Small RPAS Operations Near Regional Airports

Operational Description, Impacts, and Issues

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EXECUTIVE SUMMARY

This document discusses issues associated with the integration of Remotely Piloted Aircraft Systems (RPAS) into the airspace system. Special attention is paid to small RPAS (under 25 kg/55 lbs) and their operation near regional airports.

Operational scenarios are presented to provide insight into the potential applications for RPAS. The scenarios provided are:

- Rural search and rescue
- Suburban home alarm monitoring
- Urban hostage surveillance
- Monitoring emissions from burning coal
- Small package delivery

Aside from package delivery, virtually all RPAS applications involve some type of surveillance mission. Other notable missions we could have outlined include aerial photography, environmental monitoring, sporting events, and infrastructure inspection (pipelines, power lines, bridges, and railroads).

We highlight in those scenarios the operational challenges and integration issues. Then we summarize the integration issues and why they are challenging to operators and air navigation service providers.

The integration issues we identified are summarized below.

Airworthiness Certification – An airworthiness certificate is a government-issued document that grants authorization to operate an aircraft. Currently, RPAS operations are covered by a Certificate of Waiver or Authorization (COA) and are registered on a case-by-case basis. Current airworthiness certification assumes a pilot is onboard. Regulators will need to define all requirements for certification of RPAS in order to streamline the process compared to the COA case-by-case basis. Airworthiness certification for RPAS will need to establish requirements assuming that a pilot is *not* onboard the aircraft. Affected areas that need research into requirements for successful airworthiness certification are control station (equipment and software), control station security (e.g., cabin door locks), airframe, and data link (C2).

Detect and Avoid – Detect and Avoid (DAA) is the capability of a RPAS to remain well clear from and avoid collisions with other airborne traffic. For manned aircraft, this is satisfied by the onboard pilot's visual capabilities and by traffic alert/avoidance algorithms (e.g. TCAS). Detect-and-avoid technology for RPAS may involve a combination of artificial intelligence and synthetic vision (fed back to the remote pilot). TCAS compatibility is also a factor, because slow RPAS will not be able to apply TCAS logic, for various reasons. These technologies are still in the research and development stage and have yet to be approved by regulators.

Command and Control (C2) – Unlike with manned aircraft, the RPAS pilot must depend on a data link for control of the aircraft. This affects the aircraft's response to revised ATC clearances, other ATC instructions, or unplanned contingencies (e.g., maneuvering aircraft). C2 technologies are fairly mature, but their performance varies widely. Regulators must set standards for C2 in terms of technical standards, interoperability requirements, latency acceptability, and radio/data link security requirements.

Spectrum Allocation and Security – RPAS operators require radio spectrum to control the aircraft, often through a satellite relay. This presents safety and security concerns. Specifically, radio contact can be lost or intercepted, spoofed, or hacked by a third party. Some of the radio spectrums upon which RPAS are operated are also used by common hand-held devices. There is also a concern that there will not be sufficient spectrum allocated to accommodate all the RPAS who may require spectrum. The World Radio Conference (WRC) is addressing the spectrum allocation issue, but regulators will have to set security standards and provide standard message definitions.

Security of Physical Systems – As a result of the 9/11 terrorist attacks in the U.S., standards for cockpit security for manned aircraft were raised, but regulators have yet to set standards for RPAS. One of the advantages of RPAS is that the analog of the "cockpit" is highly flexible – it could be a segregated control station (secure room), or it could be wherever the pilot has created the portable station (e.g. laptop computer controls operated in the field). The issue is how to set standards for physical security of these systems.

Interaction with Air Traffic Control – RPAS are being operated in controlled airspace today, but are handled as special exceptions. In order for them to integrate smoothly with the overall air traffic system, policies and procedures must be set for how air traffic control will interact with RPAS without creating burdensome workloads. In particular, separation standards need to be reviewed and potentially altered; policies must be set for launch and recovery methods when departing/arriving airports; ground RPAS personnel must be trained in ATC procedures and expectations; communications performance requirements necessary to meet safety requirements are needed; training must be provided for air traffic controllers; and standardized methods must be established for how to pass RPAS performance characteristics and mission information to controllers. Procedures for emergency and/or degraded operations also need to be established.

Interaction with Traffic Flow Management – Traffic flow managers will need methods to assess the potential impact of RPAS operation, especially when their operation is potentially disruptive or requires special monitoring or segregated airspace. They must be able to assess the approximate workload impact on air traffic controllers. Also, the interaction (or lack thereof) of RPAS with traffic management initiatives (ground delay programs, traffic spacing programs) must be evaluated in real time.

Pilot Qualifications – For manned aircraft, pilot qualifications are well established, but this has not been done for pilots (operators) of RPAS. For operation of large RPAS in integrated airspace, it seems reasonable to adopt similar standards for RPAS that are in place for unmanned aircraft. But it is less clear what the standards should be for operation of small RPAS.

Privacy – Given the growing demand for RPAS and their widespread application, the public is concerned that RPAS will be used for surveillance purposes (e.g. photography) without the consent of the subjects. In the U.S., privacy advocates, such as the American Civil Liberties Union (ACLU) and Epic.org, have insisted that RPAS not be allowed to operate in the U.S. until the FAA first says how it intends to address privacy concerns. This may be an extreme position. Traditionally, privacy has not fallen under the jurisdiction of airspace regulators. Nonetheless, they will have to find ways to assure the public that their privacy concerns will be addressed while still allowing RPAS operators to conduct their missions, which often include surveillance.

While all of the foregoing issues are important, the ones that are generally cited as being the main impediments to RPAS integration are detect-and-avoid and airworthiness certification.

This report also provides a snapshot of how RPAS integration issues are being addressed by airspace regulators around the world. We conducted an informal review of RPAS integration progress in the member countries of the EU and several other countries around the world. About half (12/28) of the EU countries have in place some type of regulation for RPAS, but these are only for vehicles below 25kg or below 150kg. Only two countries, Czech Republic and France, have regulations in place for beyond line of sight. Overall, countries are grappling with the same integration issues. The U.S. and Israel are at the forefront of RPAS technology development but are not necessarily farther along in establishing regulations. A common approach to regulation is to create a special set of rules for small RPAS (e.g. under 25kg) that are much less stringent than those for large RPAS. The reasoning is that air traffic control does not (and will not) provide separation services for small RPAS at low altitudes, so they have to be self-separating.

1 Introduction

This report was produced under the TEMPAERIS (Testing Emergency Procedures in Approach and En Route Integration Simulation) project.

In developing this paper, we significantly relied upon the U.S. Joint Planning and Development Office (JPDO) draft *UAS Operational Scenarios* (2012) [2] because of its comprehensive examination of the requirements, capabilities, issues, and policy matters that need to be addressed to conduct Unmanned Aircraft System (UAS) operations safely in non-segregated airspace. While there are some differences in how various nations and governing bodies are addressing such operations, there is much commonality in both what must be done and what the outcomes must be for safe flight by UAS.

For the purposes of this paper, we will confine the discussion to Remotely Piloted Aircraft Systems (RPAS), which are a subset of the UAS family. The additional requirements and issues associated with other types of UAS, such as those that fly autonomously, are still maturing and too complex to address at this time.

The France Directorate General for Civil Aviation (DGAC) has taken a leadership role in establishing regulations for RPAS operations.

1.1 Objectives

The objective of this paper is to foster understanding of the requirements and challenges of conducting small RPAS operations, especially in the vicinity of regional airports.

1.2 Definition of Regional Airport

This paper's focus on RPAS operations at or near a "regional airport" warrants a discussion of what is considered a regional airport. To some extent, that definition will vary depending on where it is viewed. In the U.S., such airports would generally be in the "small hub" category, defined by the FAA[1] as an airport with between 0.05% and 0.25% of national total passenger enplanements. The term "regional" usually refers to the geographic area served, although flights from regional airports may cross international boundaries that are nearby.

The items most relevant to RPAS operations are the airspace classification for such airports and the associated operating requirements for that airspace. Typically, small hubs would have an associated approach control and Class C airspace. In contrast, airports with Class B airspace typically have 1% or greater of national passenger enplanements, and non-hub airports that have

[1] http://www.faa.gov/airports/planning_capacity/passenger_allcargo_stats/categories/

ATC services typically have Class D airspace. Some examples of the current 77 U.S. small hub airports are Albany International (KALB), Atlantic City International (KACY), Key West International (KEYW), Long Island MacArthur (KISP), Norfolk International (KORF), and Tucson International (KTUS).

As a comparison, Bordeaux-Merignac Airport (LFBD), where some RPAS flight demonstrations are occurring, would be typical of a medium or large hub airport, being in the top 10 airports in France in terms of passenger enplanements and having associated Class C airspace.

2 RPAS Operational Scenarios

In this section, we provide operational scenarios to provide examples of how RPAS may be used and to highlight integration issues that will arise in the operation of RPAS.

Though the focus of the report is operational issues associated with regional airports, we have deliberately kept these scenarios broad, to maintain awareness all of the major integration issues.

We use highlight boxes to provide easy extraction of the integration issues. Many of the integration issues arise in more than one scenario. We provide less elaboration of the issue once it has already been highlighted.

> Throughout this section, boxes like this one highlight integration issues being raised by the scenarios.

Several of the scenarios are based on RTCA Special Committee 203 DO-320, *Operational Services and Environmental Definition (OSED) for Unmanned Aircraft Systems (UAS)*, dated June 10, 2010 [1]. In places, we have abbreviated the scenarios or shifted their focus to be more relevant to operations in or near airports. Large sections of text have been taken from RTCA and JPDO documents, but we have tailored the material to needs of this report.

These first three scenarios address a range of operational environments: rural, suburban, and urban operations. The rural RPAS mission involves search and rescue support for locating a lost hiker. The suburban RPAS segment involves response to a home security system alarm and associated house fire. The urban RPAS segment involves monitoring a hostage situation. All three segments reflect an on-demand need for surveillance where tactical mission requirements dictate the route of flight and airspace environments where the RPAS will operate.

2.1 Scenario 1: Rural Search and Rescue, Fixed-Wing RPAS

Scenario at a Glance: Rural Search and Rescue	
Nature of the Mission	Emergency response to locate a lost hiker
Aircraft Type	Fixed wing. Small RPAS, much like Raven. 4.2 lbs, wingspan 4.3 feet. Super Bat RPAS, 34 lbs., wingspan 8.5 feet.
Flight Operator	Local government law enforcement aviation unit.
Flight duration	3-4 hours
Altitude	400 feet to 2,000 feet Above Ground Level (AGL).
Classes of Airspace Affected	B, C, D, E, and G.
Line of Sight	Both VLOS and BVLOS

Scenario at a Glance: Rural Search and Rescue	
Flight Planning	Determined tactically as the mission unfolds.
Launch Mechanism	Raven: By hand; Super BAT: Bungee catapult
Lost Link Procedure	Control of the RPAS is provided through a LOS link between the RPAS pilot's portable control console and the RPAS. In the event of a control link failure, the RPAS is programmed to circle over its current position if the control is not reestablished within a parameter time. The engine is then shut off and the RPAS makes a controlled spiral to the ground.

Los Angeles (LA) County law enforcement is notified that a young hiker became separated from his hiking party in a park north of San Fernando, CA. The county sheriff calls upon the LA County Law Enforcement aviation unit, who decide to begin a search mission. They have a Raven RPAS that can be transported to the search site in a patrol vehicle and hand-launched from that location. The high-level operational concept for this scenario segment is depicted in Figure 1.

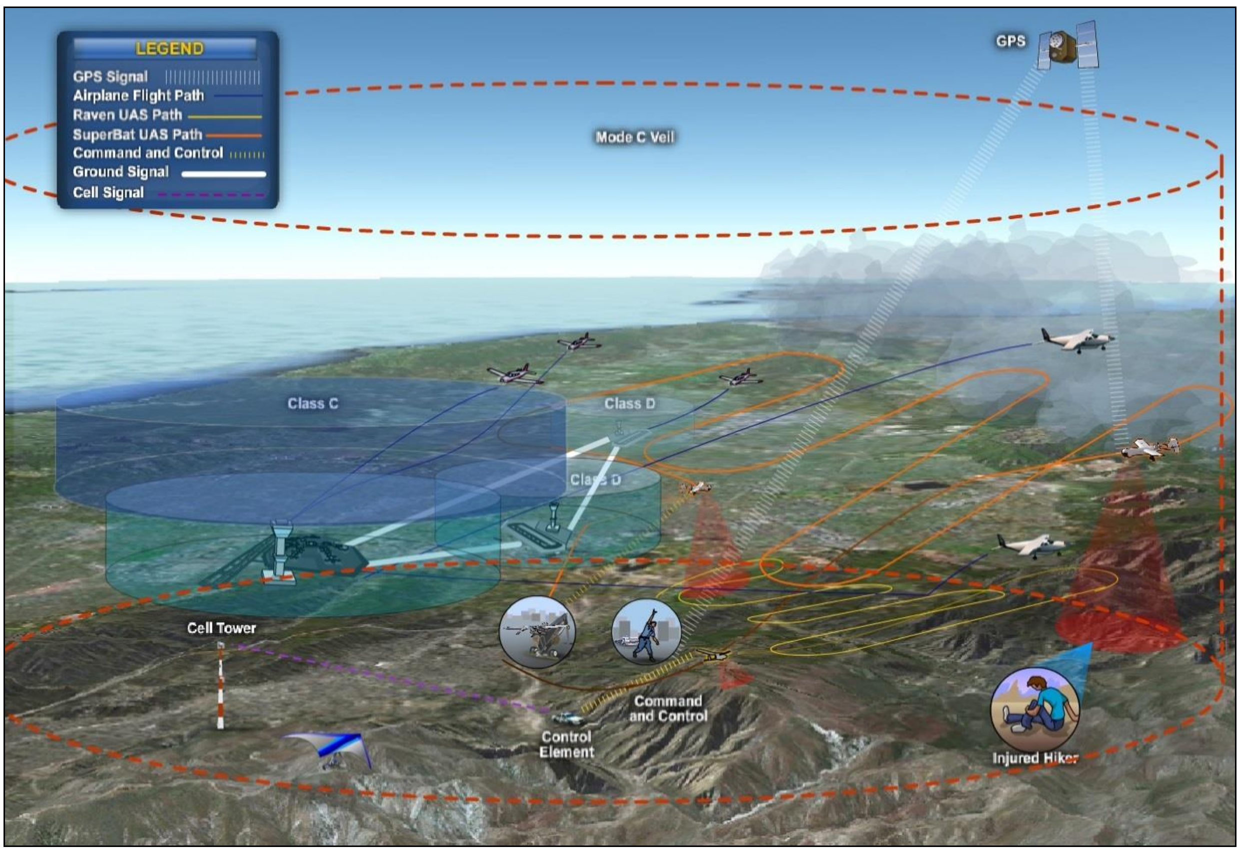


Figure 1: Rural search and rescue scenario high-level operational concept

Before beginning the flight, the RPAS pilot becomes familiar with all available information concerning the flight. He determines that

- Weather conditions are clear
- There are no NOTAMs in effect
- Immediate coordination with Air Traffic Control (ATC) and a flight plan are not required, because the surveillance location is within the Los Angeles Class B Veil area but outside of Class B, C, or D airspace.

> **RPAS weather sensitivity**: RPAS are often more susceptible to adverse weather than comparably sized manned aircraft. Having reliable/ updated forecasts will be critical.
>
> **NOTAMS**: Under what circumstances will NOTAMS be required for RPAS?
>
> **Flight Plans**: Under what circumstances must flight plans be submitted for RPAS?

- The Raven has the required equipage to operate in the Class B Veil area, as well as DAA technology for detecting other aviation operations, terrain, and weather, allowing it to operate under VFR.

The Raven RPAS team drives to a location adjacent to the targeted surveillance area, and the RPAS pilot hand-launches the Raven RPAS. The RPAS pilot flies the aircraft to an altitude of 2,000–4,500 feet MSL, an altitude where the surveillance search pattern is high enough to meet minimum altitude regulatory requirements over the varying terrain of the search area. The terrain varies between the lower launch point of 1,500 feet and a peak of 4,000 feet.

During the launch and climb to the search altitude, the RPAS observer maintains a constant view of the RPAS and its surroundings to ensure the RPAS remains clear of other airborne operations and does not come too close to people or property.

> **Ground Observer Requirements:** Agencies must clarify the circumstances under which visual (ground) observers must be used. How many are required? Are they allowed to use vision aids, e.g. cameras? What communication protocols (with the pilot) are allowable? What qualifications must observers meet?

If the RPAS pilot control station is so equipped, the RPAS pilot is provided terrain and aeronautical information as well as cooperative aircraft target activity information relevant to the flight in graphical and textual format. Such information can be provided from ADS-B Information Broadcast Services, control station mapping and database capabilities, and appropriate service-oriented architectures, such as System Wide Information Management (SWIM).

Once the Raven RPAS proceeds past where the observer is authorized to provide LOS support, the observer function ceases, and DAA capabilities on the RPAS perform the collision avoidance and right-of-way functionality required by federal regulations. The RPAS pilot can navigate the Raven RPAS by either providing Global Positioning System (GPS) coordinates or by "hand flying" it as an alternate navigation capability. However, the RPAS does not have VHF Omnidirectional Range (VOR)/Tactical Aircraft Control (VORTAC) capabilities. The RPAS pilot plans to fly close to

> **DAA System Certification:** Certification and requirements for detect-and-avoid (DAA) systems must be established.

the terrain to maximize the camera resolution of the terrain, hoping this will allow the hiker to notice the RPAS and signal his presence.

The RPAS flies over the north side of the search area where the hiking party indicated they believed the hiker may be. The search team observes the terrain below via the RPAS surveillance video. As the Raven RPAS flies over the search area, the onboard DAA system detects a hang glider that was launched near the ridge line and is gliding to the valley adjacent to the search area. Following detection of the hang glider, the DAA system ascertains that, based on their current trajectories, the RPAS will soon be close to the hang glider, and it initiates a change in trajectory to give way to the hang glider. The RPAS pilot is alerted to the DAA actions and notices the change in trajectory. Following resolution of the conflict, the RPAS automatically returns to its original track and resumes the programmed search pattern.

DAA Capabilities: Will DAA systems acknowledge, and stay clear of, restricted airspace? How would DAA work in conjunction with an airspace penetration warning tool (geofence)?

After approximately an hour of flight, the Raven RPAS is flown back to the launch site to have another battery installed. The RPAS pilot turns the Raven RPAS motor off and maneuvers it into a deep stall condition near the ground. The Raven is recovered by the Raven RPAS team. The battery is replaced in the Raven RPAS, ready for the subsequent flight.

Aircraft Endurance: Will there be standard procedures or regulations to determine an emergency landing procedure, should a small RPAS have insufficient power to complete its mission?

The RPAS pilot launches the Raven RPAS again and begins another search pattern using similar procedures as the first launch. Throughout the day, the RPAS flies additional search patterns, each lasting about one hour. The search area is widened, and it is decided that a higher flight path will allow for better views of the terrain valleys. The RPAS pilot determines that the expanded search area may infringe on the Bob Hope Burbank Airport (KBUR) Class C and the Whiteman (KWHP) Class D airspace, depending on the search pattern segment being flown. The KBUR Class C area affecting the south portion of the search pattern is between 3,000’ and 4,800’ MSL, and the KWHP Class D extends from the airport elevation of 1,003’ to 2,500’ AGL (3,503’ MSL).

IFR Certification: If the UAS has to operate IFR, the terrain in the area would necessitate that the flight be 7,000-9,000’ MSL, somewhat degrading the ability to adequately observe the terrain. A small RPAS will have difficulty in meeting IFR certification requirements.

The RPAS pilot contacts BUR Approach Control and advises the KBUR ATC controller responsible for that area of the search mission. The pilot provides the Raven RPAS registration callsign information and requests to fly a U-shaped pattern through the north portion of the Class C at 4,500’ MSL. The KBUR Approach controller and the RPAS pilot exchange the beacon code and additional

Communication with air traffic control: The method of communication available may differ depending on the communication capabilities available to different types and levels of ATC facilities.

information so that the controller can identify the surveillance target of the aircraft and its associated flight information on the controller display. Once that process is completed, the controller clears the RPAS to maintain 4,500' MSL while in Class C. The RPAS completes the search pattern circuit that infringes on the Class C. The BUR ATC controller instructs the RPAS to maintain appropriate VFR altitudes. Since the RPAS will be reentering the Class C airspace later, the controller also instructs the RPAS to maintain the same beacon code and report prior to reentering the Class C airspace.

