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Integration of Unmanned Aircraft Systems into the National Airspace System

Concept of Operations

V2.0

Concurrence:

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Document Change Record

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1.1	01 Mar 2012	Revised draft after review/comment resolution on controlled airspace, includes graphic updates.	All
1.2	07 May 2012	Incorporate "placeholder" drafts for uncontrolled airspace, VFR operations, Class E above Class A and Oceanic operations, as well as any further comments on controlled airspace; "Summary of Impacts" section; 4 additional operational scenarios plus an update on one other scenario.	4.1.1, 4.1.2, 4.3.2, 4.5, 4.7.6, 5, Glossary
1.21	07 May 2012	Revisions resulting from internal vetting discussion on 02 May 2012.	All
1.3	21 May 2012	New graphic in chapter 4.1; new ISS reference in chapter 4.7.2; new item in References.	4.1, 4.7.2, References
1.4	17 Jul 2012	New operating rules; no visual equivalence; UAS cannot comply with VFR; public aircraft; surface operations; transponder and ADS-B (Out) equipage requirements. Amended scenarios, resolution of remaining comments, including those against chapter 6.	All
2.0	28 Sep 2012	All IFR justification; ConOps hierarchy elevation to a Service (level 2); Final FAA executive review and concurrence.	Final

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1 Introduction

This Concept of Operations (ConOps) document describes the operation of Unmanned Aircraft Systems (UAS) in the National Airspace System (NAS) by any operator that is capable of meeting the requirements established by the FAA. This includes civil operators – private and commercial entities – and public operators, such as the military services, NASA, NOAA, DHS, and law enforcement.

This ConOps is presented primarily from an air traffic management perspective and describes how the integration of unmanned aircraft affects – and is affected by – many of the services envisioned for the NextGen NAS. It can be used to derive concept-level requirements for services, systems, technologies, tools, procedures, training, and policies that support the integration of UAS into the NAS. It can also be used as a reference for assessing concept feasibility through research validation activities.

This ConOps serves as input to, and guides the conduct of, follow-on systems engineering analyses, including the application of safety, security, and environmental review requirements (e.g., the National Environmental Policy Act). Policy and guidance will be provided throughout these on-going acquisition lifecycle activities.

UAS airspace integration is a Service, or Level 2, concept within the concept hierarchy shown in Figure 1.[1] This framework is used to provide traceability for NAS concept development. Examples of other Level 2 and several Level 3 concepts are shown for context. The ConOps is an iterative document and, as such, may undergo revisions to incorporate the results of ongoing research activities.

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[1] *Concept of Operations Guidance and Template*, Appendix D of the *Concept Development and Validation Guidelines*, FAA (2011)

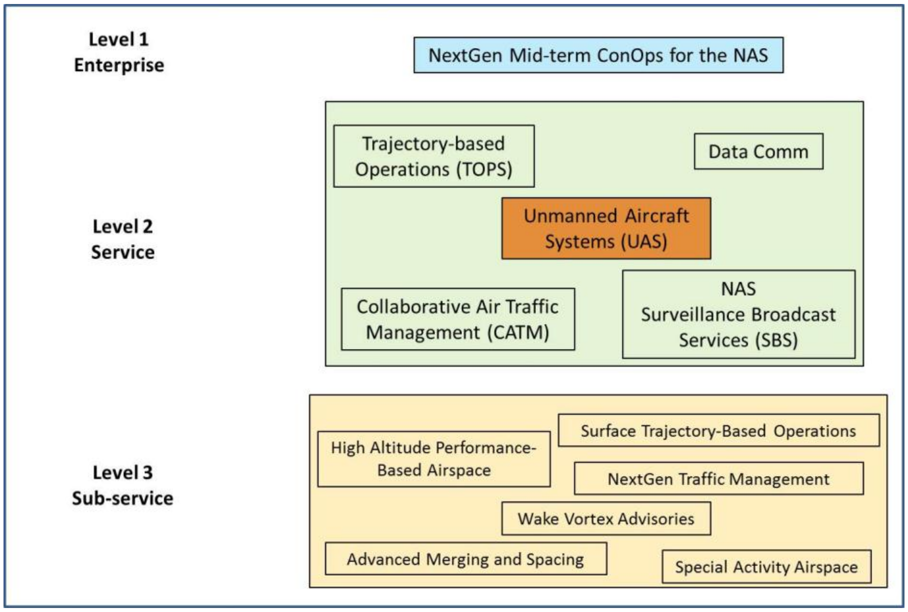

Figure 1. UAS operational concept within the concept hierarchy framework

1.1 Background

The end of the 20th century witnessed an increase in the development of UAS by the U.S. military. As key enabling technologies and systems matured, it became evident that there were uses for UAS beyond the military. The vast majority of today's UAS continue to be operated by the Department of Defense (DOD); however, the subsequent growth of the industry has led to increased demand from other public agencies, including NASA and various universities, as well as from civil operators, for example, commercial enterprises seeking to use UAS to achieve their business objectives.

This concept of operations presents a vision for integrating both public and civil UAS into the NAS. Stakeholders include, but are not limited to, the FAA, NAS users, academia, and UAS airframe, engine, and avionics manufacturers.

1.2 Problem Statement

The NAS has experienced rapid growth in UAS use and demand for airspace access. Expanding UAS research and training objectives and the resulting increase in demand for NAS access is driving the need for additional FAA policies and procedures to authorize and manage UAS operations in a safe and effective manner.

The FAA authorizes UAS flights outside of restricted airspace, prohibited airspace, or warning areas by issuing either a Certificate of Waiver or Authorization (COA) for public operators, or a special airworthiness certificate for civil operators. These authorizations require significant planning, resources, and coordination to accommodate access to the NAS.

UAS that are granted NAS access today are limited by the restrictions of each COA or special airworthiness certificate, which often impose constraints on timeframe (daylight only), weather (visual meteorological conditions only), flying over populated areas, and other operational factors. In addition, Air Traffic Control (ATC) often must segregate UAS from other air traffic by blocking airspace or imposing route restrictions. These methods of accommodation are usually sufficient for today's level of demand. However, as the demand for UAS access increases, ensuring that NAS safety and efficiency are not adversely impacted becomes a significant challenge, requiring some method beyond accommodation.

Given these mounting challenges, the FAA and UAS stakeholders seek to integrate UAS into the NAS*,* rather than accommodate them. Achieving integration involves establishing minimum performance levels and required functionality that UAS will need to demonstrate to be allowed routine access. This will significantly reduce the need for special authorizations for UAS operations. When integrated, UAS will be strategically managed to ensure they do not negatively affect the safety or efficiency of the NAS.

