Skydio

EBook

Enterprise Drone Inspection: Picking the Right Platform

Volume 4

High-Precision Utility Management:
How to get decision-quality data from your drone program

By Guillaume Delepine, Senior Product Marketing Manager

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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

The most forward-thinking Utilities have been turning to drones to help rapidly inspect their power generation, transmission, and distribution networks. 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 fourth 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 utilities 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
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)
		Focus of this volume		

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 utility drone 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 Transportation Inspection

Utilities inspecting their transmission and distribution networks have up to hundreds of thousands of towers to inspect for damage that may cause a power outage or a fire. These towers are far apart from each other, so efficiency (both speed and avoiding rework) is absolutely critical. Utility inspectors need to check for rust, loose bolts, and other damage, but this damage generally is on the scale of centimeters, not millimeters, like for identifying miniscule cracks in concrete.

Furthermore, maintaining a full library of 3D models, though useful, is still hard to do at the level of scale that utility inspectors deal with across their entire asset bases. So, in some cases, a detailed and exhaustive photo set can suffice as an output. Still, tools traditionally used for 3D modeling are useful to make sure that the photoset is fully exhaustive, providing complete and redundant coverage of the asset. To promote efficiency in these use cases, these tools can be set to take photos with less overlap, since the photos will not need to be stitched together.

Key requirements for Bridge Inspection	
Resolution	Up to 5 millimeter
Photo Quality	Consistent exposure to capture areas backlit by the sun
Photo Location	30%/30% overlap/sidelap from multiple angles of the tower infrastructure
Relative and Absolute Accuracy	Only relative accuracy typically required

Below is an example 3D model of a power grid switch at a testing facility for a test performed by the Electric Power Research Institute (EPRI). It was generated with a Skydio 2™ and Skydio 3D Scan™. The photos are taken at 12 feet from the structure, providing a 1.52 millimeter ground sampling distance, and 468 photos from every angle of the structure. In the selected shots, it is clear that the drone captures every angle of the switch, especially the underside, where manual drones cannot fly safely, because they lose GPS connections. As an inspection report, this model would show a repair crew the locations of even the smallest defects, so that they could efficiently arrive on scene, find, and repair them. The full model is on display on Skydio.com.[1] Further details on the model are listed below for reference.

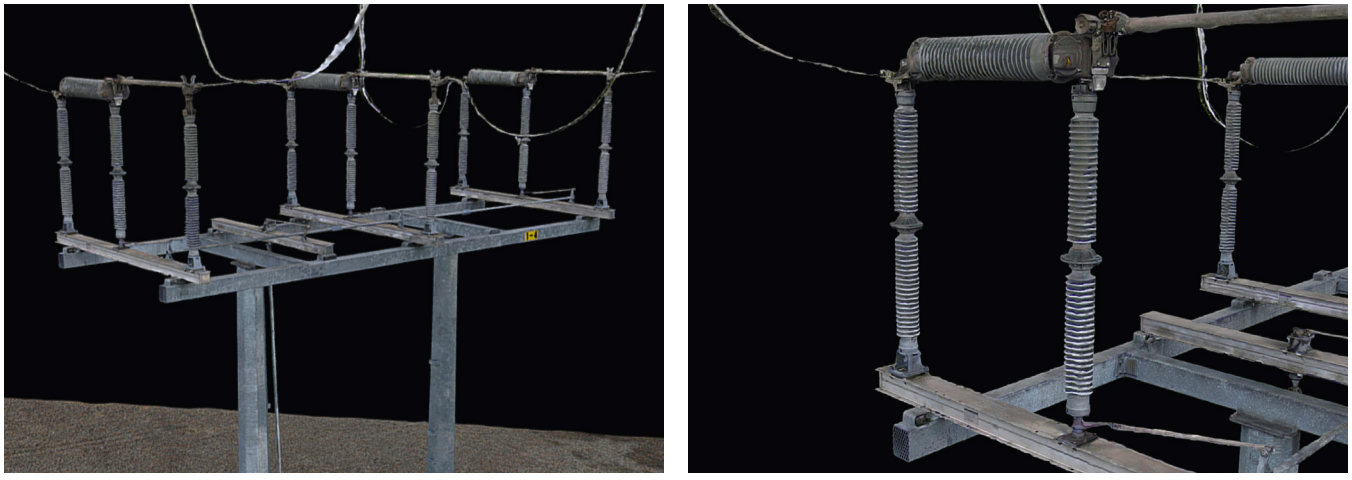
Capture

Platform: Skydio X2 Color
Date: August 17, 2021
Distance: 12 feet
Ground Sampling Distance (GSD): 1.52 mm
Overlap / **Sidelap:** 80 / 73%
Photos: 468
Flight Time: 21 min (single battery)
Processing Package: Bentley ContextCapture

Skydio thanks EPRI for their pioneering research and the opportunity to share this dataset.