Transponder Codes: Under what circumstances will transponder (beacon) codes be required for RPAS?

As the afternoon progresses, clouds begin to form, reducing the altitude at which the RPAS can operate and still maintain Visual Meteorological Conditions (VMC) and operate under VFR. The search pattern is modified so that the RPAS will be able to fly over all but the highest portion of the terrain and remain at least 500' below the clouds while in Class E and C airspace; the search altitude is reduced to 3,500' MSL. For the Class G portion of the search pattern, the RPAS pilot ensures that the Raven remains clear of clouds and at least one statute mile flight visibility. The Raven RPAS onboard DAA capabilities are able to alert the pilot if VFR cloud clearance requirements are projected not to be met.

When the RPAS first approaches the Class C airspace after changing to a lower altitude, the BUR Approach controller instructs the Raven RPAS to remain clear of the Class C area while they coordinate with the WHP Tower for the RPAS to fly through the WHP Class D. Once the controller has completed the coordination, they approve the RPAS to fly the U-shaped pattern through the Class C at 3,500' MSL.

The hiker is still not located by late afternoon, and the search leader decides they should increase their surveillance capabilities. It is determined that another RPAS, one that allows increased flight time and has infrared (IR) sensor capability to detect heat signatures, is required in case the search proceeds into the night hours. The aviation unit responds by transporting their Super Bat RPAS to the search site. Because that RPAS has different characteristics and a different control station, the aviation unit provides another RPAS pilot that has been qualified to fly that particular type of RPAS.

Multiple RPAS in the same airspace: In this scenario, they replace one RPAS with another. What if they wanted to operate two or more RPAS (with one pilot per aircraft) in the same airspace? Is safe separation entirely up to them?

Multiple RPAS operated by one pilot: Under what circumstances could the pilot operate more than one RPAS simultaneously?

On the last circuit into the Class C before landing, the RPAS pilot notifies BUR Approach that the RPAS will be changed to a different model and callsign for the next flight. After leaving the Class C, BUR Approach instructs the RPAS to change to a VFR code and says that surveillance services are terminated.

The RPAS pilot ascertains that launching the Super Bat RPAS will not interfere with other aircraft operations in the vicinity. The new Super Bat RPAS is launched using a bungee cord with the help of the ground observer. As with the Raven launch, the ground observer supports collision avoidance during the launch and initial flight, and DAA capabilities take over once the aircraft is BLOS. When the Super Bat RPAS approaches the Class C, the RPAS pilot contacts BUR Approach requesting flight through the Class C, similar to the previous RPAS flight. The BUR Approach controller and RPAS pilot exchange information by similar means as before. Identification of the new RPAS is established and the RPAS flight through the Class C at 3,500' MSL is approved.

Determination of Interference: What procedures must the pilot follow to determine his operation will not interfere with other aircraft? What tools are at his disposal?

The search pattern has been extended in a way that infringes on lateral boundaries of Class D airspace extended upwards. As the flight approaches the Class C, visibility deteriorates to below VFR weather minima because of a rain shower; continued flight would result in below-VFR conditions at that altitude. The RPAS pilot contacts the BUR Approach and requests a Special VFR clearance to continue the flight above the Class D surface area. BUR Approach requests that the RPAS remain clear of the Class C airspace while it coordinates with the Tower concerning existing traffic. The IFR facility issues the RPAS a Special VFR clearance with altitude restrictions to stay below other traffic. While the Super Bat RPAS is in the Class C area, the BUR has stopped conflicting departure traffic within the Class C surface area because of the potential conflict of the RPAS search pattern and airport departure path from WHP. When the rain shower passes, the Super Bat RPAS climbs back to its search pattern altitude.

During the night hours, the RPAS IR sensors detect heat signatures that are believed to be that of a person and not an animal. The RPAS pilot sets up a circular holding pattern centered on the heat signature location. He maintains persistent surveillance until a ground team is dispatched and reaches the site. In the holding pattern, the Super Bat RPAS orbit penetrates the corner of the BUR Class C; contact with BUR Approach is maintained throughout the orbit.

After the ground search party reaches the site and finds the hiker immobilized with a broken leg from a fall, the Super Bat RPAS starts a return to the launch location, notifying BUR Approach that the mission has been terminated. The RPAS is instructed to change to a VFR code and congratulated by ATC on their successful mission.

Landing and recovery of the Super Bat RPAS is accomplished in a manner similar to the Raven RPAS.

Launch and Recovery Procedures: Will launch and recovery regulations, policies, or procedures be created for small RPAS, or at these left to the discretion of the operator?

2.2 Scenario 2: Suburban Alarm Monitoring

Scenario at a Glance: Suburban Alarm Monitoring	
Nature of the Mission	RPAS provides surveillance support for a team responding to a potential home break-in.
Aircraft Type	Small RPAS: Quadcopter and Puma
Flight Operator	Home security monitoring company
Flight duration	Less than an hour
Altitude	0-400 feet
Classes of Airspace Affected	G
Line of Sight	VLOS for quadcopter, BLOS for Puma
Flight Planning	Determined tactically as mission unfolds
Launch Mechanism	Hand launch
Lost Link Procedure	The RPAS is programmed to orbit at its current position if the control is not reestablished within a parameter time. The engine is then shut off and the RPAS makes a controlled spiral to the ground.

A home security monitoring firm in Santa Monica, California, has acquired a number of small RPAS to provide surveillance to mitigate potential risks to their incident response teams. They receive an alarm indicating a break-in at a residence in Van Nuys, a suburb of Los Angeles. After several unsuccessful attempts to contact anyone at the property, the firm dispatches a patrol vehicle to investigate. Upon arrival, the security officer finds the house dark. He performs an exterior check of the property before attempting to enter the building and then, in accordance with company protocol, launches a quadcopter RPAS to survey the property before doing a physical walk around the building. The high-level operational concept for this scenario segment is depicted in Figure 2.

Figure 2: Suburban alarm monitoring scenario high-level operational concept

Since the planned use of the quadcopter will be within VLOS, no flight planning is performed. The alarm company has certified all its patrol personnel as RPAS pilots for VLOS operations of the quadcopter. The RPAS patrol security officer on the scene verifies that the quadcopter can be operated under VFR and that there are no restrictions to its flight in that area, because it is not within Class B, C, or D airspace. The RPAS pilot becomes familiar with all available information concerning the flight. No coordination with ATC is expected, nor is a flight plan required. The RPAS has the required equipage to operate in the Class B Veil, but it does not have DAA technology because of the VLOS nature of the operation.

> **Pilot Information Gathering**: How does the RPAS pilot become familiar with the necessary information before the flight? Can he use any mobile device (e.g. smartphone), or does he need a specific connection to an ANSP data source?

Because of the small size and limited nature of this type of RPAS flight, a separate observer is not required. The RPAS pilot surveys the area for other aviation activities, determines that there is no conflicting traffic, and decides the RPAS can be launched. Control of the RPAS is provided through a

> **Ground Observer Requirements**: Who determined the conditions under which ground observers are required?

LOS link between the RPAS pilot's portable control console and the RPAS.

The RPAS pilot hand-launches the quadcopter and flies it to an altitude of less than 400' above the ground. During the launch and climb to the operating altitude, the RPAS pilot maintains a constant view of the RPAS and its surroundings to ensure the RPAS remains clear of other airborne operations and does not pose harm to people or property.

As the RPAS pilot flies the quadcopter around the residence, he notices smoke coming from a broken back door window. Again, following company protocol, the security officer notifies his company offices, who in turn report the potential fire and break-in to the emergency call center. Since there is a likelihood of a crime in progress, the security officer maintains RPAS surveillance of the situation, but does not enter the property, waiting for a response team to arrive.

Pilot Distractions: In this scenario, the pilot is performing other activities in addition to flying the RPAS. Will there be regulations restricting his activities? (Analogous to "no texting while driving" policies for automobile operators.)

The local fire station dispatches an engine company to the subject location. As the firemen suit up and prepare to leave the fire station, other firemen prepare to launch a small RPAS from the fire station roof. Experience has shown that a RPAS can usually arrive on site before the engine company and can provide valuable early information about the situation.

Since RPAS are routinely used as part of fire and rescue missions, each fire station maintains a status monitor of the weather and flight restrictions over their area of responsibility. A quick check verifies that the station's Puma RPAS can be deployed to support this incident and satisfies the pre-flight planning requirements of 14 CFR 91.103[2]. The fire station's Puma RPAS has DAA capabilities, and selected firemen have been trained to act as RPAS pilots. The fire station's RPAS pilot notes that he must contact Van Nuys Tower as soon as practical after the Puma RPAS is airborne. They also note that the most direct route of flight will underlie the *Costal Route VFR Flyway.*

The Puma pilot ascertains that launching the Puma RPAS will not interfere with other aircraft operations in the vicinity. The pilot hand-launches the Puma RPAS and flies it to an initial altitude of 2,000' MSL.

En route to the incident location, the RPAS pilot flies the Puma RPAS at an altitude that complies with minimum altitude requirements of 14 CFR 91.119[3]. Since the flight path is along the same area as the *Costal Route VFR Flyway*, the Puma RPAS is flown at 2,000' MSL in order to be 500' below the altitude of the flyway.

[2] 14 CFR 91.103 covers Preflight Actions. See Appendix B.

[3] Minimum safe altitudes. See Appendix B.

While the intent is to fly the Puma RPAS on the most direct course to the incident site, on occasion the RPAS pilot has to adjust its course to avoid buildings within a 2,000' distance for compliance with 14 CFR 91.119.

The route of flight takes the Puma RPAS by the Van Nuys Class D airport (KVNY). The RPAS pilot contacts the KVNY Tower for approval to transit the Class D area. (The method of communication available may differ depending on the communication capabilities available to different types and levels of ATC facilities.) The Tower and the RPAS pilot exchange information about the RPAS and its anticipated flight path. The Tower provides information about other aircraft operating in the vicinity and approves the Puma RPAS flight through the Class D airspace. The RPAS pilot refers to the traffic display and attempts to correlate the information provided by the Tower with what is observed on his traffic display.

The Puma RPAS overflies a residential neighborhood where a civil RPAS is being flown by a real estate company taking aerial pictures of properties being listed for sale. The first responder community is familiar with the real estate company RPAS flights because they have received numerous complaints from residents in the neighborhoods where they were flying. The complaints included concerns about low flight over their houses, disturbing the peace, invasion of privacy, and fear that the RPAS is going to crash into their property.

Coordination Across Private Organizations: How does the Puma RPAS pilot interact with the real estate company pilots? How can they tell if real estate RPAS are actively flying at the same time? Should they have checked on this before taking off? How does this compare to interactions with KVNY Tower?

With the Puma RPAS approaching the incident location, the onboard DAA capabilities detect the alarm company's RPAS that is operating over the incident location. As a result, the fire station Puma RPAS alters its course to avoid the quadcopter RPAS.

The fire station's Puma RPAS provides incident site video to the fire trucks that are en route. When the fire trucks arrive at the incident location, the firemen coordinate with the alarm company's security officer about the current situation. Since the fire station's RPAS pilot does not have direct communications with the alarm company's security officer operating its quadcopter RPAS, the fire station's RPAS pilot requests that the on-site firemen ask the security officer to land the quadcopter RPAS so as to not interfere with the fire station's Puma RPAS.

Multiple RPAS in the Same Airspace: There was a potential here for both RPAS to be operating over the same house at the same time. How will emergency responders coordinate with each other?

The fire station's RPAS pilot flies the Puma RPAS into a close holding pattern over the incident location. The Puma RPAS continues to be controlled from the fire station location, because none of the firemen at the incident site have been certified as RPAS pilots. The Puma RPAS continues to provide video to the firemen on the ground throughout the incident response.

When the incident response is completed, the lead fireman on the ground advises the RPAS pilot that the Puma RPAS is no longer needed, and can return to the fire station. The Puma RPAS is flown back to the fire station roof, avoiding the Van Nuys Class D airspace and the need to coordinate with ATC.

Nested Missions: The RPAS could be called away to another incident before returning to base. In that case, the missions would become joined.

2.3 Scenario 3: Urban Hostage Surveillance, Vertical Takeoff and Landing RPAS

Scenario at a Glance: Urban Hostage Surveillance	
Nature of the Mission	Surveillance of an urban hostage situation as support to law enforcement officers on the scene
Aircraft Type	Skate, which is a small RPAS with vertical takeoff and landing
Flight Operator	Law Enforcement Aviation Unit
Flight duration	0-2 hours
Altitude	0 – 100 feet
Classes of Airspace Affected	G
Line of Sight	VLOS
Flight Planning	Determined tactically as the mission unfolds
Launch Mechanism	Hand launch
Lost Link Procedure	Vehicle will return to base

Scenario 3 presents an urban hostage surveillance mission, where a vertical takeoff and landing (VTOL) RPAS is used to assist with a hostage situation. Table 6 in Appendix A depicts the physical characteristics, equipage, and flight-performance characteristics of the type of RPAS discussed in this segment, Skate.

Local law enforcement has pursued a group of criminals to a warehouse in the Los Angeles Port area, where hostages have been taken. The commander on the scene requests that the aviation unit provide surveillance of the area. The aviation unit assesses its available aviation assets to determine the best aircraft to employ. Options include one of the unit's helicopters, one of the mobile hand-launched RPAS units deployed to various precincts, or a higher performance, larger, and heavier RPAS that can be catapult-launched from the unit's headquarters. Because of the location and timeliness requirements of the mission, the unit elects to use a hand-launched Skate RPAS unit from a precinct near the hostage site. The high-level operational concept for this scenario is depicted in Figure 3.

Figure 3: Urban hostage surveillance scenario high-level operational concept

> **Pilot Location**: Is the pilot stationed at the Aviation Unit building or at the local police station where the vehicle is being launched? Does the pilot have to be at the launch/recovery site?

Prior to beginning the flight, the RPAS pilot becomes familiar with all available information concerning that flight, consistent with 14 CFR 91.103[4] requirements. The RPAS pilot determines that the weather condition, NOTAMs, and other information are conducive for conducting a RPAS surveillance mission flight. The RPAS unit determines that the surveillance location is outside of Class B, C, or D airspace, so immediate coordination with ATC and a flight plan are not required. The unit drives to the area near where surveillance is to be conducted and verifies that the weather meets VFR flight requirements. The RPAS observer surveys the area for other aviation activities, determines that there is no conflicting traffic, and advises the RPAS pilot that the RPAS can be launched.

[4] Preflight action. See Appendix B.

The RPAS pilot hand-launches the RPAS and flies the aircraft to a location where a surveillance holding pattern can be established at an appropriate altitude. The altitude is below the overlying Class B airspace shelf but less than the minimum altitude regulatory requirements, because this type of RPAS has been exempted from 91.119 minimum altitude requirements. During the flight, the RPAS observer maintains a constant view of the RPAS and its surroundings to ensure the RPAS remains clear of other airborne operations and does not come too close to people or property.

> **Ground Observer Qualifications**: is the ground observer dedicated to this mission, or does he have concurrent (non-aviation) responsibilities?

The Skate RPAS enters a holding pattern over the warehouse to provide the first responders continuous surveillance. Other law enforcement personnel arrive in the area and surround the building. Local news media outlets, who have been monitoring law enforcement communications over radio frequencies, decide that the hostage situation is newsworthy and scurry to provide on-site coverage. Some local TV stations and newspapers have replaced their helicopters and fixed-wing aircraft with RPAS to increase the number of airborne resources and reduce costs. A couple of the media outlets launch RPAS from their rooftop heliports—using news crews as pilots and using cameramen as observers—as their news vans proceed to the hostage location. Being first on the scene is an objective of the competing news crews.

> **Coordination Across Multiple RPAS Operators**: A news media “frenzy” could lead to numerous RPAS competing for airspace. How is coordination handled? Should the first responders get priority?

Other media crews bring their RPAS to the hostage location and launch them once they arrive. Still other news organizations dispatch helicopters with reporters onboard. Altogether, there are over a dozen news crews, RPAS, and a couple of manned helicopters operating near the hostage location. Because there is a nearby beach, both manned and RPAS banner towing are occurring. A number of hobbyists who have been flying model aircraft from the beach area decide to route their model aircraft to the area so they can also have a look. With the large number of RPAS and model aircraft in the area, it becomes increasingly difficult for observers and model aircraft hobbyists to maintain identification of their aircraft and to ensure there are no collisions. A number of near-collisions occur. Some RPAS appear to not be fully responsive to control inputs, and video from their cameras is occasionally garbled—potentially a result of saturation and related interference within the frequency bands used for RPAS control and sensor downlink due to the number of different aircraft operating in proximity to each other.

> **Detect and Avoid Other RPAS**: How can the RPAS detect and avoid each other? They could use a system such as FLARM to detect potential collisions.

> **Radio Spectrum Interference**: There could be significant competition for radio spectrum, or interference between RPAS.

Local law enforcement determines that their tactical situation is being impacted. Their RPAS has to maneuver to avoid the other RPAS, model aircraft, and helicopters. They request their FAA point of contact to put a Temporary Flight Restriction (TFR) into effect over the hostage area. After the FAA completes internal coordination to secure approval to issue a TFR, FAA issues a NOTAM in accordance with 14 CFR 91.137[5] to limit flight within three miles of the hostage location. However, since many of the RPAS and model aircraft operators are not required to maintain constant communications with FAA data sources, it takes some time for local law enforcement to locate all the people flying RPAS and model aircraft to tell them about the TFR. The various RPAS and model aircraft are flown outside of the TFR area or recovered to the ground.

> **Timely Flight Restriction Notification**: How will the RPAS pilots receive timely notification of flight restrictions once they are already airborne?

Because 14 CFR 91.137 TFRs generally have provisions that let aircraft carrying properly accredited news representatives operate within the TFR, but require that they file a flight plan with the "appropriate FSS or ATC facility specified in the NOTAM," the media organizations quickly comply with that requirement and reenter the TFR area. They have interpreted the CFR requirement that if the RPAS is carrying their camera equipment, then the provision of carrying properly accredited news representatives applies. The news media fly in a manner that best seeks not to interfere with the law enforcement RPAS, while still meeting their individual business objectives to provide the best coverage of the ground situation. There is less congestion than before, but there are still many aircraft operating closely to each other.

> **Flight Restriction Exemptions**: Under what circumstances are RPAS operators exempt from flight restrictions?

If the suspects are captured at that point, the RPAS is flown to a vacant area and recovered by the RPAS pilot and observer.

> **News Media Surveillance Rights**: Can the news media follow the police cars all the way back to the police station? At what point do they become a nuisance to police operations?

Another possible outcome involves the suspects boarding a boat and fleeing. As the boat moves farther away from shore, the RPAS observer is no longer able to see the RPAS and support collision avoidance. As a result, the RPAS pilot has to stop the surveillance and return the RPAS to the support vehicle, unless the RPAS has DAA capabilities. With DAA capabilities, it can continue to pursue the suspects, relying on onboard capabilities to avoid other aircraft, aviation operations, buildings, people, clouds, and below-VFR visibility conditions.

[5] Temporary Flight Restrictions. See Appendix B.

2.4 Scenario 4: Monitoring Emissions from Burning Coal

Scenario at a Glance:	
Nature of the Mission	**Surveillance of industrial emissions**
Aircraft Type	Medium-sized RPAS, operating in tandem
Flight Operator	Commercial RPAS operators (RPAS for hire)
Flight duration	12 hours
Altitude	1,500–4,500 feet AGL
Classes of Airspace Affected	B, G
Line of Sight	BVLOS
Flight Planning	Performed one week in advance
Launch Mechanism	Catapult
Lost Link Procedure	The RPAS will return to its departure/arrival airport and try to reestablish communications with the control station.

The mission sponsor plans to use RPAS for a 12-hour period during the upcoming week to monitor coal emissions from factories. The sponsor wants to use a pair of medium-sized RPAS that are separated vertically by 500 feet, flying pre-determined patterns over the local area of the plants. The high-level operational concept for this scenario is depicted in Figure 4.