1.3 Concept Overview

This document contains six sections. Section 2 describes the current operations of UAS in the NAS. Section 3 describes the capability shortfalls of these operations and provides a justification for change. Section 4 presents the concept of a future NAS in which UAS are integrated. This section pertains to all UAS operations, except for small UAS (aircraft weighing less than 55 pounds) operating exclusively within visual line-of-sight (VLOS) of the flight crew. Section 5 presents operational scenarios for various UAS types within all classes of airspace. Section 6 summarizes the anticipated impacts of UAS integration from the perspectives of the FAA and the users of the NAS. Section 6 also examines this concept’s relationship with other NextGen concept documents.

This UAS ConOps addresses all classes of airspace within the NAS, as well as surface and oceanic operations. Figure 2 illustrates the airspace classes that are referred to throughout the document. Operations are described in the context of NextGen capabilities and enabling technologies expected to be mature in this ConOps timeframe. Any additional NAS capabilities required for UAS integration are described as part of the UAS operations discussion in Section 4.

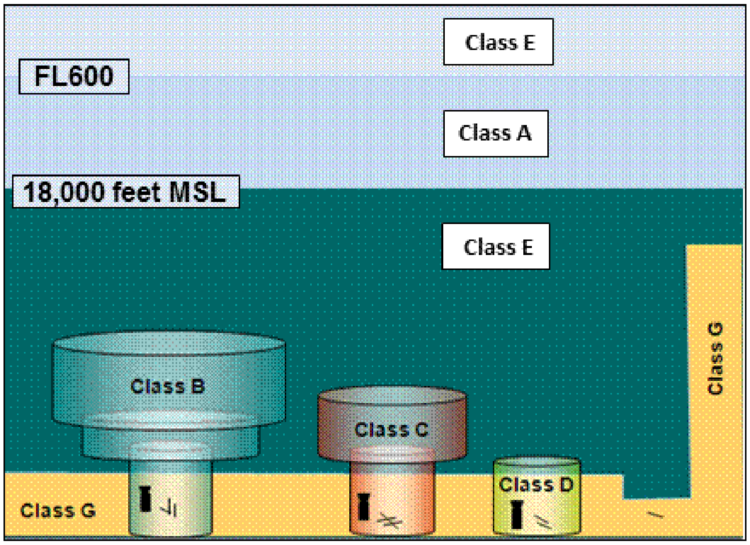

Figure 2. Airspace classes within the NAS

2 Current Operations and Capabilities

This section introduces basic UAS elements and functions and describes the predominant FAA authorization processes and operations currently associated with UAS operating outside of restricted airspace, prohibited airspace, or warning areas.

2.1 Operational System Description

Figure 3 represents one of several different notional architectures used by the UAS community to describe the system of systems comprising UAS. It illustrates five primary elements of UAS: the unmanned aircraft (UA), the control station, the crew (including the pilot-in-command or PIC), the control link to the UA, and the communications link to ATC. These components are shown in the green box, and relevant external communications nodes are provided for context.

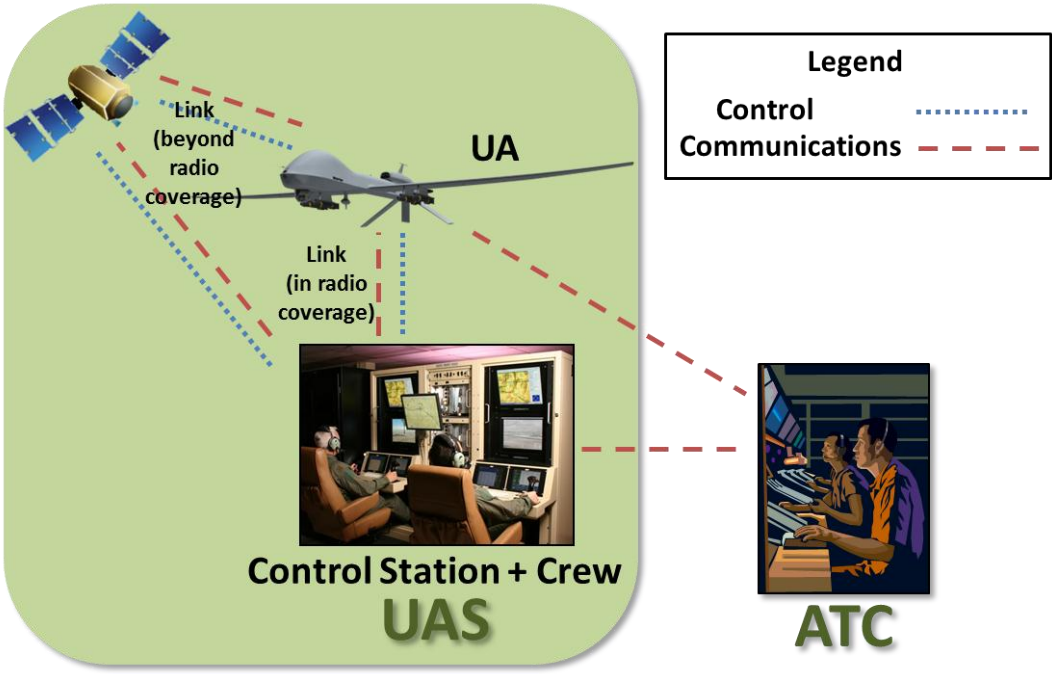

Figure 3. UAS elements in the NAS

Using the control link, the PIC transmits commands to the UA and receives telemetry data from the UA via the control station hardware and interfaces. For flight operations in which the UA is within radio coverage of the control station, the control link connects them directly. For operations beyond radio coverage, a ground (landline) or satellite relay is used.

Voice communications with ATC typically relay through the UA via VHF or UHF radio. The control station may also have a connection with the ATC facility via ground communication, such as by telephone.

Current UAS are designed to meet the specific needs of the operator, rather than a set of NAS requirements. Flight crew qualifications, however, are established by the FAA consistent with the UAS operation and its environment.

2.2 Methods of UAS Flight Authorization

Two authorization methods are currently used to grant UAS access to the NAS. A COA serves a public operator; for example, a military mission to transit a UA to and from restricted airspace used for training. A special airworthiness certificate is used for civil operators. The two types of special airworthiness certificates are special flight permits and experimental certificates. Special flight permits are used for production testing of new aircraft. Experimental certificates are used for research, crew training, and market survey activities. COAs and special airworthiness certificates are issued on a case-by-case basis. The main difference between the two is the airworthiness approval authority. Public operators have the authority to certify the airworthiness of their aircraft. For civil operators, the FAA evaluates the UAS and issues a special airworthiness certificate.

