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VIRGINIA UAV ACTIVITY STUDY

VIRGINIA LOW-LEVEL AIRSPACE ANALYSIS

URSA UNMANNED ROBOTICS SYSTEMS ANALYSIS

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EXECUTIVE SUMMARY

The widespread proliferation of small unmanned aircraft systems—often known as drones—continues to create potential hazards for aviation and security problems for local communities. Six basic characteristics that can make some SCARED of the drone problem:

- The **Scale** of sUAS proliferation is widespread and continues to grow.
- sUAS offer unique, automated **Capabilities** that make the devices easy and precise to fly.
- During flights, the aerial platform is separated from the operator, providing **Anonymity**, and making it difficult to hold perpetrators accountable.
- sUAS platforms can be easily **Retrofitted** or modified for illicit purposes, such as weaponization or delivering contraband.
- The applications of this **Emerging** technology are still not fully understood; novel uses are continuously be developed for these platforms.
- The relatively low cost of sUAS platforms makes them easily **Disposable** in the event of an incident, making it challenging to hold the operator accountable.

UAS detection technology was leveraged to capture a snapshot of sUAS activity in selected areas to codify the extent and type of sUAS operations occurring within the Commonwealth of Virginia. The goal of this report is to provide contextual information, enabling state and local stakeholders to understand the extent of sUAS operations, potential hazards, and establish data-driven responses to address community concerns.

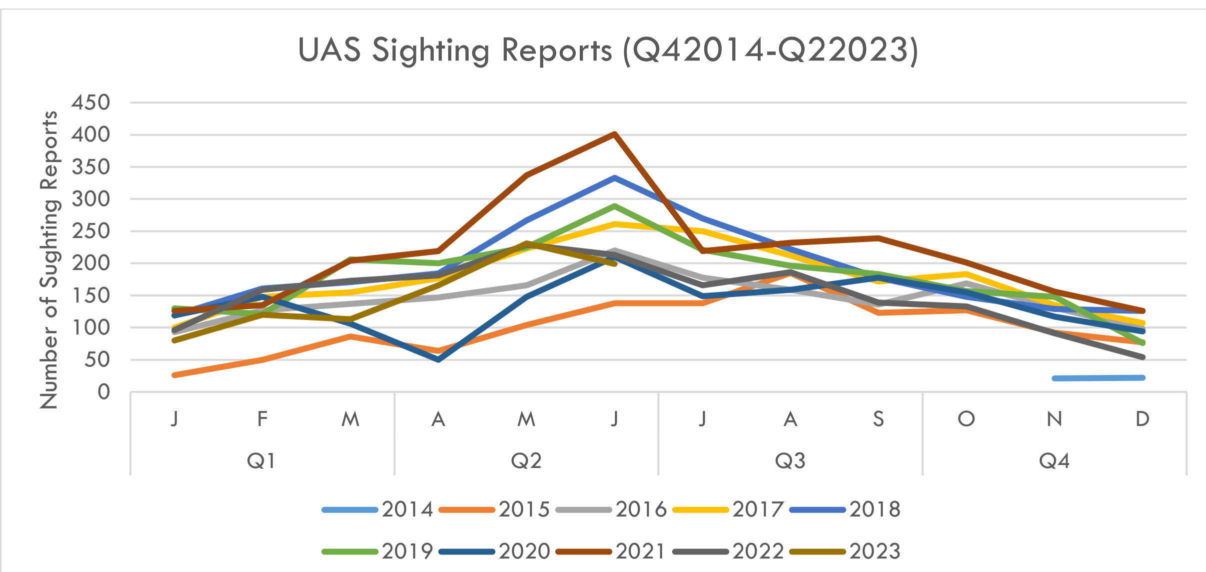
INTRODUCTION

Small Unmanned Aircraft Systems (sUAS) have become popular among both hobbyists and commercial users. Characterized by their ease of use and supported by substantial automation, these platforms enable even novice users to seamlessly fly an sUAS without significant training or experience. Unfortunately, the proliferation of these systems throughout the National Airspace System also has the potential to cause several problems: mainly issues associated with public safety, national security, and privacy.

Small unmanned aircraft systems flown in unauthorized areas—particularly in proximity to airports and heliports—can cause havoc to air traffic and other aviation operations. The Federal Aviation Administration (FAA) tracks sightings of sUAS by aircraft crewmembers, air traffic controllers, law enforcement personnel, and other aviation stakeholders through a reporting system of UAS Sighting Reports (FAA, 2023c). Since the FAA (2023c) started tracking in 2014, the agency has received a total of 16,554 reports nationwide, which include more than 900 reports in the first half of 2023 (see Figure 1).

FIGURE 1

UAS Sighting Reports (Q4, 2014 through Q2, 2023)

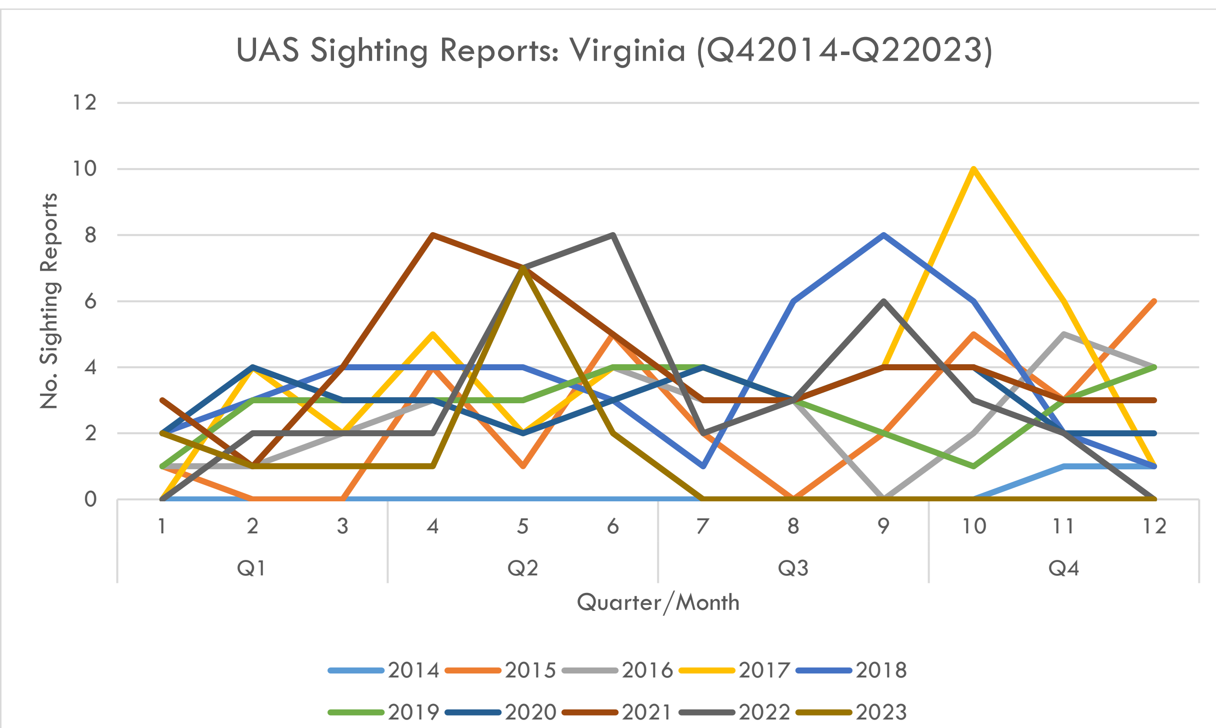


Additionally, encounters between sUAS and aircraft have become more frequent. In 2018, video emerged on YouTube of a drone flying above an A320, while on approach to McCarran International Airport in Las, Vegas, Nevada—the crew was oblivious to the drone, which performed several maneuvers in proximity to the commercial aircraft. The drone's flight path enabled its camera to clearly distinguish the aircraft type and Frontier Airlines livery (Schlosser, 2018). In May 2020, the noted Naval aerial demonstration team *Blue Angels* unexpectedly encountered a drone during a flyover near Detroit, Michigan—a stop on their nationwide tour to honor frontline workers during the COVID epidemic (Murphy, 2020). Video posted to social media allegedly taken from the drone shows a nail-biting pass of the military craft in formation just above the drone's altitude (Murphy, 2020). Experts estimated the drone came within 100 feet of the formation (Murphy, 2020). Helicopters are not immune to drones. In May 2023, a Minnesota State Patrol helicopter reported encountering a drone while performing operations in Minneapolis (Severson, 2023). In 2017, a drone flown near Midland Beach, New York struck a U.S. Army UH-60 helicopter, causing damage to its rotor blades (National Transportation Safety Board [NTSB], 2017). The sUAS operator reported being unaware of FAA restrictions for UAS operations.

