

Skydio's 5 As: The Building Blocks for Public Safety Drone Operations

By Jeff Jang, Product Marketing Manager



Prologue

This white paper explains how and why Skydio autonomous drone solutions are ideally suited for Small Unmanned Aircraft System (sUAS) use cases in the Public Safety customer segment, both now and in the future. The <u>Skydio X2E</u> and <u>Skydio 2</u> drones can help bridge current gaps with traditional manual sUAS solutions in the public safety sector and massively improve the capabilities of Pilots in Command (PIC). This white paper was crafted for and by people that understand the requirements of the departments that maintain the health, welfare, and protection of the general public.

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The Growth of Public Safety sUAS

The development of sUAS technology in the last decade has provided public safety agencies with increased flexibility in support of first responder operations. This is significant because of the almost 18,000 police agencies in the US, <u>less than 200</u> have manned aviation capabilities. For agencies with small budgets that cannot afford helicopters, sUAS allow first responders to quickly get a ground aerial view perspective to increase situational awareness, with minimal risk to personnel.

According to a <u>study</u> conducted by researchers at Bard College, 1,578 state and local police, sheriff, fire, and emergency services agencies in the U.S. are estimated to have acquired sUAS technology as of March 2020. That figure represents an increase of 355% from Bard's first study on this topic in 2017. Empirically, the demand for sUAS solutions is rapidly growing because the resulting increase in situational awareness gives human first responders more actionable information and ultimately allows them to make the best tactical decisions.



Fig 1. Total Number of Public Safety Agencies with Drones by Year¹

Barriers to Scaling an sUAS Program

Despite the advantages that sUAS bring, there are still barriers to mass adoption. Currently the public safety sector is dominated by manual sUAS, with DJI being the primary example of this category. Manual solutions suffer from serious impediments **(Complexity, Training, Reliability, Security, Regulations)** that render them ill-equipped to start or scale sUAS programs.

High Operating Complexity

It is easy enough to fly a drone in wide open spaces. It is far more difficult to operate in the complex, confined environments that characterize the majority of missions performed by first responders. In those environments, pilots face intense cognitive loads while trying to focus on the mission at hand while trying (often fruitlessly) to monitor obstacles to prevent a crash and a host of other control system indicators. In short, manual drones force pilots to focus on the flying – not the mission.

Some of these manual drones are so hard to fly single-handedly, that for example, DJI offers <u>Dual Remote</u> <u>Controller Mode</u>, where one pilot controls the drone while the other controls the gimbal/camera. Additionally, with the Matrice 300 RTK, DJI offers <u>Advanced Dual Operator Mode</u>, which gives multiple pilots equal access to gain flight control priority.

¹Fig. 1. Dan Gettinger; "Total Number of Public Safety Agencies with Drones by Year"; Center for the Study of the Drone at Bard College, <u>https://dronecenter.bard.edu/files/2020/03/CSD-Public-Safety-Drones-3rd-Edition-Web.pdf;</u> graph



While increasing reliability through redundancy can be effective for training purposes, requiring multiple pilots and controllers for real operations is not practical or economical for an agency that expects to scale up a drone program.

Heavy Training Burden

Due to the operational complexity, agencies must take significant countermeasures to minimize the risk of crashes. Agencies spend a great deal of time and money training their people how to fly drones and process data. In an sUAS program that operates with manual drones such as those made by DJI, hiring, training, and retaining qualified pilots can consume <u>up to 80%</u> of the overall budget.

Fig 2. Police Matrice Crash in the UK²

In spite of this, most drone manufacturers delegate training services to third parties. Solely relying on third party training services may dissuade agencies from investing the necessary resources into an sUAS program to begin with. The best way to enable public safety agencies is through a true partnership with the Original Equipment Manufacturer (OEM), a model that represents a gap in the drone market today.

