple damage, skid marks, weapons, broken glass	~ 1 mm

In this Volume, we will take a deep look at the technologies and outputs available to Construction operators, using both customer experiences and rigorous camera benchmarking to make sure operators in the industry have all the data they need to make the right decisions.

Meeting the Bar for Construction Inspection

Construction sites are a massive collaboration between various contractors and subcontractors working together to build against an agreed-upon blueprint. With so many moving parts, errors are inevitable and can be expensive, especially if they require the removal and re-pouring of concrete. Performing frequent, minimally-intrusive as-built assessments by drone can help sites detect minor errors before they become costly errors, and keep their jobs on track. These assessments can also serve as progress reports to keep the customer apprised of the job progress and for billing purposes.

In particular, 3D models can help with Building Information Management (BIM) coordination, where general contractors need to work with subcontractors to coordinate electrical wires, plumbing, heating ventilation and cooling (HVAC) systems, and more. Overlaying these 3D models to determine where conflicts will occur ahead of time can forestall many expensive errors. Identifying a construction error within the building phase can save substantial amounts of money and pay off the cost for a drone system.

Construction sites often require inspections of high-pressure systems, where it is safer to send a drone than a human inspector. Source: Sundt Construction.

From Skydio Solution Engineering's engagements with construction companies performing as-built assessments, the requirements below have emerged as common across a wide range of users.

Key requirements for Progress Assessments	
Resolution	Up to 1 centimeter
Photo Quality	Need strong colorization, even of reflective surfaces, to replace hands-on inspection
Photo Location	80% / 80% overlap/sidelap for model generation in complex 3D and overhung environments rich with GPS and magnetometer interference
Relative and Absolute Accuracy	Only relative accuracy typically required

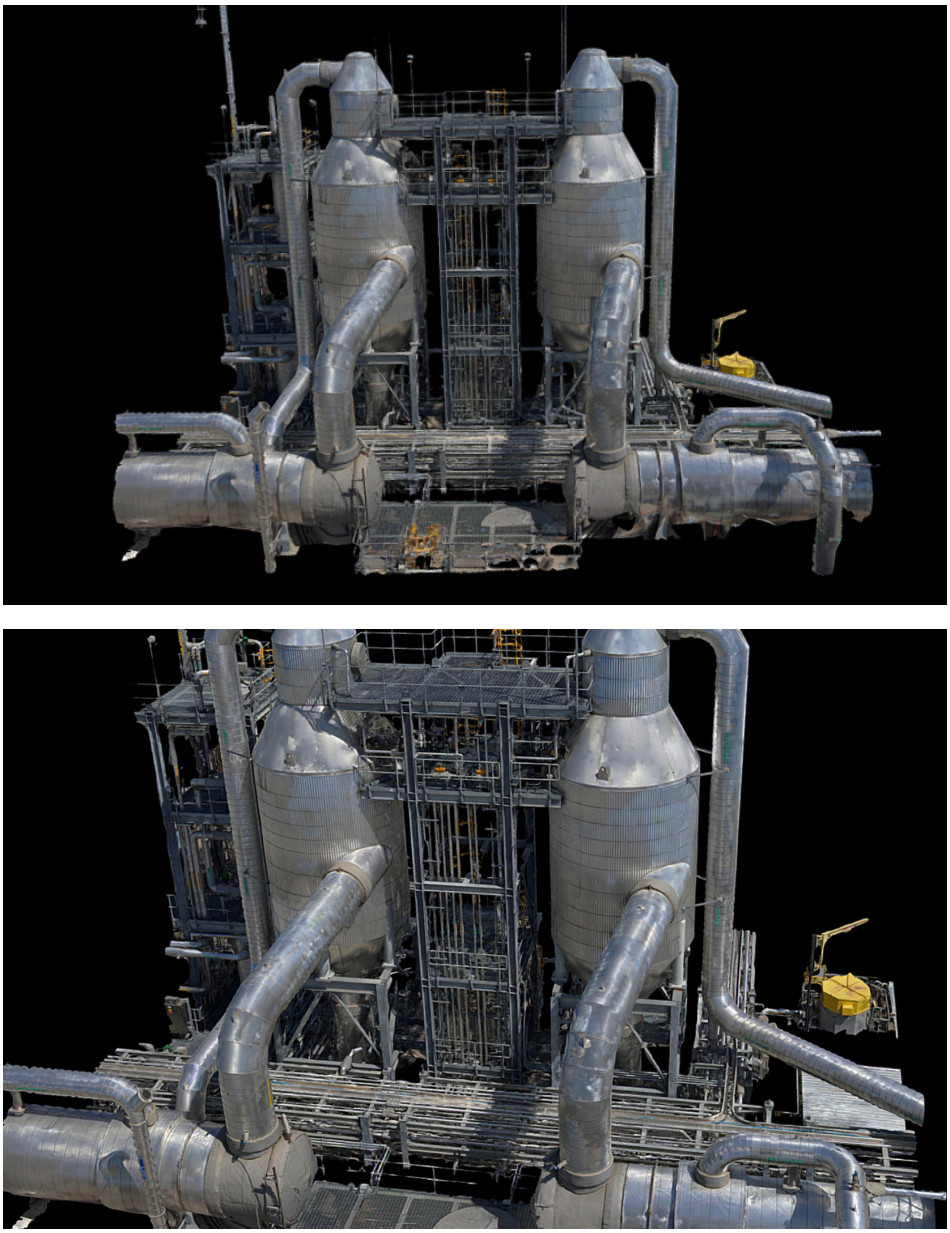
Below is a 3D model of a crystallizer water cooling tower generated fully autonomously by Skydio 3D Scan™. The structure is a high-pressure, high-temperature system that cools superheated water from over 1000 degrees Fahrenheit down to around 200 degrees. The photos were taken 20 feet from the structure, providing a 2.5 millimeter ground sampling distance (GSD), and the operator was able to capture around 400 photos in just 30 minutes. Inspecting systems like these with an automated drone eliminates the need for ground-based inspection, which can put field teams in extremely hazardous situations and often requires over 4 hours of system downtime. A 3D model like this could be used for Building Information Management (BIM) coordination, progress tracking, and visual proof of delivery at the end of a job. The full model is on display on the Skydio Sketchfab Account, which can be accessed at the URL at this footnote.[1] Further details on the model are listed below for reference.