Virginia is no exception. Since the inception of the FAA's UAS sighting report tracking in 2014, the Commonwealth experienced 320 sighting reports, from 61 separate locations (see Figure 2, Table 1). The number of UAS sighting reports in Virginia make up approximately 2.0% of the total nationwide reports.

FIGURE 2

UAS Sighting Reports: Virginia (Q4, 2014 through Q2, 2023)



Note: Derived from FAA (2023c) UAS Sighting Reports Database.

Virginia has also experienced several security incidents involving sUAS. In 2021, an unmanned aircraft carrying narcotics destined for Lawrenceville Correctional Center, a private detention facility in Lawrenceville, Virginia, landed on the grounds of a schoolyard. The drone was laden with packages containing marijuana, tobacco, cellphones, and a lightning charging cable. Suspects in a black sedan were seen recovering the drone at approximately 5:40am on the day of the incident (Covil, 2021). Yet another series of drone incidents earlier in the year at Augusta Correctional Center in Craigsville, Virginia forced prison officials to declare a lockdown. On March 11, 2021 and again on March 13, three sUAS were spotted flying over the Craigsville facility. Prison officials restricted inmate activity using lockdown procedures and conducted an extensive search for contraband. According to the Department of Corrections, the state had experienced at least 27 drone incidents in 2019 and 22 incidents in 2020 (Zinn, 2021).

TABLE 1

VIRGINIA UAS SIGHTING REPORTS BY CITY

CITY	No.	CITY	No.	CITY	No.
ALEXANRIA	1	FREDERICKSBURG	1	NEWPORT NEWS	8
AMHERST	1	GORDONSVILLE	1	NEWPORT NEWS (PHF)	1
AP HILL AAF	1	HAMPTON	2	NORFOLK	41
ARLINGTON	6	HARCUM	1	NORFOLK	1
ARMEL	1	HARRISONBURG	1	PETERSBURG	1
ASHLAND	1	HERNDON	19	QUANTICO	2
BOWLING GREEN	1	HOPEWELL	2	RESTON	1
BROOKE	3	HOTSPRINGS	1	RICHMOND	46
CAPE CHARLES	3	HUNTSVILLE	1	ROANOKE	31
CASANOVA	2	KENBRIDGE	1	SOUTH BOSTON	1
CHANTILLY	32	LAWRENCEVILLE	1	STAFFORD	2
CHARLOTTE	1	LEBANON	1	VIRGINIA BEACH	12
CHARLOTTESVILLE	10	LEESBURG	6	WALLUPS ISLAND	1
DAHLGREN	1	LEESURG	1	WARRENTON	2
DULLES	4	LOVINGSTON	1	WCHANTILLY	1
FAIRFAX	4	LYNCHBURG	11	WILLIAMSBURG	1
FARMVILLE	1	MANASSAS	16	WINCHESTER	3
FENTRESS	2	MARTINSVILLE	2	WINCHESTER RGNL ARPT	1
FLAT ROCK	2	MONETA	1	WOLF TRAP	1
FORT BELVOIR	9	MONSON	1		
FRANKLIN	2	MONTEBELLO	1		

Note: Derived from FAA (2023c) UAS Sighting Reports Database. Recording errors or duplicates contained in FAA UAS Sighting Reports Database not corrected.

The remainder of this report offers a data driven view of recent sUAS activity in various locations around the state of Virginia.

METHODOLOGY

Data for this report was generated through the deployment of airspace awareness technology designed to detect and identify small unmanned aircraft systems. One mobile sUAS detection system and one fixed sUAS detection system were deployed to selected locations around Virginia to sample sUAS activity. Additional methodological details and analysis tools are contained in the Appendix.

RESULTS

DeDrone sensors were deployed to nine sites throughout the Commonwealth of Virginia from March 13, 2023 through October 31, 2023 (233 days). Deployment locations included the Norfolk/Hampton Roads area, Richmond, Washington, D.C. area, and several additional sites in northern Virginia. One sensor was deployed atop a building in Richmond for 31 days. The remaining sites were sampled by temporarily deploying a mobile DeDrone sensor trailer to each location for variable time periods (see Figure 3; Table 2)

FIGURE 3
Sensor Locations

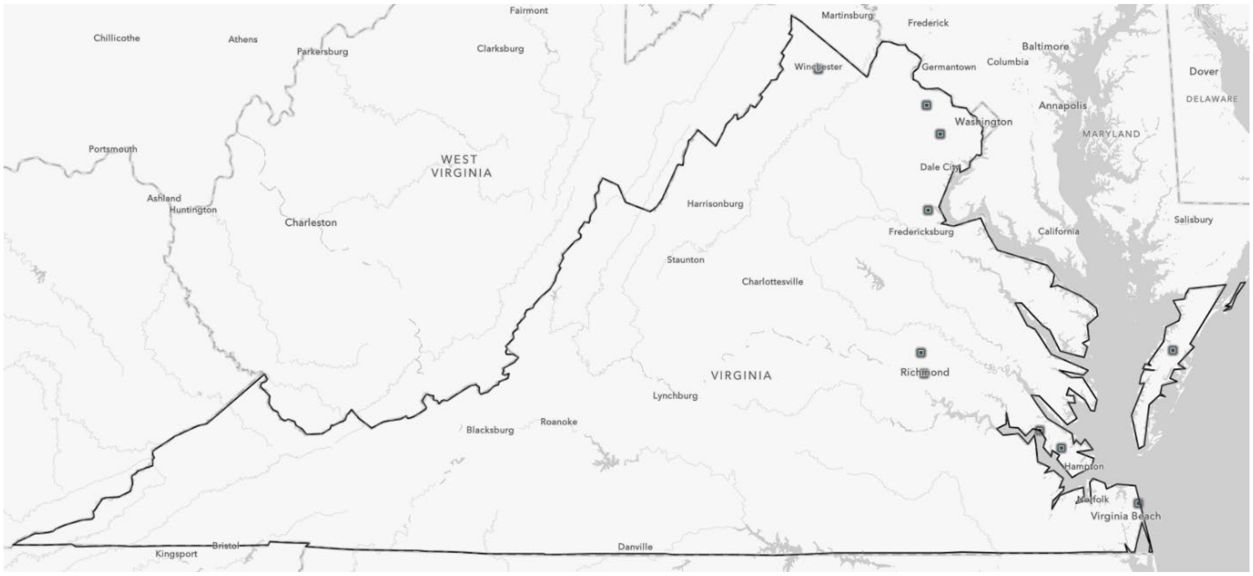


TABLE 2
SAMPLING LOCATIONS / SUAS DETECTION RESULTS

Sensor Location	sUAS Population	No. sUAS Flights	No. Sample Days	Avg No. Flts / Day
Fairfax, VA	28	160	16	10.0
Melfa, VA	25	70	76	0.9
Newport News Airport, VA	86	327	38	8.6
Richmond, VA (#1)	42	74	40	1.9
Richmond, VA (#2)*	472	1193	31	38.5
Stafford, VA	5	20	2	10.0
Sterling, VA	1	2	1	2.0
Virginia Beach, VA	11	35	2	17.5
Williamsburg, VA	15	28	3	9.3
Winchester, VA	81	327	18	18.2

*Indicates Fixed Site Deployment; Note: Population and total sUAS flights may vary from cumulative reported values, since some detected sUAS activity may occur outside designated area boundaries

