




Blue UAS for First Responders

Comparative Assessment Report

September 2026

Science and Technology

NUSTL
NATIONAL URBAN SECURITY TECHNOLOGY LABORATORY

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FOREWORD

The National Urban Security Technology Laboratory (NUSTL) is a federal laboratory within the U.S. Department of Homeland Security (DHS) Science and Technology Directorate. Located in New York City, NUSTL is the only national laboratory focused exclusively on supporting the capabilities of federal, state, local, tribal, and territorial responders to address the homeland security mission. The laboratory assists responders with the use of technology to prevent, protect against, mitigate, respond to, and recover from homeland security threats and incidents. NUSTL provides expertise on a wide range of subject areas, including chemical, biological, radiological, nuclear, and explosive detection, personal protective equipment, and tools for emergency response and recovery.

NUSTL manages the System Assessment and Validation for Emergency Responders (SAVER®) program, which provides information on commercially available equipment to assist response organizations in equipment selection and procurement. SAVER publications provide information on equipment that falls under the categories listed in the DHS Authorized Equipment List (AEL), focusing primarily on two main questions for the responder community: "What equipment is available?" and "How does it perform?" The SAVER program works with responders to conduct objective, practitioner-relevant, operationally oriented assessments and validations of commercially available emergency response equipment. Having the right tools provides a safer work environment for responders and a safer community for those they serve.

NUSTL is responsible for all SAVER activities, including selecting and prioritizing program topics, developing SAVER publications, and coordinating with other organizations to leverage appropriate subject matter expertise. NUSTL conducted an assessment of select Unmanned Aircraft Systems on the Department of Defense's Blue Cleared List. This equipment falls under the AEL reference number 03OE-07-SUAS titled "System, Small Unmanned Aircraft."

SAVER reports are available at www.dhs.gov/science-and-technology/saver.

Visit the NUSTL website at www.dhs.gov/science-and-technology/national-urban-security-technology-laboratory, or contact the lab at NUSTL@hq.dhs.gov.

U.S. Department of Homeland Security

SAVER

System Assessment and Validation for Emergency Responders ®

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EXECUTIVE SUMMARY

Over the past decade, first responders have begun integrating small, unmanned aircraft systems (UAS) as a resource for a variety of operational needs. UAS provide first responders with an aerial view of their environment and can be outfitted with various sensors tailored to address different response applications. UAS, often referred to as “drones,” are used by first responders in support of public safety activities such as search and rescue, firefighting, and post-incident reconstruction.

From June 2024 through July 2025, the System Assessment and Validation for Emergency Responders (SAVER) program conducted three operational assessments of Blue UAS in rural, urban and complex urban environments. The initial assessment was conducted June 2024 in College Station, Texas (rural), the second was conducted in November 2024 in Miami, Florida (urban), and the final assessment in the series occurred in July 2025 in New York City to represent a dense, complex urban environment.

Over the course of these three assessments, 26 experienced remote pilots from various federal, state and local jurisdictions served as subject matter expert evaluators during the operational scenarios. Platforms were assessed based on criteria identified by a focus group of emergency responders and scored on a scale from 1 to 5, where 1 means the product met none of their expectations and 5 means it exceeded expectations. The table below lists the products alphabetically with overall scores (calculated by weighted average, see Appendix B) from each event, where applicable. The body of this report focuses on eight select criteria the focus group deemed most important,[i] half of which illustrate how the operational environment poses challenges for Blue UAS.

Manufacturer	Model	Overall Scores				Price*
		Urban	Rural Day	Rural Night	Complex Urban	
Ascent AeroSystems	Spirit w/NightHawk2-UZ EO/IR	3.1	3.3	3.2	N/A	$56,195
Freefly Systems	Astro w/LR1 EO/IR & laser range finder	3.5	N/A	N/A	N/A	$47,018†
Parrot Drones	ANAFI USA GOV	3.1	3.3	2.9	2.4	$13,964
Skydio	X2D	N/A	3.1	3.1	N/A	$21,889
Skydio	X10D w/VT300-Z & NightSense	4.0	N/A	N/A	3.7	$28,382
Teal Drones	Teal 2	2.7	2.8	3.2	N/A	$15,073

Notes:
* The prices in this table are for the equipment configurations as assessed.
† GSA pricing for models/packages procured for this assessment rounded to the nearest whole dollar
‡ The Freefly Systems Astro does not offer GSA pricing as of the time of this publication, therefore the cost reported above is based on a quote received for procurement.

[i] All focus group criteria that were weighted a 4 or 5, with the exception of portability, were included in this analysis.

First responder evaluators identified significant differences in the capabilities between UAS from covered nations (systems manufactured in countries restricted under federal law) and the select Blue UAS they evaluated during these assessments.

- **GPS cannot be relied upon for positioning in dense urban environments.** Emergency responders require a stable platform that can be operated by a single remote pilot in command. The need to constantly provide position inputs to keep a platform from drifting distracts them from using the on board sensors and providing feedback to their team.
- **Inconsistent wireless connection between ground control station (GCS) and aircraft.** Emergency responders require a reliable connection between the GCS and aircraft. An inconsistent link will not only result in inconsistent real-time information but also diminish trust in a platform's capability to perform. As a result, response agencies may choose to allocate their limited resources away from using UAS. The Blue UAS that were assessed experienced disconnects as near as 50 feet from the launch point in some instances. UAS are valuable to response operations as they provide an aerial vantage point and allow operators to maintain a safe standoff distance from potential threats, thereby significantly mitigating safety risks. The inability to maintain a connection link limits, if not prevents UAS operations, eliminating the ability to assess and monitor incidents remotely.
- **Deployment time was unacceptable for most first responders**. Emergency responders must act in short order to ensure life safety, and document key details of incidents for prosecutions. If a UAS takes too long to deploy, responders will be faced with determining whether resources should be aligned to traditional methodologies as the benefits of using a UAS are minimized. The evaluators experienced a myriad of issues with the Blue UAS that were assessed, resulting in unacceptable deployment times (e.g., GCS disconnections, need for resets and repairs, GPS lock and Remote-ID failures, and pre-launch calibration delays).
- **Cost of Blue UAS is a significant barrier for many departments.** Response agencies vary vastly, but ultimately budgets must be used strategically to ensure the best investment of taxpayer dollars while maximizing the safety and security of the communities they serve. Excessive costs may lead to the diversion of funds from other critical equipment purchases and the procurement of fewer unmanned platforms which can lead to gaps in response operations.

Without capabilities such as a stable wireless connection and reliable GPS, operators cannot focus on utilizing the sensing capabilities (cameras) of the UAS because they must focus on maintaining the aircrafts position. This results in UAS operations being severely limited and may hinder a wide variety of public safety and response missions, including situational awareness, search and rescue, and hazard detection. Similarly, if a UAS takes too long to deploy or is too costly, responders may opt to use traditional methods rather than adopt UAS, as the advantages of these systems are diminished.

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1.0 INTRODUCTION

Over the past decade, first responders have begun integrating small, unmanned aircraft systems (UAS) as a resource for a variety of operational needs. UAS provide first responders with an aerial view of their environment and can be outfitted with various sensors tailored to address different response applications. UAS, often referred to as "drones," are used by first responders in support of public safety activities. This equipment falls under the AEL reference number 03OE-07-SUAS titled "System, Small Unmanned Aircraft."

From June 2024 through July 2025, the System Assessment and Validation for Emergency Responders (SAVER) program as run by the Department of Homeland Security (DHS) Science and Technology Directorate's (S&T) National Urban Security Technology Laboratory (NUSTL) conducted three operational assessments of Blue UAS[2] in rural, urban and complex urban environments. The initial assessment was conducted June 2024 in College Station, Texas to represent rural environment use cases; the second assessment was conducted in November 2024 in Miami, Florida to introduce urban complexities, and the final assessment in the series occurred in July 2025 in New York City to represent a dense, more complex urban environment. Note that covered nation platforms were tested alongside Blue UAS at the complex urban assessment as response agencies still rely on UAS from covered nations to achieve their mission of ensuring public safety based on reliability and overall performance.[3]

UAS used by state and local first responders may be espionage targets due to their presence in areas where UAS are not otherwise permitted to fly, such as critical infrastructure and mass gatherings. While "Blue List" drones are deemed cybersecure and NDAA compliant, the Blue designation does not address whether they can perform the functions needed for public safety. Therefore, a key objective of the assessment was evaluating the effectiveness of the selected Blue List drones for said missions. SAVER examined the operator experience of the tested drones noted below but did not evaluate or determine risk to national security based on relevant statute(s).

The purpose of these assessments was to obtain information on Blue UAS that will be useful for emergency responders in making procurement and operational decisions. The assessment activities were based on recommendations gathered from a focus group, conducted in November 2023, comprised of emergency responders with operational experience flying UAS. The "Blue Unmanned Aircraft Systems for First Responders Focus Group Report" can be found on the SAVER website at www.dhs.gov/science-and-technology/saver/blue-uas-first-responders.

This report compares the evaluated systems side-by-side and across all three operating environments NUSTL tested. Its body focuses on eight select criteria the focus group deemed most important, half of which illustrate how the operational environment pose challenges for Blue UAS.

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[2] The Blue UAS Cleared List or "Blue List" is a list of United States- and ally-manufactured UAS vetted by the Defense Innovation Unit (DIU) to be policy approved by the DoD. (Section 848 of the National Defense Authorization Act (NDAA) for Fiscal Year 2020 prohibits the use of UAS or any related services or equipment from certain foreign entities.) All UAS on the Blue List are NDAA-compliant and have undergone cybersecurity testing by DIU or their contractors. Each device on the Blue List is granted authority to operate (ATO) from the DIU.

[3] Results related to the covered nation platforms is available to public safety agencies upon request. Please contact NUSTL@hq.dhs.gov to request this information.

1.1 Participant Information

Over the course of three assessments, 26 experienced remote pilots – subject matter experts on UAS response operations from California, Colorado, Connecticut, Florida, Georgia, Massachusetts, Michigan, New York, North Carolina, Oklahoma, Oregon, Texas, and Virginia – assessed Blue UAS platforms in operational scenarios in both full and low light conditions. In addition to their UAS operational expertise, they were selected to participate in the assessments based on their respective geographic location, responder discipline area, and professional experience.

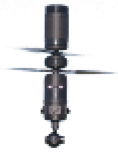
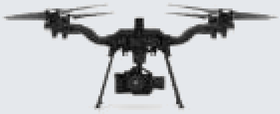
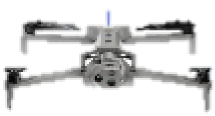
1.2 Assessed Products

The Blue UAS in Table 1-1 were selected and acquired for the assessment based on market research and recommendations from the focus group. Product selection criteria included specifications, attributes, or characteristics a product should possess to be considered for the assessment. The assessment team established the following product requirements when determining the scope of products for the assessment:

- Included on the Blue List (at the time of purchasing for the assessment)
- Battery-powered
- Single-person deployable
- Equipped with vertical take-off/landing
- Equipped with electro-optical and infrared (EO/IR) sensors
- Provides a live video feed

Based on market research and the focus group's recommendations, six products from five manufacturers were included in the assessment. In addition to the overall selection criteria, the ability to acquire the UAS in time for the assessments was also a factor in product selection. The products selected for the assessment series and their key specifications are shown on the next page in Table 1-1.