EPRI | ELECTRIC POWER RESEARCH INSTITUTE

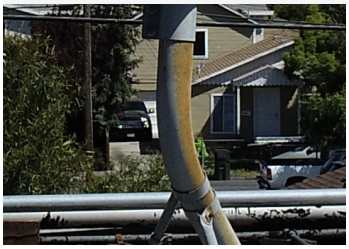
Dataset: EPRI UAS Automation Technologies for Transmission Inspection Imagery Version 1.0
Creator: EPRI, D. Lewis, P. Kulkarni
Source: IEEE Dataport
License: CC-BY 4.0



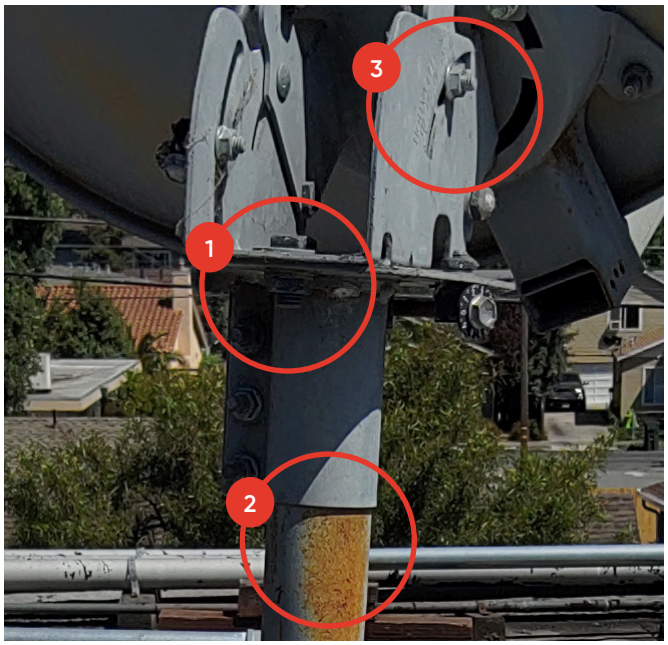
These screenshots from a 3D model of a transmission switch show the unique capabilities of the Skydio 2 and 3D Scan. Source: Skydio.

[1] View the 3D model of the Transmission switch here: https://www.skydio.com/3d-scan-gallery/epri-switch

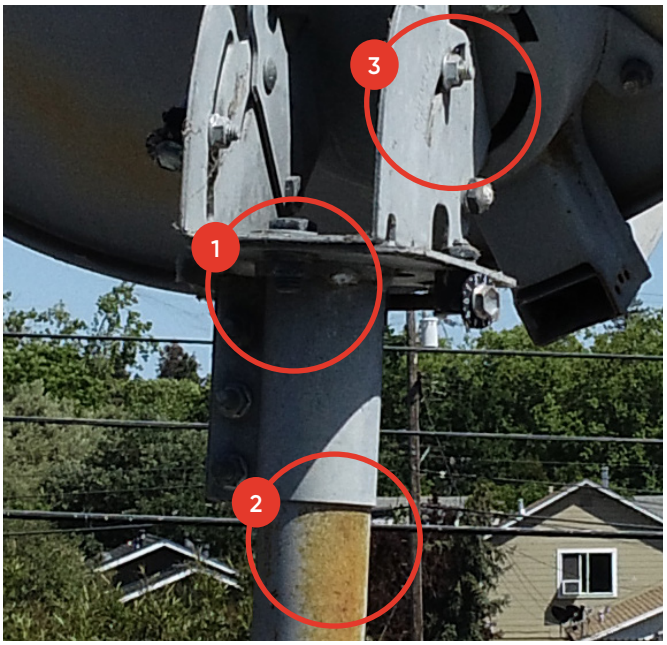
Camera Performance on Rust

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



Skydio 2 photo taken at 0.5mm ground sampling distance



DJI Phantom 4 Pro V2.0 photo taken at 0.5mm ground sampling distance

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 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:

Dynamic Range Matters

Even though these photos are at the same resolution, the dynamic range of the sensor impacts what the operator can see. Note the upward facing bolt in the shadow of the satellite dish mechanism **(1)**. In the DJI photo, it is lost in the shadows and hard to perceive, while the Skydio 2 shows the bolt with clear and vivid detail.