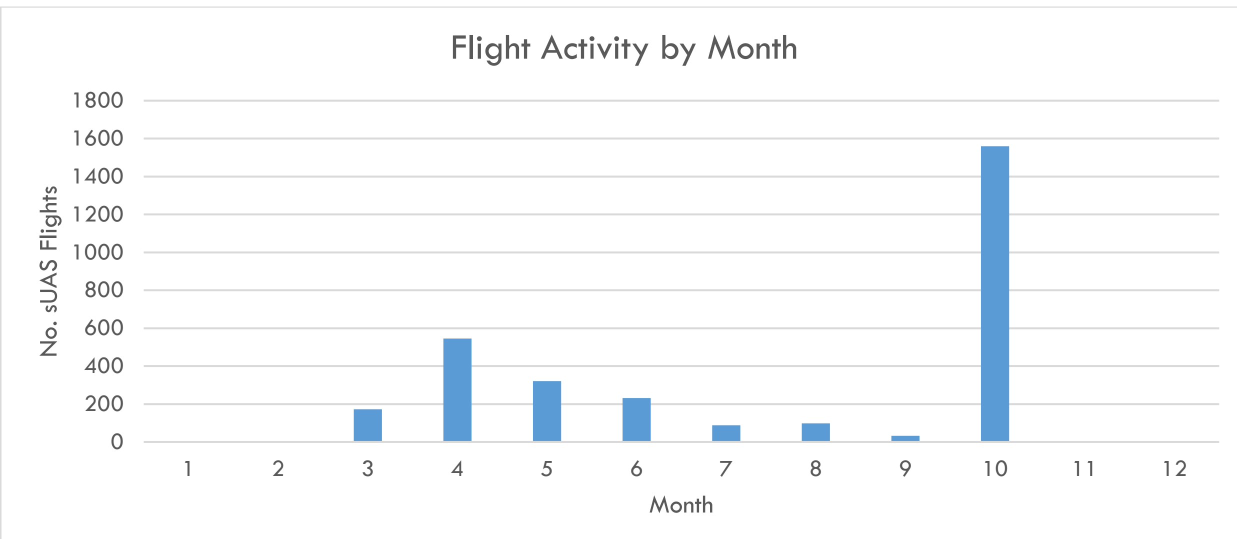
Cumulatively, 3,050 sUAS flights were detected during the study period, performed by a population of 948 sUAS aircraft. These values also account for all unmanned aircraft detected both inside *and outside* the defined areas for each sample location. Cumulative values will be used for all generalized reporting; whereas, area values will be used to describe activity within specific geographic regions or local areas.

Date & Time Analysis

The distribution of flights detected by month is provided in Figure 4. The spike in flights in October (month 10) is primarily due to the deployment of second sensor in the Richmond area. It is notable that activity within the Richmond area is strong, in spite of cooling weather conditions.

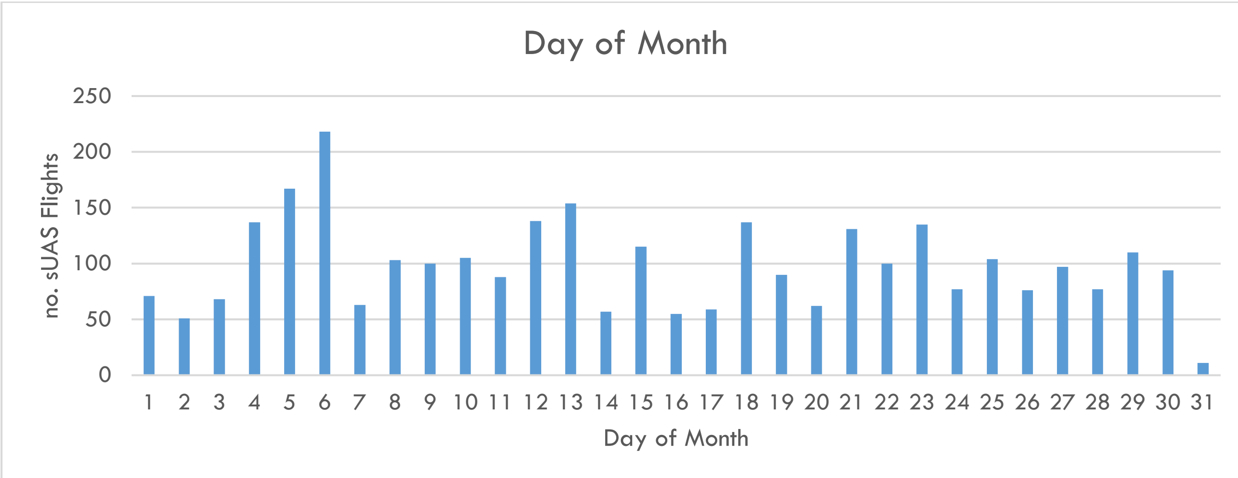
FIGURE 4

Flight Activity by Month



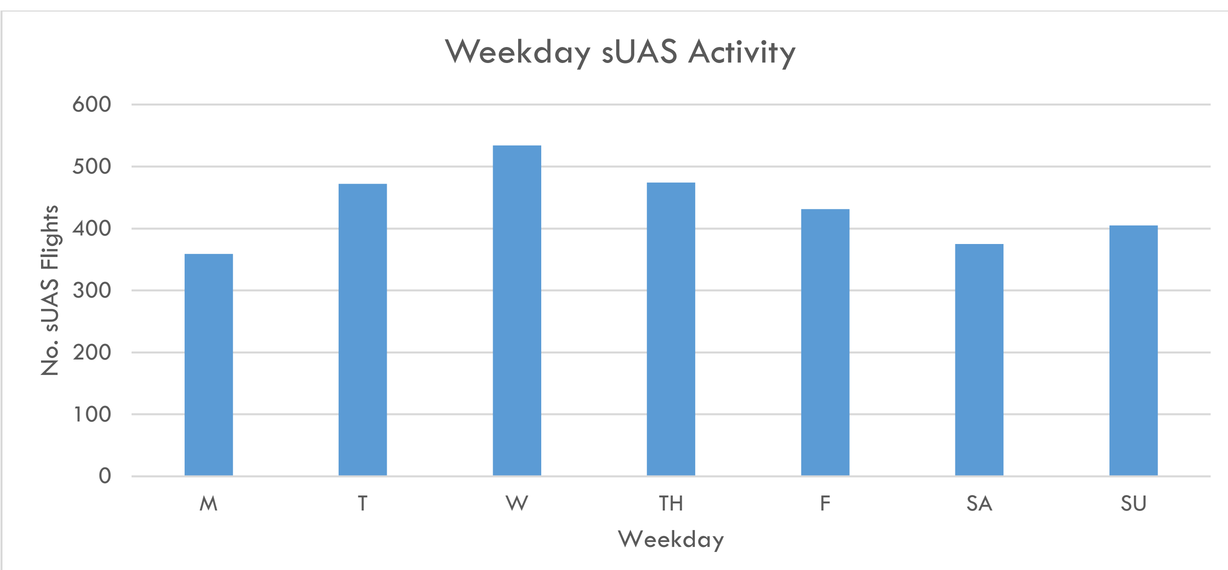
An analysis was performed to assess distribution differentials during different days of the month. Results are presented in Figure 5. Measures of central tendency yielded 98.4 daily flights, with a median of 97 daily flights. The standard deviation was relatively high at 40.3, indicating strong variation in the data. The data showed no outliers (based on 1.5 IQR from Q1,Q3).

FIGURE 5
Flight Activity by Day of Month



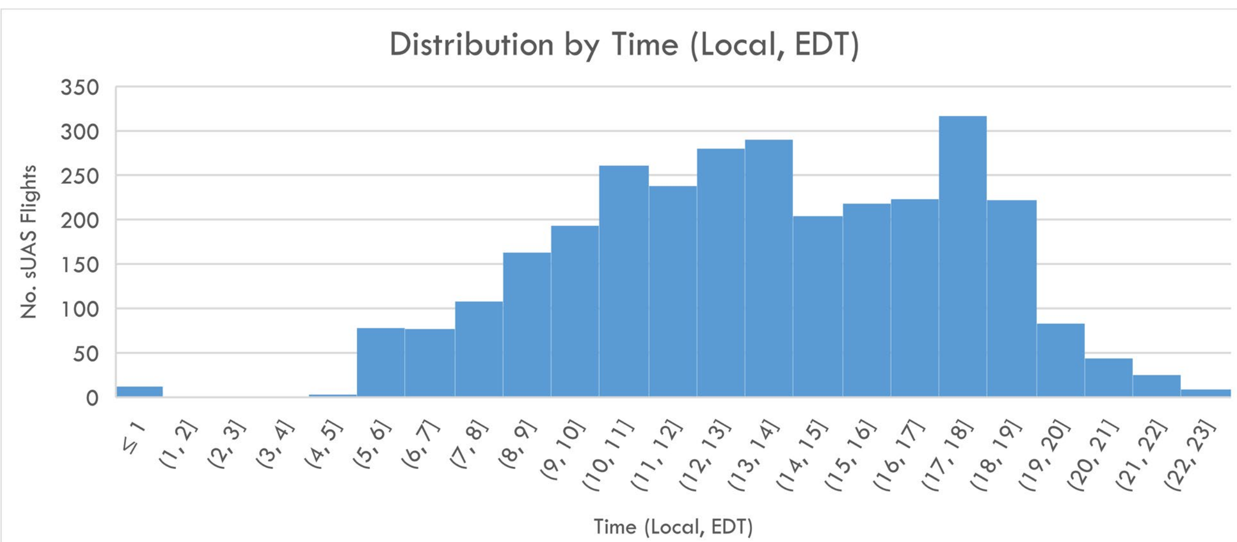
A similar analysis was performed to assess the variability of sUAS operations based on the day of week (see Figure 6). The mean number of weekday flights was 435, with a median of 431. Standard deviation was 57.3, indicating relatively high variability. There were no outliers in this data. In other detection studies, sUAS flights often skew higher on weekend days, however, the data does not reflect that tendency in this sample. Based on the data collected, sUAS activity peaks during mid-week. This may indicate a higher proportion of commercial sUAS activity.