Table 1-1 Assessed Products and Key Specifications

Product	Weight (lb)	Dimensions (in, L x W x H)	Max Flight Time* (min)	Payload	Cost†
 **Ascent AeroSystems Spirit**	7.8	12 x 4.2 x 25.5	53	NightHawk2-UZ EO/IR 1280x720	$56,196
 **Freefly Astro**	11.4	55.4 x 55.4 x 14.1	37	Sony LR1 w/FLIR Boson 640x512 & laser range finder	$47,018‡
 **Parrot Drones ANAFI USA GOV**	1.1	11.1 x 14.7 x 3.2	32	EO 4k, IR 320x256	$13,965
 **Skydio X2D**	3	26.1 x 22.4 x 8.3	35	EO 4k, IR 320x256	$21,889
 **Skydio X10D**	4.7	31.1 x 25.6 x 5.7	40	VT-300Z (2) EO Narrow (64MP) & Telephoto (48MP), IR 640x512	$28,382
 **Teal Drones Teal 2**	2.75	17 x 19 x 3	30	Hadron Payload EO 4k, IR 640x512	$15,074

Note: The specifications in this table represent the equipment configurations as assessed.
* Reported by manufacturer
† GSA pricing for models/packages procured for this assessment rounded to the nearest whole dollar
‡ The Freefly Systems Astro does not offer GSA pricing as of the time of this publication, therefore the cost reported above is based on a quote received for procurement.

2.0 EVALUATION CRITERIA INCLUDED IN THIS REPORT

The SAVER focus group on UAS used SAVER assessment categories to help participants identify evaluation criteria. The group identified a total of 18 criteria for the assessments. The focus group participants assessed the importance of the evaluation criteria by assigning each a weight. The criteria were weighed on a scale of 1 to 5, with 1 denoting minor importance (meaning that meeting this criterion or having this feature might have a minimal impact on the evaluators' decision to buy the product), and 5 indicating the highest importance (signifying that the evaluators would not consider purchasing a product that does not meet their expectations for the criterion or lacks the feature).

This report primarily explores eight criteria that the SAVER focus group deemed most important[4] and were scored in the SAVER rural, urban and complex urban assessments. Half of these criteria illustrate how the operational environment poses challenges to Blue UAS through factors such as radio frequencies, the height of nearby buildings, and airspace congestion. The SAVER assessment categories that align with select criteria are:

- **Capability** criteria relate to product features or functions needed to perform responder relevant tasks
- **Deployability** criteria relate to preparing to use the product, including transport, set up, training, and operational/deployment restrictions
- **Usability** criteria relate to ergonomics and the relative ease of use when performing responder relevant tasks

Table 2-1 presents the select evaluation criteria that were scored in all three assessments, and their associated weights aligned under the applicable SAVER categories. These evaluation criteria are defined in Appendix A.

[4] All focus group criteria that were weighted a 4 or 5, with the exception of portability, were included in this analysis.

Table 2-1 Evaluation Criteria

SAVER CATEGORIES		
Capability	**Deployability**	**Usability**
Camera’s Visual Acuity* Weight: 5	**Time to Redeploy** Weight: 5	**Ease of Use** Weight: 4
Flight Duration Weight: 5	**Deployability** Weight: 4	**Ground Control Station (GCS) Interface** Weight: 4
Command and Control Link Quality Weight: 5		
Latency Weight: 5		
* Camera visual acuity was assessed and scored separately for electro-optical (EO) and infrared (IR) to account for day and night.		

3.0 ASSESSMENT METHODOLOGY

NUSTL worked with first responder UAS operators from across the nation to assess select Blue UAS in a series of operational assessments to test and evaluate their capability, usability, and deployability. It was imperative to gather feedback in various geographical settings to ensure the national responder community's needs are considered. As such, NUSTL conducted a series of three assessments covering rural, urban and complex urban settings. Each assessment incorporated simulated realistic operational scenarios including search and rescue, damage assessment and situational awareness in representative conditions for public safety applications.

This series of assessments allowed NUSTL to:

- Identify strengths and shortfalls of selected Blue UAS
- Educate responders on NDAA-compliant, cybersecure UAS
- Provide manufacturers with valuable feedback from responder end users
- Inform policymakers on the current state of the NDAA-compliant and cybersecure UAS market

3.1 Operational Environments

Sections 3.1.1–3.1.3 include images of the operational environments for each of the three assessment locations.

3.1.1 Rural: Texas A&M Engineering Extension Service (TEEX) and RELLIS

Figure 3-1 Rural Test Sites: TEEX (top and right) and RELLIS (left and center)

3.1.2 Urban: City of Miami, Bayfront Park and LoanDepot Park

Figure 3-2 Miami Test Sites: Bayfront Park (left) and LoanDepot Park (right)

3.1.3 Complex Urban: City of New York, Hudson Yards

Figure 3-3 Hudson Yards Test Sites: Bella Park (left) and example of an “urban canyon” (right)

3.2 Data Gathering and Comparative Analysis of Select Criteria

Throughout the operational assessments, evaluators worked in teams and were paired with a data collector who observed each team as they completed the assessment activities. After each operational scenario, data collectors used a questionnaire to record the evaluators' scores for each product according to the evaluation criteria listed in Section 2.0. The questionnaire included specific questions for each criterion that the data collectors read to the evaluators. Evaluators then scored the criteria using the following 1 to 5 scale:

1. The product **meets none** of my expectations for this criterion.
2. The product **meets some** of my expectations for this criterion.
3. The product **meets most** of my expectations for this criterion.
4. The product **meets all** my expectations for this criterion.
5. The product **exceeds** my expectations for this criterion.

Once assessment activities were completed, evaluators had an opportunity to review their criteria ratings and comments for all products and to adjust them as desired. Criteria that were rated multiple times throughout the assessment were assigned an averaged final rating by the evaluators. The average overall assessment scores were calculated for each product using the formulas in Appendix B.

Data collectors also captured comments on advantages and disadvantages as well as general comments regarding the assessed products and the overall assessment process. The evaluators' comments are summarized in this assessment report.

Paring the focus group's 18 criteria down to this select set highlights those deemed most importance[5], half of which illustrate how the operational environment poses challenges to Blue UAS can help response agencies identify the system(s) best suited to the geography of their jurisdiction.

[5] All focus group criteria that were weighted a 4 or 5, with the exception of portability, were included in this analysis.

4.0 ASSESSMENT RESULTS

Assessment results are presented in Table 4-1 and Table 4-2, while additional details and evaluator comments on each product are provided in sections 4.1 through 4.6[6]. Table 4-1 presents the overall scores for each product. The products are listed in alphabetical order by manufacturer. The overall score for each product is calculated using the average scores for all evaluated criteria in that assessment, before rounding. The weighted scoring formula is provided in Appendix B. Table 4-2 presents a detailed visual comparison of each evaluated system across the eight select criteria, in each of the three operational settings. These select criteria were chosen for two reasons: they reflect the focus group's highest priorities, and they highlight how environmental factors affect UAS performance—a central takeaway of the Blue UAS assessments.

After the summary tables, each of the assessed UAS systems and evaluator feedback on that system is described in greater detail. Major takeaways from these assessments are:

- **GPS cannot be relied upon for positioning in dense urban environments.** Emergency responders require a stable platform that can be operated by a single remote pilot in command. The need to constantly provide position inputs to keep a platform from drifting distracts the pilot from using the on board sensors to provide feedback to their team.
- **Inconsistent wireless connection between GCS and aircraft.** Emergency responders require a reliable connection between the GCS and aircraft; inconsistent link will result in not only inconsistent real-time information but also lessened trust in a platforms capability to perform. Thus, responders already resource limited, may allocate resources away from the use of UAS. Blue UAS assessed experienced disconnects as near as 50 feet from the launch point in some instances. UAS are valuable to response operations as they provide an aerial vantage point, and create standoff distance from potential threats, therefore significantly mitigating safety risks to operators. The inability to maintain a connection link limits, if not prevents, UAS operations eliminating the ability to assess and monitor incidents remotely.
- **Deployment time was unacceptable for most first responders**. Emergency responders must act in short order to ensure life safety, and document key details of incidents for prosecutions. If a UAS takes too long to deploy, responders will be faced with determining whether resources should be aligned to traditional methodologies as the benefits of using a UAS are minimized. Blue UAS experienced a myriad of issues resulting in unacceptable deployment times (e.g., GCS disconnections, need for resets and to re-pair, GPS lock and Remote-ID failures, and pre-launch calibration delays).
- **Cost of Blue UAS is significant barrier for many departments[7].** Response agencies vary vastly, however ultimately budgets must be used strategically to ensure the best investment of taxpayer dollars while maximizing the safety and security of the communities they serve. Excessive cost for UAS may lead to the diversion of funds from other critical equipment

[6] Narrative feedback across assessments is limited to those criteria that would be impacted by environmental factors. The additional information sections captures comments from the complex urban assessment that is not captured elsewhere.

[7] While not a criterion that was given a score by evaluators, the price of a Blue UAS was part of discussions between the SAVER team and first responders throughout the execution of this project's focus group and three assessments. The prices for the six assessed systems, when configured as SAVER tested them, range from $13,964 to $56,195.

purchases, procurement of fewer unmanned platforms which can lead to gaps in response operations.

Without capabilities such as a stable wireless connection and reliable GPS, operators cannot focus on utilizing the sensing capabilities (cameras) of the UAS because they must focus on maintaining the aircrafts position. This results in UAS operations being severely limited and may hinder a wide variety of public safety and response missions, including situational awareness, search and rescue, and hazard detection. Similarly, if a UAS takes too long to deploy or is too costly, responders may opt to use traditional methods rather than adopt UAS, as the advantages of these systems are diminished.

Table 4-1 Assessment Results

Manufacturer	Model	Overall Scores			
		Urban	Rural Day*	Rural Night*	Complex Urban**
Ascent AeroSystems	Spirit w/ NightHawk2-UZ EO/IR	3.1	3.3	3.2	N/A
Freefly Systems	Astro w/ LR1 EO/IR & laser range finder	3.5	N/A	N/A	N/A
Parrot Drones	ANAFI USA GOV	3.1	3.3	2.9	2.4
Skydio	X2D	N/A	3.1	3.1	N/A
Skydio	X10D w/ VT300-Z & NightSense	4.0	N/A	N/A	3.7
Teal Drones	Teal 2	2.7	2.8	3.2	N/A

*as a lesson learned from the rural assessment, a single score was derived for each product. Duplication of scores for criteria that was not impacted by light or darkness in the environment was only asked one, hence single scores for urban and complex urban assessments.
** the eight criteria highlighted in this report are the only criteria scored during the complex urban assessment.

Table 4-2 presents the average scores evaluators assigned to each select evaluation criterion for each product. The graphic below (Figure 4-1) illustrates how color is used in Table 4-2, as the darker the shade of the blue is, the higher the criterion score for that criterion.