Lack of Reliability and Automation

Manual drones require reliable GPS and magnetometer readings to maintain stable flight. As a result, missions that require access to GPS-denied environments are often off-limits. Even when GPS is available, pilots have to maintain long standoff distances between their drones and their mission objective to avoid losing signal. Here again, manufacturers have tried to offset this with high-cost sensors, but having to tack on bigger and more expensive hardware is a downward spiral: **the more expensive the sensor, the greater the loss in event of a crash – leading operators to resort to longer and longer standoff distances.**

Right after the launch of the DJI Matrice 200 series, many organizations, including the UK Police, had to ground their brand new fleet due to unexpected <u>"complete loss of power during flight"</u>. Crashing a \$10,000 DJI Matrice carrying a \$14,000 Zenmuse XT2 thermal sensor and a \$4,500 Zenmuse Z30 is a significant loss. Even though the Matrice claims to have directional obstacle avoidance, it has <u>four blind spots</u> and is <u>prone</u> to crashes.

Yet another example is how today's 3D modeling processes are limited by manual drones. Operators usually fly simplistic patterns to avoid crashes, embracing the concept of Minimum Obstacle Clearance Altitude (MOCA) – the idea that flights need to take place at altitudes high enough to avoid any physical elements

²Fig 2. "Police-Matrice-Crash-UK"; sUAS news, <u>https://www.suasnews.com/2020/01/aaib-investigation-to-dji-matrice-210-uas-registration-n-a-16-</u> march-2019/police-matrice-crash-uk/; photograph

on the scene. The obvious downside is a tradeoff between safety and precision. Even with an expert pilot, manual drones use blind capture paths that take hundreds or thousands of additional photos because the drone isn't capable of understanding the data it is being asked to capture.

For public safety agencies hoping to realize the full value of drones as tools to simplify and even automate data collection, partnering with an autonomy-centric aircraft provider will lead to significant increases in ROI.

Security Concerns

End-to-end protection of public safety data and communications is essential. Malicious actions that could compromise this critical information increase risk to first responders and the citizens that they serve to protect. First responders have long represented a key foreign intelligence target, and for good reason. Malicious actors – whether foreign nations or criminal networks – may target first responder networks because they are connected to municipal, state and federal networks of interest, enabling attackers to access coveted information about critical infrastructure and personally identifiable information for citizens and government officials. For all of these reasons, protecting first responder data could not be more important.

Federal agencies, private cybersecurity firms, and bipartisan lawmakers have warned about the serious cybersecurity risks associated with drones made by Chinese companies for years. The reason is simple: companies based in China are subject to the demands of the Chinese Communist Party. Privately held data is not "private" in any sense of the word. According to <u>legal experts</u>, Chinese laws, such as the <u>2017 National</u> <u>Intelligence Law</u>, do not give companies a right to challenge requests for information. To that end, <u>DJI</u> <u>officials based in the U.S. have acknowledged</u>, under oath, the company's obligation to comply with Chinese government requests for information.

These are not idle threats. As the <u>New York Times</u> and other media outlets have reported, independent cybersecurity companies have found that DJI's products sometimes behave more like malware than software. Basic cybersecurity standards cannot buy down these risks. As a result, federal agencies have moved to ban Chinese-made drones and <u>prohibit</u> the use of federal funds to purchase Chinese-made drones. In December 2020, the U.S. Commerce Department placed DJI on the <u>Entity List</u>, also known as the economic blacklist, for enabling "wide-scale human rights abuses within China" related to DJI's sales of surveillance drones to the public security bureau of Xinjiang, <u>which uses DJI technology</u> to facilitate the interment and abuse of the Uighur people.

Public safety agencies want solutions they can trust. Cybersecurity and human rights concerns surrounding Chinese manufacturers will accelerate pre-existing trends favoring trusted providers.

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The question is not 'Can you build a drone that passes a cybersecurity test?' The question is: 'Do you trust the drone to never have a backdoor to do something that it shouldn't do?' And that's something that you can't validate with a cybersecurity test. That comes down to: Do you trust the source?

- Adam Bry, Skydio CEO

Regulatory Hurdles

When the FAA <u>finalized Part 107 regulations</u> to allow for commercial use of sUAS in 2016, it specified that sUAS aircraft must be flown within Visual Line of Sight (VLOS). Although waivers are allowed, they have been few and far between. As a case in point, as of 2018, the <u>approval rate for BVLOS waivers</u> was 1%.