The FAA conducts a safety review for special airworthiness certificates that includes both technical and airworthiness portions. Results from the safety review may impose additional limitations on the UAS flight to ensure its safe operation. After this review, a site visit is conducted. The site visit includes an inspection of the UAS and the issuance of any restrictions based on the specific UAS capabilities. The process culminates with a demonstration flight. If granted, the experimental certificate is issued for up to one year after the date of issuance. A special flight permit is effective for the period of time specified in the permit.

Under the COA process, a public operator applies on-line to the FAA for a single UAS model. Applications are reviewed typically on a first come, first served basis. In addition to describing the operational and aircraft specifications, the COA application process may include coordinating with law enforcement, local governments, and ATC jurisdictions where the UAS plans to operate.

The review and approval process can take up to 60 business days after receipt of a completed application. A COA is valid for up to two years and can be renewed for up to two additional years within 60 days of expiration if there are no changes from the initial application.

Two additional application options exist to support rapid responses. A Disaster Relief COA is used to operate in natural disaster areas and can be processed by the FAA within hours. An Emergency COA is used on an urgent basis. It is approved quickly and is typically used by law enforcement for life-threatening situations where a manned aircraft cannot be used. Both Disaster Relief and Emergency COAs require that operators have a pre-existing, active COA for that particular UAS model for other operations.

2.3 Current UAS Operations

In some cases, UAS operations authorized under the COA and special airworthiness certification processes are segregated from other air traffic. ATC blocks airspace to be used by an unmanned aircraft for a specified period of time. In other instances, UAS are integrated into daily NAS operations and provided standard ATC services. UA usually are not authorized to fly over populated areas and generally have additional constraints – such as weather and time of day – that further limit operations.

All UAS operations must compensate for the inherent inability to comply with "see and avoid" rules found in Title 14 of the Code of Federal Regulations (referred to as "14 CFR" in this document) §91.111 and §91.113. UAS flights authorized by the FAA must mitigate this shortcoming. In most cases, visual observers, either ground-based or airborne in a chase aircraft, are required to provide the "see and avoid" function for the UAS, in addition to other duties as assigned by the PIC. In some locations, the FAA creates a corridor of protected airspace that allows the UA to transition from an airport to Class A airspace or to Special Activity Airspace. Typically, only one UA is permitted in an authorized area of operation at any one time. As operations become more extensive in duration and/or volume of airspace being used, Traffic Flow Management (TFM) becomes more involved in strategically managing the airspace.

If the flight is transiting controlled Class A airspace on a track to Special Activity Airspace reserved for the operation, ATC applies standard separation services. If the transit is conducted in Class E airspace, ATC provides separation services and traffic advisories, while the PIC or designated visual observer is required to provide "see and avoid" protection from Visual Flight Rules (VFR) aircraft. UAS operations at or near airports in Class B, C, or D airspace are permitted within the limits of the COA and generally only occur at low-density airports or military towered airports.

The flight crew communicates with ATC over the VHF or UHF radio frequencies established for each airspace sector. If voice communications fail, the flight crew notifies an ATC supervisor at the appropriate facility via alternate means. The supervisor then relays the information to the sector controller working the UA.

Operations in uncontrolled (Class G) airspace also require a COA or a special airworthiness certificate and must comply with 14 CFR, including Part 91.126, “Operating on or in the Vicinity of an Airport in Class G Airspace.”

3 Integration Challenges and Opportunities

The problem statement put forth in Section 1 calls for UAS operations that are integrated into the NAS. This section describes some of the most significant challenges along the path to achieving this objective as well as the resulting benefits for the NAS and its users. Since this document is focused on the management and safety of UAS operations, privacy concerns will be addressed separately.

3.1 Current Challenges/Shortfalls

A number of significant shortfalls exist between current operations and the concept of integrated UAS operations presented in Section 4. The issues include achieving certification of UAS applicants, mitigating the inability of UAS to comply with visual rules and clearances, addressing interactions with the Air Traffic Management (ATM) system, addressing the airport environment and its infrastructure, and satisfying communications and control link concerns.

3.1.1 UAS Certification

Neither the FAA nor applicants have experience taking UAS airframes and associated technologies through the civil certification process. Therefore, a certification basis specific to UAS must either be established, or adapted from current standards. As industry and the FAA collectively gain experience with UAS certification, the need for new or updated regulatory products will be evaluated. As with many manned aircraft, UAS may require some special conditions and exemptions.

3.1.2 Operating Rules and Procedures as Applied to UAS

One of the greatest challenges to UAS integration is the use of instruments to replace the vision of a pilot, as vision is fundamental to the conduct of flight operations. The absence of a pilot onboard the UA means there is no ability to comply with operating rules and perform flight functions that are based on the use of pilot's eyes. UAS rely on technology to perform functions similar to what is achieved by human natural vision in manned aircraft. They therefore cannot comply with Visual Flight Rules (VFR) or comply with any clearance that includes a visual component, and are not able to see the airport or runway environment, or see and avoid other aircraft, obstructions, or weather.

Today's rules and procedures (e.g., FARs, ATC Handbook (7110.65), Aeronautical Information Manual) provide a basis for flying without natural vision through the Instrument Flight Rules (IFR). However, there are many visual operations under IFR.

Rules and procedures do not cover aircraft operations that incorporate technology to perform functions traditionally achieved through human vision. Current regulations that address the use of human visual references are not based on measurable or quantitative criteria; and therefore cannot be used as a basis for instrument equivalency.

UAS operations will require new regulations in several key areas, such as in defining the operator's responsibility to provide safe separation of the UA from other traffic. These new regulations will be incorporated under IFR since they are based on technology (instruments), and most of the existing IFR already apply to UAS. These rules and procedures may also be used by manned aircraft that elect to use technology to provide their own separation assurance in certain airspace or situations. In some cases, the new rules will change the meaning of IFR for ATC in terms of the responsibility to provide separation services.

3.1.3 UAS Interaction with Air Traffic Management System

UAS operations today challenge the ATM system in several ways.[2] First, most UAS do not comply with all requirements for operating in the NAS. Secondly, UAS operations typically feature unique flight profiles and aircraft performance characteristics for which ATC procedures, policies, and training do not yet exist. Finally, current ATM automation systems for flight planning, traffic flow management, and separation management do not account for the unique profiles, flight dynamics, and distributed architecture of UAS. Addressing these shortfalls is central to achieving the vision of integrated UAS operations in the NAS.

UA performance. UAS do not satisfy all communications/navigation/surveillance (CNS) performance requirements that apply to operations in specific volumes of airspace in the NAS. This includes, for example, specific altimetry requirements for access to Domestic Reduced Vertical Separation Minima (RVSM) airspace and performance-based navigation (PBN) requirements for NextGen compliance, such as Area Navigation (RNAV). These performance shortfalls exclude them from certain airspace.