Capture

Platform: Skydio 2
Date: Apr 22, 2021
Distance: 20 feet
Ground Sampling Distance (GSD): 2.5 mm
Overlap / **Sidelap:** 80 / 70%
Photos: 440
Flight Time: 30 min (approx. 2 batteries)
Processing Package: Bentley ContextCapture

[1] View the 3D model of this crystallizer water cooling tower here:
https://sketchfab.com/3d-models/oc-watr-d09e905ce2104465a2364d1e27bf3b8e

View the 3D model of the Sepulveda Dam here:
https://sketchfab.com/3d-models/sepulveda-dam-6d5b35b3d82e44eba8c3605b255dbd3b



These screenshots from a 3D model of a crystallizer water cooling tower show the detail that can be captured in only a 30 minute flight, all without the danger to personnel from the high-pressure, high-temperature system. Source: Sundt Construction.

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 valve in an HVAC system on the roof of a commercial building, which a general contractor may find themselves inspecting for an as-built assessment after a subcontractor installs the system. We took photos of the valve structure from various equivalent standoff distances (how far the camera is from the subject) and at various GSDs (how much area on the subject is covered by a single pixel), to see how the different cameras performed. An inspector needing to get precise details would need to zoom into specific features, so here we have zoomed all the photos in to the same section of piping to illustrate the cameras' performances at various GSDs. Here we present a comparison of photos at the same GSD, and further comparisons by standoff distance are available in Appendix 3.

Camera performance on HVAC Valve

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 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

Skydio 2 Photo taken at 2.37 meters for 1mm GSD

DJI Phantom 4 Pro V2.0 Photo taken at 4.21 meters for 1mm GSD

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:

Watch out for Overexposure

Overexposure can cause some pixels in the brighter regions of the scene to be completely white (burnt out), leaving no information. This is evident on the tape along the valve, which an inspector might be looking at to detect leakage. In this comparison, the Mavic 2 Pro photo at 0.25mm GSD overexposes this tape, making it look like a white blur, while the Skydio 2 exposes the tape properly, showing the details of the scene.

Emphasize Dynamic Range

Dynamic range allows the camera to capture both bright and dark regions of the scene in the same photo, with the proper exposure. Note again in the 0.25mm GSD range - the text on the warning sticker to the right side of the photo from the Phantom 4 Pro V2.0 is illegible. On the Skydio 2, with its greater dynamic range, the text on the warning sticker is clearly legible.