Even in the rare event that public safety agencies received a waiver, they came to discover that flying manual drones beyond line of sight can be a heart-stopping experience, requiring pilots to exercise supreme skill in order to avoid trees and obstacles using only the screen of the control station screen. BVLOS operations have also been inordinately expensive. The FAA traditionally required the use of expensive solutions – such as radar – designed to detect manned aircraft, even in areas manned aircraft were unlikely to fly. These restrictions on BVLOS effectively make it very difficult to allow manual sUAS operations to be scalable and broadly applicable.

Introducing the Skydio 5 As of Public Safety Drones

Skydio creates a paradigm shift in how public safety agencies view the role of sUAS in their operations. To explain this shift, Skydio has developed a framework that outlines five specific categories of capabilities/ requirements to have a full end-state operation as commonly envisioned for **automated** and **ubiquitous** UAS deployment. The 5 As are the building blocks necessary for <u>Drone as First Responder</u> and other similar use cases that are seen as the "holy grail" for utilizing UAS solutions.

Aircraft

In a survey of over 100 different organizations, the risk of crashing was the biggest concern with drones. Unless that problem is solved, drones will never represent scalable solutions. Mitigating this risk is crucial to the drone market. Aircraft evaluated by public safety agencies must solve for the barriers to scale sUAS programs by minimizing the existing complexity, training burden, and reliability constraints from manual drones.

The only solution that solves for these barriers is **true autonomous flight** – meaning an aircraft that can understand its surroundings in order to intelligently augment the human pilot's ability to avoid obstacles.

Top Concerns with Current Drone Products



*Based on poll of companies with or exploring enterprise drone fleets (greater than 100 responses)

Fig 3. Top Concerns with Current Drone Products (based on internal survey)

Embedded into both the Skydio 2 and Skydio X2E platforms, <u>Skydio Autonomy</u>^{**} **delivers the simplest and safest flight experience**, which lets the PIC focus on the mission at hand, instead of the complexity of piloting the drone. Skydio Autonomy has ushered a new generation of drone intelligence, using breakthroughs in artificial intelligence, computer vision, and robotics to fly autonomously through the most demanding environments.



Fig 4. Inside the mind of the Skydio Autonomy Engine

Autonomy fundamentally reduces the training burden, allowing anyone to become an expert pilot in hours, instead of months. These factors **drive down the total cost** of ownership of the solution by up to 40%. With all these benefits, it's no wonder that marketing teams across the drone industry, including DJI, are trying to lay claim to autonomy and drone intelligence.

Take DJI's "autonomy" framework for example, which is called Omnidirectional Obstacle Sensing. It combines sensors on the sides of their drones to achieve rudimentary obstacle avoidance. The system does <u>not have full 360</u> <u>degree sensor coverage</u> and therefore lacks comprehensive understanding of its surroundings, which is required to provide true autonomous flight. Ultimately, DJI's sensors represent a hardware-centric approach to autonomy, which risks misleading the operator into believing that the drone is truly capable of understanding its surroundings in every direction and making intelligent navigation decisions, when that is not the case.

Skydio Autonomy Reduces Total Cost of Ownership



Fig 5. Skydio Autonomy Reduces Total Cost of Ownership

Skydio's integration of autonomy software with topnotch hardware puts it ahead of the competition. For instance, **Skydio Visual Navigator™, part of Skydio Autonomy, is a**

one-of-a-kind vision-based navigation system that uses six navigation cameras to create a 3D map of its environment in real time, instead of relying on GPS or a magnetometer. Vision provides far superior perception than manual GPS-based systems, and allows the aircraft to operate in GPS-contested environments, such as indoors, and even through electromagnetic interference near metallic structures. sUAS manufacturers without this vertical integration are simply providing a half-baked solution that will either require agencies to purchase additional hardware, like DJI's Manifold 2, or replace the aging manual drone technology altogether, neither of which are particularly budget friendly.

With an autonomous drone, the aircraft works for the first responders it supports, rather than the other way around.

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The Skydio 2 flies itself, which lets my cops be cops.

- Captain Vern Sallee, CVPD



Advanced Autonomy

Manual drones that depend on hardware modifications to unlock functionality will eventually become obsolete due to the lack of flexibility and speediness to adapt to the needs of their users. Skydio's Al can transform the drone's capabilities for different users without having to change the underlying hardware. Through software, Skydio delivers an enhanced user experience and feature set to help enterprise and public sector operators accomplish their missions faster and safer.