FIGURE 6
Weekday sUAS Activity



The research team also assessed the time of detections to evaluate when the preponderance of sUAS activity was taking place (see Figure 7). The mean time of detected sUAS operations occurred between 1pm-2pm, local time, which was also reflected in the median value. The mode for this data—the hour in which operations peaked—was 6pm, local time. The standard deviation was 3.9 hours, showing relatively wide variability. There were 12 outlier values, reflected in the flights detected between midnight and 1am. As anticipated, the preponderance of sUAS flight activity occurred during daylight hours.

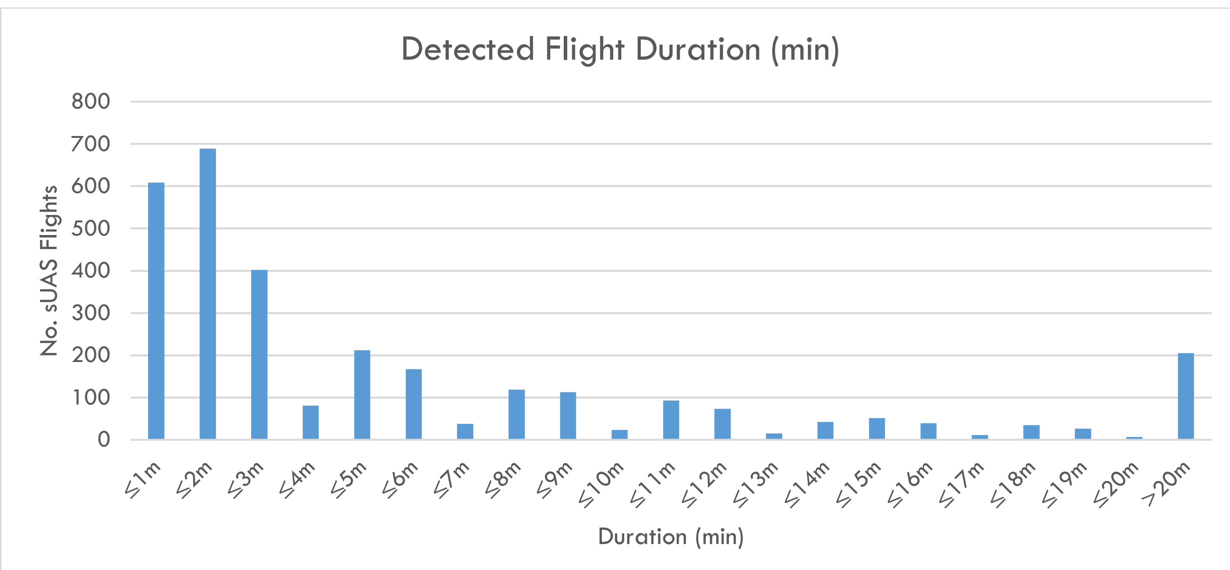
FIGURE 7
Distribution of sUAS Activity by Time (Local, EDT)



Flight Metrics
The research team conducted an assessment of flight telemetry data to provide a descriptive analysis of flight metric information. Based on the provided data, the vast majority of detected flights were of very short duration (see Figure 8). The mean duration of flights lasted only 6 minutes, with the median lasting only 3 minutes. At least 1,700 of the detected sUAS flights (55.7%) were flown for less than 3 minutes in duration. The preponderance or mode of all

flights lasted only 1 minute in duration (*n*=421). At least 234 flights flew durations that exceeded outlier criteria (greater than 18:30). Outliers represent 7.6% of the total. Overall, these findings mirror other studies that determined most sUAS flight durations are exceedingly short.

FIGURE 8
Detected Flight Duration (minutes)



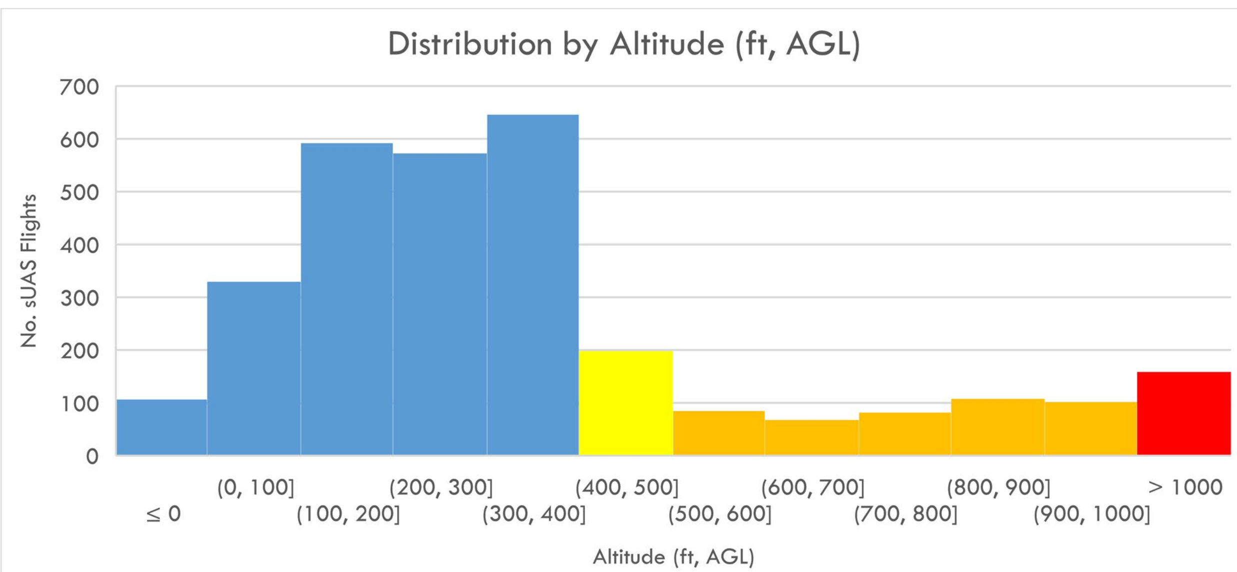
The research team further assessed the maximum altitude flown by each respective sUAS flight. Both 14 CFR §107.51 (non-recreational operations) and 49 USC §44809 (recreational operations) require that sUAS flights are conducted below 400 feet AGL, with some exceptions.

The data revealed that during the time of detection, at least 107 sUAS were in a landed or ground state (see Figure 9). Of the remaining 2,943 airborne sUAS, 2,141 (72.7%) were operated at a maximum altitude below 400 feet AGL, 198 (6.7%) were operated at altitudes between 400-500 feet AGL; 445 (15.1%) were operated at altitudes between 500-1,000 feet AGL; and, 159 (5.4%) were operated at altitudes above 1,000 feet AGL. Detected sUAS were flown at an average altitude of 383 feet AGL, with a median of 295 feet AGL. The standard deviation of altitude was 332 feet, indicating relatively high variability.

The highest recorded altitude of detected sUAS was 4,554 feet AGL. This reported altitude is somewhat suspect, since DJI aircraft are equipped with geofencing restrictions that generally restrict flight above 500m (~1,640 feet) (Poljack, 2023). Further telemetry analysis is required to assess the validity of this reported flight altitude.