SAVER Scorecard Key				
This product ____________ of my expectations for this criterion				
meets none 1	meets some 2	meets most 3	meets all 4	exceeds all 5

Figure 4-1 SAVER Scorecard Key

Below, Table 4-2 presents the average evaluation criteria scores the products received from the evaluators for each evaluation criterion. The darker the shade of blue denotes a higher the rating.

Table 4-2 SAVER Scorecard: Evaluation Criteria Ratings

SAVER	Ascent AeroSystems			Freefly Systems			Parrot			Skydio			Teal Drones		
	Spirit			Astro			ANAFI USA GOV			X2D	X10D		Teal 2		
Environment	Rural	Urban	Complex Urban	Rural	Urban	Complex Urban	Rural	Urban	Complex Urban	Rural	Urban	Complex Urban	Rural	Urban	Complex Urban
EO Camera's Visual Acuity	3.4	3.9	Not Evaluated: unable to maintain consistent position hold[8]	Was not on the Blue List at the time	2.8	Not Evaluated: unable to maintain consistent position hold	3.3	3.5	2.6	2.8	4.1	3.9	2.3	1.9	Not Evaluated: unable to maintain consistent position hold
IR Camera's Visual Acuity	3.7	4.3			3.4		2.1	1.5	2.3	2.1	3.1	3.2	2.9	2.5	
Flight Duration	2.7	3.3			4.1		3.4	3.6	3.0	3.7	4	3.9	2.8	2.5	
Command and Control Link Quality	3.3	2.9			2.8		2.7	2.6	1.8	2.8	3.9	3.4	2.6	2.3	
Latency	3.7	3.1			3.8		2	2.5	1.7	3.3	3.9	4.1	3.5	2.6	
Time to Redeploy	3.1	2.9			4.1		4.3	3.4	2.1	2.9	4.1	3.6	3.4	2.6	
Deployability	2.9	2			3		3.5	2.5	2.7	2.8	4.3	3.4	2.3	1.5	
Ease of Use	3	2.3			3		3.3	4	3	2.7	4.1	4	2.9	2.4	
Ground Control Station Interface	3.5	2.5			3.6		3.2	3.3	2.8	2.5	3.8	4	2.7	1.9	

Note: The Skydio X2D was evaluated during the rural assessment in June 2024. The X10D was added to the Blue List mid-2024 and replaced the X2D in the urban and complex urban assessments that occurred in November 2024 and July 2025.

[8] These platforms were deemed unsafe to fly during the complex urban test due to their inability to maintain a position hold without drifting. The test team and safety pilots noted issues with RF interference, GNSS sky obscuration by buildings, and GNSS multipath.

4.1 Ascent AeroSystems, Spirit

The Ascent AeroSystems Spirit (Figure 4-2) is a coaxial unmanned aircraft with multiple configuration options. The Spirit can be flown with one or two 12S 44.4 volt (V) lithium ion (Li-ion) batteries; for the assessment it was flown with one battery. The airframe is sealed to protect against dust and moisture, with an ingress protection rating of IP56. The Spirit was tested with a NextVision NightHawk2-UZ EO/IR camera that features 40x EO zoom (20x optical, 2x digital) and 4x digital IR zoom. Both cameras have a resolution of 1280 x 720 pixels. Other camera options are also available, including the NextVision Raptor, NextVision DragonEye2, and Gremsy ZIO. The Spirit uses the Navigator Tab3 GCS and can perform autonomous flights. The product includes a storage case that holds the Spirit aircraft, Navigator Tab3 GCS, three batteries, a charger, and one set of four propellers. The Spirit's dimensions are 12.0 x 4.2 inches; with the blades fully extended the tip-to-tip diameter is 25.5 inches. It weighs about 7.8 lbs. with one battery and the NightHawk2-UZ camera payload.

Figure 4-2 Ascent AeroSystems Spirit

Image Credit: Ascent AeroSystems

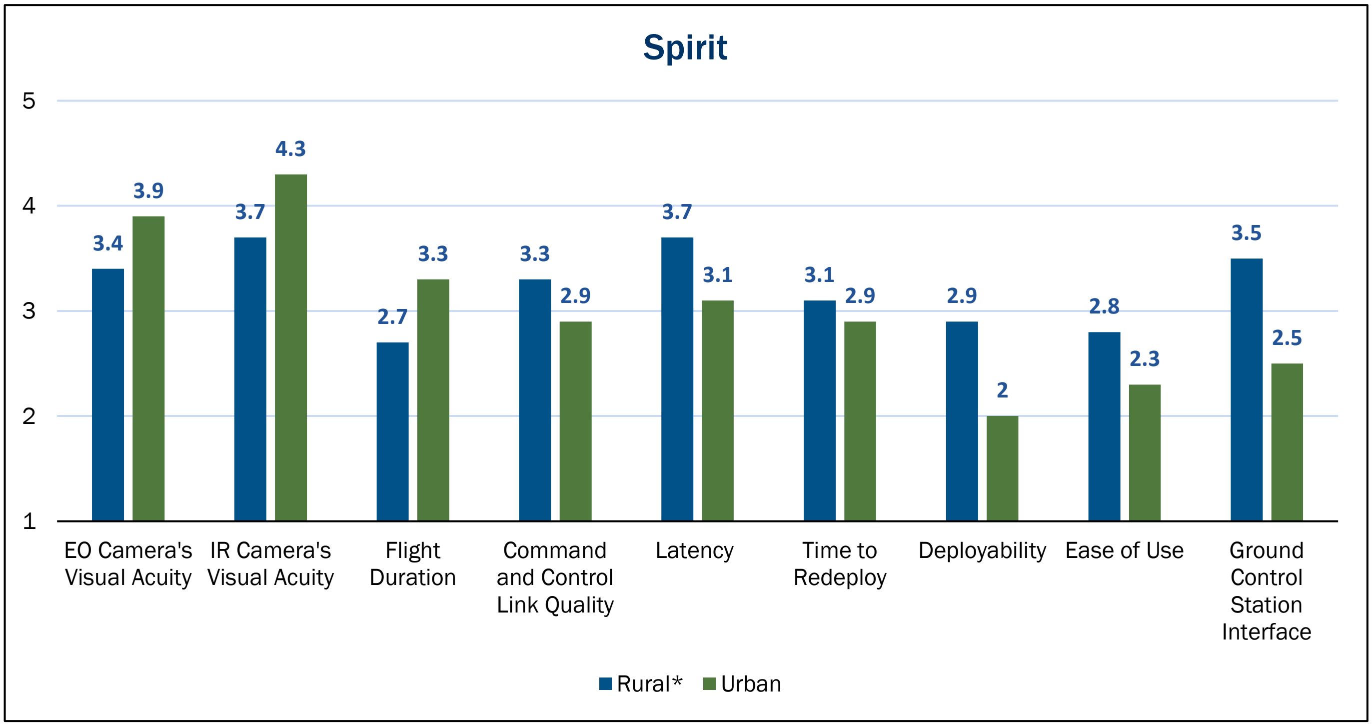
As configured for the assessments with the NightHawk2-UZ, the Spirit cost $56,195.

Assessments: ✓ Rural ✓ Urban X Complex Urban

The Ascent AeroSystems Spirit was assessed at two of the three events: the rural and urban assessments. This platform was unable to maintain a consistent position hold in a complex urban environment, leading to its exclusion from that test.

The Spirit received overall scores of 3.3 (day) & 3.2 (night) in the rural assessment and 3.1 in the urban assessment. Overall, evaluators highlighted aspects of the Spirit including the point to track target tracking capability and the high resolution of the IR camera (1280x720) as well as the zoom capabilities of both the EO (40x [20x optical + 2x digital]) and IR (4x digital) cameras. This enabled evaluators to easily identify various targets by taking advantage of the high detail resolution. The Spirit had some limitations including the location of the controls, which made it difficult to maneuver the camera while the drone was in motion and added to the length and complexity of the assembly and deployment process. Evaluators appreciated the ability to outfit the Spirit with two batteries, but desired more than the manufacturer-provided run time of 16 minutes with one battery and 32 minutes with two batteries.

Figure 4-3 shows the select criteria scores for the Spirit from the rural and urban assessments.



*Note: Rural assessment scores from day and night operations are averaged in this graph, with the exception of EO and IR cameras' visual acuity

Figure 4-3 Ascent AeroSystems Spirit Select Criteria Scores

The evaluators provided comments and feedback on criteria throughout each assessment. The summary of those comments below outlines key takeaways across assessments, focusing on criteria that would be impacted by environmental factors, as well as criteria identified of the utmost importance by focus group weighting. The criteria are grouped by SAVER category then listed according to their order of importance as assigned by the focus group.

4.1.1 Capability

- **Command and Control Link Quality:** The Spirit's command and control link quality met most of the evaluators' expectations across each assessment. During the rural assessment, evaluators experienced link issues, such as short disconnections from the GCS during the day that did not occur during night operations, which was in a more rural, open environment with minimal structures present. However, during urban operations all the evaluators experienced frequent issues with signal loss at both test sites, including video feed stuttering, limited flight range, and both automatic and unprompted emergency activation of the return-to-home feature.
- **Latency:** The Spirit performed better during the rural assessment than at the urban assessment when it came to latency. Across both assessments evaluator feedback was mixed; some evaluators reported intermittent latency issues while others found the system to react to their inputs as expected. Notably, during the urban assessment, the feedback yielded lower scores due to issues such as high latency and response delays, particularly when in proximity of other airborne drones, and difficulties in binding the aircraft to the GCS as the Spirit radio system uses fixed channels as opposed to spread spectrum frequency hopping.

4.1.2 Deployability

Figure 4-4 Spirit GCS displaying pre-flight checklist

- **Time to Redeploy:** The Spirit had mixed feedback for time to redeploy. Evaluators commented that the redeployment process was complicated primarily due to the multi-component assembly. Components had to be removed to swap the battery, which evaluators noted would delay operations and introduce the risk of damaging or losing parts. However, other evaluators found the battery swap itself to be fairly simple. Additionally, because there is no indicator that confirms when the drone components are secured in place, evaluators emphasized that this lack of assurance would increase the complexity of assembling the Spirit at night. Evaluators noted that the arming checklist (Figure 4-4) also needs to be repeated during redeployment and would take more time. They commented that the unexceptional flight time did not justify the amount of time required for redeployment.

Figure 4-5 Evaluator indexing propellers during deployment of the Ascent Spirit

- **Deployment:** The majority of evaluators across both rural and urban assessments had concerns with the deployment process of the Spirit. Although they appreciated the safety confirmations provided by the required pre-flight checklist that appears on the GCS (Figure 4-4), they voiced concerns that it took too much time for mission circumstances. The operator must use three different power buttons to activate the system, further lengthening the time needed to deploy. In addition to its lengthy deployment time, evaluators also commented negatively on the large number of UAS components and their frustration with the non-intuitive design, both of which increased possibilities for assembly mistakes, system errors, and damage. One evaluator was frustrated with needing to index the propellers before each flight (Figure 4-5); they also noted that although the locks need to be in place, there is no safety indication to confirm the propellers are secure. Evaluators also expressed concern about the lack of a locking mechanism for the legs, noting that it might result in damage and replacement costs.