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[2] Use of the term "ATM" throughout this ConOps refers to the entire Air Traffic Management system, which consists of Air Traffic Control (ATC), Traffic Flow Management (TFM), and Airspace Management (ASM) services and encompasses all infrastructure components necessary for those services. Further definitions of these separate terms are provided in the Glossary.

Operational profiles. UAS operations often include atypical flight segments, such as long-duration flights, loitering around a particular area, or flying a grid pattern.[3] This presents a challenge for the air traffic controller, who is accustomed to ensuring longitudinal separation within – and vertical and lateral separation between – aircraft flows on point-to-point routes.

In addition, UAS aircraft performance characteristics – such as climb rate and cruise speed – can be quite different from manned aircraft flying in the NAS. ATC training that addresses their unique features is not standardized or distributed uniformly throughout the NAS. Such training is administered locally, within only those facilities where UAS operations occur.

ATM automation. Today's automation systems are not adapted to support ATC in managing the additional complexity introduced by UAS operations. They lack data on unique operational profiles and flight characteristics to effectively support flight planning and assess the impact of proposed UAS operations. In addition, the trajectory modelers running within separation assurance and decision support tools - such as conflict detection and resolution (CD&R) algorithms - do not contain specific UAS performance parameters in their adaptation. Current automation systems also lack policy rules and guidelines for balancing demand for airspace access and determining priorities for manned and unmanned flights - a mix that introduces a wide range of operational profiles, performance envelopes, and flight durations.

3.1.4 Airport Operations

Many airports and their associated support infrastructure are not designed, equipped, or staffed to host UAS. Further, neither airport operators nor controllers are fully familiar with UAS capabilities and requirements for taxi, surface movements, parking, and storage. For integrated UAS operations to occur, the following must be addressed and resolved:

- Airport design considerations and adaptations specific to UAS
- Statutory requirements (and airport user rights) for federally-obligated airports
- Security concerns
- Allocation and distribution of space on the airport surface
- Environmental impact and/or assessments (when required) concerning noise, emissions, and any unique fuels and other associated concerns.

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[3] The terms "loitering" and "grid pattern" refer to specific flight profiles and are defined in the Glossary of Terms. While not terms normally used by ATC, they will become familiar as more UAS operations are integrated into the NAS.

3.1.5 UAS Communications Link

The voice communications link between the UAS PIC and ATC often lacks the consistency and quality of the link between manned aircraft pilots and controllers. The link also experiences additional latencies and degradations due to signal processing, atmospheric conditions, interference, and other factors.

For UAS in which the control station is within radio coverage of ATC, the PIC can receive ATC instructions and clearances over the air-to-ground frequency just like manned aircraft. Some UAS do not use traditional air-to-ground communications links, however. The controller or front line manager must contact the PIC by manually calling over ground-to-ground communications lines.

In other cases, the UA may be beyond radio coverage from the PIC and control station. A satellite relay links the control station to the UA for voice communications between the UA and the ATC facility with control jurisdiction. This adds a potentially detrimental communications delay.

3.1.6 UAS Control Link

Each UAS includes a control link, enabling the PIC to control the vehicle. In a manner similar to the communications link, a ground or satellite relay is used to transmit and receive control instructions. This introduces some amount of control latency. When combined with the voice communications latency, the resulting delays in receipt of and response to ATC instructions may adversely affect aircraft separation and NAS safety.

The reliability of this link is also important. Unlike manned aviation where the control link is internal to the aircraft, unmanned aviation extends this link to external components.

Specific procedures are determined for each operation and often for each phase of flight to account for the UAS designs when lost link occurs. ATC is notified when such a loss occurs, but the delay in that notification introduces an element of risk to other operations, and potentially an increase in controller workload.

Lost or degraded link events – for either control or voice communications – currently occur too frequently for NAS integration. Lost link procedures are not contained in the ATC automation system and UA responses during lost link for some UA platforms are not consistent or predictable. ATC may not be immediately aware that a lost link has occurred. UAS response to a lost link may result in the UA changing course or altitude without clearance.

UAS integration is precluded by the unknown reliability of the communications links and the lack of uniform procedures to respond to link anomalies. Additionally, such occurrences greatly increase controller workload, and may cause controllers to affect traffic flows by applying increased separation buffers between UA and manned aircraft.

3.2 Technological Opportunities

NextGen initiatives (discussed in Section 4.5) support the integration of UAS with technologies and associated procedures that include PBN, digital voice switching, and data communications. When combined with trajectory-based operations (TBO) and decision support tools, these can provide the foundation for managing an increased number of UAS, enabling diverse flight profiles, and addressing the unique performance characteristics of UAS operations.

3.3 Benefits to be Realized

Successful NAS integration of unmanned aircraft supports future FAA objectives while improving services to both the UAS community and current operators. The primary objective is to preserve the safety of the NAS. The following are the benefits that can be realized from the ability to integrate UAS into the NAS safely:

- **Efficiency** – UAS will meet CNS performance standards that will increasingly enable them to file and fly their desired flight path, rather than the less optimal routes used today.
- **Access** – UAS compliance with operational performance requirements, coupled with improved ATM automation, will enable integration of UAS without service disruptions to other airspace operators.
- **Environmental** – Increased use of UAS for selected applications, such as traffic monitoring and border surveillance, could provide potential reductions in noise and emissions compared to similar operations flown by manned aircraft.

Civil aircraft operators benefit from increased use of UAS for commercial purposes, including agricultural applications, news and sporting event coverage, real estate mapping, and point-to-point transport of goods using unmanned variants of existing cargo aircraft.[4]

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[4] "Point-to-point transit" refers to a specific flight profile and is defined in the Glossary of Terms.

Public UAS operators benefit across multiple applications, including border surveillance, scientific research, law enforcement, military training, and humanitarian response to natural disasters.

3.4 Path Forward

The FAA has identified three key perspectives regarding UAS airspace integration. They constitute a continuum of UAS operational expansion in the NAS.

Accommodation. The FAA currently approves limited UAS access to the NAS via special procedures and mitigations. These include the COA and special airworthiness certification processes and the use of restricted airspace to segregate UAS operations from manned operations. Such operations are considered on a case-by case basis to ensure that today's non-standardized UAS performance and operational features do not adversely affect NAS safety or efficiency. As UAS research, rulemaking, and policy developments enable an increase in integrated operations, the need for accommodation will decline significantly.

Integration. The establishment of UAS performance requirements provides operators a means to integrate operations in the NAS. Assisted by external industry organizations, the FAA develops policy and publishes regulations, standards, and procedures that enable routine UAS operations.