Security and Privacy Concerns: Is this mission conducted with the consent of the coal plant owner/operator? What if this were a nuclear power plant? Are there blanket restrictions in place for flight over these types of facilities?

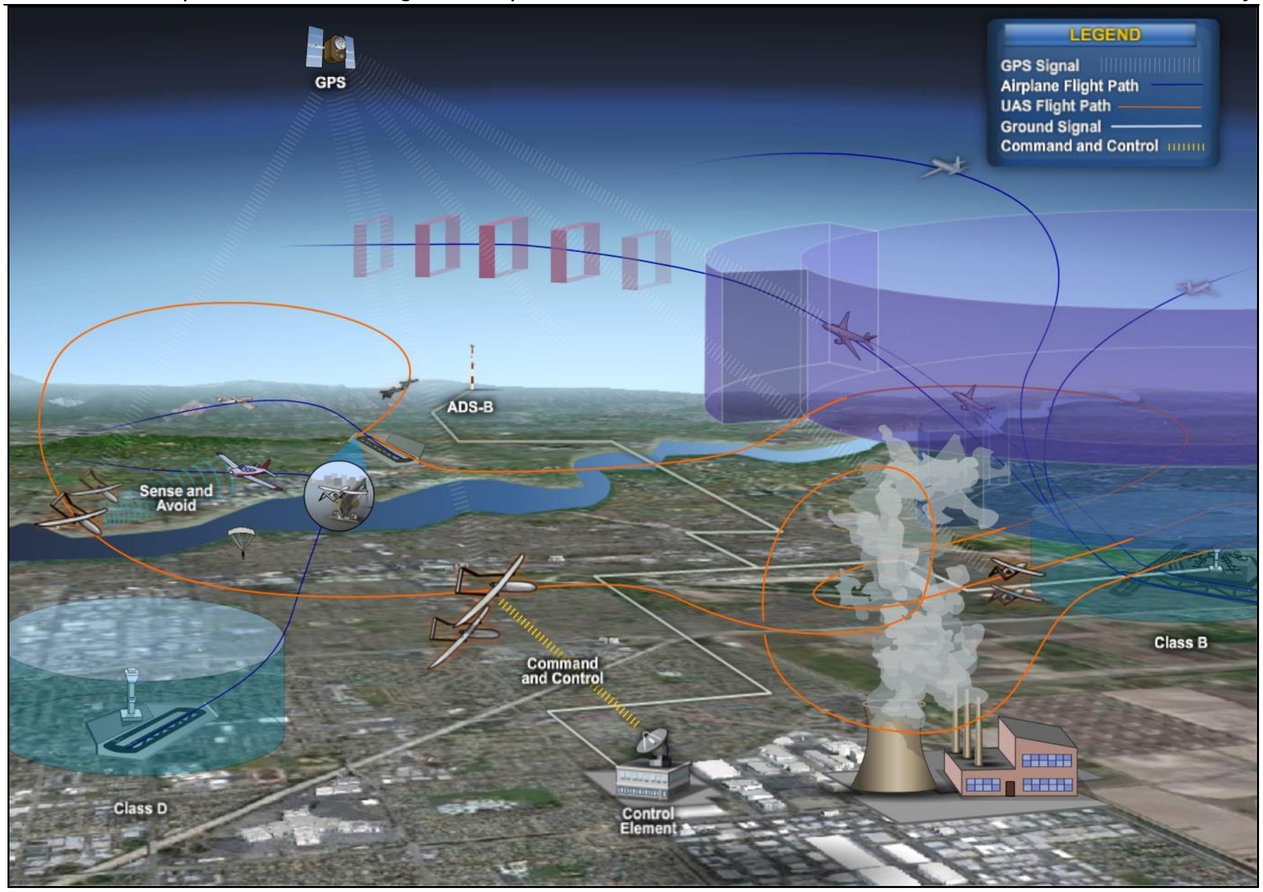


Figure 4: Emissions monitoring scenario high-level operational concept

The sponsor plans for the aircraft to fly the pattern in sets of incremental altitude bands of 500 feet between altitudes of 1,500–4,500 feet AGL. From the flight track plot depiction, the sponsor determined that the large altitude references indicated the highest terrain/obstruction in the flight area was 2,100 feet MSL, and that the northeast corner of the flight pattern infringed on the Class B airspace surrounding Pittsburgh International Airport (KPIT) between 3,000–8,000 feet MSL.

Separation Requirements: What are the separation requirements for this sized RPAS? Are unmanned-unmanned requirements the same as for unmanned-manned?

The sponsor contracted with an operator of medium-sized RPAS to conduct the mission, providing both a description of the mission and a plot of the mission flight patterns. The week before the planned mission, the RPAS pilots reviewed the sponsor's mission information and determined that some adjustments in the flight profile were needed, because the terrain in the actual flight pattern area is 1,000–1,200 feet MSL, with obstructions in the area as high as 1,700 feet MSL, and because of 14 CFR 91.179 altitude for direction of flight requirements.[6] The pilots recommended to the sponsor that the most appropriate altitude range would be 4,000–6,000 feet MSL instead of 3,500–6,500 feet MSL, with operations above 4,000 feet MSL conforming to CFR 91.179 cardinal altitude requirements. Complying with those requirements would also necessitate increasing the vertical separation between the two RPAS.

The pilots plotted the flight profile using an FAA Aeronautical Charting database (see Figure 5) and determined that a number of operational issues needed to be addressed. When looking at an area larger than the plot provided by the sponsor, the pilots observed that the entire flight profile area was within the geographical limits of the KPIT Class B airspace at 4,000 feet MSL and above, in addition to the northeast pattern corner within the Class B airspace at 3,000 feet MSL. The pilots determined that the flight track intersected the main runway centerlines at KPIT. Further analysis revealed that the principal Required Navigational Performance (RNP) arrival paths to those runways also overlapped the flight pattern, as did two of the Instrument Approach Procedures (IAP) for Wheeling Ohio County Airport (KHLG). The pilots noted the proximity of the KHLG Class D airspace to the transit route between the operating base at Jefferson County Airpark (2G2) and the flight work area. Their last operational observation was that the eastern portion of the flight area is close to a designated parachuting jump area. In addition to filing an IFR flight plan, the pilots also determined that they would recommend pre-coordination with the IFR facility managing the KPIT Class B airspace to determine if they could accommodate the operation and if there would be any restrictions on the flight[7].

Coordination Requirements: What criteria did the pilots use to determine they need to coordinate with the IFR facility?

[6] 14 CFR 91.179 - IFR cruising altitude refers to odd or even altitudes for flights above 3,000 feet AGL. For IFR flight rules, eastbound are odd 1000-foot altitudes and westbound are even 1000-foot altitudes. See Appendix B.

[7] Without pre-coordination, there was concern that the facility managing the Class B airspace might not be able to tactically accommodate the mission because of the overlap with traffic arriving and departing KPIT, especially within typical resource availability to affect the non-standard coordination and flight services.

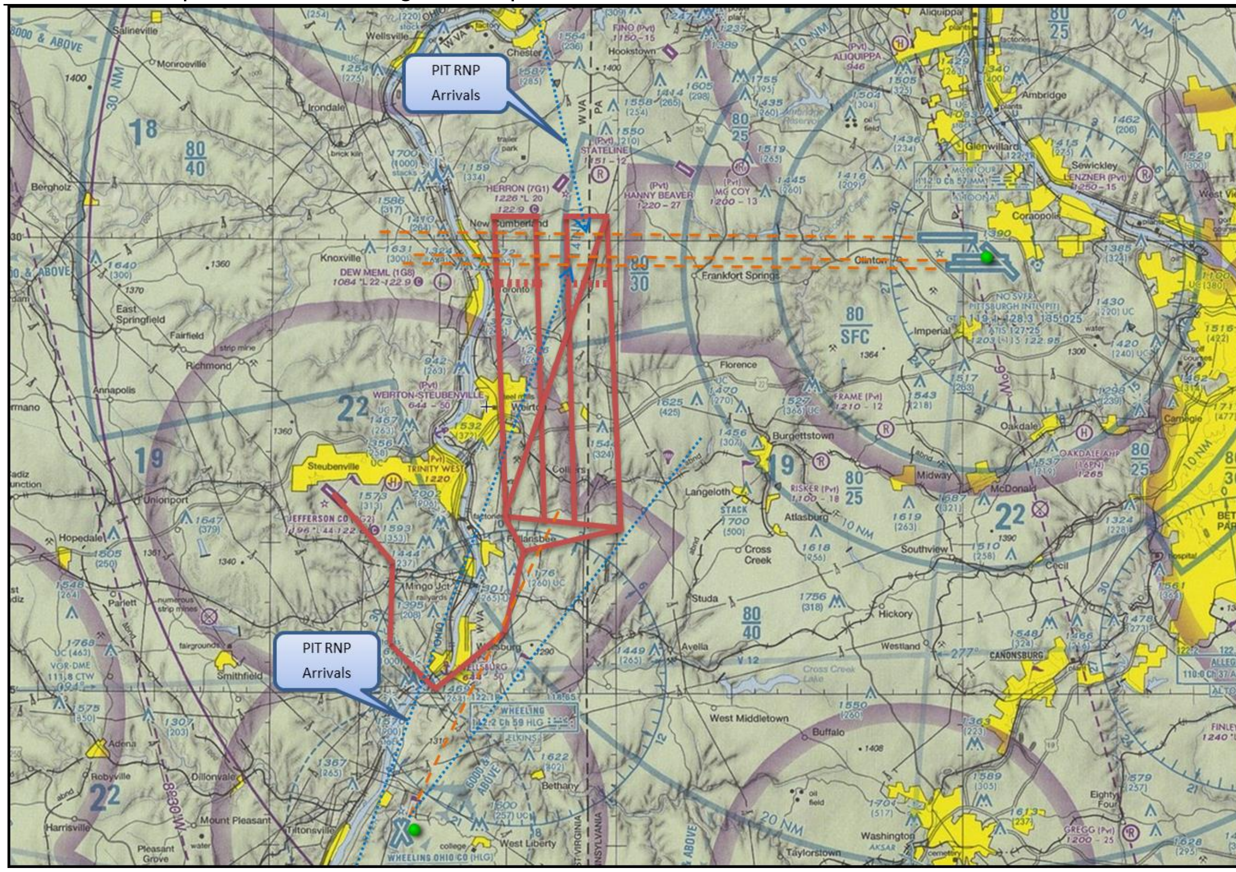


Figure 5: Emissions monitoring scenario planned mission route

> **Pre-coordination**: When is this type of coordination required, and when is it merely advisable? When does coordination and intent sharing imply approval to operate?

A multi-party communications session between the pilots, operator, and ATC was held to pre-coordinate the mission. In reviewing the proposed flight trajectory during coordination with ATC, it was determined that even at the RPAS maximum speed of 60 knots, as the RPAS crossed the arrival path to KPIT, it could occupy the protected airspace of the arrival procedures for 15 minutes or longer—depending on winds—and would involve extensive coordination associated with the separate ATC controllers responsible for operations on runways 10L and 10C/10R. ATC also determined that providing a large gap in the arrival rate to the airport to accommodate the RPAS flight track as it crossed the runway centerlines was not practical. All parties agreed that when KPIT was in an Eastern Flow, the RPAS would move to the northern edge of the survey tracks no closer than 3 miles south of the KPIT runway 10R centerline for tracks in the 4,000-5,000 foot MSL range. ATC agreed that it would use its discretionary authority to assign lower than normal crossing altitudes on the arrival procedures as needed, so the RPAS could cross the final approach courses at 5,000 feet and above. Because of IFR separation requirements, it was decided that the two RPAS would operate on flight tracks with 1,000 feet vertical separation instead of 500 feet as proposed by the sponsor.

At 5:00 a.m. on the day of the monitoring flight, the ground crew at the 2G2 airport prepares both RPAS for flight. The RPAS pilots for both aircraft check out each ground control station and satellite communications link that will be used for the flight. Because adequate LOS coverage will not be available for the lower portions of the flight, satellite communications are necessary. Should control link interruptions occur for more than a short period of time, procedures have been established to advise ATC of the interruption. If the control link is restored, the RPAS can continue its flight. If the link is not restored, the RPAS is programmed to return toward its departure/arrival airport and try to reestablish communications with the control station. If communications are restored, the RPAS will be allowed to retry flight for its primary mission. If communications are not restored, the RPAS will land at its departure/arrival airport. Contingency airports were not included in the flight planning because of the need to survey the airport and provide adequate control-link response for airport vicinity and surface operations to support landings without VLOS observation and control links. After each ground crew states that its RPAS is ready, one of the crew members from each RPAS ground team switches roles and becomes the visual observer for the RPAS he or she was supporting.

Flight Plan Limitations: Current flight planning systems with the ANSP may not be able to accommodate complex descriptions. Fixes or other points of reference may not be meaningful to ATC.

ATC Procedures for Control Link Interruptions: Procedures must be established for how and when to advise ATC of control-link interruptions. What constitutes a “short interruption”?

Start and Taxi

Each of the RPAS pilots confirms with their respective visual observers that the RPAS can be safely started. When ready, each RPAS visual observer instructs the ground crew to yell “Clear Prop” and the pilot remotely starts the first RPAS (RPAS A). One of the RPAS pilots contacts the ANSP ATC facility with responsibility for KPIT, or the flight service station, to get their IFR clearances. The method of communication depends on what is most appropriate for the situation, including digital messages and VoIP. The ATC-assigned ADS-B codes are entered into the RPAS control stations to indicate that the flight will be operating under IFR. The RPAS are now ready for launch.

ADS-B Mandate: Has ADS-B usage been mandated by the airspace regulator?

Launch and Departure

These particular RPAS are launched via a catapult that is located adjacent to the active runway. RPAS activities at the airport, including locating the catapult, are consistent with approved FAA Advisory Circulars and guidance for airport activities. The pilot of RPAS A ascertains by coordination with the observer that launching the RPAS will not interfere with other aircraft operations on the airport or during initial departure, and broadcasts

Launch Procedures: Are these catapult devices regulated? Presumably, they would be considered part of the remotely piloted system, and therefore, regulated.

on the 2G2 Common Traffic Advisory Frequency (CTAF) that the RPAS is being launched along RWY 14, the active runway. The pilot issues the command to the ground control crew to launch the RPAS. The pilot climbs the RPAS to a pattern altitude of 2,000 feet MSL as the aircraft flies a standard left airport traffic pattern.

The second RPAS (RPAS B) is started and launched using the same procedures as RPAS A. Once RPAS B is airborne, it also climbs to traffic pattern altitude and sequences behind RPAS A in the traffic pattern. Once the aircraft is airborne, the observer support function ceases. Both RPAS use onboard Detect-and-Avoid (DAA) capabilities to ensure they are properly integrated with any other airport traffic. At an appropriate point in the pattern, the first and then the second RPAS exit the pattern, following standard pattern procedures, and start their flight plan route. The control link is transitioned from LOS to satellite.

Airport Traffic Avoidance: Note the dependency on onboard DAA devices to avoid other airport traffic.

En Route

The RPAS pilots contact the KPIT radar approach control on departure. The ATC facility acknowledges surveillance contact and then instructs the RPAS to proceed southeast along the predefined first-course segment, with RPAS A assigned to climb to 5,000 feet MSL and RPAS B assigned to climb to 4,000 feet MSL. Since RPAS B is able to level off and transition to cruise speed before RPAS A, RPAS B is directly underneath RPAS A by the time it reaches cruising altitude. The two pilots coordinate to make sure the flights remain vertically sequenced.

Aerial Work

As the flights follow their predefined course and cross the Ohio River, the RPAS pilot watches for traffic operating along the natural flyway along the river and for other aircraft operating to/from KHLG, which is about five miles south of their crossing location. The RPAS pilot can navigate the RPAS by providing GPS coordinates. However, should a GPS interruption occur, the RPAS pilot does not have an alternate navigation capability and must request assistance from ATC using local radar capabilities. With a transponder, the RPAS would be detected by primary radar. The flights turn northeast and prepare to enter the western leg of the flight pattern. At the cruising speed of these RPAS, each leg of the trip will take approximately 12 minutes to fly, with a complete pattern taking slightly less than one hour.

Visual Technology: What technology is the pilot allowed to use to watch for other traffic? Is this part of the certified system?

Transponder Requirements: Which RPAS are required to carry a transponder?

As the two aircraft turn northbound, RPAS A contacts the ANSP ATC facility with responsibility for KPIT and requests permission to enter the Class B airspace and, if possible, to maintain 3,000 feet MSL for the initial circuit, which would allow it to get at least one set of environmental sample data set at 3,000 feet MSL. The method of communication depends on what is most appropriate for the situation, with options including digital messages, VoIP, or VHF radio. The controller establishes identification of the RPAS through its ADS-B aircraft-specific code and associates information about the flight characteristics (e.g., IFR in coordination with an ATC facility). The controller coordinates with the controller responsible for the North Departure area (flights departing RWY 28R) and, after receiving approval, clears the RPAS through the Class B airspace at 3,000 feet. IFR aircraft, including RPAS, are provided sequencing and separation from other aircraft while operating within Class B airspace. KPIT is currently on a west-flow configuration, and the KPIT departures can easily climb above the flight track at either altitude. (Alternatively, it could be restricted below the RPAS or the RPAS held away from the departure corridor.) Because of the relatively short time that the RPAS will be in the north departure controller's airspace, the two controllers agree that a frequency change will not be required for the north controller.

ATC advises the pilot that the RPAS is leaving Class B airspace. By pre-arranged agreement, the RPAS remains on the controller's frequency and is provided basic radar services (e.g., safety alerts and traffic advisories) when outside of Class B; separation services are not provided. The flights complete the eastern flight segment and turn west. RPAS A advises ATC of its request to climb to 5,000 feet MSL and enter the Class B airspace. ATC clears RPAS A to enter the Class B airspace and to climb to 4,500 feet MSL. RPAS A initiates a climb to 4,500 feet MSL and RPAS B starts climbing to 3,500 feet MSL. As RPAS A has a greater altitude range to climb than RPAS B, it is still climbing when RPAS B reaches 3,500 feet MSL. RPAS B remains at climb speed until RPAS A has reached 4,500 feet MSL. At that point they both accelerate to cruise speed to stay in vertical sync. Both flights turn north on the western-most flight segment and fly the flight pattern for a second time.

> **ATC Agreements**: with whom did the pilot agree that the RPAS would be provided basic radar services even though it is outside Class B airspace?

Following the RPAS aircraft turning north onto the third flight segment, RPAS B contacts ATC and requests clearance to fly through the Class B airspace at 3,500 feet MSL. Following previous coordination procedures between the two departure-area controllers, ATC clears RPAS B to enter Class B airspace.

> **Multiple RPAS:** Under what circumstances could these two aircraft be treated as a single entity? Is formation flight feasible? Could a block altitude request be a solution?

As the aircraft are turning east transitioning between segments 3 and 4, the South Departure controller at KPIT is given an alert that the trajectory of RPAS A will conflict with an airline turbojet aircraft that is about to depart. The RNP departure procedure includes a 30-degree left turn off RWY 28L (the turn in the procedures is to support simultaneous departures from parallel runways). The controller is given a conflict-resolution advisory for the departing flight to maintain 4,000 feet MSL until it is clear of RPAS A. The controller issues traffic information to the departure about both RPAS A at 4,500 feet MSL and RPAS B at 3,500 feet MSL, and requests the pilot advise when he gets the 4,500 feet traffic in sight. Because the departing flight is equipped with ADS-B In capabilities, it observes the remotely piloted aircraft on its flight deck Cockpit Display of Traffic Information (CDTI). The controller planned to instruct the aircraft to provide visual separation if the aircraft was seen, because use of CDTI for separation has not yet been approved for application of visual separation. Additionally, because of the small visual profile of the RPAS, the departure flight crew does not see either of them. Once the departure has passed RPAS A, ATC clears the departing flight to resume its departure flight profile.