AI-Pilot Assistance

The first step in the advanced autonomy category is to augment the core autonomy with a suite of enhanced AI-pilot assistance capabilities. These features are aimed at making it easier than ever to navigate the complex environments that first responders must face – and that manual drones struggle to handle. Some of those key software-driven features that can be added Skydio drones, which are packaged into a product called Skydio Autonomy Enterprise Foundation are:

• **Close Proximity Obstacle Avoidance** allows the pilot to safely fly closer to obstacles without the risk of crashing. For first responders, this is key, because it allows them to rely on the drone for navigation as they focus on collecting the tactical information they need. Combined with the Skydio Visual Navigator that enables GPS-denied navigation, it offers the ideal combo for indoor inspections.

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Close Proximity Obstacle Avoidance allows us to fly our aircraft into tight, complex environments without giving up the safety that normally comes with flying Skydios. We are excited to use it for search and rescue missions

- Ryan Gifford, Sacramento Metro Fire Department Captain / UAV Program Manager



- **Superzoom** blends the drone's seven on-board cameras to present the pilot with an omnidirectional view of the scene. Unique to Skydio drones, this capability is perfect for overwatch and search and rescue scenarios.
- Point of Interest Orbit, while possible with traditional drones, obtains new levels of impact and functionality on a Skydio thanks to autonomy. Combined with the drone's 360° obstacle avoidance, operators can place the drone on orbit in dense, urban environments with confidence, enabling them to focus on the mission while maintaining safety of flight.



Fig 6. See in all directions with Superzoom

Fully automated workflows

The next step in the advanced autonomy progression is to embed entire workflows into software, turning the drone into an edge IoT device that can fully automate the data collection process without intervention from the pilot, increasing both the speed of the process and the quality of the data.

One such workflow that can greatly benefit from automation is generating a 3D model of a certain complex structure, such as a crime or accident scene.



Fig 7. 3D Scan autonomously collects data navigating around complex structures

Skydio 3D Scan is a dynamic 3D image capture solution that enables Skydio aircraft to autonomously navigate around a user-defined area or volume in order to scan a structure with complete coverage in ultra-high resolution. The result is a set of geotagged images that can be fed into a photogrammetry engine to generate a breathtaking 3D model.

Fully automated scan workflows provide the following key benefits:

- 1. Scan any scene manual drone mapping patterns are limited to capturing simple scenes, disqualifying them from many types of public safety use cases. 3D Scan can capture all the complexity of a traffic accident, active shooter scene, search & rescue operation, or indoor incident response where a manual drone would fail to fly at all due to a lack of GPS.
- 2. Reduce your training burden 3D Scan automates the data capture process without requiring any prior knowledge of the structure or human input. This allows operators to use drones as a tool with minimal lead time.

The outcome of the advanced autonomy solutions delivered by Skydio is reduced cognitive load on pilots and state-of-the-art 3D scan products for Crime and Accident scene capture. The smarter the drone, the smarter the pilot.

I have been using Pix4D for years, and can see that 3D Scan is completely different and revolutionary. It will help our traffic team generate better 3D models with less training and time spent on drone data capture than ever before.



- David Cameron UAS Program Manager, Campbell Police Department

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Approvals

Beyond Visual Line of Sight Operations

BVLOS operations are critically important for the public safety community, enabling first responders to **fly beyond visual range, cover much greater distances, collect more data with fewer deployments, and can keep operators out of dangerous situations.** In an age defined by manual drones without limited ability to sense and avoid stationary obstacles, it has always been difficult to obtain BVLOS authorizations.

Now that we have entered the age of autonomy, Skydio's trustworthy autonomy is helping to unlock safe and routine advanced BVLOS operations. To pave the path to autonomous sUAS deployment, Skydio is working with public safety agencies to secure meaningful, incremental regulatory advances.