FIGURE 9

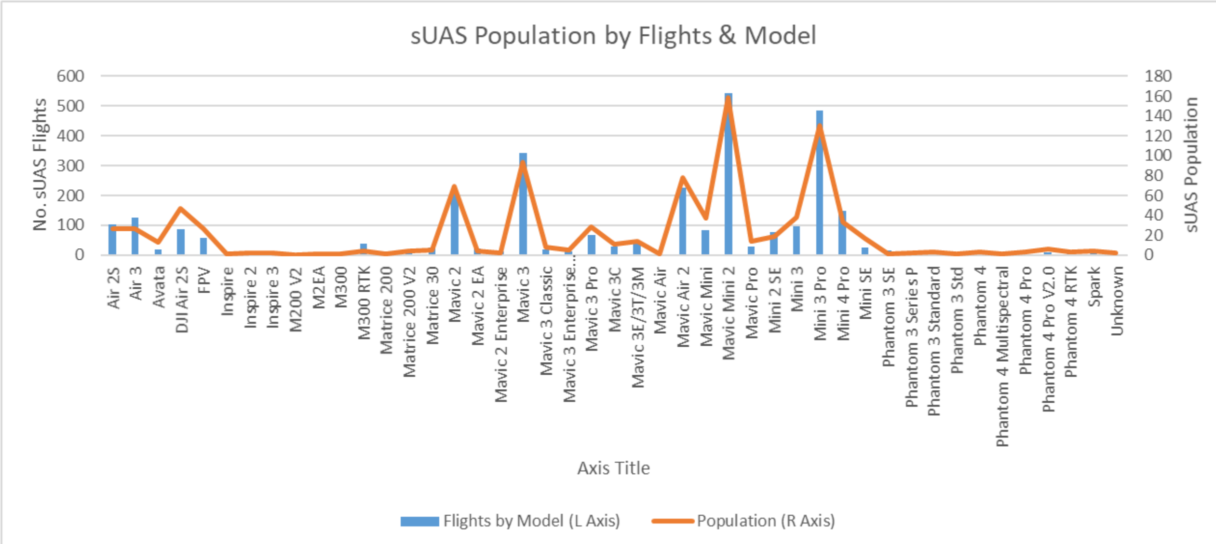
Distribution of sUAS Flights by Altitude (feet, AGL)



The research team assessed the make up of flown platforms to evaluate potential disproportionality. The data showed a strong, correlation [*r*(43)=.98] between the number of flights and the population of sUAS platforms. This finding can be easily identified in Figure 10.

FIGURE 10

SUAS Population by Flights & Model



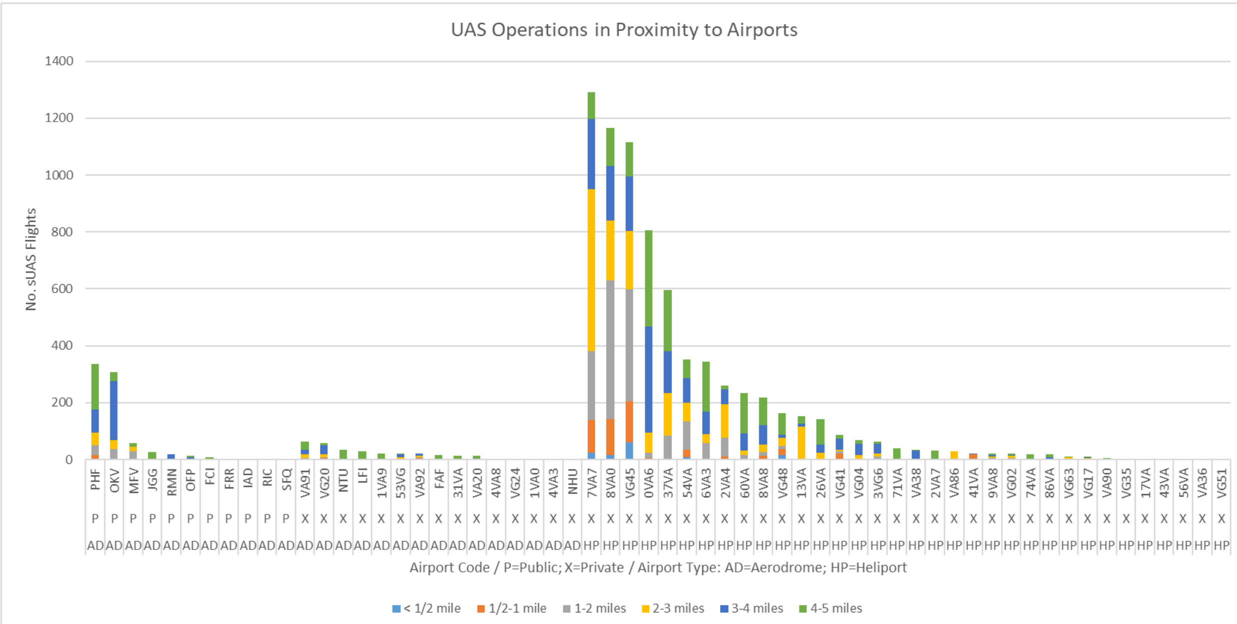
The five most common platforms by population include the Mavic Mini 2* (16.8%); Mini 3 Pro* (13.7%); Mavic 3 (9.8%); Mavic Air 2 (8.2%); and Mavic 2 (7.2%). It is notable that the most common drone platforms are both small and light. Both the Mavic Mini and Mini 3 Pro both weigh less than 250g. The Mavic 3, Mavic Air 2, and Mavic 2 all weigh less than 1 kg (~2.2 lbs). This finding reflects data collected in other studies which reveal that sUAS operators generally favor smaller, newer, more capable platforms.

Based on a regression equation, the relationship between population and flights yields approximately three flights per platform.

Impact to Aerodromes

The research team assessed the potential impact of detected sUAS flights to nearby aerodromes. Results are presented in Figure 11. The assessment included both public and private airports and heliports within the nine selected detection areas. During the sampling period, the research team detected sUAS activity within 5 miles of sixty aerodromes, including 11 public airports, 15 private airfields, and 34 private heliports. Flight activity was highest near private heliport locations. This is reflective of previous research. Heliport locations are often embedded within urban infrastructure and are less conspicuous than airports. Moreover, heliport locations are generally not included in common aeronautical references, such as sectional charts. As a result, sUAS operators may be unaware they are flying near these locations.

FIGURE 11
UAS Operations in Proximity to Airports



UAS Facility Map / Low Altitude Authorization & Notification Capability (LAANC) Compliance

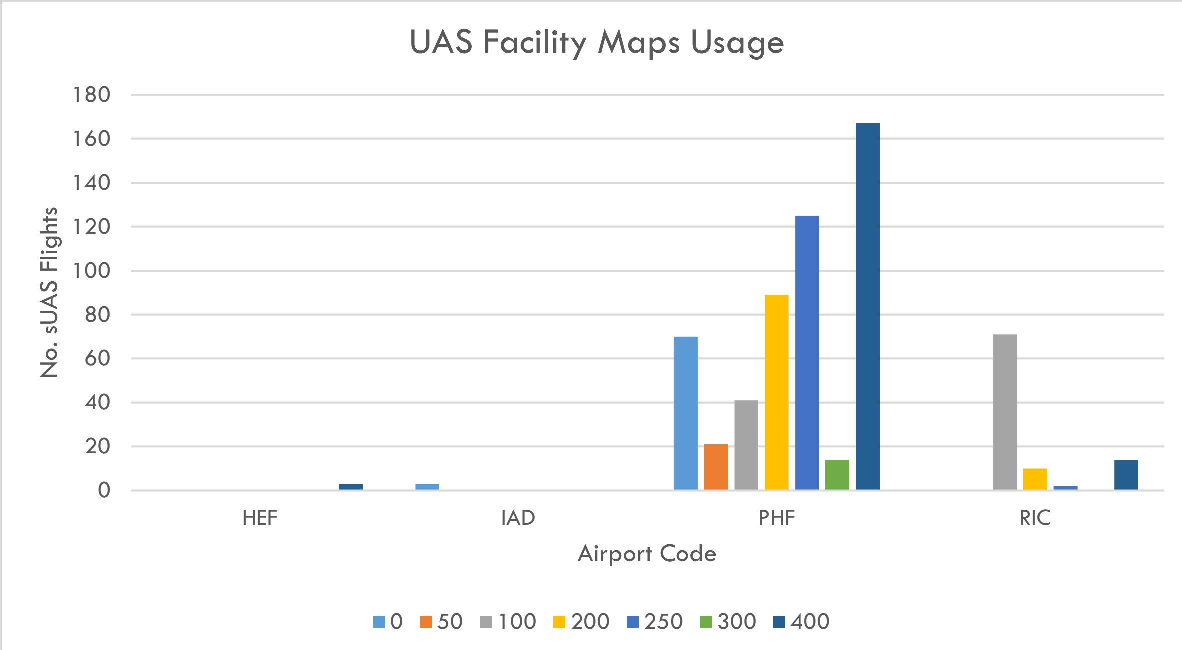
The research team also assessed activity within established UAS Facility Map areas contained within controlled airspace around public airports and some military installations. Small UAS operators are generally restricted to flying within uncontrolled, Class G airspace (Exception for Limited Recreational Operations on Unmanned Aircraft, 2023; Operation in Certain Airspace, 2016). Operators are also generally restricted from operating near airports in a manner that would cause interference with air traffic (Operation in the Vicinity of Airports, 2016).