Following the departure passing the RPAS, RPAS B encounters turbulence with vertical velocities and roll rates greater than what the autopilot can handle. The RPAS executes appropriate recovery procedures and alerts the pilot and ATC of the altitude and heading non-conformance incident. The aircraft recovery procedures involve certification-based maneuvers and procedures that will have an expected deviation from altitude and track conformance. Once the RPAS has regained adequate control authority for the autopilot to re-engage, it notifies the pilot and vectors back to its interrupted flight plan. The RPAS pilot notifies the ANSP ATC facility that aircraft control has been reestablished. If the autopilot cannot regain control authority, the recovery procedures configure the RPAS into a flight termination mode that would minimize damage to life and property, and appropriate location and incident warning messages are broadcast.

The flights complete the eastern flight segment and turn west. RPAS A advises ATC that it wants to climb to 6,000 – 7,000 feet MSL. RPAS B requests to climb to 4,500 feet MSL and enter Class B airspace. ATC clears both aircraft as requested, and they climb to the requested altitudes following the same tracks as before.

Once on the third flight circuit, the flights request lower altitudes and receive similar clearances as before, but for descent. As they start the bottom set of circuits, ATC requests that RPAS A limit its lower altitude to 4,000 feet MSL because traffic levels are getting heavier, and because ATC needs the 3,000 feet MSL IFR altitude to be available for an approach into KHLG.

During the lowest altitude flight circuit, winds have increased from the southeast and KPIT is changing its operation to an east flow. Arrivals will be using RWY 10L and RWY 10R, and departures will be using RWY 10C and RWY 10L. ATC advises the RPAS that, because of the arrival flows, the northern edge of their flight patterns in Class B airspace be limited south of the runway-extended centerlines, as previously coordinated. Since it is important to the emission collection process that both RPAS aircraft stay vertically synchronized, both RPAS fly the shortened pattern. As the runway reconfiguration occurs, the RPAS are switched to a different frequency, because the airspace in which they are going to be operating has transferred to the South Arrival control function.

The RPAS flight segments proceed in a similar manner as during the first set of flight circuits. One difference is that the RNP arrival procedure from the southwest crosses much of the RPAS flight path. On numerous occasions, arrival aircraft are instructed to level off in their descent trajectories to ensure tactical separation from the RPAS. The RPAS also experience more encounters with wake turbulence.

During one of the eastern-most flight segments, ATC advises the RPAS of parachute operations in their vicinity and suggest they use caution. The RPAS pilots are aware of the NOTAMs concerning parachute operations, which they obtained through their digital connection to a service-oriented architecture, such as SWIM. They also have subscribed to the ADS-B Traffic Information Service-Broadcast (TIS-B), which provides them with target information about the jump aircraft, but not of the actual parachutists.

Both RPAS complete the second series of climb and descent maneuvers, and are flying southbound on the last flight segment leg. Upon leaving the Class B airspace segment that extends down to 4,000 feet MSL, ATC informs the RPAS that they are leaving Class B airspace, and to remain on their ADS-B assigned IFR code and to change frequency to KPIT TRACON. The RPAS contact KPIT TRACON and follow the predetermined routes back to the 2G2 airport, flying at 2,500 feet MSL to ensure they meet minimum obstacle-clearance requirements as they overfly the congested area of Wellsburg, WV.

En Route Return

On its return flight, as it approaches the river north of the KHLG airport, RPAS B's onboard DAA capabilities detect a potential collision with an aircraft flying south along the river and advises ATC. The pilot of RPAS B is alerted to the pending conflict and advises ATC it will follow the DAA directions to avoid the other aircraft.

Once past the river, both RPAS are assigned descent to 2,000 feet MSL, which is the pattern altitude for the 2G2 airport.

Approach and Landing

As RPAS A approaches 2G2 airport, ATC clears the RPAS for an approach to the active runway at 2G2 and provides the local wind and the altimeter setting. It is likely that ATC will lose surveillance, in which case ATC will advise the RPAS that surveillance is lost and a change to the advisory frequency is approved. RPAS A announces on the CTAF that it is approaching and will enter a left downwind for RWY 14. When within LOS of the control station, the control link is transitioned from satellite to LOS. The RPAS A pilot hears on the CTAF that another aircraft is in the pattern on the crosswind leg. Although RPAS A has ADS-B capabilities to detect other ADS-B equipped aircraft, 2G2 is beyond the area where ADS-B is required, and a number of the older aircraft in the area—gliders, Light Sport Aircraft (LSA), and weight-shift aircraft—are not similarly equipped. Since the unequipped aircraft would be a potential conflict, RPAS A searches for the traffic and advises ATC it is using its onboard DAA to detect the other aircraft. RPAS A adjusts its flight track to fall in behind the pattern aircraft. RPAS B announces that it is also entering the pattern and following RPAS A. The RPAS pilots announce their positions as they turn on to each pattern leg. RPAS A provides continued visual spacing on the aircraft ahead and follows it, paralleling the runway final for its intended

> **Merging Traffic Types**: There could be an issue merging with VFR traffic off an instrument approach, especially if circling ensues.

established landing area near the catapult location. The RPAS pilot coordinates with the visual observer to determine that the landing area is clear and acceptable for landings. The RPAS pilot terminates the flight in the landing area.

Airport Surface Observers: Under what circumstances are observers required for landing or takeoff? Can the RPAS maneuver safely around an airport surface?

Post Landing

After landing, the pilot of RPAS A performs a safe shutdown. RPAS B follows in kind, using the same techniques between its pilot and visual observer. The RPAS pilots contact flight service or the ATC facility to close their IFR flight plan. Although the RPAS have airborne collision-avoidance capabilities, the multitude of unrelated operations on the surface and sensor clutter precludes this medium class of RPAS from having effective surface collision-avoidance capabilities.

2.5 Scenario 5: Small Package Delivery

Scenario at a Glance:	
Nature of the Mission	Medical supply delivery to a remote village
Aircraft Type	Fleet of quadcopters
Flight Operator	Private package delivery company
Flight duration	4 hours
Altitude	0-400 feet
Classes of Airspace Affected	G
Visual Line of Sight	BVLOS
Flight Planning	Automated route without notification to Air Traffic Control
Launch Mechanism	Automated
Lost Link Procedure	Divert to nearest way station

Matternet Medical Supply Delivery

Matternet is a startup company founded in 2011. According to Matternet CEO Andreas Raptopolous, there are one billion people in the world today who do not have reliable access to road transportation.[8] In remote regions, roads are often impassible during the rainy season. Despite best efforts to modernize road systems, it will be many years (e.g. 50+) before this happens. In the meantime, many people require package delivery for critical items such as medical supplies.

The future vision of Matternet is to leapfrog road transportation development by providing delivery of goods and packages via RPAS. This is analogous to countries, such as India, where handheld communication devices (smart phones) have become more prevalent than ground-based telecommunications (telephone poles and wires).

In this scenario, we imagine that Matternet has established a network of 50 way stations to service 150 quadcopters in the Kingdom of Lesotho, a country surrounded geographically by South Africa. It is estimated that over ¼ of the Lesotho population is infected with AIDS. In cooperation with the Lesotho Prime Minister's Office, The South African Development Council (SDAC) and other international organizations, such as the World Health Organization (WHO), are sponsoring an AIDS treatment and prevention program. Although Matternet is a for-profit company, they have partnered with these organizations for humanitarian reasons and to test their transportation network and delivery capabilities. This is a concept demonstration opportunity for them and should bring widespread publicity.

Blood samples and medical supplies are being delivered in the district of Maseru (the capital of Lesotho). The cost of transporting 2 kg of goods over 10 km is estimated at US$0.24. In the Maseru region, there are 47 clinics and 6 labs. Samples are taken at the clinics on a daily basis and delivered to the labs via Matternet's RPAS. All of the vehicles are identical quadcopters with a 2 kg payload capacity. Special deliveries to the one hospital in Lesotho or other locations are handled on an ad hoc basis.

Cargo Restrictions: Blood samples could be considered hazardous material, especially if potentially contaminated with AIDS. Regulations will have to be set for what type of cargo can be carried over which areas.

Infrastructure which Matternet has established with their own financial contributions includes a central distribution center located in in Maseru. The distribution center houses

[8] This scenario and discussion is loosely based on video presentations and materials provided at the Matternet web site, https://matternet/us. The company is real, and although the details of the delivery scenario are fictitious, they represent operational intentions of the company.

- Quadcopter parts and repair services
- Local administrative offices
- An operations center, replete with RPAS pilots and dispatchers.

In addition, the distribution center serves as home base for the quadcopters, where they return every night.

The creation of the way stations was the biggest infrastructure investment. The way stations are 75-100 feet high and often placed in remote sections of the countryside. They have solar powered batteries, which maintain a small supply of freshly charged batteries for the quadcopters (3–5 batteries per tower). To guard against unauthorized entry, the towers have been designed to be tall enough and secure enough that they are not easily scaled. (Ironically, their primary weakness is attack from the air. For instance, an alien quadcopter could perform some malicious activities on the landing pad. RPAS are not prevalent enough in Lesotho to present any serious threat.) Towers located in more urban areas of villages have been placed just on the outskirts to minimize interference with humans or livestock.

Way Station Regulation: The way stations are analogous to cell phone towers. Regulators would have to decide if they are to be considered "airports" or as part of the remotely piloted aircraft system. If the latter, then they would be certified along with the other system components.

The RPAS are fully automated, meaning that once they leave the distribution center, they can navigate to any of the way stations on a pre-programmed route. The battery swaps are completely automated. The only part of the deliveries that requires human intervention is acceptance and acknowledgement of deliveries, which take place only at the base of the way stations. The recipients manually disengage the package from the vehicle and press a small button to acknowledge delivery, at which point the vehicle returns to a way station or to the distribution center. Routes are predefined to stay clear of trees, houses, and other terrestrial objects.

Pre-programmed Routes: Creation of established RPAS delivery routes may increase safety and predictability, the way it does for manned aviation. However, flight between the route and an ad hoc delivery point could still be problematic.

Eventually, the way stations will become hubs in a larger network, which would be optimized to make maximal utility of the vehicles and to minimize delays in deliveries. For now, the network was optimized for static routes and regular deliveries, using simplistic optimization software. Later, more sophisticated software will be used to manage dynamic routes and delivery requests.

RPAS Airports: Research has already begun to design airports devoted strictly to RPAS. Regulation would have to be constructed to guide their development and location.

The RPAS pilots generally remain in the operations center, acting as humans over the loop in piloting of the vehicles. (Occasionally, they are called to the field or special operations.) They have more of a monitoring role, sometimes with as many as 32 RPAS at a time, but four to five being more common. The dispatchers are primarily responsible for the timing and coordination of deliveries and troubleshooting problems.

Extent of Automation: Many RPAS, even large ones, are capable of autonomous takeoff and landing. The question is how much of the flight can be automated before it is considered "fully automated". In the U.S., the FAA is not even considering these types of operations.

The delivery network has been in operation successfully for five months. There have been a few vehicles lost. They may have been stolen, but this is generally not a concern because the local inhabitants are recipients of the services and act as monitors. Quadcopter landings in the villages or urban environments are still a notable event, and a small crowd generally gathers to watch.

There has been some talk of extending the cargo to include other types of supplies or goods, but as of yet, there is no way to fund the deliveries. Only a small proportion of the population could afford such services, and they generally live in the urban region where road transportation is already sufficient.

Restrictions on Scope of Operations: In principle, deliveries could be requested for any locale. Policies or regulations must be set to limit operations (e.g. away from a school zone).

Eventually, Matternet envisions establishing RPAS delivery networks in urban environments, such as major metropolises. These large cities usually have mature road networks, but traffic congestion has become highly problematic. A network of aerial routes would be created and operate in the backdrop, much the way the internet does today. (Hence the name, "Matternet".)

Detect and Avoid: In this delivery scenario, there was no air traffic to be considered. Such would not be the case in a dynamic, urban environment.

Scope of pilot duties: In this scenario one pilot is operating several RPAS. Is this appropriate, given the level of autonomy of the RPAS? How can safety level be demonstrated?

3 Discussion of impacts, issues, and concerns

In this section, we discuss the issues surrounding integration of RPAS with existing air traffic. Each of the sub-sections will address an issue, including a brief description of the issue, the major stakeholders concerned, and an outline of the next steps to be taken to resolve the issue.

3.1 Airworthiness Certification

The Issues

An airworthiness certificate grants authorization to operate an aircraft in flight. In the U.S., the FAA provides information regarding the definition of the term "airworthy" in FAA Order 8130.2, Airworthiness Certification of Aircraft and Related Products. Currently, RPAS operations are covered by a Certificate of Waiver or Authorization (COA) and are registered on a case-by-case basis. U.S. military RPAS operations are currently certified via airworthiness criteria specified in the Department of Defense Handbook.

Airworthiness certification currently assumes a pilot is onboard. Regulators will need to define all requirements for certification of RPAS in order to streamline the process compared to the COA case-by-case basis. Airworthiness certification for RPAS will need to establish requirements assuming that a pilot is *not* onboard the aircraft. Areas that need research into requirements for successful airworthiness certification are control station (equipment and software), control station security (e.g., cabin door locks), airframe, and data link (C2).

Stakeholders

- ANSP: Air Navigation Service Providers will have to validate the requirements relative to the equipment and operation rules of a RPAS, as far as these requirements have an impact upon ATC.
- Regulating Authorities (e.g. FAA, DGAC, CAA): these authorities will have to develop and/ or enforce suitable regulations for RPAS certification and operations.
- International bodies (e.g. ICAO, EASA, JARUS, RTCA, EUROCAE) will produce basic documentation and do some rulemaking.
- Domestic organizations: DoD already has a certification process for their RPAS. NASA and other research organizations are researching control station human factors, ground-based DAA, and airborne DAA.
- Private sector entities: RPAS designers with Type Certification (e.g. Insitu, AeroVironment) have been through the FAA's Type Certification process.

- RPAS operators will have to ensure that their procedures for operating RPAS are compliant with regulations including ATC procedures.
- RPAS manufacturers will work together with regulators in order to establish Type Certification process.

The Road Forward

Short-term steps
First, allowing existing RPAS designs to operate with strict airworthiness and operational limitations to gain operational experience and determine their reliability in very controlled circumstances, either under the existing COA concept or through regulations specific to RPAS.

Next, developing design standards tailored to a specific RPAS application and proposed operating environment. This step would enable the development of useful unmanned aircraft and system design and operational standards for the RPAS to facilitate safe operation, without addressing all potential RPAS designs and applications. This would lead to type certificates (TC) and production certificates with appropriate limitations documented in the aircraft flight manual.

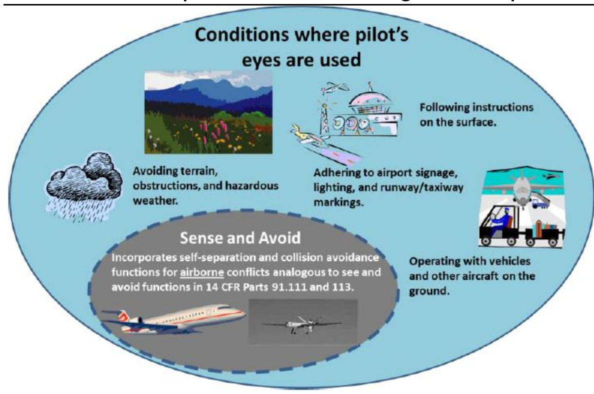
Lastly, defining standards for repeatable and predictable FAA type certification of a RPAS designed with the redundancy, reliability, and safety necessary to allow repeated safe access to the NAS, including seamless integration with existing air traffic.

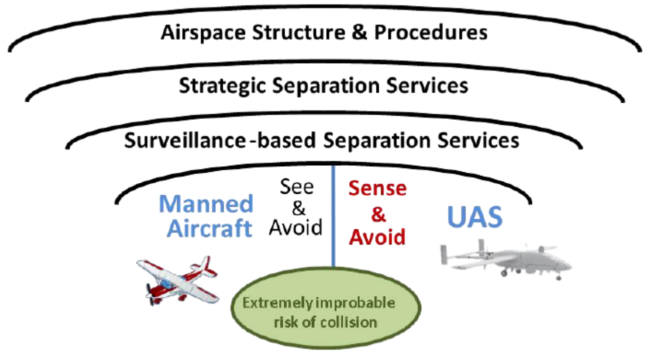
Mid-term
The FAA will work with the RPAS community in defining policy and standards that facilitate agreement on an acceptable RPAS certification basis for each applicant. This may involve the development of new policy, guidance, rulemaking, special conditions, and methods of compliance.

Far-term
Certification of RPAS will evolve as future technologies evolve and will be consistent with all other aircraft airworthiness and operational approval processes, adding more capability to the RPAS through data analyses and trending, which will identify areas for change and improvement in operations, human factors, communication links, and maintenance.

3.2 Detect and Avoid

Detect and Avoid (DAA) is the capability of a RPAS to remain well clear from and avoid collisions with other airborne traffic. DAA – sometimes called “Sense and Avoid”, as in the graphic below – provides the functions of self-separation and collision avoidance to establish an analogous capability to see-and-avoid required of manned aircraft.





The Issues

- Policy, Guidance, and Regulatory Product Challenges: Need to define minimum standards for DAA to meet new or existing operational and regulatory requirements for specified airspace.
- Air Traffic Operational Challenges: Need to establish procedures involving DAA.
- Technical challenges: RPAS pilots do not have the ability to directly comply with see-and-avoid, and RPAS DAA systems do not meet current operational rules. DAA system standards must be developed to assure both self-separation and collision avoidance capability for RPAS. Interoperability constraints must be also defined for safe and secure interactions between DAA-enabled RPAS and other airborne and ground-based collision systems.

Stakeholders

- ANSP: Seamless insertion of airborne and ground based DAA techniques into ATM procedures
- Regulating Authorities: Approval of the Airborne Collision Avoidance System (ACAS); Unmanned Aircraft Integration; Concept of operations, policy, standards, requirements
- RTCA: SC-228 (Minimum Operational Performance Standards for Unmanned Aircraft Systems) developing MASPS and MOPS; standards, requirements
- SESAR JU, FAA-NextGEN together with research partners (e.g. NASA, DLR, ONERA, ENAC). Development of:
  - New sensors
  - Airborne DAA algorithm/software/hardware design and flight tests
  - Separation Assurance/Sense and Avoid Interoperability (SSI) and Interoperability with ATC environment (TCAS, HITL, etc.), adapted to RPAS mission and performance characteristics

- Air and Ground forces: Ground-based DAA technology development, Airborne DAA technology development

- RPAS manufacturers, avionics manufacturers: industrialization of
  - Airborne DAA algorithms, modeling and simulation
  - Ground-based DAA algorithms, modeling and simulation
  - ACAS X, DAA algorithms, modeling, simulation

The Road Forward

Short-term steps

- Establishment of DAA system definitions and performance levels
- Assessment of DAA system multi-sensor use and other technologies
- Minimum DAA information set required for collision avoidance maneuvering
- Ground Based DAA: Concept-of-use demonstration under way
- Airborne DAA: Research is under way, but significant progress not expected until mid-term.

Mid-term

- Flight demonstration of self-separation and collision avoidance algorithms, with multiple sensors and intruders
- Assessment of the performance of various self-separation concepts as a function of surveillance data configurations, and evaluation of risk-based self-separation algorithms and policy issues
- Assessment of the performance of various separation assurance concepts, and flight demonstration of separation assurance algorithms, with criteria-based separation
- Assessment of RPAS performance for delegated spacing applications (e.g. defined interval clearances)
- Fully certified RPAS-based collision avoidance solutions may not be feasible until the long-term and are deemed to be a necessary component for full RPAS NAS integration. This includes research on safe and efficient terminal airspace and ground operations, followed by ground demonstrations of autonomous airfield navigation and ATC interaction.

Far-term

- DAA research that focuses on algorithm development and compatibility with current and future manned aircraft collision avoidance systems such as TCAS II/ACAS X and surveillance systems (e.g. ADS-B), as well as compatibility with ARC separation management procedures and tools.

- Detailed research on DAA flight operations, using certified sensor systems, could allow aircraft to maintain safe distances from other aircraft during flight conditions that would not be appropriate for visual flight in a manned aircraft. This capability would rely heavily on network-enabled information, precision navigation, and cooperative surveillance and would require the development and integration of NextGen-representative technologies for traffic, weather, and terrain avoidance. This conceptual model will be enlarged with sensors that expand the ability to maintain separation from other aircraft past the current visual spectrum and flight conditions restrictions.