Skydio's collaboration with the Chula Vista Police Department (CVPD) in the San Diego UAS Integration Pilot Program, led to the FAA's <u>Tactical BVLOS (TBVLOS) operations</u> approval process for all public safety agencies. The result is a groundbreaking Certificate of Authorization (COA) that appropriately authorizes public safety

agencies nationwide to send drones into areas that are too dangerous to send people, without having to wait for an FAA approval or set up a network of visual observers. Skydio's autonomy technology is the key to unlocking BVLOS operations because Skydio's drones are capable of seeing and avoiding stationary obstacles on the pilot's behalf. Although the COA does not require the use of a Skydio drone, the risk of collisions with ground obstacles is dramatically reduced with the use of Skydio Autonomy, providing unquestionable peace of mind.



Fig 8. Operational Construct of TBVLOS

Furthermore, Skydio's partnership with the North Carolina Department of Transportation (NCDOT) led to a <u>first-of-a-kind waiver</u> under Part 107 to inspect bridges beyond visual line of sight. One of the first Part 107 waivers that does not require visual observers, the new waiver allows NC bridge inspectors to send a Skydio drone to inspect elements of the bridge that would otherwise require the use of dangerous repels or snooper trucks. The waiver is based on the use of Skydio drones due to its ability to avoid stationary obstacles.

Security and Trustworthiness

As discussed in a prior section of this paper, another regulatory hurdle recently faced by many of the manual drones on the market is related to cyber security and supply chain security. <u>DOJ has advised</u> state and local public safety agencies to ensure cyber security and supply chain security when developing UAS programs.

Skydio X2E is designed to deliver ironclad, end-to-end protection. From a cybersecurity standpoint, the entire system is protected from data exfiltration or compromise of command-and-control by nefarious actors:

- Wireless connection encryption and authentication (AES-128)
- Encrypted and signed software updates
- Skydio Enterprise Controller has an encrypted hard drive with password protection and trusted boot
 with anti-rollback

Ultimately, the only way to trust the security of a digital device – including a drone – is to trust the company that developed it and the legal framework in which they operate. Skydio takes pride in designing, assembling and supporting drones in the United States.

Skydio's products meet the highest levels of supply chain security demanded by the US government, including compliance with National Defense Authorization Act (NDAA). This means that when first responders take X2E on a mission, they can have confidence that they have full control over their data.

For these reasons, the Skydio X2D aircraft (the defense-oriented variant of the X2E) was selected as a trusted drone platform for the Department of Defense and the Federal Government as part of <u>DIU's Blue</u> <u>sUAS Program.</u>

Skydio Core Values

As a leader in autonomous flight technology, Skydio is committed to using its position to advance standards and practices that promote the responsible use of drones. In 2020, Skydio developed a pathbreaking set of policy and ethical principles to guide its work and drive the industry forward. Known as the <u>Skydio</u> <u>Engagement and Responsible Use Principles</u>, this framework outlines the commitment to pursue responsible use in the way Skydio develops its products and engages with customers. Skydio is driven by core values of accountability, transparency, and the protection of privacy and civil liberties. Those values are reflected in the products that we build and the partnerships we form.

To that end, Skydio partnered with DRONERESPONDERS to develop principles designed to advance the responsible and effective deployment of drones by public safety agencies. Known as <u>The Five C's</u>, this important document outlines five core principles that should be embodied by every public safety drone program, including:

- 1. Community engagement and transparency
- 2. Civil liberties and privacy protection
- 3. Common operating procedures on the use of drones
- 4. Clear oversight and accountability
- 5. Cybersecurity

Skydio commends DRONERESPONDERS for their leadership in advancing the responsible use of drones by law enforcement and other first responders.

Aircraft Management

For a fully scalable solution, the combination of groundbreaking autonomy and OEM integrated training will increase the effectiveness of current training levels within organizations. Despite the out-of-box solution that Skydio's aircraft and software provide, training is still incredibly important when considering aircraft management. By practicing pre-flight checks, in-flight checks, post-flight checks, and troubleshooting steps, operators will improve their knowledge and skills, and reduce complacency. As long as humans are involved in drone deployment, proper training will mitigate risk of crashes or other catastrophic incidents.

Unlike other OEMs, Skydio is committed to partnering with agencies to help stand up their training and management programs instead of relying on third parties who lack the resources necessary to adequately assist customers.