Evolution. Once UAS operations are integrated, unmanned aviation evolves alongside manned flight as policies, regulations, procedures, training, and technologies are routinely updated to meet the needs of the NAS community.

This ConOps describes the NAS when it has achieved Integration, and addresses certification, operations, ATM, and ATC-specific issues.

4 Concept of Operations

This section presents the concept for UAS integration from the perspective of the targeted timeframe; that is, the narrative is written in the present tense and assumes UAS have evolved sufficiently to permit integration into the NAS. The section entitled *Assumptions* establishes the ground rules underlying integrated UAS operations. *System Description* describes the basic elements of UAS and their key characteristics. *UAS Certification and Approval* addresses the certification and approval processes, accommodation alternatives, and Sense and Avoid capability. The *NAS Operating Environment* section discusses specific features of the NAS that support UAS operations. *UAS Operations* describes normal operations with emphasis on ATC and ATM interactions, and is organized primarily by airspace classification. *Contingency Operations* discusses potential off-nominal UAS behavior and the associated NAS impacts. *Enterprise Services and Infrastructure* describes important auxiliary issues such as safety and security of UAS operations and facilities.

4.1 Terminology

Performance. This ConOps uses the term "performance" in two different contexts. The first usage pertains to communications, navigation, and surveillance performance requirements or capabilities, traceable to equipage such as RNAV or Automatic Dependent Surveillance – Broadcast (ADS-B). This type of performance determines eligibility to use specific airspace or routes and always refers to equipage and airspace access.

The second usage pertains to the performance envelope and associated dynamic characteristics of the aircraft from an ATC/ATM perspective, such as cruise speed, climb rate, and turn rate. These performance parameters are considered in terms of managing airspace capacity and controller workload, but they are not necessarily prerequisites for access to the NAS. When the performance issue in this concept relates to the performance envelope, the additional terms "envelope" or "limitation" are used to make the distinction.

ATC Separation Standards. The use of the term "separation standards" throughout this ConOps means those basic separation criteria applied by ATC. This is distinguished from UAS airborne separation standards that are integral to the Sense and Avoid capability. No additional ATC separation is applied based solely upon whether the aircraft is manned or unmanned.

Sense and Avoid (UAS Responsibilities for Safe Separation). Sense and Avoid represents the capability of the UAS flight crew to provide safe separation from other airborne traffic. This capability is divided into two distinct functional components:

1. Self-separation – this function applies a quantitative set of values consistent with an approved airborne separation standard analogous to the visually-based requirement for manned aircraft to remain well clear of other aircraft.
2. Collision avoidance – similar to the Traffic Alert and Collision Avoidance System (TCAS) technologies implemented on some manned aircraft, this function serves to provide maneuver advisories to avoid an imminent collision with another aircraft.

Together, these two functions of Sense and Avoid deliver a capability analogous to the visually-based requirements for manned aircraft to "see and avoid." UAS integration into the NAS requires the operator to be able to fulfill these responsibilities in compliance with an accepted airborne separation standard. The technologies that provide this capability must demonstrate a functionality that is at least as effective as manned aircraft, while also providing an overall level of safety that is equal to (or superior to) manned aircraft.

The Sense and Avoid capability is a subset of the UAS flight crew's responsibilities in conditions where pilots traditionally use their eyes to comply with 14 CFR requirements, including ATC clearances and instructions. Figure 4 shows examples of these conditions, and where the Sense and Avoid capability resides.

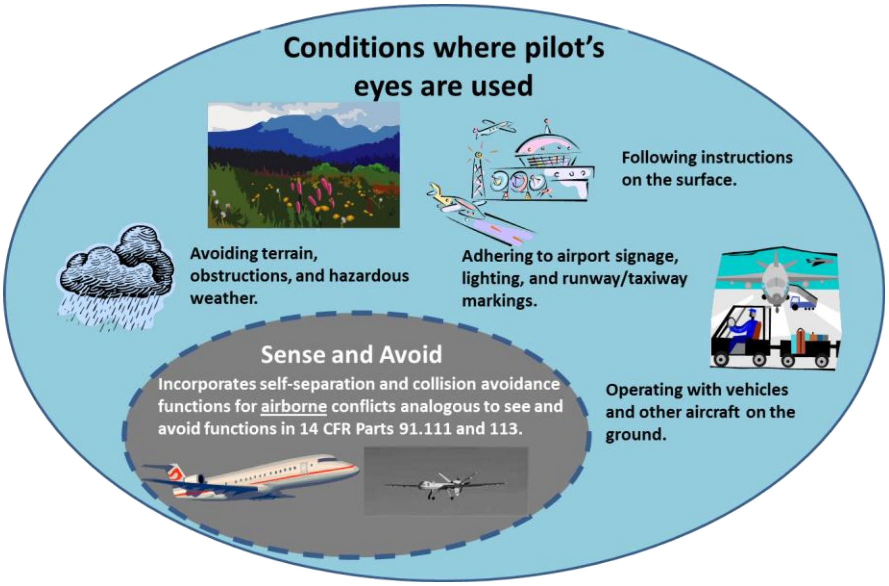

Figure 4. Sense and Avoid in context of traditional visual responsibilities

4.2 General Requirements and Assumptions for Integration

The following general requirements and assumptions apply to all UAS operations that are integrated into the NAS. Requirements for integration apply universally, regardless of type of user or operational domain. Subsequent sections discuss each of these requirements and assumptions in more detail. Small UAS (aircraft weighing less than 55 pounds) designed to operate exclusively within visual line-of-sight (VLOS) of the flight crew are not addressed in the concept narrative and are not bound by these requirements for integration.[5]

1. UAS operators comply with existing, adapted, and/or new operating rules or procedures as a prerequisite for NAS integration.
2. Civil UAS operating in the NAS obtain an appropriate airworthiness certificate while public users retain their responsibility to determine airworthiness.
3. All UAS must file and fly an IFR flight plan.
4. All UAS are equipped with ADS-B (Out) and transponder with altitude-encoding capability. This requirement is independent of the FAA's rulemaking for ADS-B (Out).
5. UAS meet performance and equipage requirements for the environment in which they are operating and adhere to the relevant procedures.
6. Each UAS has a flight crew appropriate to fulfill the operators' responsibilities, and includes a PIC. Each PIC controls only one UA.[6]
7. Autonomous operations are not permitted.[7] The PIC has full control, or override authority to assume control at all times during normal UAS operations.
8. Communications spectrum is available to support UAS operations.
9. No new classes or types of airspace are designated or created specifically for UAS operations.

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[5] Other VLOS operations (i.e., UAS weighing more than 55 pounds) may be conducted in accordance with the requirements set forth in this ConOps or by a special authorization request.