The Low Altitude Authorization and Notification Capability (LAANC) enables sUAS operators access to controlled airspace by automating airspace authorizations through a network of third-party service suppliers. These entities evaluate drone operator airspace requests against UAS Facility Maps, Special Use Airspace, Airports, Airspace, Temporary Flight Restrictions, and other data sources to provide near-real-time authorization (FAA, 2023b).

Cumulatively, 630 flights were detected within UAS Facility Map areas. Of the 630 sUAS flights, 410 (65%) remained below the maximum altitudes of UAS Facility Map grids. At least 220 sUAS flights (35%) violated the maximum altitude of UAS Facility Map Grids.

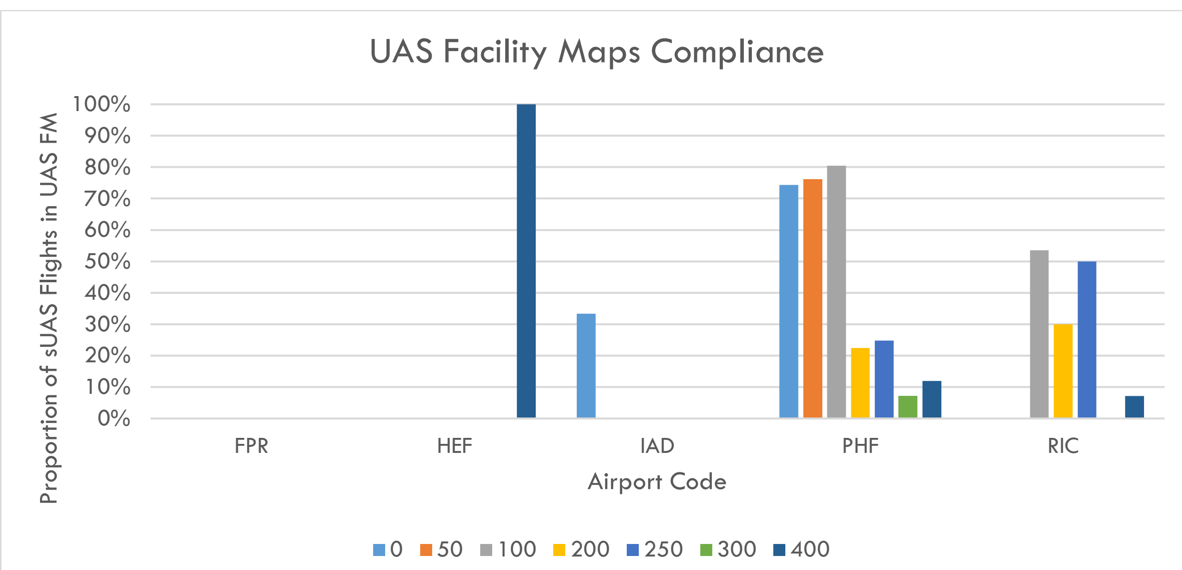
The research team evaluated sUAS activity for four airports that contained established UAS Facility Map areas, including: Manassas Regional Airport (HEF), Dulles International Airport (IAD), Newport / Williamsburg International Airport (PHF), and Richmond International Airport (RIC) (see Figure 12). Both Manassas and Dulles were at the extreme limits of sUAS detection sensor range and recorded only a small number of sUAS operations within their respective UAS Facility Maps. At least 527 sUAS operations were detected within the Newport/Williamsburg Airport UAS Facility Map and 97 were detected within the Richmond International Airport UAS Facility Map.

FIGURE 12
UAS Facility Map Utilization



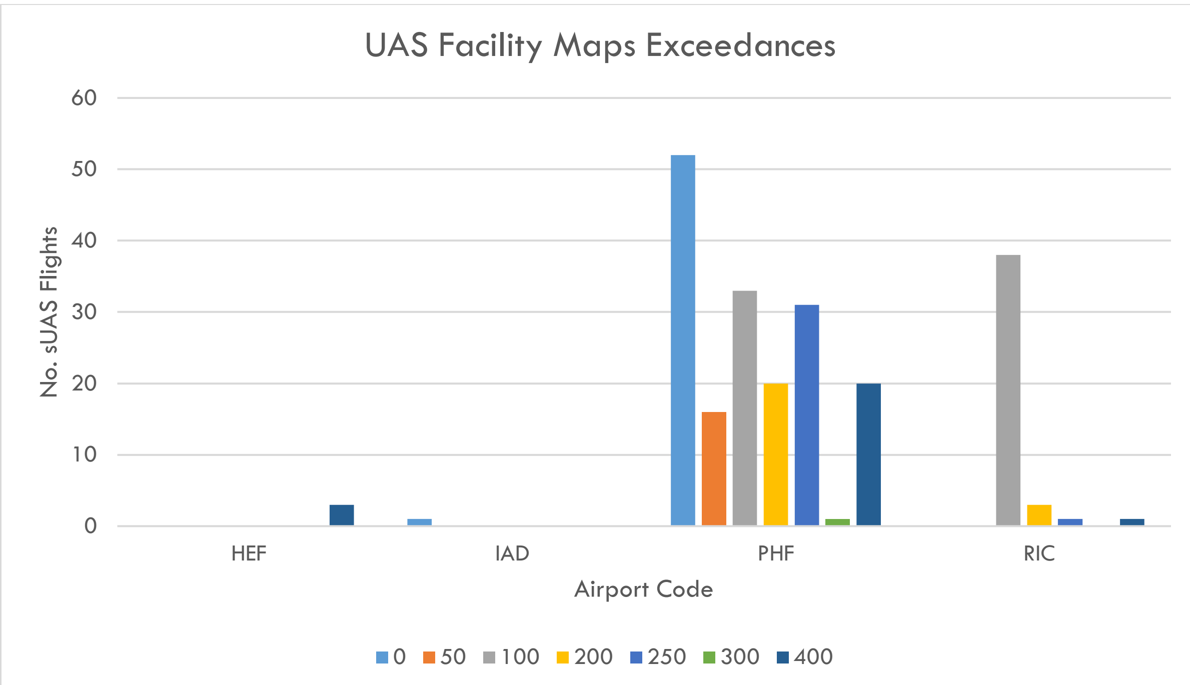
At Newport/Williamsburg Airport, compliance within low-altitude UAS Facility Map grids was consistently 75-80%; whereas compliance rates within higher altitude grids [above 100 feet AGL] were less than 20% (see Figure 13). Richmond International Airport compliance values were less consistent.

FIGURE 13
UAS Facility Maps Compliance



The distribution of altitude exceedances within UAS Facility Map grids at the four sampled locations is presented in Figure 14. Exceedance data is relatively consistent with other studies. It is notable that the research team did not have access to LAANC approval data, therefore, it was not possible to validate if operations that exceeded UAS Facility Map values had received authorization that permitted such exceedances. For the purposes of this study, any operation in excess of UAS Facility Map maximum altitudes was counted as an exceedance.