4.1.3 Additional Information

During the complex urban event at Hudson Yards, the Spirit could not be fully assessed because it lacked sufficient global navigation satellite system (GNSS) reception to reliably hold position. During the familiarization session before the assessment activities, however, evaluators highlighted the capability of the camera and zoom the NextVision NightHawk2 (Spirit's payload). They also noted the coaxial design of the Spirit made it challenging to fly as it gives the operator no physical indication of the aircraft's orientation. Its 360° camera also contributed to disorientation experienced by the pilot during flight. Additionally, the platform was slow to respond to pilot inputs from the GCS.

4.2 Freefly Systems, Astro

The Freefly Systems Astro (Figure 4-6) is a quadrotor vertical take-off and landing (VTOL) platform with dual hot-swappable SL-8 Air batteries (6S 21.6V) and a swappable payload via the Freefly Smart Dovetail adapter. The Astro was tested with a Sony LR1 EO camera with an integrated laser range finder and FLIR Boson 640 x512 pixel IR radiometric sensor. The Astro received video feed from and was operated using a Pilot Pro controller. The system has two Pelican case options for transport. Both cases house the aircraft, the GCS, payload, and miscellaneous tools. The smaller case holds two batteries mounted into the aircraft and two chargers, while the larger case holds eight batteries with two mounted in the aircraft and six chargers. The platform has length of 55.4 inches, width of 55.4 inches, height of 14.1 inches, and measures 36.1 inches diagonally. The Astro weighs approximately 6.6 lb. without payload.

Figure 4-6 Freefly Systems, Astro
Image Credit: Freefly Systems

As configured for the assessment, the Astro cost $47,018.

Assessments: X Rural ✓ Urban X Complex Urban

The Freefly Systems Astro was assessed only at the urban test as it was not on the Blue List at the time of the rural assessment, and it was unable to maintain a position hold at the complex urban assessment due to a variety of urban canyon effects (e.g., signal reflections and blockages caused by tall buildings). During the urban assessment, the Astro received an overall score of 3.5. Evaluators appreciated the approximate 30.1 minute flight duration, the ability to customize safety features and the hot-swappable batteries capability. Operators did, however, experience command and control link issues, and found the system was complicated to deploy. They also noted its lack of an EO camera for optical zoom.

Figure 4-7 shows the select criteria scores for the Astro from the urban assessment in Miami.

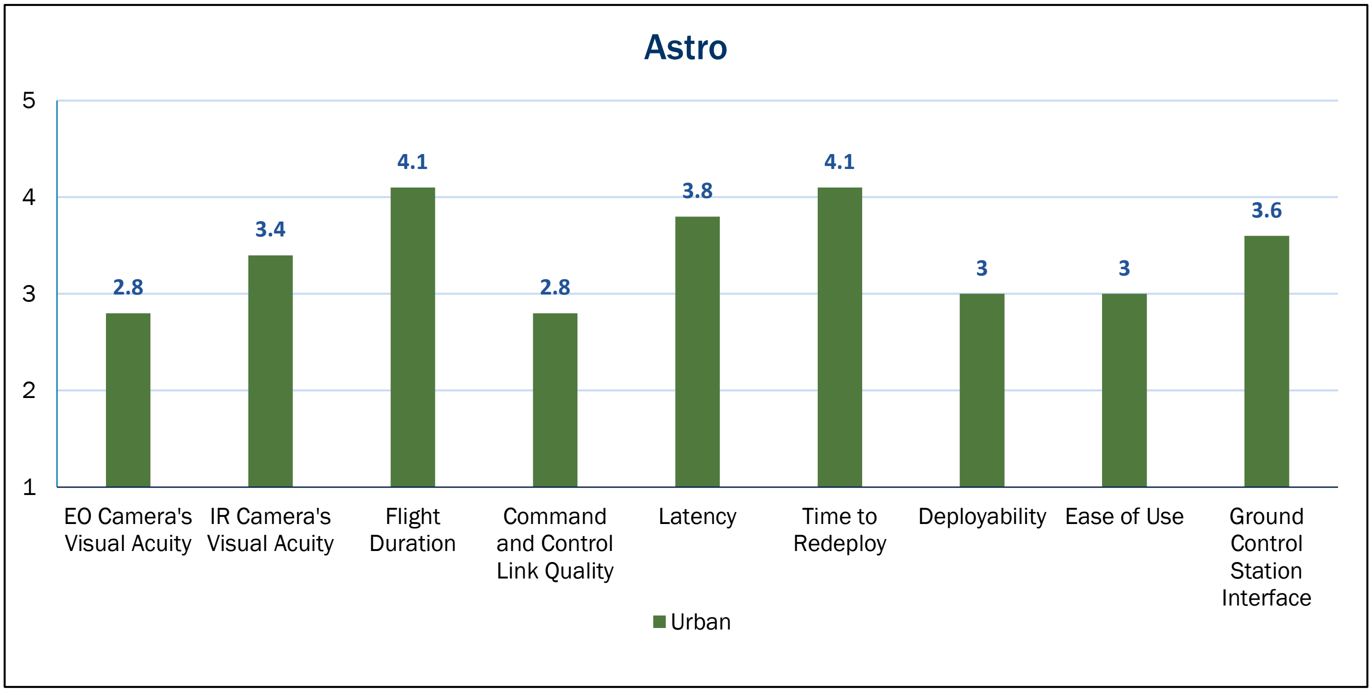


Figure 4-7 Freefly Systems Astro Criteria Scores

The evaluators provided comments and feedback on criteria throughout each assessment. The summary of those comments below outlines key takeaways across assessments, focusing on criteria that would be impacted by environmental factors, as well as criteria identified of the utmost importance by focus group weighting. The criteria are grouped by SAVER category then listed according to their order of importance as assigned by the focus group.

4.2.1 Capability

Figure 4-8 Channel selection scan on the Astro GCS

- **Command and Control Link Quality:** Across the board, evaluators stated the Astro struggled to maintain a solid link during day operations at Bayfront Park, which is a dense RF environment. Signal loss and interference, which could impact operational reliability, were noted at moderate distances. These issues were particularly evident in areas with high RF noise or physical obstructions. Of note, during the daytime scenarios, the Astro began losing its video and command and control link at approximately 750 feet away from the GCS or when reaching marginal line of sight. Some evaluators noted that once the aircraft was configured and airborne for the nighttime scenario at LoanDepot Park, performance improved, however others had difficulty launching the aircraft due to signal interference and needing to select a discrete GCS channel for the aircraft to operate on.

- **Latency:** During day operations at Bayfront Park, evaluators experienced video latency and some control latency issues that also presented problems when toggling and configuring menu options. During night operations at LoanDepot Stadium, evaluators noted these issues were mostly resolved. Overall, the system was able to keep up with most real-time commands during standard operations.

4.2.2 Deployability

- **Time to Redeploy:** Evaluators found the Astro met all of their expectations for redeployment, attributing this to the ability to hot swap the batteries. They noted that the requirement to turn the batteries on before locking them into place, however, could cause confusion or delays in redeploying (Figure 4-9).

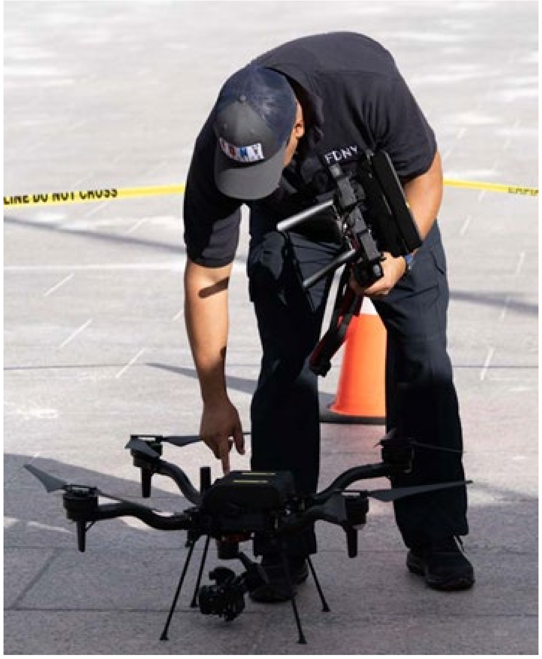


Figure 4-9 Battery placement and power buttons (circled, left) and an evaluator powering on the batteries prior to flight (right)

- **Deployability:** The Astro received mixed feedback from the evaluators. Some noted the design made it easy to transport and set up in various environments, while others thought the Astro's design would be too complex for their operational needs. Those who remarked on the complexity cited the need to attach the gimballed payload and manually perform channel selection prior to flight.

4.2.3 Additional Information

During the complex urban assessment, the Astro could not be fully assessed. Evaluators attempted to fly the Astro at Hudson Yards and found that it would not enter position mode, causing the aircraft to drift constantly. A safety pilot from the test team took control of the aircraft and attempted to switch into position hold at a higher altitude, to no avail.

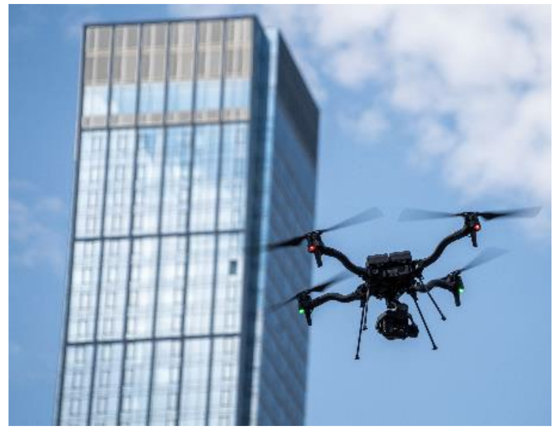


Figure 4-10 Astro during a test flight at Hudson Yards

During familiarization flights at Fort Totten, evaluators had similar feedback to those in the urban assessment. Some appreciated its more substantial size for applications with sufficient deployment space and others noted its size would not be ideal for emergency operations that demand a shorter deployment time or reduced footprint. Evaluators found value in the ability to swap payloads and hot swap batteries on the aircraft, which made it the easiest to redeploy of all assessed platforms at the urban and complex urban events. While using the camera, evaluators noted the lack of optical zoom made it insufficient for their operations. They reported that switching the camera into video mode improved visual acuity, however this did not change their overall impressions of the daytime camera capabilities. Regarding the IR camera, evaluators said it provided industry standard resolution and clarity, but they would have liked it to include an optical zoom as well.

4.3 Parrot Drones, ANAFI USA GOV

The Parrot ANAFI USA GOV (Figure 4-11) is a quadrotor UAS with an integrated EO/IR payload containing two EO cameras (21 MP telephoto and 21 MP wide angle), and 320 x 256-pixel IR camera. The telephoto lens provides 5x zoom from a wide angle, with all other zooms being digital. The IR, a FLIR Boson LWIR micro-bolometer sensor, is rated at 20 Hz and a thermal sensitivity of 0.05°C. The ANAFI USA GOV uses a lithium polymer battery. Other notable features include the ability to blend the EO and IR feeds, and the ability to stream the video feed from the controller to a computer with an RTP-compatible video player via ethernet cable. The ANAFI weighs approximately 1.1 lb. and has a flight time of up to 32 minutes. The product comes with the ANAFI USA GOV aircraft, Parrot Skycontroller 3 GCS (which houses a Samsung tablet), a carrying case, three batteries with a charger, and various spare parts including propellers and USB-C cables.