[6] This restriction does not preclude the possibility of a formation of UA (with multiple pilots) or a "swarm" (one pilot controlling a group of UA) from transiting the NAS to or from a restricted airspace, provided the formation or swarm is operating under a COA. This constraint addresses generally only those UAS operations that will be integrated into the NAS.

[7] As defined in the Glossary of Terms, autonomous operations refer to any system design that precludes any person from affecting the normal operations of the aircraft.

10. FAA policy, guidelines, and automation support air traffic decision-makers on assigning priority for individual flights (or flight segments) and providing equitable access to airspace and air traffic services.
11. Air traffic separation minima in controlled airspace apply to UA.
12. ATC is responsible for separation services as required by class of airspace and type of flight plan for both manned and unmanned aircraft.
13. The UAS PIC complies with all ATC instructions and uses standard phraseology per FAA Order (JO) 7110.65 and the Aeronautical Information Manual (AIM).
14. ATC has no direct link to the UA for flight control purposes.

4.3 Operational System Description

Figure 5 depicts the five primary elements of UAS: the aircraft, control station, crew, control link, and data communications link. The remainder of the graphic provides context for the following discussion of UAS integration into the NAS.

The UA consists of the vehicle that operates in the NAS, including all installed systems and components. It is equipped to comply with the operational requirements of the airspace in which it flies. These requirements are detailed in Section 4.4.

The control station includes the systems and interfaces required to operate the UA, including communicating with ATC. The control station may be in a fixed position, in a vehicle capable of operating on the airport surface, or in another location entirely. The control station is not necessarily ground-based, and its functionality may be distributed across multiple locations. Security requirements are defined during both the certification and operational approval processes.

Each UAS has a PIC and may include additional flight crewmembers, such as a second pilot, payload specialist, and/or a dedicated sense and avoid crewmember, as appropriate for the particular operation. Like the control station itself, crewmembers may be located in different sites. UAS crewmembers are capable of communicating with one another in order to perform the necessary flight tasks.

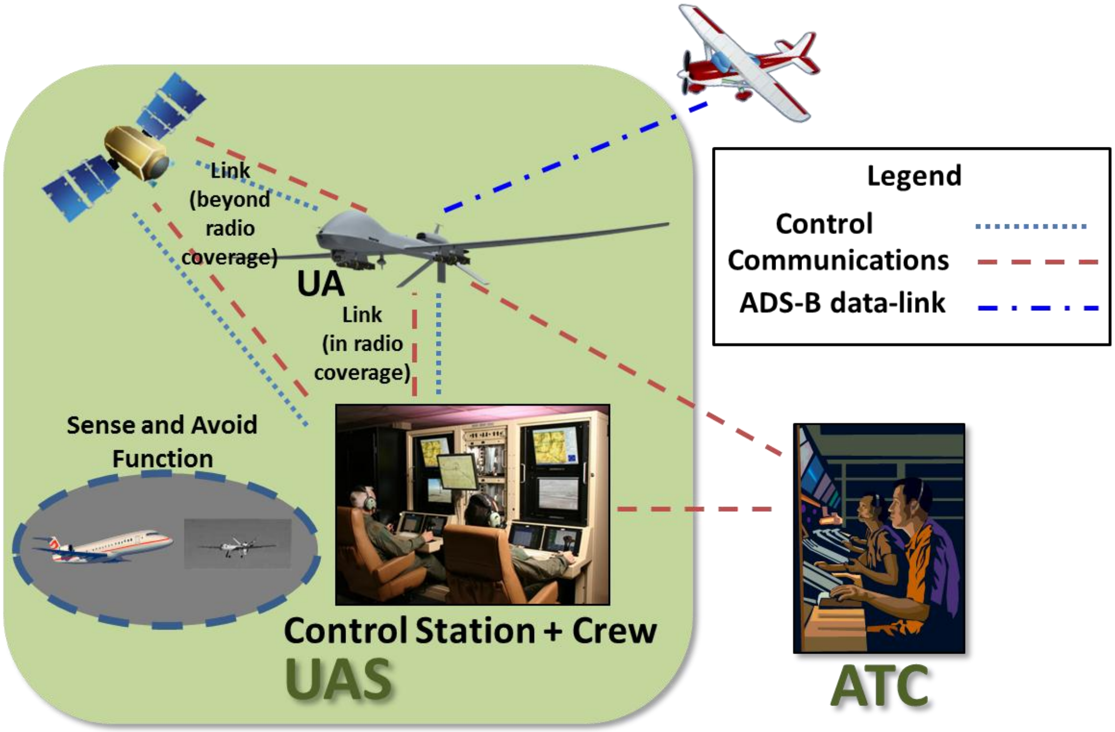

Figure 5. UAS elements in the NextGen NAS

An encrypted or secure control link enables the exchange of data between the UA and the control station regarding flight operations. This link uses spectrum that is allocated specifically for UAS operations. The UAS control link enables the PIC to comply with ATC-issued instructions by transmitting flight commands to the UA. The UA transmits telemetry and status data back to the control station over the control link. When the UA is within radio coverage of the control station, this may be a direct link. However, for beyond radio coverage operations, a satellite or ground relay may be employed as a node in the control link.

A communications link independent of the control link connects the PIC in the control station with ATC. As with manned aircraft, UAS operating in controlled airspace communicate on radio frequencies or through an ATC-to-PIC ground communications link assigned to that sector, terminal area, or airport. These communications may be voice, data, or both. A communications link that uses voice-switching capabilities to favor a ground-based infrastructure provides UAS with a reliable link to ATC while minimizing latency concerns. Similar to the control link, the communications link may also require a ground or satellite relay for beyond radio LOS operations or contingencies.

4.4 UAS Certification and Operational Approval

This section describes the processes and products for UAS certification and operational approval of UAS. It also discusses accommodation alternatives for non-compliant UAS.

4.4.1 Process and Products

A single basic tenet provides the basis of UAS certification and flight authorization: a UAS is an aircraft. UAS share many of the same design considerations as manned aircraft – airworthiness, dynamic performance, and hardware and software safety systems. Other aspects are unique, including defining the boundary of the UAS cockpit (in the control station) and the provisions for third-party data communications for the control link. In addition, the operational approval of the UAS addresses unique attributes such as launch and recovery and Sense and Avoid capabilities in the context of ATC separation responsibilities.

Approving civil UAS to operate in the NAS is a two-step process, as illustrated in Figure 6. The steps generally occur in a chronological order and each one is technically separate from the other.

The FAA grants airworthiness based on certification requirements appropriate to the UAS. Certification requirements are derived from standards, which may be developed in collaboration with industry. Operational approval of the UAS is granted consistent with published operating rules.

The Air Traffic Organization is provided information necessary to develop procedures, operational standards, and other guidance materials, indicating the UAS is qualified for the airspace in which it intends to operate.