FIGURE 14
UAS Facility Maps Exceedances

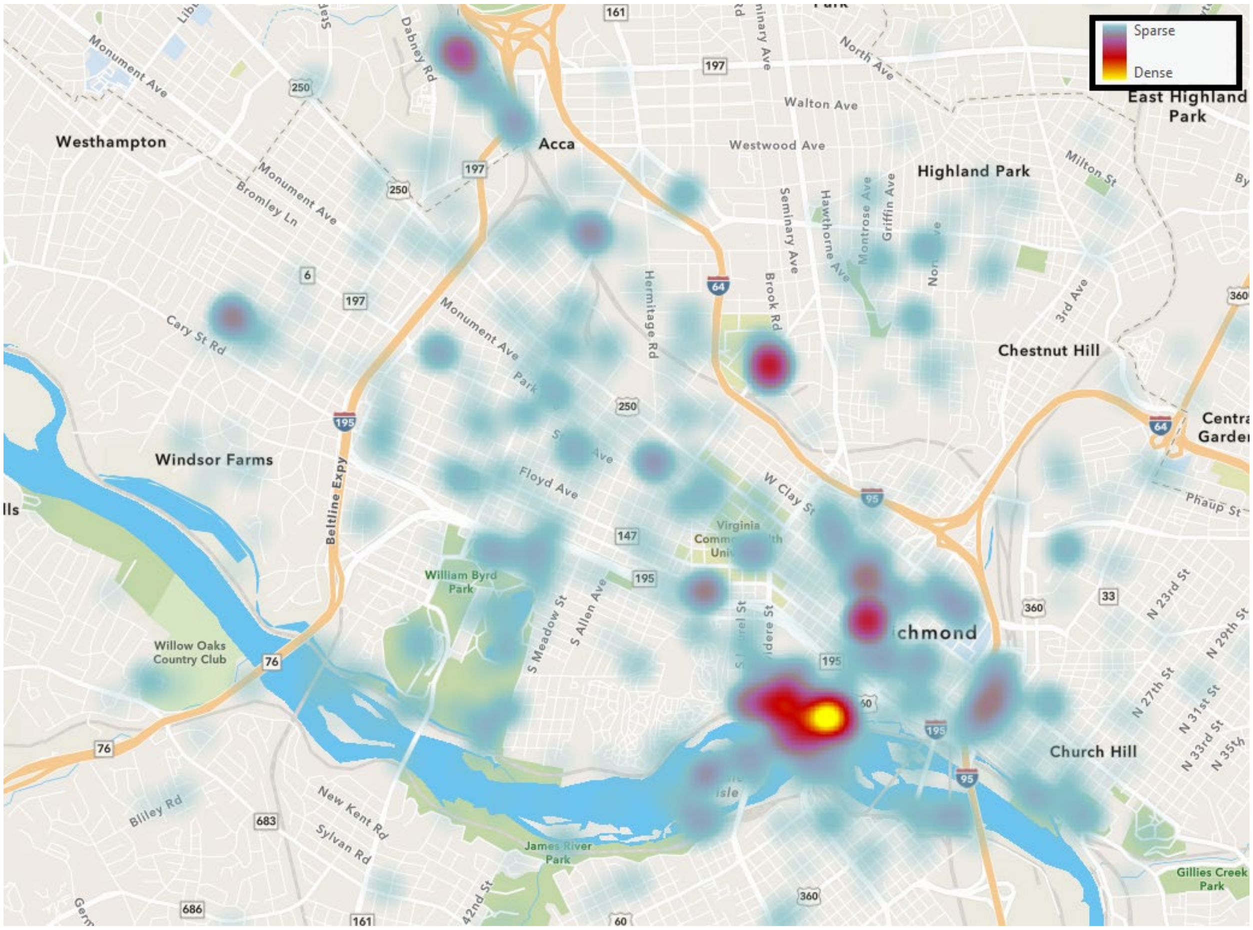


UAS Activity Case Study: Richmond, Virginia

Based on the 1,267 sUAS flights conducted in the Richmond, Virginia area, the research team conducted a geographical analysis to understand the concentrations of sUAS activity in the area (see Figure 15). The highest concentration of sUAS flight activity centered around Brown's Island, a public park situated along the James River. This area is directly proximate to several areas of concern, including the Federal Reserve Bank of Richmond (a financial center), and the American Civil War Museum, a public historical attraction. Other areas of elevated sUAS activity include an area near several downtown hotels and the U.S. District Court for the Eastern District. Elevated activity was also noted at the southern portion of Virginia Union University and near the CSX Transportation North Acca Yard Office (railroad infrastructure).

FIGURE 15

Drone Activity Density Analysis (Richmond, Virginia)

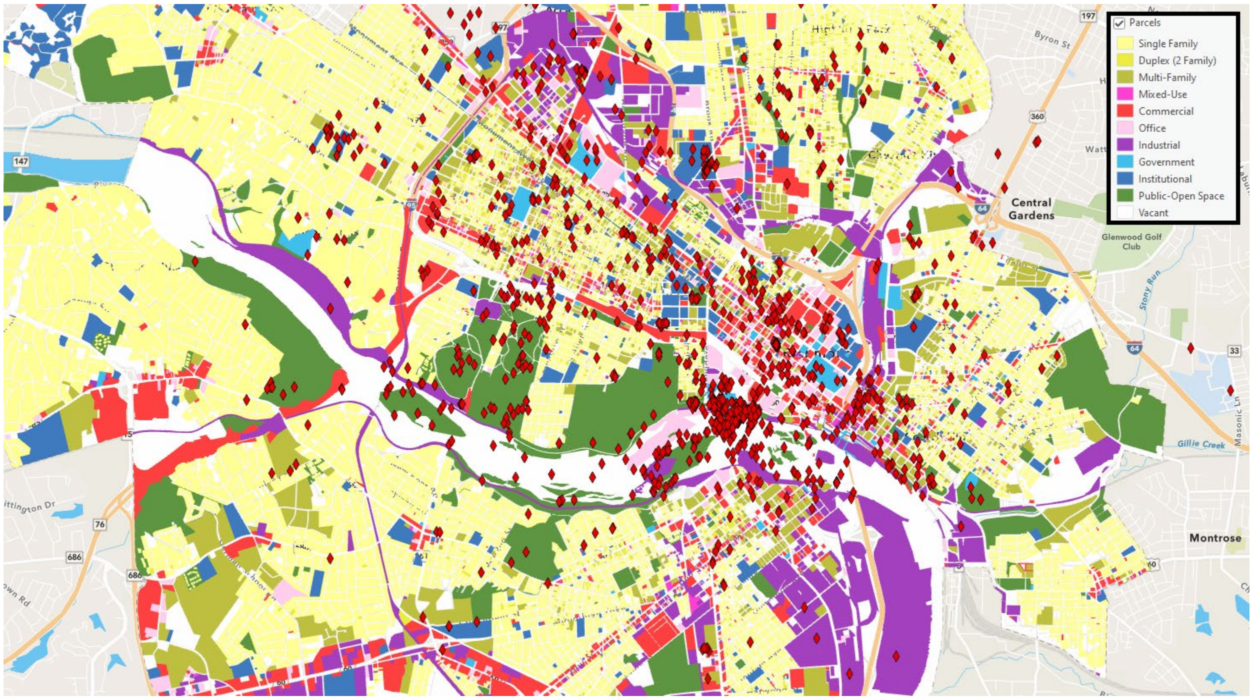


Land Use Proximate to sUAS Activity Locations

Using land use information derived from the City of Richmond Land Use Administration, the research team conducted an intersection analysis using ArcGIS (City of Richmond, n.d.; Mercer, 2021) (see Figure 16). Heavy sUAS activity was assessed in the downtown commercial areas, single-family areas, and public open spaces.

FIGURE 16

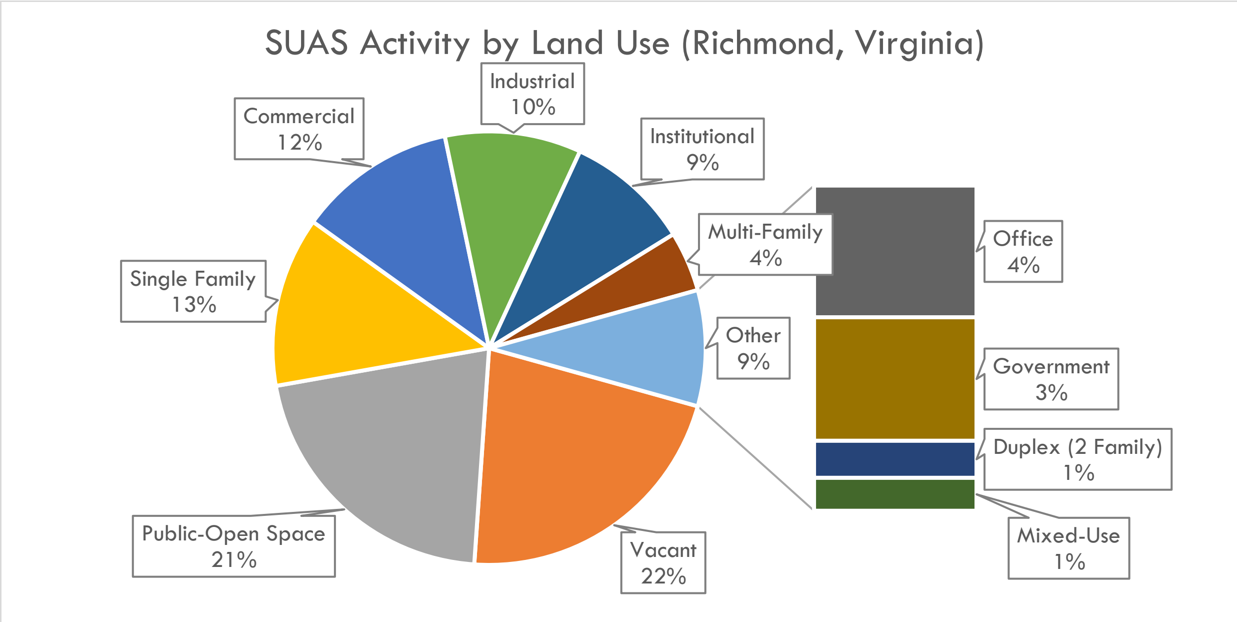
SUAS Activity Locations & Land Use Data, Richmond, Virginia



The distribution of sUAS activity by land use is highlighted in Figure 17. The preponderance of sUAS activity takes place over vacant lots (22%), followed by public open-areas (21%), single-family properties (13%), commercial venues (12%), industrial spaces (10%), and institutional structures (9%).