Figure 4-11 Parrot ANAFI USA GOV

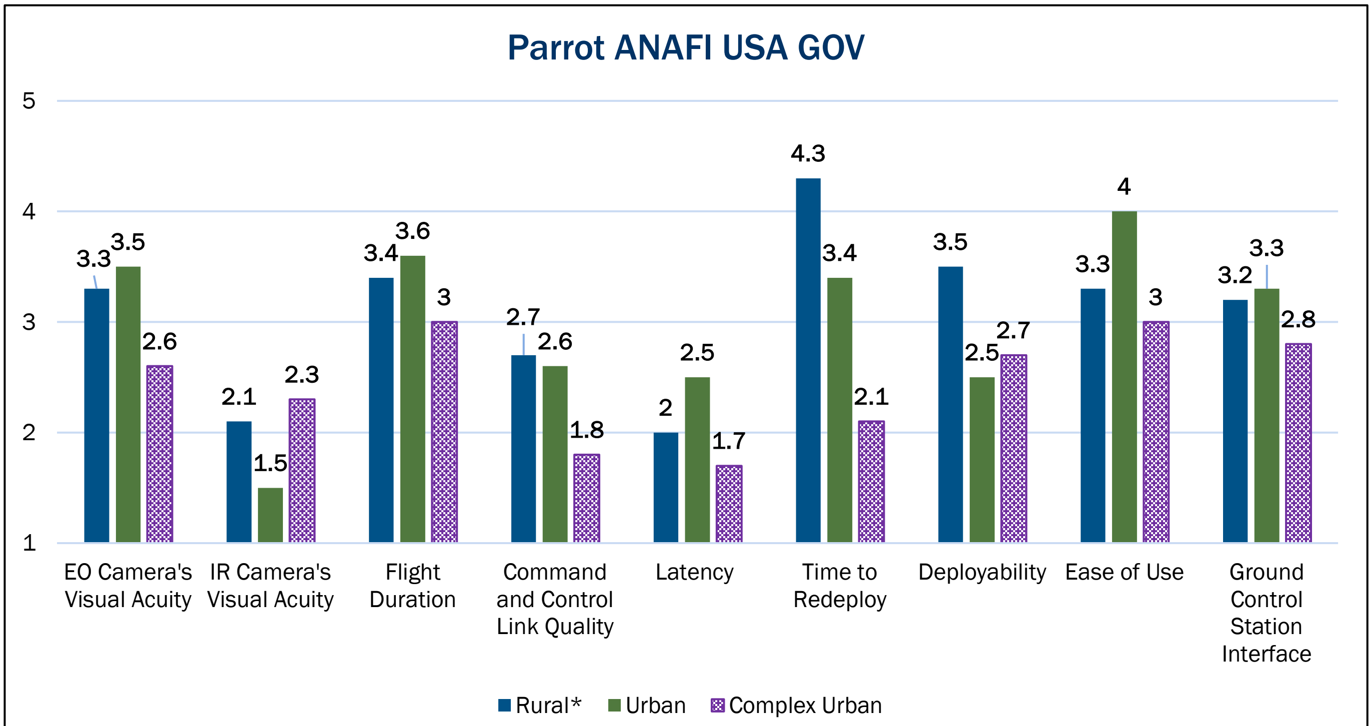
Image Credit: Parrot Drones

As configured for the assessment, the ANAFI USA GOV cost $13,964.

Assessments: ✓ Rural ✓ Urban ✓ Complex Urban

The Parrot ANAFI USA GOV was evaluated at all three assessments. It tied for highest daytime operations score at the rural assessment with a 3.3, though it received a lower score for rural night operations (2.9). During the urban assessment it received a score of 3.1 (combined day and night scenarios), and a 2.4 at the complex urban assessment (day and night scenarios). Evaluators found ANAFI has a satisfactory flight duration as well as being easy to transport, and intuitive to set up and maintain. However, evaluators considered the reliability of the command and control link a limitation of the platform across all three assessments. The ANAFI USA GOV struggled the most in the complex urban environment where operators experienced connectivity issues between the drone and GCS as near as 50 feet from the launch point.

Figure 4-12 shows the select criteria scores for the ANAFI USA GOV from all three assessments.



Note: Rural assessment scores from day and night operations are averaged in this graph, with the exception of EO and IR cameras' visual acuity.

Figure 4-12 Parrot ANAFI USA GOV Criteria Scores

The evaluators provided comments and feedback on criteria throughout each assessment. The summary of those comments below outlines key takeaways across assessments, focusing on criteria that would be impacted by environmental factors, as well as criteria identified of the utmost importance by focus group weighting. The criteria are grouped by SAVER category then listed according to their order of importance as assigned by the focus group.

4.3.1 Capability

Figure 4-14 A Parrot ANAFI USA GOV flies in Hudson Yards

- **Command and Control Link:** Evaluators found the command and control link for ANAFI USA GOV to be similar in rural and urban environments as the platform was able to connect and launch but experienced intermittent connectivity issues (Figure 4-14). The magnetic interference introduced in the complex urban landscape challenged the platform even more, resulting in connectivity issues as near as 50 feet from the launch point. Across each of the three assessments, evaluators cited issues with slow reaction to inputs, limited range and unreliability to connect to the GCS on a cold start. Evaluators said they would have appreciated a numeric satellite count display on the GCS main screen to assist in identifying launch points and managing expectations for usability during operations. During the complex urban assessment, every evaluator experienced challenges that would limit how useful the platform could be during response operations; this included insufficient GPS and satellite connections, the inability to take off between two high-rise buildings, warning messages about signal strength, the need to reset the radio to mitigate connectivity errors, loss of link resulting in flyaway, and the need to move locations for launch.

Figure 4-13 Banner interference indicators (yellow and red alerts across the bottom of the GCS) from the Complex Urban (top) and Urban (bottom) Assessments

- **Latency:** Evaluators experienced latency between the UAS and GCS across all three assessments. The latency impacted camera controls (significantly so during the complex urban assessment) and zoom abilities, causing loss of video. as well as aircraft control. In at least one instance, the latency worsened when additional UAS were in the area or when the GCS was near a handheld radio. At the complex urban assessment, evaluators stated that there was an unacceptable lag when zooming or switching between the EO and IR cameras. Additionally, they noted the SD card records the latency, which can cause responders to miss important information evidentiarily.

4.3.2 Deployability

- **Time to Redeploy:** Scores for time to redeploy varied greatly across the three assessments. During the rural assessment evaluators found the ANAFI USA GOV met or exceeded their expectations. During the urban assessment, evaluators found it took approximately 60 seconds to land, change the battery and redeploy the drone–which most evaluators said met their expectations; all the same, other evaluators desired a faster deployment time, ideally under 30 seconds. Evaluators from the complex urban assessment noted that the lack of a clear and consistent indicator for being powered on – for both the drone and controller – caused confusion. Nearly every evaluator noted an issue with powering the system on and stated it was not intuitive, involved too many steps, and/or required them to press the power button in a specific spot for success. They also commented on the lengthy boot up time. These factors led to the overall determination that the ANAFI USA GOV met only some of the evaluators' expectations for this criterion.
- **Deployability:** Across all three assessments, evaluators found the deployment of the ANAFI USA GOV fairly straightforward with the fewest steps to deploy in comparison to the other assessed products. However, evaluators cited delays with the GCS booting up and issues pairing the GCS with the aircraft that resulted in deployment times upward of three minutes in some instances, which was deemed too long for first responders' operational needs. Specifically, during the complex urban assessment, the insufficient GPS connections (referenced in the Command and Control Link section above) impacted deployment with additional delays/prevented deployment altogether. Other feedback included that the additional step of removing joysticks from their stored position on the back of the GCS (Figure 4-15) could be problematic during night operations. Evaluators also had concerns over the fragility of the battery connectors that exhibited stress fractures after limited use during the rural assessment. Further feedback collected at night showed that having to attach an anti-collision light proved difficult due to the small size of the aircraft. Evaluators would have preferred onboard LED's and an anticollision light for regulatory compliance.

Figure 4-15 Parrot ANAFI USA GOV joysticks (circled) stored on the rear of the GCS

4.3.3 Additional Information

The ANAFI USA GOV's IR camera has a resolutions of 320 x 256-pixels, which was the lowest specification for IR cameras, alongside the Skydio X2D. It tied the X2D with the lowest score for IR camera visual acuity during the rural assessment and had the lowest score in both the urban and complex urban assessments. The scores were attributed to lack of clarity or resolution, significant pixelation, lack of discernable thermal signature, and lack of radiometric capability (Figure 4-16). Evaluators noted that it provided noisy imagery, especially at higher altitudes, and experienced issues ranging from delays to blacked-out screens when toggling between the EO and IR cameras.

Figure 4-16 Image illustrating the lack of discernible thermal signature with the ANAFI USA GOV when locating a mock casualty (center) during night operations at the Rural Assessment.

4.4 Skydio X2D

The Skydio X2D (Figure 4-17) is a quadrotor UAS with an integrated EO/IR payload that includes a 12.3MP Sony IMX577 EO camera and a FLIR 320 x 256 pixel IR sensor. It is also equipped with six navigation cameras to provide 360° obstacle avoidance. The GCS uses the Skydio enterprise application and Q Ground Control. It is available with 5 GHz, 1.8 GHz and multiband radios. The airframe has an operating temperature range of 14°F to 109°F. It measures 26.1 inches long, 22.4 inches wide and 8.3 inches high and weighs 2.9 lbs. The Skydio X2D in the tested configuration included the vehicle, EO/IR camera payload, Skydio Enterprise Controller, three Li-ion batteries, a dual charger, spare propeller blades set, soft and hard cases, two 256GB pre-installed SD cards, and used the 5 GHz radio.

Figure 4-17 Skydio X2D

Image Credit: Skydio

The Skydio X2D received an overall assessment score of 3.1 for both daytime and nighttime operations at the rural assessment. Evaluator comments provided throughout that assessment are reported below, grouped by SAVER category. In each category, the criteria are listed according to their order of importance as assigned by Blue UAS focus group. The X2D was only assessed during the rural field test then replaced with the Skydio X10D, a similar sized platform with enhanced features and capabilities.

This configuration and a Skydio Autonomy Enterprise perpetual license with one year of maintenance and support costs $21,889.

Assessments: ✓ Rural **X** Urban **X** Complex Urban

Figure 4-18 shows the select criteria ratings evaluators gave the Skydio X2D during the rural assessment.