3.3 Command and Control

The Issues

Unlike with manned aircraft, the RPAS pilot must depend on a data link for command and control (C2) of the aircraft. This affects the aircraft's response to revised ATC clearances, other ATC instructions, or unplanned contingencies (e.g., maneuvering aircraft). Issues to be resolved include:

- Policy
- Certification Requirements
- Technical Standards
- Airworthiness Standards
- Interoperability Requirements
- Guidance Material
- Coordinated Aviation Radio Frequency Spectrum
- Standardized Control Architectures
- Measures of Performance
- Radio/Data Link Security Requirements

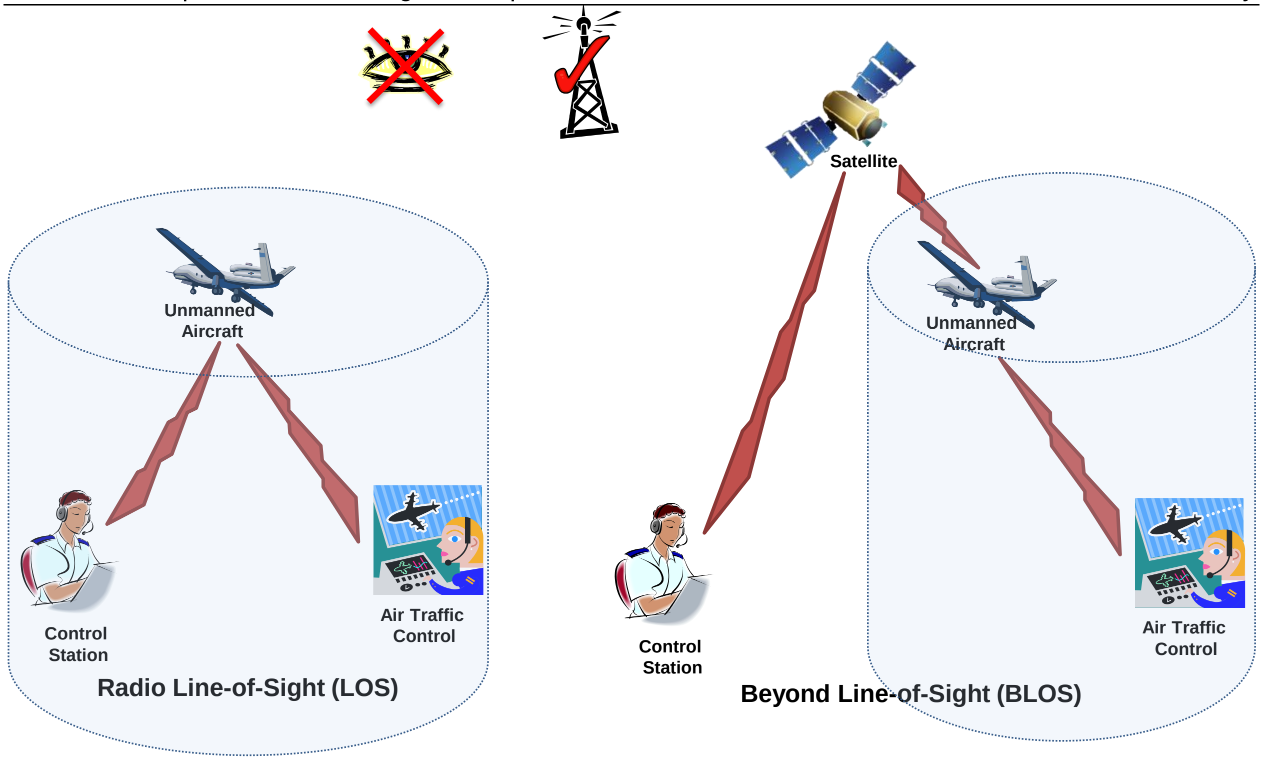


Figure 6: Line of sight means within radio line of sight, not visual line of sight.

Stakeholders

- International bodies: International Telecommunications Union (ITU) – World Radio Communications Conference (WRC) is part of ITU. ITU delegates the management of the spectrum for aeronautical frequencies to ICAO which, in turns delegates it to National regulating authorities.
- Aeronautical Regulating Authorities: Flight standards – C2 standards and certification requirements. Air traffic – C2 controller training requirements, impact on air traffic, etc. Policy – Setting frequency.
- RPAS Operators: Need to understand C2 requirements and comply with them.
- National Telecommunications Regulating Authorities: various regulating bodies organize the management of the spectrum at local or national level. This is an important factor as small RPAS may use non aeronautical frequencies for C2, which could result in an improper protection from jamming.
- Domestic organizations: RTCA, NASA; National Telecommunications and Information Administration (NTIA) manages and authorizes all federal use of the radio frequency spectrum; Federal Communications Commission (FCC) manages and authorizes all non-federal use of the radio frequency spectrum, including state and local government as well as public safety.

- Private sector communication service providers: Harris Corp., ARINC, SITA, etc.

What Needs to Happen

- C2 system performance requirements are needed – RTCA is developing consensus-based recommendations for the FAA to consider in C2 policy, program, and regulatory decisions.
- The resulting C2 requirements need to support the minimum performance required to achieve RPAS level performance and safety requirements.
- Third-party communication service providers are common today (e.g., ARINC, Harris) and the FAA has experience with setting and monitoring performance of third parties.
- The use of third parties is dependent on the RPAS architecture chosen, but these are still being evaluated in terms of feasibility from a performance, cost, and safety perspective.

C2 Certification: The FAA shall establish acceptable thresholds for control link latency (time from initiation of a command to the RPAS until a measurable response). The FAA shall establish acceptable thresholds for communications latency (time from issuance of an ATC instruction until acknowledgement by the RPAS flight crew).

C2 Operations: The FAA shall provide "party line" communications services to RPAS in addition to manned aircraft. The FAA shall exchange ATC messages and instructions with RPAS flight crews via data communications for those RPAS who elect to equip with this capability.

C2 Policy: The FAA shall assign frequency spectrum for RPAS command, control, and communications.

C2 Training: FAA shall provide training for ATC and TFM personnel on RPAS specific topics, such as RPAS flight envelope characteristics, typical operational profiles, communications and control link latency, contingency procedures (e.g., lost link), and automation support tools.

The Road Forward

Short-term

- A primary goal of C2 research is the development of an appropriate C2 link between the RPAS and the control station to support the required performance of the RPAS in the NAS and to ensure that the pilot always maintains a threshold level of control of the aircraft.
- Research will be conducted for RPAS control data link communications to determine values for latency, availability, integrity, continuity, and other performance measures.
- RPAS contingency and emergency scenarios also require research (e.g., how will a RPAS in the NAS respond when the command link is lost, through either equipment malfunction or malicious jamming, etc.).

- This research will drive standards that are being established through: Development and validation of RPAS control link prototype; vulnerability analysis of RPAS safety critical communications; completion of large-scale simulations and flight testing of initial performance requirements.

Mid-term

- Advanced research is required in data link management, spectrum analysis, and frequency management.
- Efforts will focus on completing development of C2 link assurance and mitigation technologies and methods for incorporating them into the development of certification of the RPAS. This will include identification of satellite communication spectrum from the ITU through its WRC; verification and validation of control communication final performance requirements; establishment of RPAS control link national/international standards; and development and validation of technologies to mitigate vulnerabilities.
- Complete characterization of the capacity, performance, and security impacts of RPAS on ATC communication systems will be completed.

Far-term

Research on new tools and techniques to support avionics and control software development and certification, to ensure their safety and reliability. FAA Goals established for Command and Control are:

Goal 1: International agreements, industry standards, and FAA regulations established by 2015 for civil RPAS C2 capabilities such that C2 subsystems can be certified by the FAA.

Goal 2: Beyond-Line-of-Sight (radio, not visual) C2 links and capabilities are addressed in international agreements, industry standards, and FAA regulations.

Goal 3: Adequate spectrum is available for both radio LOS and BLOS C2 links to meet the demand generated by civil RPAS operations in the NAS. International spectrum identified for LOS and BLOS RPAS C2 links reviewed at WRC by 2020.

3.4 Security

The Issues

- Communications link between control station and RPAS. An attacker could gain control by hacking the communications channel, and crash the RPAS, fly it into a building, subtly interfere with its navigation so it thinks it's somewhere it's not (spoofing, jamming), or capture the RPAS – i.e. steal it by flying it to their own location.
- Security of control station: An attacker could break into the control station, if secure cockpit door standards for commercial flights not extended to RPAS. They could then do any of the things a remote hacker could.

- Data or information collected by RPAS. Someone could remotely copy all this data, possibly without the operator's knowledge. Corporate espionage is another potential problem. Privacy risk: interceptor might not follow the privacy policy of the RPAS operator.
- Operator Security: With the anticipated increase in number of RPAS operations, screening and vetting of RPAS pilots will be important. Many operators will not have been pilots before. Any RPAS operator could choose to turn rogue and use RPAS as a weapon. Any pilot could do this today, but threat to his or her own safety usually deters this. With that factor removed, the question is how to keep would-be terrorists from acquiring and arming RPAS. If a RPAS causes damage, what methods are available to track it? Possible solutions may include electronic signatures or trails or an analog to automobile registration.
- Defense against rogue RPAS: What if one or more RPAS appear in the sky flying toward strategic objectives (government buildings, nuclear plants, etc.)? RPAS are small and fly low – truly "under the radar". Need a method for detecting potential rogue RPAS before they reach their destination and also a method for diverting or disarming them.
- Control station security should be addressed. Need to define what constitutes a "cockpit" in RPAS context. It is OK to treat small RPAS differently?

Stakeholders

- RPAS manufacturers
- Communications researchers
- Security experts
- Test site operators (in the U.S.)
- RPAS operators
- Aeronautical Regulating Authorities: Need registry of all owners / operators / pilots of RPAS. Similar to license / registration for cars and trucks. Could there be an analog to the state or province level department of motor vehicles?
- Defense departments
- IATA / ICAO

3.5 Air Traffic Control

The Issues

Separation standards
Separation standards need to be reviewed and potentially altered. Identify policies and requirements for RPAS to comply with ATC clearances and instructions to the degree they are for manned aircraft. Identify high-risk areas when a mixed environment is present. Provide controllers with better tools to distinguish separation standards that will vary with situations.

Policy

Establish policy and guidance for Ground and Local control. Launch and recovery methods when departing/arriving airports. Assess impact to other operations. Introduction of more vehicles on airport surface provides opportunities for incursions. Training for ground RPAS personnel in ATC procedures and expectations. Communications with the tower and with airport operators.

Communications

Performance requirements that support minimum performance required to meet safety requirements are needed. RTCA is developing consensus-based recommendations for the FAA to consider in C2 policy, program, and regulatory decisions. These must be established before separation standards can be established. Third-party communication service providers are common today (e.g., ARINC, Harris, EUROCAE) and the FAA/EASA/DGAC/CAA has experience with setting and monitoring performance of third parties. Separation standards increased in these scenarios?

Training

Establish new training for ATC. RPAS performance characteristics. Establish techniques for handling UA. Simulation in the radar environment displaying realistic performance is limited – advances needed. What to expect from pilots of RPAS. PIC training and certifications understood by ATC. Cultural and mindset changes.

Contingency Procedures (e.g. lost communication, security)

ATC already has contingency procedures in place for all aircraft (e.g. loss of radio, loss of power). When communication with the pilot is broken, it can be assumed that the aircraft will maintain its filed flight path to its destination. However, for RPAS, it is not clear what the vehicle is programmed to do. Since it is usually not a transit mission, the notion of a destination may have no meaning. Some vehicles will return to home base, while others will loiter hoping to regain communication with the pilot (if that be the problem), while other will perform a spiral descent (a controlled crash). The main issue is that ATC needs to know which of these options the vehicle will adopt. A primary issue is how the controller can access this information.

Airport Surface Integration

Will RPAS be able to operate on the airport surface? Will the technology to stay clear of objects and vehicles be the same as it is for en route? Will ground observers be required, and if so, what qualifications must they have?

Latency

Latency in pilot responses during communications and latency in response of the aircraft to controller instructions are often cited as two areas of concern. According to the most experienced RPAS operators (specifically, the US Air Force), latency is a minor nuisance at best (fractions of a second), somewhat akin to a slight hesitation in verbal conversations. Other sources have estimated latency (in aircraft response) to be on the order of 3 seconds, which could be problematic in evasive or other emergency procedures. Standards must be set for how much latency can be tolerated by controllers.

- ANSP:
  - System Operations
  - Procedures to ensure safety
  - ATC – management and labor
  - Access/ Reservation of airspace: must be optimized to maintain flight efficiency at an acceptable level
  - Access to airports: to ensure optimal flight efficiency
  - Aeronautical Information: to guarantee an acceptable level of safety and performance
- Aeronautical Regulating Authorities: edit rules and survey that performances are in line with objectives in the following topics (at least)
  - System Operations
  - Homologation/ Certification
  - Safety
  - Access to airspace
  - Access to airports
- International bodies
  - ICAO
  - IATA
- Domestic organizations
  - NATCA
  - PASS
  - AOPA
  - Airlines for America
  - DoD
  - Airport Operators
  - RTCA
  - NASA

- National Telecommunications and Information Administration (NTIA) manages and authorizes all federal use of the radio frequency spectrum.
- Federal Communications Commission (FCC) manages and authorizes all non-federal use of the radio frequency spectrum, including state and local government as well as public safety.
- State government aviation organizations
- Airspace users will express their requirements in terms of mission definition and required level of performance
  - Drone operators and their representative bodies
  - AOPA/ EBAA/ national associations or federations: represent private pilots
  - Airlines for America, European Low Fare Airlines Association, Association of European Airlines, etc. represent “legacy” airlines
  - Departments of Defense: express the military point of view
  - Airport Operators: considered as airspace users, as the concerns they address are mostly those that impact airlines
- ITU and organizations responsible for allocating the spectrum (at a national level, or local or for specific purposes): avoid datalink, radio and C2 jamming
- Other professional organizations:
  - ATCO Unions
  - Pilots Unions
  - RTCA, EUROCAE

The Road Forward

Short-term

- Determine facility Position usage and ensure staffing available for opening additional positions
- Determine administrative workload for planning and coordination. Consider administrative tasks assigned to operational management detract from primary responsibility of overall supervision of the current operation.
- Assess availability of beacon codes
- Clearly define access expectations and priority
- Define operations in SFRA

- R&D Activities:
  - Develop tools to assist controllers with primary responsibility of a safe orderly operation. Possible data block revision to include weight class.
- RPAS contingency and emergency scenarios require research (e.g., how will a RPAS in the NAS respond when the command link is lost through either equipment malfunction or malicious jamming, etc.). Develop scenarios and conduct tabletop exercises.
- Research will drive separation standards and communications expectations:
  - Development and validation of RPAS control link prototype
  - Wake turbulence studies
  - Vulnerability analysis of RPAS safety critical communications
  - Completion of scenarios, simulations to determine CPC training and indoctrination on the revised standards needs.

Mid-term

- Apply current prioritization policies to RPAS. Determine if equal level of safety exists.
- Traffic Flow Management: Give facilities some idea of expected demand. Assess impact. Develop TMIs suited to RPAS operation
- Alter internal airspace boundaries to establish parallel corridors for low performance aircraft if frequent impact exists. There are environmental implications.
- R&D Activities:
  - Advanced research is required in data link management, spectrum analysis, frequency management, and wake and vortex turbulence.
  - Efforts will focus on completing development of Communications assurance and mitigation technologies and incorporating them into the development of ATC requirements. Development and validate technologies to mitigate vulnerabilities.
  - Complete characterization of the capacity, performance, and security impacts of RPAS on ATC communication systems will be completed.

Far-term

- Re-define “immediate communication”
- Alter airspace based on frequent impact
- R&D Activities: Research on new tools and techniques to support avionics and control software development and certification, to ensure their safety and reliability.

3.6 Traffic Flow Management

The Issues

Traffic flow managers will need methods and assess the potential impact of RPAS operation, especially when their operation is potentially disruptive or requires special monitoring or segregated airspace. They must be able to assess impact approximate workload on air traffic controllers. If RPAS require larger separation standards than manned aircraft, then the impact on controllers and traffic flow must be assessed in real time.

Currently, all RPAS operations in controlled airspace are considered potentially disruptive and allowed only via special permission. Mission descriptions and flight plans are submitted 24 hours or even days in advance. In the future, policies must be set for how far in advance these flight plans should be submitted and what format they will take. Ideally, RPAS operators would like to have the same file-and-fly privileges as manned aircraft, and will be concerned that they are being singled out, if they are required to give long lead times on their intentions.

Under some circumstances, RPAS will still require reserved airspace for their operation.

Also, the interaction (or lack thereof) of RPAS with traffic management initiatives (ground delay programs, traffic spacing programs) must be evaluated in real time. Will RPAS be able to comply with and participate in these programs (e.g. in the U.S., collaborative decision making)?

Stakeholders

- ANSP
  - Systems Operations (central flow units – responsible for all air traffic management activities in the considered airspace)
  - ATC – helps execute traffic management plans
- International organizations
  - ICAO RPAS Study Group – focal point for international RPAS developments
- Domestic organizations
  - Flight Operators – RPAS, passenger, cargo
  - Universities – Ongoing RPAS research, test sites
  - Military – RPAS operators, NAS users

The Road Forward

Short-term

- Case-by-case approvals.

- Modeling and Simulation: FAA and other government agencies and industry are developing a collaborative RPAS modeling and simulation environment to explore key challenges to RPAS integration. Near-term goals include: Validate current mitigation proposals; Establish a baseline of end-to-end RPAS performance measures; Establish thresholds for sage and efficient introduction of RPAS into the NAS; Develop NextGen concepts, including 4D trajectory utilizing RPAS technology.

Mid-term

- Develop procedures, standards, and regulations that support integration efforts
- DAA research in self-separation concepts and assessment of RPAS performance for delegated spacing applications
- C2 research to develop and validate technologies designed to mitigate vulnerabilities
- Human factors data will be collected to determine the safest technologies and best procedures for pilots and ATC controllers to interact with each other and with the aircraft. For separation and collision avoidance, human decision making versus automation must be identified.

Far-term

- Improved technologies
- DAA research focuses on algorithm development and compatibility with current and future manned aircraft collision avoidance systems (TCAS) and surveillance systems (ADS-B)
- Research on new tools and techniques to support avionics and control software development
- Early Intent
  - Increased coordination required for RPAS operations, especially if operations cross boundaries
  - No process in place to accept a flight plan with an unknown destination
  - Nature of RPAS operations may prevent notice of early intent
- Traffic Management Initiatives
  - RPAS operators vs Major operators
  - How responsive will RPAS be to speed control mechanisms
  - Demand estimation becomes a challenge with circuitous flight plans
- Weather-related
  - Weather avoidance – If you can't communicate with the RPAS pilot during a weather event, then you can't tell what the RPAS is going to do
  - Weather Availability – RPAS operators may not have the same weather information once the RPAS is airborne
  - Weather Translation – Models use very different flight characteristics for RPAS

- Off-nominal operations: Aborted missions, Jamming/Spoofing; Diversions; Pilot errors

3.7 Pilot/Operator

The Issues

- Operator approval is done on a case-by-case basis and often restricts operators to special use airspace
- Pilot certification is based on certificates for manned aircraft – there is no direct path to RPAS operation.
- Pilot training requirements are defined by each individual operator and approved by the FAA on a case-by-case basis
  - Example: DoD RPAS pilot classifications
- No defined types or classes of RPAS in current policy – handheld RPAS subject to the same requirements as a Predator (Upcoming RPAS may help)
- Currency requirements require pilots to maintain both RPAS and manned aircraft currency (3 takeoffs and landings within the preceding 90 days, IFR currency, biennial flight reviews)

Stakeholders

Regulators (e.g. FAA, EASA, DGAC, CAA): Responsible for actually writing the certification requirements, practical test standards, and FARs

Operators: Government Agencies including military, Local/State Government, Agriculture, Survey, other civil operators. Many of these organizations have developed in-house training standards. These groups pay for training the pilots to whatever standard is implemented.