The processes and regulatory products that apply to a UAS operator depend upon whether the applicant is operating the aircraft for civil or public use. Title 49 CFR establishes the authority of the FAA, while the authority for public users is defined under Title 10 CFR. Government-owned aircraft that operate for commercial purposes or engage in the transport of passengers are subject to the regulations applicable to civil aircraft. Similar to the manned aircraft paradigm, public UAS operators will need to operate under FAA regulations in order to be integrated into the NAS.

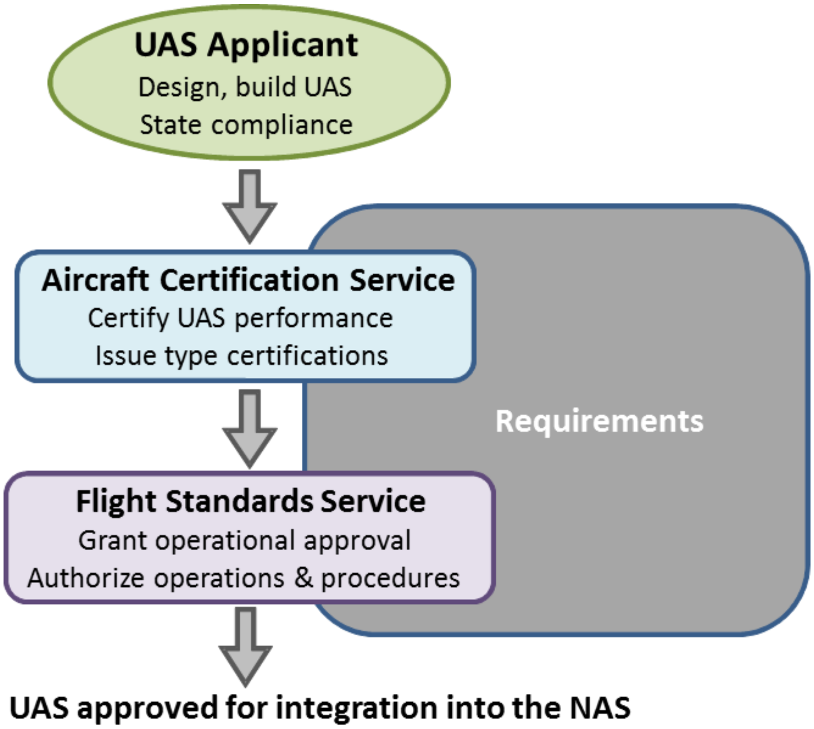

Figure 6. Civil UAS authorization process

4.4.1.1 Aircraft Certification

The FAA's Aircraft Certification Service issues a type certificate after finding that an applicant has shown that the UAS satisfies the relevant airworthiness requirements. Title 14 CFR describes the certification standards that govern the design, construction, manufacturing, and airworthiness of aircraft used in private and commercial operations. The Aircraft Certification Service also publishes Technical Standard Orders (TSO) that define equipment standards, and Advisory Circulars (AC) that provide guidance on complying with airworthiness regulations.

4.4.1.2 Operational Approval

The FAA's Flight Standards Service grants operational approval for UAS to fly in the NAS. This organization ensures UAS operators provide information on flight crew qualifications, training, and flight operations, and that UAS can comply with all general operating regulations and other regulations applicable to their planned operations. This also includes overseeing UAS compliance with applicable airspace requirements. The objective for compliance with these regulations and requirements is to ensure UAS can safely operate in the NAS with all other users in a manner that is consistent with ATC expectations.

Existing operational standards for the safe operation of manned aircraft are contained in 14 CFR Part 91 and other parts, based on a variety of factors. UAS operational standards are based on compliance with existing, modified, and/or new operating rules or procedures to address the unique aspects of UAS. Approval to operate under these rules addresses the challenges created by the absence of an onboard pilot, which include:

- UAS must comply with “sense and avoid” responsibilities.
- UAS must be able to comply with ATC instructions and clearances.

These challenges are described in more detail in subsequent sections.

Control Station. Regardless of the physical architecture, the control station complies with security, integrity, and continuity standards analogous to a manned aircraft cockpit. In addition, the control station satisfies requirements regarding interoperability with existing NAS systems.

Control Link. The UAS control link enables the PIC to comply with ATC instructions issued by voice or data, and results in navigation capability and performance consistent with published airspace, route, and procedural requirements.

The control link avionics and control station equipment are certified as part of the UAS, and intermediate communications equipment may be approved as part of the UAS or approved for use under the operating requirements. The UAS requirements also include security and integrity measures and associated design features that preclude disruption or a hostile takeover of the UA control link. Acceptable control link latency (time from initiation of a maneuver to a measurable response by the UA) is established for UAS at a level that is similar to that of manned aircraft.

Communications Link. Voice and data communications between the flight crew and ATC satisfy established latency requirements. Instructions from ATC to the PIC result in the same pilot acknowledgement response times as those typical for manned aircraft. In addition, whether communications are from a UAS PIC or a pilot of a manned aircraft is seamless to ATC.

Flight Crew. The PIC and all UAS flight crew satisfy training, licensing, medical, and currency requirements equivalent to pilots of manned aircraft performing similar operations. Additional flight crew regulations also apply to UAS such as duty time limitations, crew rest, and Crew Resource Management. PIC responsibility that transfers among multiple personnel (such as with long-duration flights) is seamless to ATC. Each PIC controls only one UA unless a waiver is issued for a specific operation. New flight crew roles may be necessary, such as a crew position responsible for monitoring the Sense and Avoid system.

4.4.2 UAS Accommodation Alternatives

Some UAS types are unable to achieve a type certification or meet operational requirements to integrate into the NAS. UAS operators who do not obtain a type certification or meet all 14 CFR Part 91 or other performance requirements continue to operate under the COA (public aircraft) or special airworthiness certification (civil aircraft) processes, which impose restrictions and constraints that mitigate any performance shortfalls.

In the targeted timeframe, the COA process is streamlined with improved user access to shared information and lessons learned. These upgrades decrease the amount of information UAS operators must collect and file for each application.

4.5 Layers of Separation Assurance

Air Navigation Service Providers (ANSPs) employ multiple layers of structure and protection to ensure that all aircraft are separated safely. Determination of how to apply separation procedures at any moment in time depends on the airspace, mixture of operations, type of flight plan, and other factors. The PIC retains ultimate responsibility for the safe operation of the aircraft.

The way a given airspace is structured and its associated procedures provide the first layer of protection. This includes performance-based routes, published approach and departure procedures, and altitude assignments based on direction of flight.