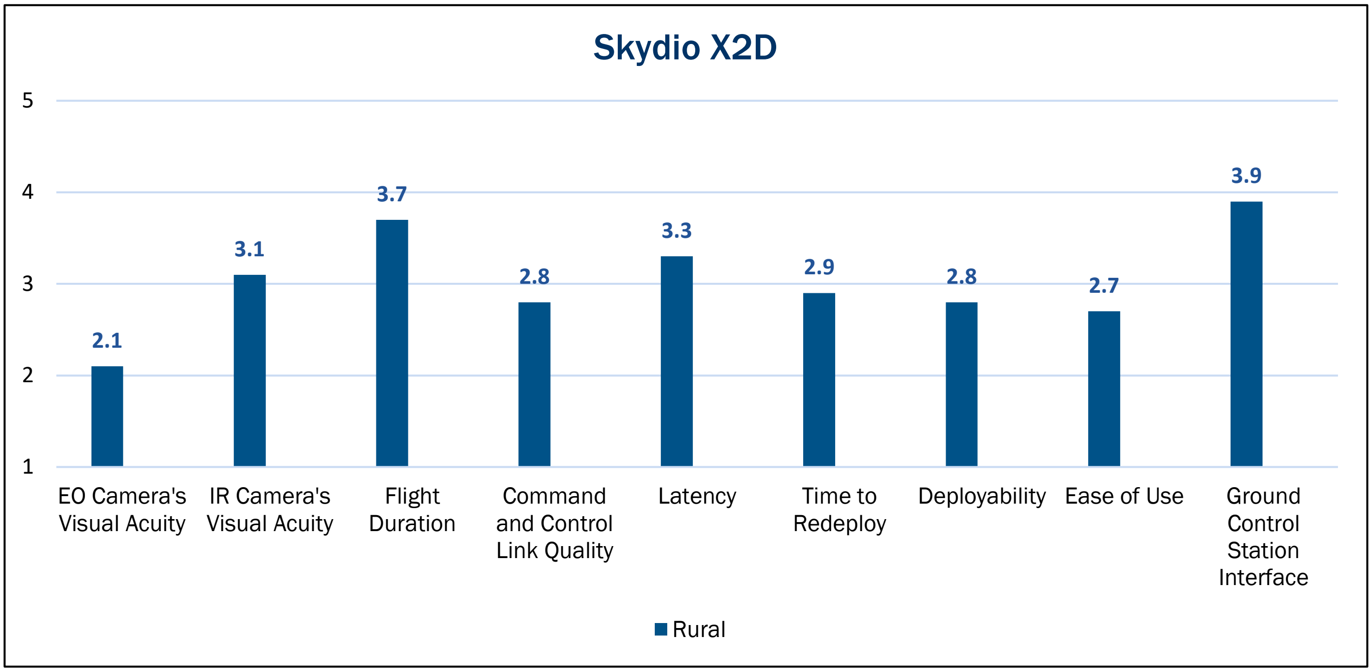


Figure 4-18 Skydio X2D Criteria Scores

The evaluators provided comments and feedback on criteria throughout each assessment. The summary of those comments below outlines key takeaways across assessments, focusing on criteria that would be impacted by environmental factors, as well as criteria identified of the utmost importance by focus group weighting. In the case of the Skydio X2D, this model was tested in only the rural operational environment with the Skydio X10D replacing the X2D in the urban and complex urban assessments. The criteria are grouped by SAVER category then listed according to their order of importance as assigned by the focus group.

4.4.1 Capability

- **Command and Control Link Quality:** Evaluators had mixed experiences with the connectivity between the controller and the platform during the rural assessment. While some evaluators did not experience any problems, others encountered interference when multiple platforms were flying in proximity and lost link connection when the drones were positioned directly above the operators.
- **Latency**: Evaluators experienced delays in control inputs and images updating, noting that the latency was enough to prevent smooth operations. Some evaluators noted the flight movements were jerky and experienced an inability to descend and move forward simultaneously.

4.4.2 Deployability

- **Time to Redeploy:** The Skydio X2D scored the lowest rating for redeployment during the rural assessment. Evaluators attributed this to the drone's' internal calibration taking approximately two minutes and thirty seconds to reboot after a battery change, which they deemed too long a wait to get the aircraft back in the air.
- **Deployability:** Overall the Skydio X2D met most of the evaluators' expectations for deployability, however scores were negatively impacted by the time needed to connect/recalibrate the aircraft and the requirement that operator's log in with a passcode. Additionally, the arm clamp, which serve as the joint between the arm to the body of the drone, created confusion and impeded the time required to deploy.

Figure 4-19 Evaluators configuring the and rotors of the Skydio X2D to prepare for takeoff

4.4.3 Additional Information

The Skydio X2D's IR camera has a resolution of 320 x 256-pixels, which was the lowest specification for IR cameras, alongside the ANAFI USA GOV. During the rural assessment, the X2D tied with ANAFI USA GOV for the lowest score for the IR camera's visual acuity. Evaluators specifically noted the system was insufficient for search operations due to the low quality, grainy images from the thermal camera and the pixelation of images when zooming. Evaluators also found the thermal color palettes available for IR were insufficient for identifying objects, noting that having an option for certain temperatures at a different contrast would be valuable. There was similar feedback in regard to the X2D's EO camera (visual in Figure 4-20), noting the optical zoom resulted in pixelated images that required users to fly closer to items/areas to get clearer views. Additionally, evaluators wished the camera had a wider field of view without zooming. During night operations, evaluators found the X2D's night vision performance inadequate, making the platform difficult to land. The obstacle avoidance appeared to cause issues in the landing sequence, and the orientation of the propellers positioned them so close to the ground that small rocks could cause the propeller to catch and flip or damage the aircraft.

Figure 4-20 Skydio X2D EO camera

4.5 Skydio X10D

Figure 4-21 Skydio X10D

Image Credit: Skydio

The Skydio X10D (Figure 4-21) is a quadrotor UAS that offers two integrated EO/IR payload options; the VT300-Z and VT300-L. During the urban and complex urban assessments, the X10D was equipped with the VT300-Z payload that contains two EO cameras and a 640-x 512 pixel radiometric thermal camera. The two EO cameras are a 48 MP telephoto camera and a 64 MP camera with 50° field of view that produce a zoom of up to 128x. The zoom starts with digital and then transitions to the telephoto lens. The thermal camera is the FLIR Boson + Uncooled VOx micro-bolometer sensor with a thermal sensitivity of <30mK. The X10D uses an 18.55V Li-ion polymer battery with 150 Wh. Other notable features include a six-lens AI-powered obstacle avoidance system that, when paired with a NightSense IR lighting system, works in total darkness. Evaluators used the NightSense IR system during night operations. The Skydio X10D has an IP55 rating, uses modular connector ports to swap additional payloads, and has position strobe lights that can be adjusted in flight, including turning off all visible lights while retaining the IR light. The Skydio X10D has no outside connectivity or video streaming capability. The Skydio X10D (4.65 SL/4.72 MH version) measures 31.1 in. long, 25.6 in. wide, and 5.7 in. high, weighs 4.65 lb., and has a manufacturer reported average flight time of up to 40 minutes. The product comes with a carrying case, the Skydio X10D aircraft, Skydio X10D Controller (IP54 rating), three batteries, battery and controller chargers, and various spare parts including propellers. Note that as of October 2024, due to supply chain issues, Skydio X10D systems will initially be delivered with one battery with the promise of two additional batteries once they are available.

At the time of the Urban assessment, the configuration cost was $28,382.

Assessments: X Rural ✓ Urban ✓ Complex Urban

Figure 4-22 shows the select criteria ratings evaluators gave the Skydio X10D for the urban and complex urban assessments.

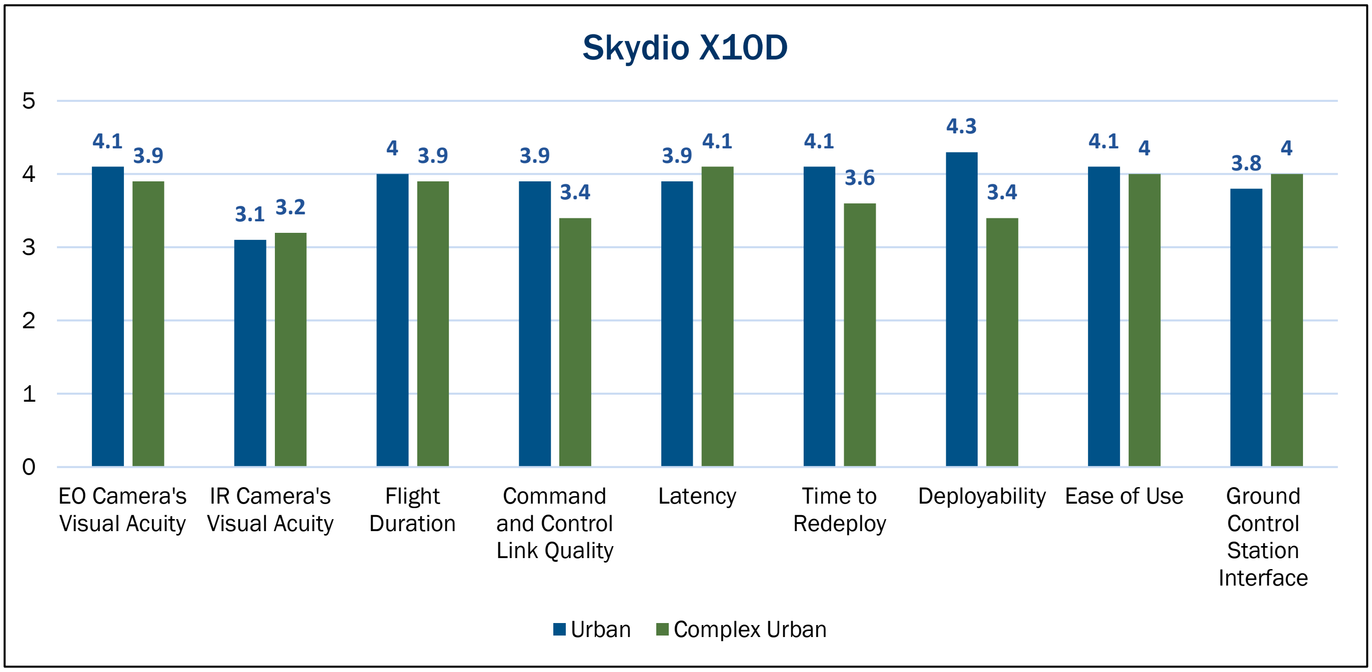


Figure 4-22 Skydio X10D Criteria Scores

The evaluators provided comments and feedback on criteria throughout each assessment (urban and complex urban). The summary of those comments below outlines key takeaways across assessments, focusing on criteria that would be impacted by environmental factors, as well as criteria identified of the utmost importance by focus group weighting. The criteria are grouped by SAVER category then listed according to their order of importance as assigned by the focus group.