FIGURE 17

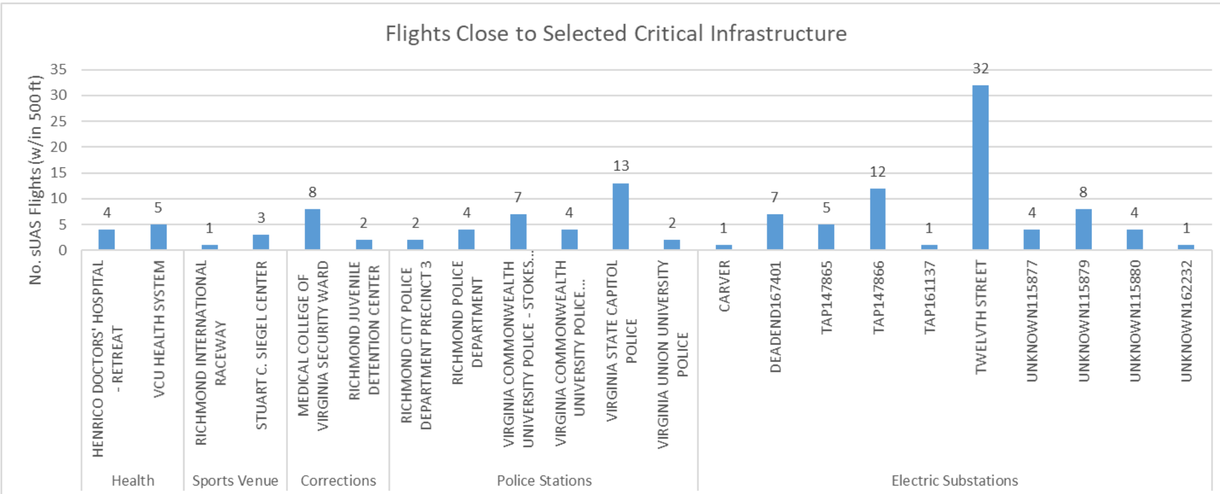
Distribution of Land Use Proximate to SUAS Activity Locations (Richmond, Virginia)



Flights Close to Critical Infrastructure

A proximity analysis was conducted to assess the frequency in which sUAS flights occurred near certain critical infrastructure. For this analysis, the research team selected critical infrastructure sites from healthcare, sports venues, correctional institutions, law enforcement facilities, and electric power infrastructure. Critical infrastructure locations were flagged if sUAS operations came within 500 feet of an established boundary for the respective facility. Results are presented in Figure 18. Electric substations were among the most commonly overflown facilities. This may be due to the fact that most of these facilities contain only limited physical security measures—generally fencing—for protection. It is notable that the research team was unable to determine from the data if flights carried out near critical infrastructure were authorized or otherwise permitted.

FIGURE 18
Flights Close to Selected Critical Infrastructure



CONCLUSIONS

Small unmanned aircraft systems continue to create problematic safety and security challenges for state and local agencies. As these devices continue to proliferate, state and local governments will be forced to establish policies for detecting, tracking, and responding to problematic sUAS flights.

URSA's unique analytic tools are designed to integrate disparate data sources, analyze their meaning, and pinpoint problematic areas or forms of operation. This report serves as a snapshot of sUAS activity within selected areas within the Commonwealth of Virginia. It is designed to highlight potential problem areas, and provide contextual understanding of operational risks.

To effectively address localized sUAS hazards, further detection, analysis, and enforcement policymaking is required. Local agencies should be prepared to work with stakeholders adversely affected by sUAS operations to develop holistic response measures.

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APPENDIX

Data Analysis & Tools

The analyst for this project made use of the following data sources and analytics tools to produce this report:

DeDrone, Inc.

Organization

Dedrone (https://www.dedrone.com/) provides airspace awareness and counter-UAS system solutions for government, military, public safety, correctional institutions, critical infrastructure, airports, data centers, enterprises, VIPs, and private property customers. Their product and service line includes various detection measures radio frequency, radar, and camera technology integrated into a customized, user-friendly interface to enhance customer situational awareness of sUAS activity in nearby airspace. The company offers both mobile and fixed-site systems, as well as a city-wide pay for service model in selected locations. They also provide mitigation solutions, including jammer, takeover, and kinetic means to disable or disrupt sUAS activity (DeDrone 2023a).

DeDrone Sensor Technology

The cornerstone of DeDrone's detection solution relies on radio frequency (RF) detection technology to detect, track, and identify nearby sUAS activity. The advantages of this technology include: 1) reliable detection, classification, and localization of sUAS; 2) detection and localization of remote controller; 3) superior range; 3) rapid installation; 4) automated operation; 5) not subject to external approval (such as emitting radar systems) (Dedrone, 2023b).

The detection device used for this research project is known as the *Aeroscope*, an RF-based solution that interprets radio communication signals exchanged between the remote controller and the aerial vehicle. The Aeroscope enables real-time tracking of the position of an unmanned aircraft, as well as its takeoff point, and pilot location (Aerial Armor, 2022). According to Aerial Armor (2022), the detection range for Aeroscope is dependent upon its antenna configuration. For the four-panel G-8 antenna, detection range is approximately 12-20 miles. For the larger G-16 antenna array, detection range increases to 20-30 miles (Aerial Armor, 2022). These units are limited to detecting only drones manufactured by DJI.

Unmanned Robotics Systems Analysis, Inc.

Organization

URSA (https://ursainc.com/) is a leading UAS and airspace awareness data analytics company. URSA has supported U.S. Air Force (USAF) counter-UAS/airspace awareness (C-UAS) integration efforts through Small Business Innovation Research (SBIR) grants, Customs & Border Protection (CBP) and the FAA through UAS forensics contracts, and is involved with airspace awareness test and evaluation exercise for the Bureau of Prisons as the system of record for all C-UAS and UAS telemetry data. URSA's platform enables operators, law enforcement, and regulators to investigate UAS behavior and activity by bringing together a wide variety of data sources into a single, flexible platform (URSA, 2023).

Airspace Awareness Platform

URSA's customizable Airspace Awareness platform provides scalable vendor-agnostic data analytics capable of processing multi-source telemetry and geographical information systems (GIS) data. The system operates on an integrated web-based platform supported by the powerful Amazon Web Services framework for performing both generalized assessment and detailed case-level data analysis. Leveraging modern data science and AI capabilities, the platform provides rapid pattern detection, data visualization, and automated reporting capabilities.

Federal Aviation Administration Aeronautical Data Delivery Service

The Aeronautical Data Delivery Service, as facilitated by the FAA, is a web-based service designed to provide data in multiple formats such as CSV, JSON, KML, and Shapefile, catering to the specific requirements of developers and various stakeholders (FAA, 2018a). Within this database, there are a total of 47 distinct datasets encompassing diverse aeronautical information, which comprises data on National Defense Temporary Flight Restriction (TFR) zones, aeronautical obstacles, stadiums, airports, airspace boundaries, and related information.

Federal Aviation Administration UAS Facility Maps Dataset

UAS Facility Maps serve as visual representations of the maximum altitudes permissible for Part 107 UAS operations near airports without the need for supplementary safety assessments by the FAA. These maps are a valuable resource to guide requests for Part 107 airspace authorizations and waivers, particularly in controlled airspace (FAA, 2023a). However, it is important to note that possessing a facility map alone does not grant permission to operate a drone within controlled airspace. To operate a drone in Class B, C, D, and Surface Area E airspace, you are required to initiate an online request and await FAA approval (FAA, 2018b).

Federal Aviation Administration Visual Flight Rules (VFR) Raster Charts

The FAA regularly updates digital, georeferenced raster images of FAA Visual Flight Rules (VFR) charts. These charts accurately reflect the same information as published VFR Sectional charts used by pilots and other stakeholders for navigation.