<u>Skydio Academy</u> is a professional training program designed for enterprise and public sector operators to become certified operators of Skydio's autonomous drones. As enterprise and public sector organizations of all sizes switch to AI-based autonomous drones, traditional approaches to drone missions will become

obsolete and inefficient. Skydio Academy is designed to help organizations prepare the next generation of pilots that can take advantage of the new autonomous flight paradigm, and ensure they have the expertise to scale their autonomous drone programs efficiently. Skydio Autonomy can turn any operator into an expert pilot and Skydio's expert trainers can help any size organization to unlock the full value of autonomous drone operations.



Fig 9. Skydio Academy's Online Curriculum

Airspace Awareness

sUAS The two environments in which sUAS missions take place are **above** and **below** the treeline. sUAS are less likely to encounter static obstacles operating above the treeline, but are more prone to encountering static obstacles such as buildings, cars, infrastructure, and foliage when operating below the treeline.

Skydio's autonomous technology is the key to unlocking below the treeline operations because Skydio drones can go where manual drones cannot. The resulting increased situational awareness opens the door for entire new categories of below the treeline missions that pilots would not dare with any other aircraft. Features such as **Close Proximity Obstacle Avoidance** and **Superzoom** will help pilots single-handedly take in the maximum amount of visual information while flying confidently in tight spaces.

Skydio's) Trustworthy obstacle avoidance makes it possible for us to do flights at low-altitude and in complex urban environments that we would otherwise not be able to perform.

- Austin Worcester, Civil Air Patrol

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As Skydio continues to work with domestic and global regulators to enable successively greater autonomous operations, we expect that there will be robust "docked" solutions to deploy autonomous missions remotely that consistently augment human beings, complemented by automated airspace awareness tools (such as software aided cameras networked directly with the drone).

Ultimately, the key features of Skydio Autonomy mean that it's the only platform with the DNA to satisfy automated UAS deployment requirements in the future.

How Skydio Autonomous Drones Support the Mission

Here's a glimpse of how Skydio drones can be a part of the various public safety missions and the unique value they provide to ensure the success of the mission:



Fig 10. Framework of The Future of Airborne Public Safety

Mission Type	Skydio Solution	Positive Impact on the Mission
Situational Awareness	 Skydio X2E or Skydio 2 4K HDR color camera 360° Obstacle Avoidance Skydio Visual Navigator 	Skydio is the ultimate situational awareness tool, meaning first responders no longer enter high pressure situations blind. The PIC can easily and efficiently gather real time information about terrain, friendly, and hostile elements at an incredible 4K resolution.
	Skydio Autonomy Enterprise Foundation • Superzoom	Even a highly skilled PIC can encounter GPS signal failure, making manual sUAS worthless. Skydio's 360° obstacle avoidance and GPS-denied flight unlocks TBVLOS flight below the treeline in obstacle-rich environments.
		GPS-denied flight unlocks BVLOS flight below the treeline or height of structures/terrain in obstacle-rich environments.
Hostile Scene De-escalation	 Skydio X2E FLIR[®] Boson 320x256 LWIR Thermal imager GPS Night Flight Strobe Lighting 	Subject detection and pursuit is now made easy using autonomy-based Object and Subject Recognition, which allows the Skydio drone to detect desired subjects with full collision avoidance.
	Skydio Autonomy Enterprise Foundation • Close Proximity Obstacle Avoidance	Close Proximity Obstacle Avoidance allows Public Safety agencies to inspect from up close through a reduced obstacle avoidance margin – flying as close as 16" to obstacles and easily going through standard size doors.
Search & Rescue	 Skydio X2E or Skydio 2 Object and Scene Detection Motion Planning Skydio Autonomy Enterprise Foundation 	The FLIR thermal imager, coupled with Skydio X2E's mechanical and digital stabilization, make it the ideal search and rescue platform. Body heat or hot spots can quickly be identified through high fidelity thermal imagery, which help find missing people or put out fires faster.
 Offline Maps Visual Return-to-Home 	Operating UAS in the middle of the night is challenging and risky due to significantly reduced sensory input. GPS Night Flight gives first responders the power to fly at night by cutting through visual obscuration that affects traditional visual-spectrum cameras.	
		Visual Return-to-Home (RTH) allows X2E to get back to base through those same GPS-denied environments by navigating home using the computer vision system.
Crime & Accident Scene Reconstruction	Skydio 3D Scan	3D Scan will become an integral part of a unit's Incident Response analysis, because it gives the ability to capture comprehensive scene reconstructions. This will save on the cost on high end sensors, get better angles on evidence and accident scenes, and decrease societal impact thanks to a more efficient process.