Color Muting

Color rendering matters for rust **(2)** detection because it helps inspectors understand the severity and depth of any rust damage. In the Skydio photos, the rust is rendered in vivid color, while the DJI photos mute the rust and make the damage look less severe. Accurate color rendering makes a tremendous impact in accurate damage assessments, especially in safety critical situations.

Tone Mapping

Tone mapping is an output of exposure. The arc of text on the right side of the dish mounting plate **(3)** is clear in the Skydio photo, but nearly completely invisible in the same photo from the Mavic 2 Pro. Skydio's exposure tuning allows it to capture detail in key areas where other cameras lose the information.

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

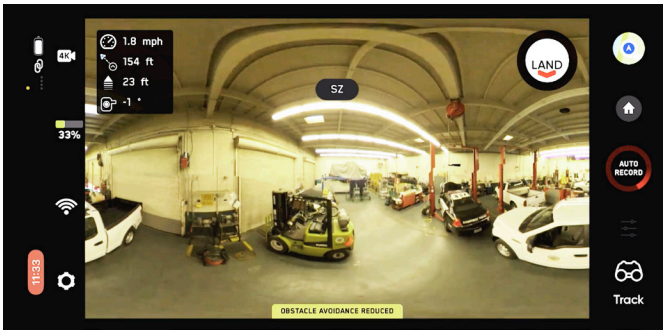
Skydio Enterprise Controller

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

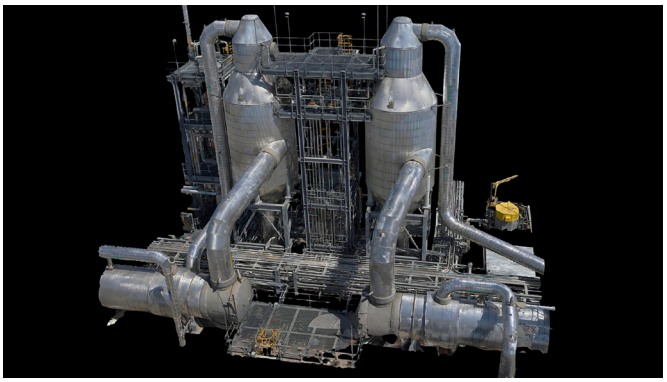
An add-on software package that augments the core autonomy engine. It's designed to assist the pilot through software capabilities that enhance flight control in obstacle-dense environments. Key features of this package include **Close Proximity Obstacle Avoidance**, **Vertical View**, and **Visual Return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



Skydio Autonomy Enterprise Foundation

Skydio 3D Scan™

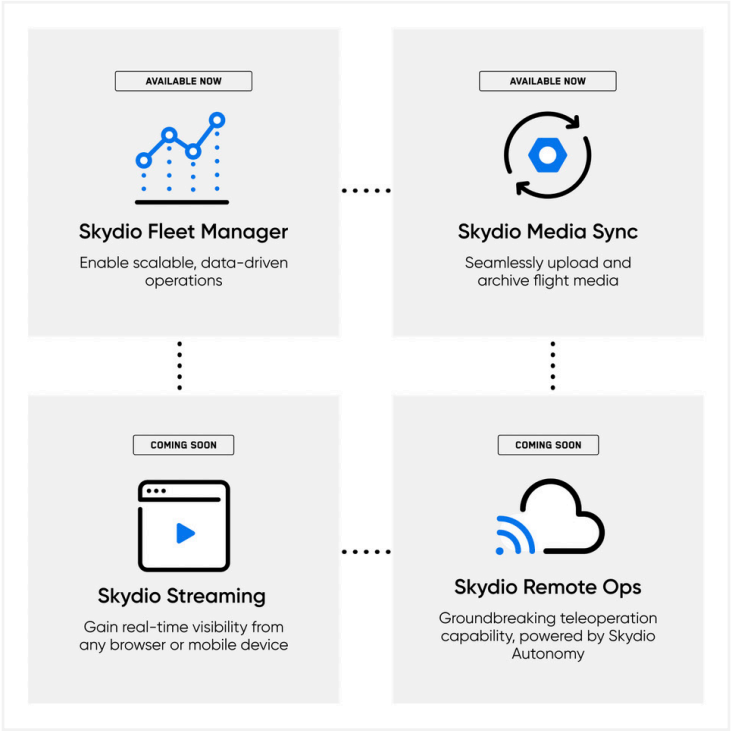
The first-of-its-kind adaptive scanning software built on top of Skydio Autonomy. 3D Scan allows the drone to automate the data capture process needed to generate 3D models with comprehensive coverage and ultra-high resolution, so that crews can perform higher quality scans in less time and with minimal 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 utilities select the right drones for the job. Stay tuned for the next volume!

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