Pilot Unions: ALPA, etc. represent manned aircraft pilots that may have concerns over RPAS standards. May represent RPAS pilots in the future.

Pilot Advocacy: AOPA, EBAA, etc. advocate for GA pilot issues. Concerned with airspace access and proper training of RPAS pilots.

Private RPAS Pilot Training Institutions. Already have RPAS curriculum that may be used as input. Private RPAS pilot courses will have to meet FAA requirements.

The Road Forward

Short-term
RPAS training standards will mirror manned aircraft training standards to the maximum extent possible, including appropriate security and vetting requirements.

Mid-term

Emphasis will shift toward integration of RPAS through the implementation of civil standards for unmanned aircraft pilots and new or revised operational rules, together with necessary policy guidance and operational procedures.

Far-term

As new RPAS evolve, more specific training will be developed for RPAS pilots, crew members, and certified flight instructors based on lessons learned and data collection.

- Standards for airmen will proceed following the RPAS regulation. The FAA will issue RPAS airman certificates and support activities to enable RPAS operations to include:
  - Development of practical test standards (PTS) and RPAS airmen knowledge test question banks
  - Development of a RPAS handbook for airmen
  - Training of aviation safety inspectors (ASI) at the FSDO level to provide practical test oversight
  - Identification of designated pilot examiners (DPE) to assist the FSDOs
  - Development of a RPAS handbook for pilot and instructors
  - Development of PTS and RPAS pilot knowledge test question banks
  - Development of RPAS mechanic training and certificate process
  - Development of flight crew security requirements by the relevant United States Government agencies

Pilot endorsements may be developed for specific RPAS makes and models to permit commercial operations. Pilot qualifications by make and model will be built into training and will be expanded based on pilot experience.

3.8 Privacy

The Issues

RPAS have brought about many opportunities for revenue and the pursuit of business models. These range from very small RPAS used, as they are today, for photography, real estate, surveying, inspecting – some of these activities are for personal use, but many are intended as commercial enterprises, where the product (photos or video) is sold to the client(s). This is especially true for small RPAS.

The FAA intends to publish a notice of proposed rule making for small RPAS. That publication has been stalled for several years for a variety of reasons (e.g. safety, insurance, security). More recently, a major obstacle was the need to address privacy concerns.

Specifically, the public is concerned that RPAS will be used for surveillance purposes (e.g. photography) without the consent of the subjects. For purposes of discussion here, we will call these uses “unwarranted,” meaning that is it against the wishes of the person being surveilled. The unwarranted uses fall into two basic categories: (1) those conducted by a non-government (civil) entity, such as a neighbor spying on another neighbor through their bedroom window, and (2) those conducted by a government entity, such as the U.S. National Security Agency (NSA) listening to a private conversation between two individuals in a public park. Protection against the latter concern is safeguarded by the Fourth Amendment to the U.S. Constitution. Privacy advocates, such as the American Civil Liberties Union (ACLU) and Epic.org, have insisted that RPAS not be allowed to operate in the U.S. until the FAA first says how it intends to address privacy concerns. However, this is not the traditional purview of the FAA. Initially, the FAA argued that, just as with manned aircraft, if someone is using an RPAS to perform unwarranted or illegal activities, it is the responsibility of the Department of Justice or some other legal entity to address it. (What would be under the FAA purview is to address someone operating an aircraft carelessly or recklessly.)

Some counterarguments to the privacy concerns are that virtually all the unwarranted activity can be conducted now using manned aircraft, so RPAS are not really introducing anything new. However, privacy advocates point out that the ease with which RPAS can now be adopted for these uses makes it much more likely they will take place.

No matter whether the FAA should rightfully be addressing the privacy concerns regarding RPAS, it seems that they have been forced into addressing it. This caused a significant delay of the small RPAS rules.

Europe has a comprehensive framework of privacy and data protection legislations. The Charter of Fundamental Rights of the EU establishes, in particular, the rights to respect private and family life, home, and communications (Article 7) and addresses the protection of personal data (Article 8). These rights are implemented through specific EU and national regulations (Article 16 of the Treaty on the Functioning of the European Union, Directive 95/46/EC, national laws on data protection, video surveillance, etc.). RPAS operators must also comply with this regulatory framework.

In France, many of the privacy concerns seem to have been quelled by assuring the public that RPAS use will be primarily by public servants. Also, European laws tend to be much stricter than in the U.S. regarding photographing someone against their wishes. For instance, the paparazzi are strongly controlled in Europe, whereas in the U.S. they have nearly free rein. This addresses much of the concern regarding non-government unwarranted use. As for government unwarranted use, the French public seems to be more trusting that their government will act responsibly. In the U.S., however, this type of assurance backfires. There is a stronger tendency in the U.S. than in other countries to challenge and curtail central authority.

No matter which government entity is responsible for restricting unwarranted use of RPAS surveillance, the issue has added another layer of complication to the integration of RPAS into the airspace.

Stakeholders

Privacy advocates: EPIC, ACLU, EFF, Rutherford Institute, national institutions dedicated to protecting privacy for citizens

RPAS operators: Public, Civil (will be concerned about onus of having to establish policies and curtail certain operations due to privacy concerns).

Test site operators (6 sites in the U.S., one in the U.K., plus some others in Scandinavia, France, and Italy). Each must produce a privacy policy. Will be used as trial balloons for what future privacy policies should be.

Airspace regulators

4 State of RPAS Integration Issues Around the World

4.1 World Trends by Country

In this section, we present trends that are taking place around the world with respect to integration of RPAS.

We conducted an informal review of RPAS integration progress in the member countries of the European Union and several other countries around the world. Overall, countries are grappling with the same integration issues. The U.S. and Israel are at the forefront of RPAS technology development but are not necessarily further along in establishing regulations. A common approach to regulation is to create a special set of rules for small RPAS (e.g. under 25kg) that are must less stringent than for large RPAS. The reasoning is that air traffic control does not (and will not) provide separation services for small RPAS at low altitudes, so they have to be self-separating.

Australia has been proactive in attempts to regulate and permit RPAS operations. They have published guidelines for RPAS operators. This website contains training information for prospective RPAS operators in Australia.

Canada has been proactive to the extent of providing restricted airspace for RPAS operations and testing, and Transport Canada has issued Knowledge Requirements for pilots of RPAS 25 kg or less, operating within visual line of sight. This website has information about flying an unmanned aircraft in Canada.

China has issued the first pilot licenses for RPAS operations, but civil aviation in China lags behind the Western nations. Recently, China used armed helicopters to shoot down an unauthorized RPAS involved in mapping operations.

England appears willing to allow RPAS operations and is actively examining regulations to oversee operations.

Europe, the **EU** specifically, has taken steps to define, regulate, and integrate RPAS.

Successful integration tests in **France** will have to be coordinated with EU decisions.

Germany: The **German** Parliament is about to approve a new law to include unmanned aircraft in air traffic laws.

India: The Directorate General of Civil Aviation (DGCA) in India has started formulating rules and regulations for the operation of RPAS. However, the aviation regulator has declared that until the policies are announced, the use of RPAS is prohibited.

Ireland, along with the rest of Europe, is taking a measured approach that seems to assume RPAS are here to stay. The Irish Aviation Authority has issued 22 RPAS permits.

Israel has tested urban warfare observation RPAS.

The RPAS sector is now regulated in **Italy**, and this new regulation, which is in line with the European RPAS vision, is expected to have a very positive influence on the growth of the Italian RPAS market (aeronautical products and services).

New Zealand has issued a Notice of Proposed Rule Making and is receiving comments on new rules for RPAS.

In **Russia**, Moscow hosted the 2nd international workshop on experimental RPAS.

Singapore is reviewing RPAS regulations.

In **South Africa**, the Commercial Aviation Association (CAA) in December 2014 published RPAS legislation for public comment. CAA reached agreement with the Commercial Unmanned Aircraft Association of Southern Africa (CUAASA) and industry on the details of these Phase 1 RPAS Regulations. The goal is to have legislation in place by the end of March 2015.

In **Spain**, drones are banned as of April 2014. The first BLOS RPAS test was in 2014.

Turkey is building RPAS capabilities.

The **UAE** has held a Drones for Good Award competition. The winner was an application that used cell phone location to direct an autonomous UAS with an Automatic External Defibrillator to a person in need.

In the **United States**, the Federal Aviation Administration has created test sites for RPAS experimentation. Currently, individual Certificates of Authorization are issued for non-commercial use, and also some permits for the film industry. The big unknown in the U.S. remains in the area of enforcement. A notice of proposed rule making for small RPAS is expected soon.

Uzbekistan has banned the import, sale, and use of pilotless drone aircraft, citing air safety and security concerns.

4.2 Regulatory Status in Europe

About half (12/28) of the EU countries have in place some type of regulation for RPAS, but these are only for vehicles below 25kg or below 150kg. Only two countries, Czech Republic and France, have regulations in place for beyond line of sight.

Table 1: Regulatory status in European countries

Country	In Place	In Preparation	Operations Facilitated
EU countries			
Austria	<150 kg, VLOS		Yes
Belgium		<150 kg, VLOS	Yes
Bulgaria			
Croatia			
Cyprus			
Czech Republic	<150 kg, VLOS, BLOS		Yes
Denmark	<150 kg, VLOS		Yes
Estonia			
Finland		<150 kg, VLOS	Yes
France	<25 kg, VLOS, BLOS	VLOS, BLOS	Yes
Germany	<25 kg, VLOS		
Greece			Yes
Hungary		<150 kg	Yes
Ireland	<20 kg, VLOS		Yes
Italy	<25 kg, VLOS		Yes
Latvia			
Lithuania	<25 kg, VLOS	<150 kg, VLOS	Yes
Luxembourg			
Malta		<150 kg, VLOS	Yes
Netherlands	<25 kg, VLOS	<150 kg, VLOS	Yes
Poland	<150 kg, VLOS		Yes
Portugal			
Romania			Yes
Slovakia			
Slovenia			Yes

Country	In Place	In Preparation	Operations Facilitated
Spain		<25 kg, VLOS	Yes
Sweden	<150 kg, VLOS		Yes
UK	<20 kg, VLOS		Yes
non-EU countries			
Iceland			
Norway		<150 kg, VLOS, BLOS	Yes
Switzerland			Yes

4.3 Recent Events

In this section, we present excerpts from reports and articles describing recent events relevant to increasing worldwide use of RPAS.

ICAO UAS Circular attempts to provide the fundamental regulatory framework

Taken from ICAO Circular 328, "Unmanned Aircraft Systems (UAS)", 2011

Civil aviation has to this point been based on the notion of a pilot operating the aircraft from within the aircraft itself and more often than not with passengers on board. Removing the pilot from the aircraft raises important technical and operational issues, the extent of which is being actively studied by the aviation community. Many of these issues will be identified in this circular.

Unmanned aircraft systems (UAS) are a new component of the aviation system, one which ICAO, states, and the aerospace industry are working to understand, define, and ultimately integrate. These systems are based on cutting edge developments in aerospace technologies, offering advancements which may open new and improved civil/commercial applications as well as improvements to the safety and efficiency of all civil aviation. The safe integration of UAS into non-segregated airspace will be a long-term activity with many stakeholders adding their expertise on such diverse topics as licensing and medical qualification of UAS crew, technologies for detect and avoid systems, frequency spectrum (including its protection from unintentional or unlawful interference), separation standards from other aircraft, and development of a robust regulatory framework.

The goal of ICAO in addressing unmanned aviation is to provide the fundamental international regulatory framework through Standards and Recommended Practices (SARPs), with supporting Procedures for Air Navigation Services (PANS) and guidance material, to underpin routine operation of UAS throughout the world in a safe, harmonized, and seamless manner comparable to that of manned operations. This circular is the first step in reaching that goal.

ICAO anticipates that information and data pertaining to UAS will evolve rapidly as states and the aerospace industry advance their work. This circular therefore serves as a first snapshot of the subject.

A Kitty Hawk moment – the start of an era in which RPAS will change the world

Popular Science, August 2014, "25 Reasons to Love Drones and 5 Reasons to Fear Them"

Once the U.S. Federal Aviation Administration (FAA) establishes airspace rules, which is likely to happen in 2015, the drone industry could fuel a decade-long, $82-billion economic boom, according to a study done by the industry's leading trade group. Already, one analyst estimates the global market for small unmanned aerial vehicles (UAVs) at $250 million to $300 million. The truth is, we're witnessing a Kitty Hawk moment—the start of an era in which drones will change the world and the way we live in it. They've saved lives overseas; at home, they will make our cities and grids smarter, keep people safer, and help save our planet.

Some opposing views

From the same article, the "5 reasons to fear" RPAS:

In the wrong hands, drones could be deployed in unintended—and sinister—ways. Here's why we shouldn't rush headlong into this new age without careful deliberation about how and where drones can be used.

1) Global warfare. Remotely controlled vehicles keep human operators out of harm's way. This, of course, means that world leaders can be tempted to engage in a kind of combat with almost no on-the-ground risks—creating a new kind of geopolitical calculus that everyone from President Obama to George R.R. Martin, the author of Game of Thrones, has puzzled over.

2) Blowback. Drones have been a powerful tool in the battle against terrorism; they are responsible for the deaths of 58 high-ranking members of the Taliban and al-Qaeda and its affiliates in Pakistan alone. But drone strikes have also killed civilians and fueled a wellspring of anger. The would-be Times Square bomber became a terrorist out of his rage over drone strikes overseas.

3) Misuse. Hobbyists love quadcopters and their ilk because they're easy to use, but that quality also makes them appealing to people with undesirable motives. Terrorists have started to use the technology as cheap aerial improvised explosive devices (IEDs), while criminals use them to smuggle contraband over prison walls and across international borders.

4) Accidents. More flying objects with less-experienced human operators (or even no human pilot at all) has created a new category of personal risk. In April, a drone fell out of the sky and

hit a triathlete at a race in Australia; a month later, an American Airlines jet nearly hit an unmanned aircraft about 2,300 feet over Florida—an incident the FAA is now investigating.

5) Loss of privacy. In a world where drone operators will include police and paparazzi, it will be hard to escape from probing eyes in the sky. California lawmakers are likely to pass a measure this summer that would curb drone-based surveillance—a law pointedly created to deter overzealous celebrity-chasing photographers.

Air traffic management system for RPAS

UAS Vision, 10/17/2014, citing MIT Technology Review

A startup called Airware is working with NASA on a project exploring how to manage the swarms of commercial drones expected to start appearing in U.S. skies. The four-year program will create a series of prototype air traffic management systems and could shape how widely commercial drones can be used. Airware's main business is selling control software and hardware to drone manufacturers and operators.

The first prototype to be developed under NASA's project will be an Internet-based system. Drone operators will file flight plans for approval. The system will use what it knows about other drone flights, weather forecasts, and physical obstacles such as radio masts to give the go-ahead.

Later phases of the project will build more sophisticated systems that can actively manage drone traffic by sending out commands to drones in flight. That could mean directing them to spread out when craft from multiple operators are flying in the same area, or taking action when something goes wrong, such as a drone losing contact with its operator.

RPAS out-perform satellite-based system for monitoring the Amazon

UAS Vision, 04/27/2014, citing Mongabay

Brazilian municipalities are planning to use UAS to map properties and monitor forest cover as they move to step up enforcement of the country's Forest Code, reports *The Financial Times*.

The municipality of Altamira in the state of Pará recently purchased a UAS for a pilot monitoring project that aims to support the development of the Cadastro Ambiental Rural (CAR), a government-managed database that will contain details on all properties in the Amazon region. The CAR underpins Brazil's recently revised Forest Code by establishing who owns what land and is therefore legally liable for complying with environmental laws.

Altamira says the UAS has become a necessity because Brazil's current satellite-based system isn't timely or accurate enough to ensure implementation at a property-level scale.

China Eyes UAS for Civilian Use

UAS Vision, 07/16/2014, citing Want China Times

UAS for civilian use are proving increasingly popular in China, but a dearth of innovation is hindering domestic producers, experts said at an international UAS exhibition that concluded last week. Although the unmanned aerial vehicle (UAV) industry is just a few years into its development, UAVs are now extensively applied in China for civilian purposes, according to Li Yong, vice president of Wuhan Ewatt Aerospace Technology Company, which specializes in making drones. "UAVs are increasingly used in a variety of fields, including electric power industries, disaster-relief work, as well as shooting TV programs," Li said at the fifth UAV China Conference & Exhibition in Beijing. In the latest example, remote sensing drones, known for their safety and high efficiency, were employed to help with rescue efforts following a mudslide in southwestern China's Yunnan province that left 17 people missing on Wednesday. The domestic drone industry lacks the talent and technology needed to innovate, and instead tends to imitate other countries, said Xu Huaying, a retired official from the Aviation Industry Corporation of China. According to Xu, a UAV market must be fostered in which small private firms compete with those with state backing, with the competition hopefully driving up standards. The government should support the industry by issuing more preferential policies, encouraging the cultivation of skilled personnel and enhancing international exchanges, he said. "Only in this way can we truly bring the industry to the next level."

Facebook Expands Drone Team, intends to use RPAS to provide universal internet access

UAS Vision, 11/26/2014, citing Capital Wired, WQAD

Facebook is bulking up its drone team.

The company has posted more than a dozen jobs for aeronautical engineers, technicians and other specialists for its drone business. It's all part of Facebook's plan to connect the whole world to the Internet using drones, lasers and satellites.

Facebook wants to know: Are you an avionics engineer who can create an autopilot system? How about a thermal engineer who can keep a drone cool during long flights? Or a systems engineer who can manage lasers in outer space?

They'll all be members of Facebook's Connectivity Lab, where the company is researching ways to bring an Internet connection to everyone on the planet. An estimated two-thirds of the world's population doesn't currently have access to the Internet.

Most of the positions are based in California, split between Facebook's Menlo Park headquarters and the Los Angeles suburb of Woodland Hills. The rest are in London, where they'll likely work with the engineers that Facebook brought on board from the small aviation company

Ascenta earlier this year. Ascenta's founders were behind the early versions of Zephr, which claimed the record as the longest-flying solar-powered unmanned aircraft.

Mark Zuckerberg, the CEO of Facebook, informed that the firm plans to build a satellite, drones, and special lasers in order to make internet service available to everyone. The social networking service company will launch its first drone airborne in the middle of 2015.

Critical missions: DHL RPA delivers needed goods when no other option available

UAS Vision 09/25/2014, citing Reuters

Logistics firm DHL is using a quadcopter to fly parcels to the German island of Juist, in what it says is the first time an unmanned aircraft has been authorized to deliver goods in Europe. The company, owned by Germany's Deutsche Post, has developed the "parcelcopter" which can fly at up to 65 km (40 miles) an hour. It will deliver medication and other urgently needed goods to the car-free island of Juist, off Germany's northern coast, at times when other modes of transport such as flights or ferries are not operating. If the trial is successful, the craft could be used to deliver such packages to other remote areas or in emergencies.