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 Inspection

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 industrial asset inspection. 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 inspection 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 23 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

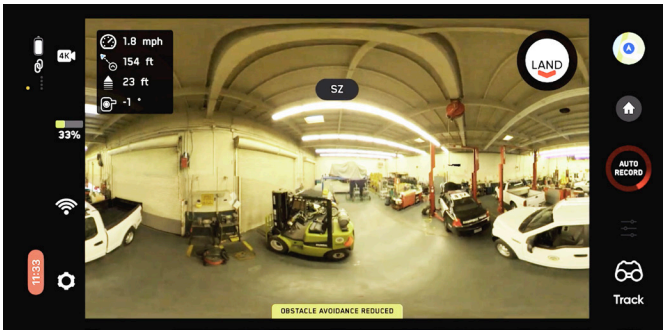
Skydio Enterprise Controller

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 Foundation

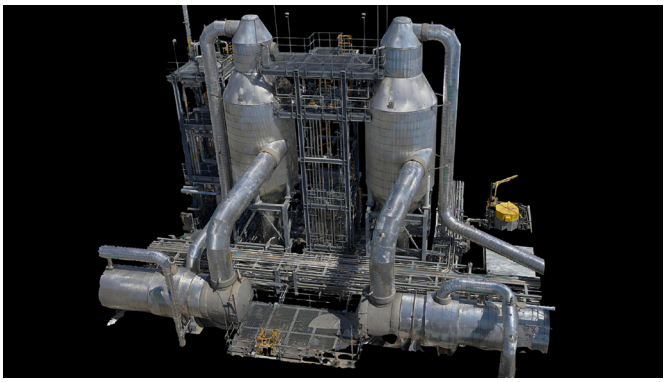
An add-on software package that augments the core autonomy engine. It's designed to assist the pilot through software capabilities that enhance flight control in obstacle-dense environments. Key features of this package include **Close Proximity Obstacle Avoidance**, **Vertical View**, and **Visual Return to Home**.



Skydio Autonomy Enterprise Foundation

Skydio 3D Scan™

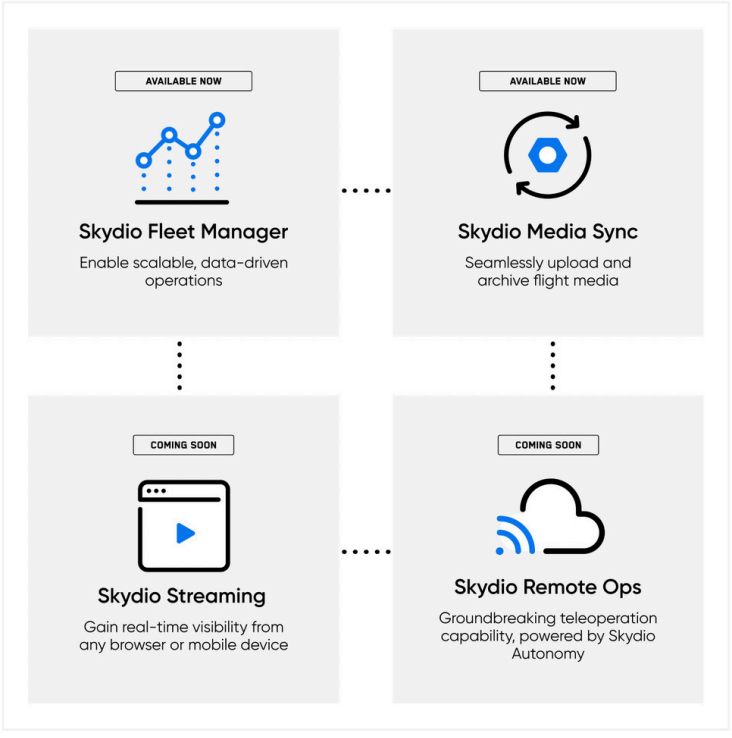
The first-of-its-kind adaptive scanning software built on top of Skydio Autonomy. 3D Scan allows the drone to automate the data capture process needed to generate 3D models with comprehensive coverage and ultra-high resolution, so that crews can perform higher quality scans in less time and with minimal 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 product is the most important output of a drone program, and producing a useful dataset can help a drone program reach scale within a large organization full of consumers of that data. 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 yet another deep dive using similar analytic techniques, to help transportation firms select the right drones for the job. Stay tuned for the next volume!