Components of the Skydio Solution for Public Safety

Skydio technology can address pain points and challenges of the existing manual sUAS status quo and enhance key operating requirements. The following are the components required to take advantage of Skydio's autonomous solutions.

Skydio 2. Small-sized quadcopter with built-in Skydio Autonomy, allowing operators to perform flight maneuvers that not even expert pilots would be able to execute. With a 4K60 HDR sensor, 3.5km wireless range, and 23 minute battery life, Skydio 2 was designed to make the drone useful in every capacity.

Skydio Beacon. A first-of-its-kind drone controller for subject tracking and intuitive "magic wand" control. Skydio Beacon provides accurate user positioning while also enabling lightweight controllability. Easy drag-and-drop controls enables the operator to quickly reposition Skydio 2 anywhere in the sky.

Skydio X2E. Pairs the breakthrough Skydio Autonomy engine with a ruggedized and highly portable airframe with foldable arms. It features a dual color/thermal sensor, long-range 5GHz wireless radio, and extended battery life for up to 35 minutes. Core autonomy capabilities of the drone previously described in this paper include **360° Obstacle Avoidance, Object and Scene Recognition**, and **Skydio Visual Navigator**.

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.





Fig 12. Skydio Beacon



Fig 13. Skydio X2E



Fig 14. Skydio Enterprise Controller



Fig 15. Skydio AEF

Skydio Autonomy Enterprise Foundation.

An add-on software package that augments the core autonomy engine. It provides Alpilot assistance capabilities that enhance situational awareness and facilitate flight in obstacle-dense environments. Key features of this package previously presented in this paper include Superzoom, Close Proximity Obstacle Avoidance, POI Orbit and Visual Return-to-Home.



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.

Fig 16. Skydio 3D Scan

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	
SKYDIO PROFESS THIS CERTIFICATE	IONAL OPERATOR
Attende	e Name
This is to cartify that (name) has completed the 4 2 system and Skyalo Autonomy E	sundational professional training for the Skydio Interprise Foundation software.
DATE	SIGNATURE

Skydio Professional Operator (SPO)

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

Skydio	
SKYDIO EXPE THIS CERTIFICAT	
Attend	ee Name
This is to certify that (nome) has completed flight skills for the Skydio 2 system and Sky	practical training and has demonstrated expert dia Autonomy Enterprise Foundation software.
DATE	SIGNATURE

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.

Why Autonomy Matters to Public Safety Agencies

There are a growing number of agencies that believe in and are invested in Skydio's situational awareness capabilities. In a recent <u>DRONERESPONDERS poll</u>, 11% of public safety agencies included Skydio drones in their fleets, second only to DJI, after just 7 months in the market. Autonomy is critical to Public Safety Agencies because it will protect their investment. At the heart of sUAS autonomy is a massive reduction in the risk of collisions. Protecting drone investment is increasingly important for high-end enterprise drones like the Skydio X2E.

Public safety agencies that have already invested heavily in manual drones must consider what the future of their programs look like relying on manual drones without advanced situational awareness, and whether the opportunity cost is worth it long-term. First responders undoubtedly will benefit from having a trustworthy drone that can fly below the treeline and out of view, but still safely navigate unknown environments to complete the mission. Even the most skilled FPV pilots can't outperform Skydio drones when it comes to avoiding obstacles and crashes.

While we work towards the solutions of tomorrow, consider how autonomy can help drone operators today. As the demand for mission-specific BVLOS waivers indicate, first responders who want to conduct advanced sUAS operations safely must have a drone that can avoid unseen objects and obstacles on its own.

Skydio's software-driven approach offers a unique intelligent aircraft that can expand in its capabilities to reduce risk to first responders and increase efficiency in a way that no other drone on the market can provide.

Better Pilots + Better Situational Awareness = Safer Communities