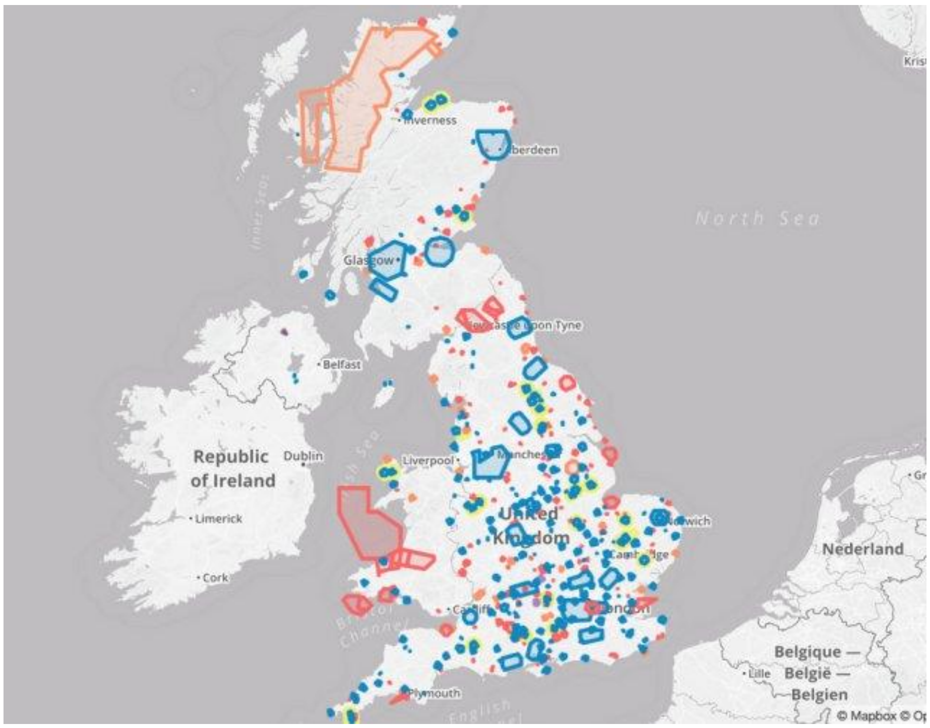
For the Juist project, Deutsche Post has received permission from the German transport ministry and air traffic control authority for a restricted flight area that will be used only by its parcelcopter. The drone will also not fly over any houses, a spokeswoman for DHL Parcel told Reuters. The craft has four rotors, weighs around 5 kg and can carry loads of up to 1.2 kg. Its flight is completely automated, although it will be monitored from the ground and, depending on weather conditions, the 12 km trip to Juist will take 15-30 minutes. Flights to the North Sea island, home to around 1,700 people, will start from Friday, weather permitting, and will continue until the middle or end of October, the spokeswoman said.

Canada issues info-graphic for flying RPAS

Graphics available at Transport Canada's website

Don’t Fly Drones Here – U.K. Edition

UAS Vision, 11/18/2014, citing NoFlyDrones website



UK drone enthusiast James Harvey has created a free site, not for profit, called NoFlyDrones that just highlights the areas in the UK that RPAS operators should not operate in. He made it after he saw numerous complaints and difficulties that non-aviation related people were having when reading aviation maps. So this puts the same information pertinent to RPAS operators on a simple interface.

Drone Regulations in the UK are extremely mature when compared to the rest of the world, they are fair and proportionate enough to allow us to fly drones in some stunning locations across the country. The rules and regulations that do exist are in place to ensure the safety of other airspace users, third parties on the ground as well as locations of national security, such as high security prisons, royal residences and military danger areas. Breaches of these regulations are not taken lightly by the CAA and ignorance of the law is no excuse, so learn from the lessons of others and check the airspace before you fly.

This website's sole purpose is to provide drone operators with a quick and easy means of determining where they should and shouldn't be flying based on the airspace above them.

SESAR 2020 Civil RPAS, Research and Development activities must be undertaken

Press Release, 09/15/2014

It is well understood that Remotely Piloted Aircraft Systems (RPAS) have great potential for civil application, however, in order for Europe to take advantages of these benefits, civil RPAS Research and Development (R&D) activities must be undertaken in full alignment with ongoing ATM R&D activities and meet existing requirements for manned aviation – as described in the Roadmap for the integration of civil RPAS into the European Aviation System– particularly within the context of the European Single European Sky (SES) initiative.

Against this background, the SESAR Joint Undertaking (SJU) has initiated a "Definition Phase" to shape an R&D Programme on civil RPAS integration, for implementation as part of the SESAR 2020 Programme. The RPAS Definition Phase will detail essential R&D activities taking into account the following:

- The EU RPAS Roadmap handed over by RPAS stakeholders to the EC
- Current developments in SESAR Research and Innovation (R&I) Programme
- Experience of the RPAS European industry, research organisations and the relevant actor in the field
- Delivered outlined actions, policy paper and existing results available from EU and other initiatives
- Previous studies and projects on RPAS establishing good and solid R&D baseline
- Input to the next ATM Master Plan update (June 2015)

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12	European RPAS Steering Group, "Roadmap for the integration of civil Remotely-Piloted Aircraft Systems into the European Aviation System," final report, June 2013.
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Appendix A Small RPAS Attributes

Table 2: Attributes of a Raven-like RPAS

Physical characteristics, equipage, and flight performance characteristics of a Raven-like small RPAS (VFR Only)	
Mean Takeoff Weight	4.2 lbs
Aircraft Dimensions	Length 3.7 ft, Wingspan 4.3 ft
Wing Loading	-
Equipage	Color and infrared imagery
Avionics	GPS, ADS-B Out, Transponder with Mode C
Control Station (Portable)	Moving map with depiction of terrain, airspace, and aviation surveillance targets
Airframe Materials	Composite
Cruise Speed Range	17-40 KTAS
Normal Approach Speed	10 KTAS
Sea Level Climb Speed	25 KTAS
Sea Level Climb Rate	200-1,000 ft/min
Cruise Descent Speed	30 KTAS
Cruise Descent Rate	200-400 ft/min
Vertical Climb Acceleration (Normal)	-
Vertical Descent Acceleration (Normal)	-
Cruise Altitude	100-500 ft AGL
Max Ceiling	10,000 ft MSL
Average Range	6.2 nm
Max Range	-
Average Flight Time	1.2 hrs
Max Flight Time (Endurance)	1.5 hrs

Table 3: Attributes of a Super Bat-like RPAS

Physical characteristics, equipage, and flight performance characteristics of a Super Bat-like small RPAS (VFR Only)	
Mean Takeoff Weight	34 lbs
Aircraft Dimensions	Length 5.0 ft, Wingspan 8.5 ft
Wing Loading	-
Equipage	Video and still color and infrared imagery
Avionics	GPS, ADS-B Out, Transponder with Mode C
Control Station (Portable)	Moving map with depiction of terrain, airspace, and aviation surveillance targets
Airframe Materials	Composite
Cruise Speed Range	35-65 KTAS
Normal Approach Speed	30 KTAS
Sea Level Climb Speed	30 KTAS
Sea Level Climb Rate	200-1,000 ft/min
Cruise Descent Speed	30 KTAS
Cruise Descent Rate	200-400 ft/min
Vertical Climb Acceleration (Normal)	-
Vertical Descent Acceleration (Normal)	-
Cruise Altitude	200-3,000 ft AGL
Max Ceiling	10,000 ft MSL
Average Range	6.2 nm
Max Range	10 nm
Average Flight Time	6-8 hrs
Max Flight Time (Endurance)	10 hrs

Table 4: Attributes of a quadcopter RPAS

Physical characteristics, equipage, and flight performance characteristics of a small quadcopter RPAS (VFR Only)	
Mean Takeoff Weight	34 oz
Aircraft Dimensions	Length 25 in, Width 25 in
Wing Loading	-
Equipage	Color and infrared video and still imagery
Avionics	GPS, ADS-B Out, Barometric Pressure Sensor
Control Station (Portable)	Altitude, Climb Rate, Throttle, Data Link, Attitude Video Output, Battery Information
Airframe Materials	Carbon Fiber
Cruise Speed Range	-
Normal Approach Speed	-
Sea Level Climb Speed	-
Sea Level Climb Rate	-
Cruise Descent Speed	-
Cruise Descent Rate	-
Vertical Climb Acceleration (Normal)	-
Vertical Descent Acceleration (Normal)	-
Cruise Altitude	100-500 ft AGL
Max Ceiling	2,000 ft MSL
Average Range	2 nm
Max Range	-
Average Flight Time	20 min
Max Flight Time (Endurance)	20 min

Table 5: Attributes of a Puma-like RPAS

Physical characteristics, equipage, and flight performance characteristics of a Puma-like small RPAS (VFR Only)	
Mean Takeoff Weight	13 lbs
Aircraft Dimensions	Length 4.6 ft, Wingspan 9.2 ft
Wing Loading	-
Equipage	Color and infrared imagery
Avionics	GPS, ADS-B Out, Transponder with Mode C
Control Station (Portable)	Moving map with depiction of terrain, airspace, and aviation surveillance targets
Airframe Materials	Composite
Cruise Speed Range	20-40 KTAS
Normal Approach Speed	10 KTAS
Sea Level Climb Speed	25 KTAS
Sea Level Climb Rate	200-1,000 ft/min
Cruise Descent Speed	30 KTAS
Cruise Descent Rate	200-400 ft/min
Vertical Climb Acceleration (Normal)	-
Vertical Descent Acceleration (Normal)	-
Cruise Altitude	100-500 ft AGL
Max Ceiling	5,000 ft MSL
Average Range	7 nm
Max Range	9 nm
Average Flight Time	1.5 hrs
Max Flight Time (Endurance)	2.0 hrs

Table 6: Attributes of a Skate-like RPAS

Physical characteristics, equipage, and flight performance characteristics of a Skate-like small RPAS (VFR Only)	
Mean Takeoff Weight	2.0 lbs
Aircraft Dimensions	Length 1.6 ft, Wingspan 2.0 ft
Wing Loading	-
Equipage	Color and infrared imagery
Avionics	GPS, ADS-B Out, Transponder with Mode C
Control Station (Portable)	Moving map with depiction of terrain, airspace, and aviation surveillance targets
Airframe Materials	Composite
Cruise Speed Range	Hover: 50 KTAS / Cruise: 20 KTAS
Normal Approach Speed	-
Sea Level Climb Speed	-
Sea Level Climb Rate	-
Cruise Descent Speed	-
Cruise Descent Rate	-
Vertical Climb Acceleration (Normal)	-
Vertical Descent Acceleration (Normal)	-
Cruise Altitude	300-500 ft AGL
Max Ceiling	13,000 ft MSL
Average Range	2.0 nm
Max Range	3.1 nm
Average Flight Time	1.0 hrs
Max Flight Time (Endurance)	1.5 hrs

Table 7: Attributes of an Aerosonde-like RPAS

<table>
<tr><th colspan="2">Physical characteristics, equipage, and flight performance characteristics of an Aerosonde-like small RPAS (IFR Capable)</th></tr>
<tr><td>Mean Takeoff Weight</td><td>55 lbs</td></tr>
<tr><td>Aircraft Dimensions</td><td>Length 7.1 ft, Height 2.6 ft, Wingspan 11.3 ft</td></tr>
<tr><td>Wing Loading</td><td>7.2 lbs/sq ft</td></tr>
<tr><td>Equipage</td><td>Forward field of vision cameras ,color and infrared imagery, magnetometer</td></tr>
<tr><td>Avionics</td><td>GPS, WAAS, ADS-B Out, Transponder with Mode C, VHF aviation band communications radios, Sense and Avoid –Airborne, including weather (clouds and visibility) and terrain</td></tr>
<tr><td>Control Station (Fixed)</td><td>Moving map with depiction of terrain, airspace, and aviation surveillance targets, CDTI capability</td></tr>
<tr><td>Airframe Materials</td><td>Carbon fiber, fiberglass, balsa</td></tr>
<tr><td>Cruise Speed Range</td><td>880 miles</td></tr>
<tr><td>Normal Approach Speed</td><td>50 KEAS</td></tr>
<tr><td>Sea Level Climb Speed</td><td>45 KEAS</td></tr>
<tr><td>Sea Level Climb Rate</td><td>580 ft/min</td></tr>
<tr><td>Cruise Descent Speed</td><td>50 KEAS</td></tr>
<tr><td>Cruise Descent Rate</td><td>337 ft/min – Clean
Unavailable ft./min – Full Flap</td></tr>
<tr><td>Vertical Climb Acceleration (Normal)</td><td><table>
<tr><th>Altitude (ft)</th><th>Vertical Climb Acceleration (ft/sec^2)</th></tr>
<tr><td>0</td><td>4.26</td></tr>
<tr><td>2,000</td><td>3.83</td></tr>
<tr><td>4,000</td><td>3.39</td></tr>
<tr><td>6,000</td><td>2.95</td></tr>
<tr><td>8,000</td><td>2.52</td></tr>
<tr><td>10,000</td><td>2.09</td></tr>
<tr><td>12,000</td><td>1.67</td></tr>
<tr><td>14,000</td><td>1.25</td></tr>
<tr><td>16,000</td><td>0.83</td></tr>
</table></td></tr>
</table>

Vertical Descent Acceleration (Normal)	-
Cruise Altitude	3,000 ft MSL
Max Ceiling	20,000 ft MSL
Average Range	7 nm
Max Range	850 nm
Average Flight Time	11.1 hrs
Max Flight Time (Endurance)	>11.1 hrs

Appendix B U.S. Federal Aviation Regulations

This section gives a brief explanation of the some of the federal aviation regulations (FARs) cited in this document. Source: http://www.ecfr.gov.

Title 14 of the Code of Federal Regulations (CFR) covers aeronautics and space. Within Title 14, Part 91 covers general operating and flight rules.

§91.103 Preflight action.

Each pilot in command shall, before beginning a flight, become familiar with all available information concerning that flight. This information must include—

(a) For a flight under IFR or a flight not in the vicinity of an airport, weather reports and forecasts, fuel requirements, alternatives available if the planned flight cannot be completed, and any known traffic delays of which the pilot in command has been advised by ATC;

(b) For any flight, runway lengths at airports of intended use, and the following takeoff and landing distance information:

> (1) For civil aircraft for which an approved Airplane or Rotorcraft Flight Manual containing takeoff and landing distance data is required, the takeoff and landing distance data contained therein; and
>
> (2) For civil aircraft other than those specified in paragraph (b)(1) of this section, other reliable information appropriate to the aircraft, relating to aircraft performance under expected values of airport elevation and runway slope, aircraft gross weight, and wind and temperature.

§91.119 Minimum safe altitudes: General.

Except when necessary for takeoff or landing, no person may operate an aircraft below the following altitudes:

(a) *Anywhere.* An altitude allowing, if a power unit fails, an emergency landing without undue hazard to persons or property on the surface.

(b) *Over congested areas.* Over any congested area of a city, town, or settlement, or over any open air assembly of persons, an altitude of 1,000 feet above the highest obstacle within a horizontal radius of 2,000 feet of the aircraft.

(c) *Over other than congested areas.* An altitude of 500 feet above the surface, except over open water or sparsely populated areas. In those cases, the aircraft may not be operated closer than 500 feet to any person, vessel, vehicle, or structure.

(d) *Helicopters, powered parachutes, and weight-shift-control aircraft.* If the operation is conducted without hazard to persons or property on the surface—

(1) A helicopter may be operated at less than the minimums prescribed in paragraph (b) or (c) of this section, provided each person operating the helicopter complies with any routes or altitudes specifically prescribed for helicopters by the FAA; and

(2) A powered parachute or weight-shift-control aircraft may be operated at less than the minimums prescribed in paragraph (c) of this section.

§91.137 Temporary flight restrictions in the vicinity of disaster/hazard areas.

(a) The Administrator will issue a Notice to Airmen (NOTAM) designating an area within which temporary flight restrictions apply and specifying the hazard or condition requiring their imposition, whenever he determines it is necessary in order to—

(1) Protect persons and property on the surface or in the air from a hazard associated with an incident on the surface;

(2) Provide a safe environment for the operation of disaster relief aircraft; or

(3) Prevent an unsafe congestion of sightseeing and other aircraft above an incident or event which may generate a high degree of public interest.

The Notice to Airmen will specify the hazard or condition that requires the imposition of temporary flight restrictions.

(b) When a NOTAM has been issued under paragraph (a)(1) of this section, no person may operate an aircraft within the designated area unless that aircraft is participating in the hazard relief activities and is being operated under the direction of the official in charge of on scene emergency response activities.

(c) When a NOTAM has been issued under paragraph (a)(2) of this section, no person may operate an aircraft within the designated area unless at least one of the following conditions are met:

(1) The aircraft is participating in hazard relief activities and is being operated under the direction of the official in charge of on scene emergency response activities.

(2) The aircraft is carrying law enforcement officials.

(3) The aircraft is operating under the ATC approved IFR flight plan.

(4) The operation is conducted directly to or from an airport within the area, or is necessitated by the impracticability of VFR flight above or around the area due to weather, or terrain; notification is given to the Flight Service Station (FSS) or ATC facility specified in the NOTAM to receive advisories concerning disaster relief aircraft operations; and the operation does not hamper or endanger relief activities and is not conducted for the purpose of observing the disaster.

(5) The aircraft is carrying properly accredited news representatives, and, prior to entering the area, a flight plan is filed with the appropriate FAA or ATC facility specified in the Notice to Airmen and the operation is conducted above the altitude used by the disaster relief aircraft, unless otherwise authorized by the official in charge of on scene emergency response activities.

(d) When a NOTAM has been issued under paragraph (a)(3) of this section, no person may operate an aircraft within the designated area unless at least one of the following conditions is met:

(1) The operation is conducted directly to or from an airport within the area, or is necessitated by the impracticability of VFR flight above or around the area due to weather or terrain, and the operation is not conducted for the purpose of observing the incident or event.

(2) The aircraft is operating under an ATC approved IFR flight plan.

(3) The aircraft is carrying incident or event personnel, or law enforcement officials.

(4) The aircraft is carrying properly accredited news representatives and, prior to entering that area, a flight plan is filed with the appropriate FSS or ATC facility specified in the NOTAM.

(e) Flight plans filed and notifications made with an FSS or ATC facility under this section shall include the following information:

(1) Aircraft identification, type and color.

(2) Radio communications frequencies to be used.

(3) Proposed times of entry of, and exit from, the designated area.

(4) Name of news media or organization and purpose of flight.

(5) Any other information requested by ATC.

§91.179 IFR cruising altitude or flight level

Unless otherwise authorized by ATC, the following rules apply—

(a) *In controlled airspace.* Each person operating an aircraft under IFR in level cruising flight in controlled airspace shall maintain the altitude or flight level assigned that aircraft by ATC. However, if the ATC clearance assigns “VFR conditions on-top,” that person shall maintain an altitude or flight level as prescribed by §91.159.

(b) *In uncontrolled airspace.* Except while in a holding pattern of 2 minutes or less or while turning, each person operating an aircraft under IFR in level cruising flight in uncontrolled airspace shall maintain an appropriate altitude as follows:

(1) When operating below 18,000 feet MSL and—

(i) On a magnetic course of zero degrees through 179 degrees, any odd thousand foot MSL altitude (such as 3,000, 5,000, or 7,000); or

(ii) On a magnetic course of 180 degrees through 359 degrees, any even thousand foot MSL altitude (such as 2,000, 4,000, or 6,000).

(2) When operating at or above 18,000 feet MSL but below flight level 290, and—

(i) On a magnetic course of zero degrees through 179 degrees, any odd flight level (such as 190, 210, or 230); or

(ii) On a magnetic course of 180 degrees through 359 degrees, any even flight level (such as 180, 200, or 220).

(3) When operating at flight level 290 and above in non-RVSM airspace, and—

(i) On a magnetic course of zero degrees through 179 degrees, any flight level, at 4,000-foot intervals, beginning at and including flight level 290 (such as flight level 290, 330, or 370); or

(ii) On a magnetic course of 180 degrees through 359 degrees, any flight level, at 4,000-foot intervals, beginning at and including flight level 310 (such as flight level 310, 350, or 390).

(4) When operating at flight level 290 and above in airspace designated as Reduced Vertical Separation Minimum (RVSM) airspace and—

(i) On a magnetic course of zero degrees through 179 degrees, any odd flight level, at 2,000-foot intervals beginning at and including flight level 290 (such as flight level 290, 310, 330, 350, 370, 390, 410); or

(ii) On a magnetic course of 180 degrees through 359 degrees, any even flight level, at 2000-foot intervals beginning at and including flight level 300 (such as 300, 320, 340, 360, 380, 400).