4.5.1 Capability

Figure 4-23 Skydio X10D imagery with low quality connection signal at the Urban Assessment

- Command and Control Link Quality: During both the urban and complex urban assessments, evaluators had mixed experiences with connectivity. Some operators did not encounter any problems with the controller and platform connectivity. At the urban assessment, however, half of the operators noticed discontinuations and pixelations in the video feed when the UAS was in motion. Although manually adjusting the radio-control frequency improved signal loss, evaluators regarded this as a disadvantageous consideration when deploying and operating the platform in an urban setting. These problems recurred during the complex urban assessment, where some evaluators experienced connection loss operating below 100 ft. and at short horizontal distances when flying between high-rise buildings. Figure 4-23 shows an example of what the GCS looked like while the platform was experiencing a connectivity interruption during the urban assessment.

- **Latency:** During the urban assessment, some evaluators experienced unpredictable intermittent delays and non-responsiveness to controller inputs. They also noticed video skipping, where the image would briefly freeze and then jump ahead. During the complex urban assessment, evaluators experienced latency where the video stream would be briefly interrupted when they changed between the EO and IR cameras. Although the interruption time was relatively short, evaluators noted it was significant enough to be detrimental to operations.

4.5.2 Deployability

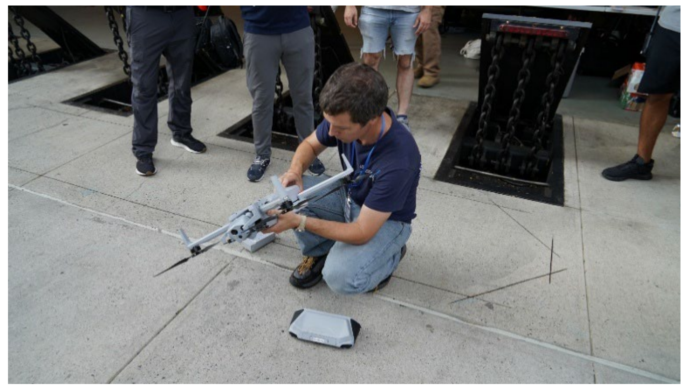


Figure 4-24 Evaluator redeploying Skydio X10D during the Complex Urban assessment.

- **Time to Redeploy:** During both the urban and complex urban assessments, evaluators noted that most of the redeployment time was spent waiting for the controller to reconnect to the drone after being restarted after battery changes. During the urban assessment, it took evaluators just under two minutes on average to redeploy the X10D, while during the complex urban assessment it took up to three minutes for some evaluators. The X10D's redeployment time was further extended by the need to wait for the drone to acquire a GPS lock.
- **Deployability:** The deployability of the Skydio X10D exceeded some of the evaluators' expectations, who noted —the system was fast and easy to unfold, power on, and connect. Other evaluators, however, found aspects of deployability cumbersome, like putting on and removing the gimbal cover, the length of the pre-operation controller software checklist, the need to carry a separate case for IR accessories, and the requirement to preload basemaps before deployment. In one instance, an evaluator's GCS completely reset and hard rebooted, resulting in the aircraft performing a landing in place where it lost link, requiring the test team to clear the area of obstacles and observers as the aircraft utilized its internal obstacle avoidance to navigate to a flat landing area.

4.5.3 Additional Information

The Skydio X10D overall received the best rating across the assessed systems mainly due to its ease of deployment, intuitive usage, autonomous navigation modes, and the NightSense accessory.

A noteworthy feature was the integration of automatic dependent surveillance-broadcast (ADS-B) data into the controller interface to provide situational awareness of and alert operators to nearby aircraft. Figure 4-25 shows an incoming aircraft notification on the display of the Skydio X10D GCS.

Figure 4-25 Alert of incoming aircraft on the Skydio X10D GCS

Evaluators suggested additional features that would be beneficial to their operations, such as hot swappable batteries, an audible alert to indicate the system has powered on, preloaded base maps, and a built-in spectrum analyzer to allow for dynamic switching frequences.

4.6 Teal 2

The Teal 2 is a quadrotor UAS equipped with an integrated dual axis EO/IR gimbal with a Hadron 16MP EO and 640 x 512 pixel IR payload. Teal 2 operates on one Teal Performance Battery Pack, a 22,2 V Li-ion battery that produces 60 Wh. The GCS is compatible with Teal Q Ground Control, Tomahawk Robotics Kinesis, and the Android application, ATAK, with the UAS Tool plug in. The Teal 2 weighs 2.75 pounds and has a manufacturer reported average flight time of up to 30 minutes. Purchase of the Teal 2 includes the aircraft, EO/IR camera payload, Teal Air Controller, two battery/charger kits (each including one charger and two batteries), Teal 2 Tactical Case, a field repair kit containing tools, two rotor arms, one set of propellers, a micro-SD card, quick start guide, drone transport pouch, and a one-year warranty.

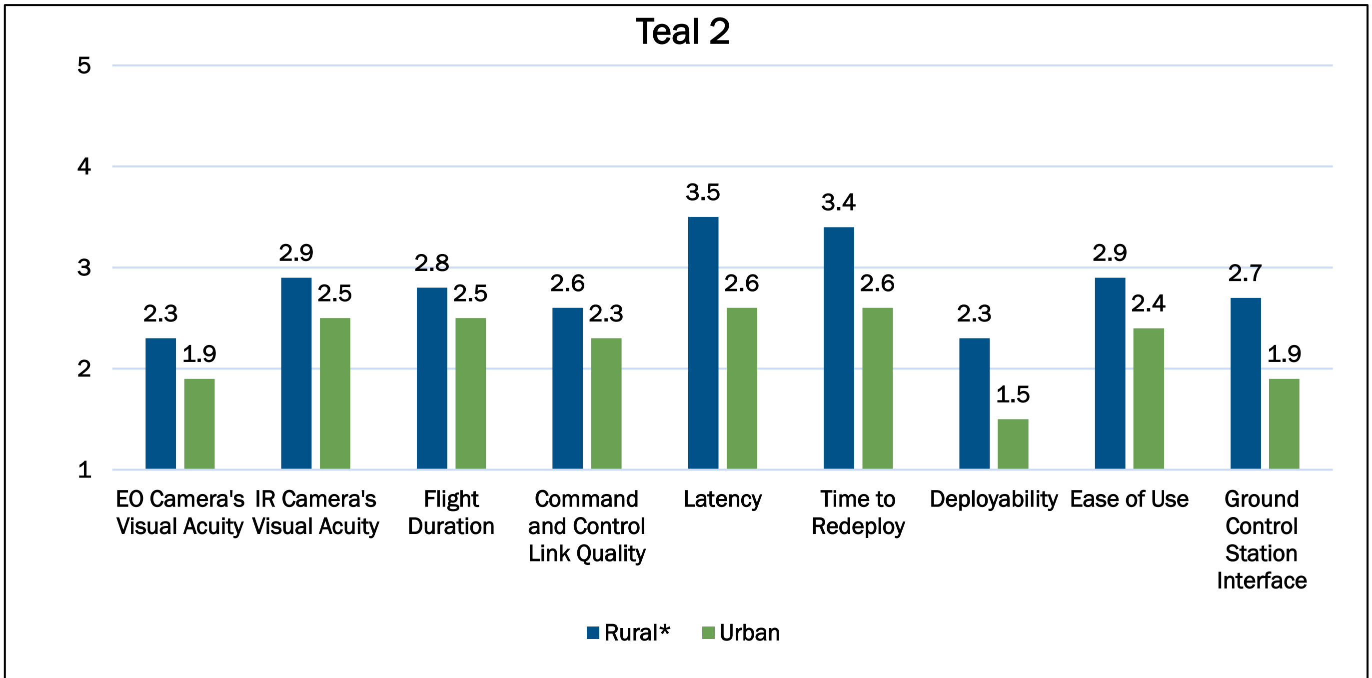
Figure 4-26 Teal 2
Image Credit: Teal Drones

As configured for the assessment, the cost of the Teal 2 is $15,073.

Assessments: ✓ Rural ✓ Urban **X** Complex Urban

During the rural assessment's night operations, the Teal 2 received the highest overall score, a 3.2. Evaluators across assessments highlighted strengths of the Teal 2 including the availability of geofencing and ceiling setting, its backlit buttons on the GCS, and ease of adjusting the brightness of the GCS screen. Additionally, the evaluators found it easy to transport and appreciated the secondary, streamlined transport pouch for transporting the drone. Evaluators did, however, experience extensive issues in pairing the Teal 2 with the GCS in both rural and urban assessments, which caused deployment delays of up to 15 minutes in some instances.

Figure 4-27 shows select criteria ratings evaluators gave the Teal 2 during the rural and urban assessments.



*Note: Rural assessment scores from day and night operations are averaged in this graph, with the exception of EO and IR camera's visual acuity

Figure 4-27 Teal SAVER Scorecard: Evaluation Criteria Ratings

The evaluators provided comments and feedback on criteria throughout each assessment. The summary of those comments below outlines key takeaways across assessments, focusing on criteria that would be impacted by environmental factors, as well as criteria identified of the utmost importance by focus group weighting. The criteria are grouped by SAVER category then listed according to their order of importance as assigned by the focus groups.

4.6.1 Capability

Figure 4-28 Pairing Teal 2

- **Command and Control Link Quality:** Evaluators experienced GCS and GPS connectivity issues during both the rural and urban assessments, with Teal 2 receiving slightly higher scores in the rural environment. Evaluators noted that the system continuously had issues properly pairing and syncing the GCS with the aircraft (i.e., establishing GPS link and awaiting Remote ID), An example pairing alert is shown in Figure 4-28. The connectivity issues caused delays, in some instances up to 15 minutes, before the UAS was ready to take off. Some evaluators also experienced some aircraft movement without controller input and drift in the camera. During the urban assessment, evaluators found that any physical obstruction between the GCS and drone caused issues with the connection and caused the video to lag or skip, and the video dropped out periodically despite being in direct line of sight of the drone. Evaluators also expected the operational distance from the GCS to the drone to be greater. Evaluators found that the link quality was better during night operations when flying at LoanDepot stadium since there were fewer obstructions, which was consistent with the experience in during the rural assessment.
- **Latency:** The Teal 2 received an average latency score of 3.5 in a rural environment, and a 2.6 in an urban environment – the largest discrepancy in its Capability category scores. During the rural assessment, Teal 2 met most or all of the expectations of the evaluators during day operations. Three evaluators indicated the Teal 2 met all their expectations for latency, though they experienced some instances of video failure and pixilation, as well as lag in response to commands. Latency issues were less pronounced during nighttime operations where the area was more open; the flight controls were very responsive to movement inputs and evaluators experienced minimal delays with video transmission. During the urban assessment, most evaluators found the Teal 2 met most of their expectations, yet they experienced delays between joystick input and drone movement, and between drone movement and subsequent changes in the video. Evaluators' concerns with latency varied from not bad to significant. One evaluator would have preferred the video cut out rather than its lagging as they found it to be very difficult to operate the drone without timely video, speculating that knowing to switch to visual would be especially important in an operationally complex environment. The video skipped and lagged at times in the presence of physical obstructions. Some evaluators experienced the Teal 2 being unable to provide a clear picture due to pixelation and continuous loss of video, sometimes even when direct line of sight was not at all obscured.