Appendix C Acronyms

Table 8: Acronyms and definitions

Term	Definition
AD	Airworthiness Directive
ADS-B In/Out	Automatic Dependent Surveillance-Broadcast In/Out
AGL	Above Ground Level
ANSP	Air Navigation Service Provider
ATC	Air Traffic Control
ATIS	Automated Terminal Information Service
ATM	Air Traffic Management
AW	Airworthiness
BVLOS	Beyond Visual Line of Sight
CA	Collision Avoidance
CBP	Customs and Border Protection
CDTI	Cockpit Display of Traffic Information
CFR	Code of Federal Regulations
CG	Coast Guard
ConOps	Concept of Operations
CTAF	Common Traffic Advisory Frequency
DAA	Detect and Avoid
DoD	Department of Defense
DST	Decision Support Tool
FAF	Final Approach Fix
FL	Flight Level
FMS	Flight Management System
GBAS	Ground-Based Augmentation System
GC	Ground Control
GPS	Global Positioning System

Term	Definition
IAP	Instrument Approach Procedure
ICAO	International Civil Aviation Organization
IFR	Instrument Flight Rules
IMC	Instrument Meteorological Conditions
IR	Infrared
IS	Information Services
JPDO	Joint Planning and Development Office
LAWS	Low Airspeed Warning System
LC	Local Control
LOS	Line of Sight
LSA	Light Sport Aircraft
MOA	Military Operations Area
MON	Minimum Operational Network
MSL	Mean Sea Level
MTR	Military Training Route
NAS	National Airspace System (U.S.)
NAVAID	Navigation(al) Aid
NextGen	Next Generation Air Transportation System
nm	Nautical Mile
NOTAM	Notice to Airmen
NRS	Navigation Reference System
NVS	NextGen Voice Switch
OSED	Operational Services and Environmental Definition
PBN	Performance-Based Navigation
RNAV	Area Navigation
RNP	Required Navigation Performance
RTCA	Radio Technical Commission for Aeronautics
RVSM	Reduced Vertical Separation Minimum
RWY	Runway

Term	Definition
S&A	Sense-and-Avoid
SAA	Special Activity Airspace
SME	Subject Matter Expert
SOA	Service-Oriented Architecture
STBO	Surface Trajectory-Based Operations
sUAS	Small Unmanned Aircraft System
SWIM	System-Wide Information Management
TBO	Trajectory-Based Operations
TFDM	Tower Flight Data Manager
TFR	Temporary Flight Restriction
TIS-B	Traffic Information Service-Broadcast
UAS	Unmanned Aircraft System
VFR	Visual Flight Rules
VHF	Very High Frequency
VMC	Visual Meteorological Conditions
VoIP	Voice over Internet Protocol
VOR	VHF Omnidirectional Range
VORTAC	VHF Omnidirectional Range/Tactical Aircraft Control
VTOL	Vertical Takeoff and Landing
WAAS	Wide Area Augmentation System

Appendix D Glossary

Table 9: Terms and definitions

Term	Definition
Air Navigation Service Provider (ANSP)	The organization, personnel, and automation that provide separation assurance, traffic management, infrastructure management, meteorological & aeronautical information, navigation, surveillance services, clearances, airspace management, and aviation assistance services for airspace users.
Air Traffic Control (ATC)	A service operated by appropriate authority to promote the safe, orderly, and expeditious flow of air traffic.
Air Traffic Management (ATM)	The aggregation of functions, comprising variously those of air traffic services, airspace management, and air traffic flow management, including their interacting aircraft functional capabilities, required to ensure the safe and efficient movement of aircraft during all phases of operations.
Aircraft	Any machine that can derive support in the atmosphere from the reactions of the air other than the reactions of the air against the earth's surface. An aircraft can include a fixed-wing structure, rotorcraft, lighter-than-air vehicle, or a vehicle capable of leaving the atmosphere for space flight.
Airport	A defined area on land or water (including any buildings, installations, and equipment) intended to be used either wholly or in part for the arrival, departure, and surface movement of aircraft.
Airspace	Any portion of the atmosphere sustaining aircraft flight and which has defined boundaries and specified dimensions. Airspace may be classified as to the specific types of flight allowed, rules of operation, and restrictions in accordance with ICAO standards or State regulation.
Airworthiness (AW)	The aircraft must conform to its type certificate (TC). Conformity to type design is considered attained when the aircraft configuration and the components installed are consistent with the drawings, specifications, and other data that are part of the TC, which includes any supplemental type certificate (STC) and field approved alterations incorporated into the aircraft. The aircraft must be in a condition for safe operation. This refers to the condition of the aircraft relative to wear and deterioration, for example, skin corrosion, window delamination/crazing, fluid leaks, and tire wear.
Alternate Airport	An airport at which an aircraft may land if landing at the intended airport becomes inadvisable.

Term	Definition
Alternate Navigation	Aircraft using GPS navigation equipment under IFR must be equipped with an approved and operational alternate means of navigation appropriate to the flight. Active monitoring of alternative navigation equipment is not required if the GPS receiver uses Receiver Autonomous Integrity Monitoring (RAIM) for integrity monitoring. Active monitoring of an alternate means of navigation is required when the RAIM capability of the GPS equipment is lost.
Area Navigation (RNAV)	A method of navigation that permits aircraft operation on any desired flight path within the coverage of ground- or space-based navigation aids or within the limits of the capability of self-contained aids, or a combination of these. Due to the different levels of performance, area navigational capabilities can satisfy different levels of required navigation performance (RNP).
Automatic Dependent Surveillance-Broadcast (ADS-B) In/Out	A surveillance system in which an aircraft or vehicle to be detected is fitted with cooperative equipment in the form of a data link transmitter. The aircraft or vehicle periodically broadcasts its GPS-derived position and other information such as velocity over the data link, which is received by a ground-based transmitter/receiver (transceiver) for processing and display at an air traffic control facility. The ADS-B OUT portion is the broadcast of the position. The ADS-B IN portion provides the OUT broadcast of position information to other aircraft and vehicles that are equipped with ADS-B IN.
Autonomous	Not controlled by others or outside forces; independent judgment.
Beyond Visual Line of Sight (BVLOS)	RPAS operations where direct radio frequency (RF) communication with a UA is not possible due to it being obscured by the earth's curvature (i.e. over the horizon (OTH)) or terrain or by man-made features. BVLOS requires a relay, e.g., satellite, to transmit a signal.
Class A Airspace	Generally, that airspace from 18,000 feet MSL up to and including FL 600, including the airspace overlying the waters within 12 nautical miles of the coast of the 48 contiguous States and Alaska. In Class A Airspace, unless otherwise authorized, all persons must operate their aircraft under IFR.
Class B Airspace	Generally, that airspace from the surface to 10,000 feet MSL surrounding the nation's busiest airports in terms of airport operations or passenger enplanements. The configuration of each Class B airspace area is individually tailored and consists of a surface area and two or more layers (some Class B airspaces areas resemble upside-down wedding cakes), and is designed to contain all published instrument procedures once an aircraft enters the airspace. An ATC clearance is required for all aircraft to operate in the area, and all aircraft that are so cleared receive separation services within the airspace. The cloud clearance requirement for VFR operations is "clear of clouds."

Term	Definition
Class C Airspace	Generally, that airspace from the surface to 4,000 feet above the airport elevation (charted in MSL) surrounding those airports that have an operational control Tower, are serviced by a radar approach control, and that have a certain number of IFR operations or passenger enplanements. Although the configuration of each Class C area is individually tailored, the airspace usually consists of a surface area with a 5 nautical mile (NM) radius, a circle with a 10NM radius that extends no lower than 1,200 feet up to 4,000 feet above the airport elevation, and an outer area that is not charted. Each person must establish two-way radio communications with the ATC facility providing air traffic services prior to entering the airspace and thereafter maintain those communications while within the airspace. VFR aircraft are only separated from IFR aircraft within the airspace.
Class D Airspace	Generally, that airspace from the surface to 2,500 feet above the airport elevation (charted in MSL) surrounding those airports that have an operational control Tower. The configuration of each Class D airspace area is individually tailored, and when instrument procedures are published, the airspace will normally be designed to contain the procedures. Arrival extensions for instrument approach procedures may be Class D or Class E airspace. Unless otherwise authorized, each person must establish two-way radio communications with the ATC facility providing air traffic services prior to entering the airspace and thereafter maintain those communications while in the airspace. No separation services are provided to VFR aircraft.
Class E Airspace	Generally, if the airspace is not Class A, Class B, Class C, or Class D, and it is controlled airspace, it is Class E airspace. Class E airspace extends upward from either the surface or a designated altitude to the overlying or adjacent controlled airspace. Included in the Class E designation is the airspace extending upward from 14,500 feet MSL to, but not including, 18,000 feet MSL, and above FL 600, excluding the airspace below 1,500 feet above the surface unless so designated. When designated as a surface area, the airspace will be configured to contain all instrument approaches. Also in this class are Federal airways, airspace used to transition to/from the terminal or en route environment beginning at either 700 or 1,200 feet above the surface, and en route domestic and offshore airspace areas designated below 18,000 feet MSL.
Class G Airspace	All airspace that is not classified as Class A, B, C, D, or E. Commonly referred to as uncontrolled airspace.
Collision Avoidance (CA)	The sense and avoid (SAA) system function where the unmanned aircraft system (RPAS) takes appropriate action to prevent an intruder from penetrating a volume of airspace centered on the unmanned aircraft (UA).
Communicate	To inform others or to be informed. Communicating is both the conveying of intent and the receiving of instructions. (Note: This refers to voice communication and transponder-like operations; it does not encompass command/control of the UA.)
Communication Link	The voice or data relay of instructions or information between the RPAS pilot and the air traffic controller and other national airspace users.

Term	Definition
Conflict	Any situation involving an aircraft and a hazard in which the applicable separation minimums may be compromised.
Control Link	The combination of the telecommand link (uplink) and the telemetry link (downlink).
Control Link Failure	When the UA detects a control link interruption, it typically begins a countdown sequence. If the control link interruption is not restored by the end of the countdown, "link failure" occurs and link failure contingency procedures begin.
Control Link Interruption	Control link interruption occurs when either the UA or UA control station detects lost reception of information, even momentarily, from the command link, status link or both links. The interruption may be the result of a hardware/software malfunction, satellite signal interruption/blockage, weather, or some temporary condition.
Control Station	The equipment used to maintain control of, communicate with, guide, or otherwise pilot an unmanned aircraft.
Cooperative Aircraft	Aircraft that have an electronic means of identification (i.e., a transponder) aboard and operating.
Crew member	A person assigned to perform duties during the operation of the RPAS. This term can be further qualified as "ground crew member" or "flight crew member."
Data Communication	The transfer of information between functional units by means of data transmission according to a protocol.
Data Link	A ground-to-air communications system that transmits information via digital coded pulses.
Detect and Avoid (DAA)	The capability of a RPAS to remain well clear from, and avoid collisions with, other airborne traffic. DAA provides the functions of self-separation (SS) and collision avoidance (CA) to fulfill the regulatory requirement to see and avoid.
Elevation	The height above a fixed reference point, often the mean sea level.
Event	An occurrence whose origin is distinct from the aircraft, such as atmospheric conditions, runway conditions, or cabin and baggage fires. The term is not intended to cover sabotage.
Failure	A loss of function, or malfunction, of a system or part thereof resulting in the inability of an item to perform its intended function.
Flight Crew	The individual or group of individuals responsible for the control of an individual aircraft while it is moving on the surface or while airborne.
Flight Level (FL)	A level of constant atmospheric pressure related to a reference datum of 29.92 inches of mercury. Each is stated in three digits that represent hundreds of feet (e.g., FL180 represents a barometric altimeter indication of 18,000 feet).

Term	Definition
Flight Object	The representation of the relevant information about a particular instance of a flight. The information in a flight object includes (1) aircraft capabilities, including the level of navigation, communications, and surveillance performance (e.g., FMS capabilities); (2) aircraft flight performance parameters; (3) flight crew capabilities, including level of training received to enable special procedures; (4) 4DT profile and intent, containing the “cleared” 4DT profile plus any desired or proposed 4DTs; and (5) aircraft position information and near-term intent. Standards for the definition of a flight object are in development.
Flight Plan	Specified information relating to the intended flight of an aircraft that is filed orally or in writing with FAA or an ATC facility.
Flight Planning	A series of activities preformed before a flight that includes, but is not limited to, reviewing airspace and navigation restrictions, developing the route, obtaining a weather briefing, completing a navigation log, filing a flight plan, and inspecting the aircraft.
Function	The action or actions that an item is designed to perform.
Global Positioning System (GPS)	A space-based radio positioning, navigation, and time-transfer system. The system provides highly accurate position and velocity information, and precise time, on a continuous global basis, to an unlimited number of properly equipped users. The system is unaffected by weather, and provides a worldwide common grid reference system. The GPS concept is predicated upon accurate and continuous knowledge of the spatial position of each satellite in the system with respect to time and distance from a transmitting satellite to the user. The GPS receiver automatically selects appropriate signals from the satellites in view and translates these into three-dimensional position, velocity, and time. System accuracy for civil users is normally 100 meters horizontally.
Information Services	A service that provides data and information to subscribers when and where needed in a common format. Ensures questions raised by data consumers are answered correctly and consistently.
Instrument Flight Rules (IFR)	Rules governing the procedures for conducting instrument flight. Also a term used by pilots and controllers to indicate type of flight plan.
Instrument Meteorological Conditions (IMC)	IFR flight conditions. Weather conditions below the minimum for flight under visual flight rules.
International Civil Aviation Organization (ICAO)	A specialized agency of the United Nations whose objective is to develop the principles and techniques of international air navigation and to foster planning and development of international civil air transport.
Latency	The time incurred between two particular interfaces. The total latency is the delay between the true time of applicability of a measurement and the time that the measurement is reported at a particular interface (the latter minus the former).
Line of Sight (LOS)	The condition where two systems, usually the control station and the UA, are within electronic point-to-point link.

Term	Definition
Lost Link	The loss of telecommand or telemetry link between a pilot and an unmanned aircraft (UA).
Maneuver	The ability to move to a position of advantage in all environments in order to generate or enable the generation of effects in all domains and the information environment.
Manned Aircraft	Aircraft piloted by a human onboard.
Military Operations Area (MOA)	Airspace established outside Class A airspace to separate or segregate certain non-hazardous military activities from IFR traffic and to identify for VFR traffic where these activities are conducted.
Minimum Operational Network (MON)	In 2020, the MON will consist of roughly half of today's VHF Omnidirectional Range (VOR) systems to serve as a backup navigation system in the event of a GPS outage. The MON would enable aircraft anywhere in the CONUS to proceed safely to a destination with a GPS-independent approach within 100 nm. MON coverage is planned to be provided at altitudes above 5,000 feet above ground level (AGL).
Mission Plan	The route planning, payload planning, data link planning (including frequency planning), and emergency recovery planning (rules of safety) for a RPAS.
Mode C Veil	The airspace within 30 nautical miles of an airport listed in Appendix D, Section 1 of 14 Code of Federal Regulations (CFR) Part 91 (generally primary airports within Class B airspace areas), from the surface upward to 10,000 feet mean sea level (MSL). Unless otherwise authorized by Air Traffic Control, aircraft operating within this airspace must be equipped with automatic pressure altitude reporting equipment having Mode C capability. However, an aircraft that was not originally certificated with an engine-driven electrical system or which has not subsequently been certified with a system installed may conduct operations within a Mode C Veil provided the aircraft remains outside Class A, B, or C airspace and below the altitude of the ceiling of a Class B or Class C airspace area designated for an airport or 10,000 feet MSL, whichever is lower.
Monitor	The ability to adequately observe and assess events/effects of a decision.
National Airspace System (NAS)	The common network of U.S. airspace; air navigation facilities, equipment and services, airports or landing areas; aeronautical charts, information and services; rules, regulations and procedures, technical information, and manpower and material. Included are system components shared jointly with the military.
Navigate	The directing of the aircraft's flight path to a desired location. The ability to navigate implies the RPAS is capable of maintaining navigational control, which involves maintaining knowledge of the current position, the destination, and the four-dimensional path (latitude, longitude, altitude, time) to the destination.
Non-Cooperative Aircraft	Aircraft that do not have an electronic means of identification (i.e., a transponder) aboard or not operating such equipment due to malfunction or deliberate action.

Term	Definition
Non-Cooperative Traffic	Traffic that does not broadcast position or other information that assists in detecting and assessing conflict potential.
Operate	With respect to aircraft, means use, cause to use or authorize to use aircraft, for the purpose (except as provided in 14 CFR 91) of air navigation including the piloting of aircraft, with or without the right of legal control (as owner, lessee, or otherwise).
Operator	The organization or individual who uses, causes to use, or authorizes to use aircraft, for the purpose (except as provided in 14 CFR 91.13) of air navigation including the piloting of aircraft, with or without the right of legal control (as owner, lessee, or otherwise).
Performance Requirements	Set of requirements that define a function's performance, and expressed by a set of characteristics/attributes associated to all or part of a system. Those include transaction and expiration times, continuity, availability, and integrity characteristics.
Performance-Based Navigation (PBN)	RNAV based on performance requirements for aircraft operating along an ATS route, on an IAP, or in a designated airspace. Note: Performance requirements are expressed in navigation specifications (RNAV specification, RNP specification) in terms of accuracy, integrity, continuity, availability, and functionality needed for the proposed operation in the context of a particular airspace concept.
Phase of Flight	A distinct stage of flight that includes ground operations or taxiing, takeoff, climb, en route, mission operations, descent, approach, or landing.
Pilot	The individual that monitors, controls, and maneuvers the RPAS through the real-time issuance of command and control input to the aircraft and possesses the applicable FAA pilot certifications and ratings.
Reduced Vertical Separation Minimum (RVSM)	The decrease in vertical separation distance between aircraft from 2,000 feet to 1,000 when flying between FL 290 and FL 410.
Remotely Piloted Aircraft System (RPAS)	A RPAS is a UAS whose vehicle is piloted remotely by a human. This is distinct from UAS that operate autonomously.
Required Navigation Performance (RNP)	A statement of navigation system performance accuracy, integrity, continuity, and availability necessary for operations within a defined airspace.
Requirement	An identifiable statement of a specification that can be validated and against which an implementation can be verified.
Route	The flight path of HALE ROA from the departure airport to the arrival airport, excluding any mission route and mission area, and where course changes have no impact on the mission objectives.

Term	Definition
Safety	Freedom from unacceptable risk of harm.
Semi-Autonomous	Mode of control of a RPAS where the pilot executes changes and conducts the mission through a flight management system interface. Without this input, the RPAS will perform pre-programmed automatic operations. This can, but might not, include some fully autonomous functions (like takeoff, landing, and collision avoidance).
Separation	The minimum distance between aircraft/vehicles allowed by regulations.
Service Oriented Architecture (SOA)	A design for linking computational resources (principally, applications and data) on demand to achieve the desired results for service consumers (which can be end users or other services). The Organization for the Advancement of Structured Information Standards (OASIS) defines SOA as the following: A paradigm for organizing and utilizing distributed capabilities that may be under the control of different ownership domains. It provides a uniform means to offer, discover, interact with, and use capabilities to produce desired effects consistent with measurable preconditions and expectations.
Situational Awareness	A service provider or operator's ability to identify, process, and comprehend important information about what is happening with regard to the operation. Airborne traffic situational awareness is an aspect of overall situational awareness for the flight crew of an aircraft operating in proximity to other aircraft.
Small Unmanned Aircraft System (small RPAS)	RPAS with a maximum gross takeoff weight of 55 lb. or less.
Special Activity Airspace (SAA)	Any airspace with defined dimensions within the National Airspace System wherein limitations may be imposed upon aircraft operations. This airspace may be restricted areas, prohibited areas, military operations areas, ATC assigned airspace, or any other designated airspace areas. The dimensions of this airspace can be designated as either active or inactive. Aircraft trajectories are constantly tested against the dimensions of active areas and alerts issued to the applicable sectors when violations are predicted.
Surveillance	The systematic observation of aerospace, surface, or subsurface areas, places, persons, or things, by visual, aural, electronic, photographic, or other means.
Surveillance Services	This service integrates cooperative and non-cooperative airport surface and airspace surveillance systems, fostering real-time air and airport situational awareness and enhancing safety and security.
Traffic	All aircraft/vehicles that are within the operational vicinity of own-ship.
Trajectory-Based Operations (TBO)	The use of 4D trajectories as the basis for planning and executing all flight operations supported by the Air Navigation Service Provider.
Unmanned Aircraft System (UAS)	A system consisting of an unmanned aircraft and its associated elements required for operation.

Term	Definition
Visual Flight Rules (VFR)	Rules that govern the procedures for conducting flight under visual conditions. The term “VFR” is also used in the United States to indicate weather conditions that are equal to or greater than minimum VFR requirements. In addition, it is used by pilots and controllers to indicate type of flight plan.
Visual Meteorological Conditions (VMC)	Weather conditions in which visual flight rules apply; expressed in terms of visibility, ceiling height, and aircraft clearance from clouds along the path of flight.