4.6.2 Deployability

- **Time to Redeploy:** Within the Deployability category, evaluators experienced pronounced differences while redeploying the Teal 2 in different environments. During the rural assessment, the time to redeploy met all or most of the evaluators' expectations. The required step of recalibrating and reconnecting the drone after every battery change (roughly 150–180 seconds) was deemed too long for their needs by some. During the urban assessment, all evaluators found that it took too long to change the battery and redeploy due to difficulties with pairing the GCS and drone, as well as connecting Remote ID.
- **Deployability:** The Teal 2 received an average deployability score of 2.3 in a rural environment and a 1.5 in an urban environment. The platform struggled in both environments due to the complexity and unreliability of the Teal 2 start-up and pairing sequence. Evaluators had similar experiences including the duration of boot up, complexity of pairing the Teal 2 with the GCS, difficulty in establishing a Remote ID connection, and the amount of time it took to troubleshoot the issue when the drone failed to pair. They also noted that the GCS cannot be connected to Wi-Fi and the drone at the same time, which could add several steps of disconnecting and connecting different components in situations when quick deployment is needed. Evaluators did, however, appreciate the portability of the system, particularly the size and weight of the carrying case, and highlighted the camouflaged secondary case to carry the drone (Figure 4-29), noting it would be particularly useful when needing to navigate to and launch a drone from scenes in challenging environments. They also appreciated the UAV's soft foldable antennas.

Figure 4-29 Teal 2 in its carrying case, with camouflaged secondary case shown

4.6.3 Additional Information

During the complex urban assessment, evaluators could not safely launch the Teal 2 without sufficient GPS lock. They experienced challenges with this during familiarization flights at Fort Totten (urban but not "complex") and at the Hudson Yards test site. During the training at Fort Totten, some evaluators experienced RemoteID failures that prevented the Teal 2 from taking off. After approximately 10 minutes of troubleshooting, the error was resolved for a successful launch. Evaluators reported experiencing latency even at short distances as well as a shaky, pixelated video feed.

In urban and complex urban environments, evaluators noted the quality of the camera zoom was insufficient for capturing license plates and large text. They also expressed that the thermal camera lacked resolution sufficient for response operations. Evaluators observed controller gimbals that felt unsteady and expressed alarm that the kill switch was readily accessible, worrying that they could accidently activate it during flight. They nevertheless appreciated the controller's large screen and course setting capabilities. Evaluators appreciated that the batteries had an audible click and felt secure when properly installed as well as the shared batteries between the platform and the GCS. Still, they noticed rapid battery loss even during shorter flights.

5.0 SUMMARY

Over the course of the three assessments, 26 experienced remote pilots from various federal, state and local jurisdictions served as subject matter expert evaluators throughout operational scenarios in rural, urban, and complex urban environments. Major takeaways from these assessments are:

- **GPS cannot be relied upon for positioning in dense urban environments.** Emergency responders require a stable platform that can be operated by a single remote pilot in command. The need to constantly provide position inputs to keep a platform from drifting distracts them from using the on board sensors and providing feedback to their team.
- **Inconsistent wireless connection between ground control station (GCS) and aircraft.** Emergency responders require a reliable connection between the GCS and aircraft. An inconsistent link will result in not only inconsistent real-time information but also will diminish trust in a platform's capability to perform. As a result, response agencies may choose to allocate their limited resources away from using UAS. The Blue UAS that were assessed experienced disconnects as near as 50 feet from the launch point in some instances. UAS are valuable to response operations as they provide an aerial vantage point and allow operators to maintain a safe standoff distance from potential threats, thereby significantly mitigating safety risks. The inability to maintain a connection link limits, if not prevents UAS operations, eliminating the ability to assess and monitor incidents remotely.
- **Deployment time was unacceptable for most first responders**. Emergency responders must act in short order to ensure life safety, and document key details of incidents for prosecutions. If a UAS takes too long to deploy, responders will be faced with determining whether resources should be aligned to traditional methodologies as the benefits of using a UAS are minimized. The evaluators experienced a myriad of issues with the Blue UAS that were assessed, resulting in unacceptable deployment times (e.g., GCS disconnections, need for resets and repairs, GPS lock and Remote-ID failures, and pre-launch calibration delays).
- **Cost of Blue UAS is a significant barrier for many departments.** Response agencies vary vastly, but ultimately budgets must be used strategically to ensure the best investment of taxpayer dollars while maximizing the safety and security of the communities they serve. Excessive costs may lead to the diversion of funds from other critical equipment purchases and the procurement of fewer unmanned platforms which can lead to gaps in response operations.

Without capabilities such as a stable wireless connection and reliable GPS, operators cannot focus on utilizing the sensing capabilities (cameras) of the UAS because they must focus on maintaining the aircrafts position. This results in UAS operations being severely limited and may hinder a wide variety of public safety and response missions, including situational awareness, search and rescue, and hazard detection. Similarly, if a UAS takes too long to deploy or is too costly, responders may opt to use traditional methods rather than adopt UAS, as the advantages of these systems are diminished.

Additionally, Table 5-1 summarizes the advantages and disadvantages of each product as identified by the evaluators.

Individual responder agencies that intend to purchase UAS should carefully research the capabilities and features of available technologies or equipment to identify the product best suited to their operational needs.

Table 5-1 Advantages and Disadvantages

Manufacturer/Product	Advantages	Disadvantages
Skydio, X10D  **GSA Price: $ 28,382**	• Easy to set up and deploy • Highly rated flight duration • Infrared lighting kit for night operation • Intuitive to use • (CU): Autonomous navigation modes increased stability	• Lack of basemaps by default • GCS buttons are not backlit • Touch screen required for some functions • Inconsistent tracking feature • Non-ergonomic GCS • (U): Some pixelation/lag in video feed • (U): Manual frequency adjustment required for optimal RF Link • (CU): Latency when shifting between EO and IR Cameras
Freefly Systems, Astro  **Price: $47,018**	• Flight duration • Hot swappable batteries • Easy to transport, two case sizes • Offers customizable safety features such as ability to change flight modes quickly via physical push buttons, and ability to adjust sensitivity of controls during flight with knobs • Clear GCS display in low light	• Lack of EO camera optical zoom • Command and control link issues • Manual frequency adjustment required for optimal RF link • Complex deployment process • Heavy GCS • Inadequate screen brightness in full light • (CU): Unable to safely operate in dense urban environment
Ascent AeroSystems, Spirit  **GSA Price: $56,195**	• Good visual acuity of high resolution (1280x720) IR camera • IP56 rating for adverse weather • Highest rated IR camera image clarity and high resolution even during operations in full light and when zoomed • Camera can track objects and perform automated searches for people or vehicles • (R): Low latency experienced	• Complex, lengthy deployment • Poor command and control link • High latency • Non-intuitive design of GCS • Location of controls makes it difficult to maneuver the camera while the drone is in motion • GCS screen brightness issues in full light • (CU): Unable to safely operate in dense urban environment

Manufacturer/Product	Advantages	Disadvantages
Parrot Drones, ANAFI USA GOV  **GSA Price: $ 13,964**	• Good visual acuity of EO camera and optical zoom • Easy to transport • Easy to use GCS interface • Quick redeployment • Good in-house maintenance • Batteries on the aircraft are easily accessible • Very portable due to small size • (CU): IR fusion with EO helped with image resolution and clarity	• Poor visual acuity of low resolution (320x256) IR camera • Screen brightness insufficient in full light, GCS auto brightness sensor covered by case • Lack of anti-collision lights • EO camera does not handle scenes with high and low contrast objects well • (R): Occasional high latency between aircraft and GCS, especially when multiple UAS operating in the same area • (U): Command and control link issues • (CU): Connectivity issues as near as 50 feet from GCS • (CU): Lack of numeric satellite count shown on GCS main screen
Teal Drones, Teal 2  **GSA Price: $ 15,073**	• Easy to transport • Emits low amounts of light and sound • Easy propeller and arm replacement • GCS has ergonomic shape and favorable size and weight • Backlit GCS buttons	• Poor visual acuity of EO and IR cameras • Remote ID connectivity issues • Frequent command and control link issues • High latency between controller and aircraft • Complex deployment process • Non-intuitive GCS interface • Lack of lighting for night operations • (R): Significant degradation of battery during daytime operations in high temperatures

Manufacturer/Product	Advantages	Disadvantages
Skydio, X2D  **GSA Price: $21,889**	• Ability to turn off the visible lights for covertness • Portable, lightweight, and easy to fit in a vehicle • Magnet-based battery system • Sufficient battery life • Graphical overview of GCS buttons affixed to antenna casing for quick reference	• IR camera has limited resolution and no optical zoom • (R): Occasional interference experienced when multiple UAS operating in close proximity • Directional antenna needs to face aircraft for best link quality • Deploying at night requires manually calibrating by waving in a specific pattern and can take an unpredictable amount of time, causing a delay in aircraft deployment. • GCS buttons are not backlit • GCS screen dims automatically in high heat • Propellers' proximity to the ground results in striking the landing surface if it is not flat

Note: Items that reflect feedback particular to one set of environmental conditions are marked:
(R): arising from the rural test results
(U): arising from the urban test results
(CU): arising from the complex urban test results

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APPENDIX A. SELECT EVALUATION CRITERIA DEFINITIONS

Capability

Camera's Visual Acuity refers to the subjective clarity of the image produced by the camera. The EO and IR camera scores are reported separately to help maintain a distinction between a system's daytime (EO) and nighttime (IR) camera capabilities.

Flight Duration refers to the approximate time of flight considered suitable for a first responder's operational needs based on varied conditions (perching, weather, such as wind).

Command and Control Link Quality refers to the reliability of the radio frequency data link between the ground control station and the UAS. This includes the ability to stream live video from the UAS, and share the feed, through complex environments with minimal interference.

Latency refers to the amount of time between the moment data is captured by the UAS and the moment it is received by the ground control station.

Deployability

Time to Redeploy refers to the amount of time it takes to change the UAS battery (or batteries) and return to flight.

Deployability refers to the ease of and the amount of time it takes to remove the UAS from its case in addition to its boot up and configuration time prior to take off.

Usability

Ease of Use refers to the intuitiveness of setting up and deploying and operating the UAS.

GCS Interface refers to the ease of use of the GCS, including the intuitiveness and human factors integration of the graphical user interface (GUI), configuration adjustments, menu navigation, control buttons, joystick, etc.

APPENDIX B. ASSESSMENT SCORING FORMULA

Overall assessment scores for each product were calculated by multiplying the average criterion rating by the criterion weight assigned by the focus group, thus resulting in a weighted criterion rating. The sum of the weighted criterion scores was then divided by the sum of the weights for each criterion across all SAVER categories as seen in the formula and example below:

Overall Score Formula

$$\frac{\sum(Average\ Criterion\ Rating \times Criterion\ Weight)}{\sum(Criterion\ Weights)} = \begin{matrix} Overall \\ Score \end{matrix}$$

Overall Score Example[9]

$$\frac{(4.3 \times 4) + (5 \times 4) + (4 \times 3) + (4.5 \times 3) + (4.5 \times 3)}{4 + 4 + 3 + 3 + 3} = 4.5$$

[9] Examples are for illustration purposes only. Formulas vary depending on the number of criteria and categories assessed