The next layer, strategic separation services, involves demand-capacity balancing to ensure that controller workload remains within safe and manageable limits. On a tactical level, ATC personnel use surveillance data and decision support tools to predict conflicts and then issue trajectory amendments to modify course when two or more participating aircraft may breach separation minima.

Finally, manned aircraft have the ability to “see and avoid” other aircraft, as required by regulations governing the general operation of aircraft in the NAS under Title 14 CFR Part 91, Parts 91.111 (Operating near other aircraft) and 91.113 (Right of Way Rules: Except water operations). These and other regulations state that aircraft must remain “well clear” of other aircraft and avoid collisions. Flight crews achieve this by visual observation. Other technology, such as TCAS, supplements this capability for aircraft so equipped.

For UAS, the absence of an onboard pilot means that a Sense and Avoid capability is required to provide a means for “self-separation” and collision avoidance. Self-separation is analogous to the requirements for manned aircraft to remain well clear of other aircraft.

"Well clear" as described in 14 CFR Part 91 is not an established quantitative set of values, but is qualitative and subjective. There are no measures of distance, altitude, or time that translate to "remaining well clear." New operational rules establish accepted airborne separation standards for the Sense and Avoid capability that provide for that set of quantitative values. Sense and Avoid capabilities may incorporate data from airborne sensors, ADS-B (Out) messages, ground-based radar or other inputs.

Figure 7 illustrates the different layers used to keep aircraft safely separated, beginning with airspace classification and design, and ending with the responsibility of the pilot to prevent collisions.[8]

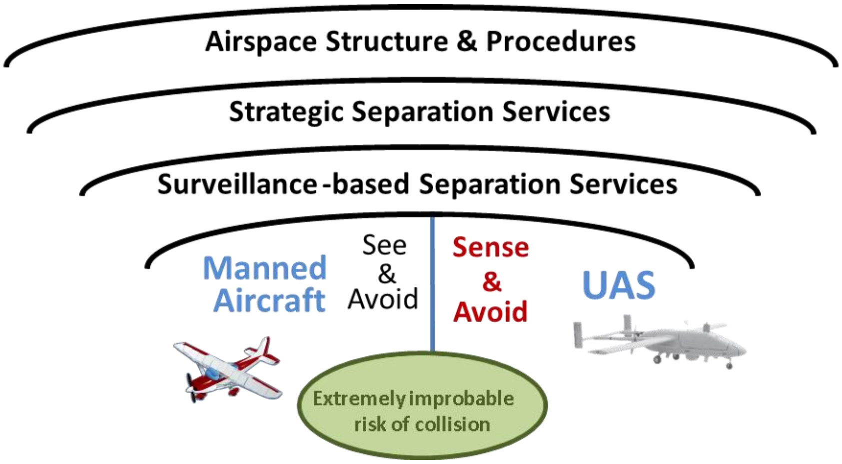

Figure 7. A layered approach for collision avoidance

Sense and Avoid "Self-Separation." The Sense and Avoid self-separation function is used by the PIC to comply with an accepted airborne separation standard when ATC separation services are not being provided.

Sense and Avoid self-separation differs from the manned aircraft requirement to "remain well clear" in that it applies a set of quantitative values (e.g., time, feet, or miles) by which calculations are made to determine if a threat exists that indicates a requirement to maneuver. These values must be selected to mitigate the instances of "false alarms" and unnecessary maneuvers.

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[8] The "Sense and Avoid" capability described in this section is traceable to current and ongoing work by FAA sponsored Sense and Avoid Workshops and the reports issued from them.

In an encounter situation between a UA and another aircraft on an IFR flight plan, the UA would not use its self-separation capability unless ATC authorized its use. There can only be one separation provision for two IFR aircraft - either ATC or an aircraft to which ATC has delegated this responsibility.[9] When the self-separation function is active, the maneuvers executed by the PIC in response to it are not considered "deviations" from an ATC clearance, as long as those maneuvers are within the tolerances established for the airspace or route. Any maneuvers that are projected to exceed those tolerances require ATC approval.

In an encounter situation between a UA and an aircraft on a VFR flight plan that is not receiving ATC services (e.g., Class E airspace), the UA is authorized to use its self-separation capability. In this case, the separation provision between an IFR UA and a VFR aircraft is the responsibility of the pilots of both aircraft. The UA may request assistance from ATC (if applicable) or maneuver using its self-separation capability.

The VFR aircraft is obligated to remain well clear. Because "well clear" is subjective, the VFR aircraft may remain in or be predicted to enter the UAS Sense and Avoid capability's alert parameters. Further, the VFR aircraft may never visually acquire the UAS. Therefore, the self-separation function provides the UAS an additional layer of separation assurance. To aid pilots of manned aircraft in visually acquiring a UA, some of which may be difficult to see or have a small radar cross-section (RCS), UAS meet stringent and specific aircraft lighting (position and anti-collision) requirements.

Sense and Avoid "Collision Avoidance." The PIC always has a responsibility for collision avoidance using the Sense and Avoid collision avoidance function in compliance with an accepted airborne separation standard. This is true whether or not ATC separation services are being provided.

During a collision avoidance situation, the UAS flight crew takes appropriate action to prevent another aircraft from penetrating the UAS collision volume (considering the surveillance/sensing performance and response times to avoid a collision). Maneuvering is initiated within a relatively short time horizon when the other aircraft is declared a collision threat. The UAS PIC must ensure the collision avoidance function is always active and fully functional. ATC is notified as soon as practicable if it is not fully functional. UAS collision avoidance is interoperable with collision avoidance systems used in manned aircraft.

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[9] Use of the term "delegated separation" throughout this ConOps refers specifically to the transfer of separation responsibility from ATC to the PIC, where technologies and procedures using instruments provide a capability analogous to visual operations, to achieve safe separation.

4.6 NAS Operating Environment

The NAS in the timeframe of this ConOps sees an introduction of several key enabling technologies, including ADS-B, collaborative air traffic management, data communications, integration of weather into decision-making, voice switching, network-enabled information sharing, and performance-based navigation (PBN). Each of these capabilities is described below – in general, and in the context of UAS operations.

4.6.1 Automatic Dependent Surveillance – Broadcast (ADS-B)

ADS-B is a bi-directional data-link application that transmits (the "Out" function) and receives (the "In" function) aircraft position and state information derived from on-board navigational systems. ADS-B (Out) improves the likelihood for both ATC and other equipped aircraft of detecting the UA and giving other aircraft that are equipped with ADS-B (In) an enhanced ability to remain well clear. ADS-B (Out) messages enable ATC to detect and depict the UA on its displays, regardless of the size of the UA. ADS-B (In) also supports other delegated spacing applications, such as flight deck interval management and in-trail climb and descent procedures. This ConOps requires that all UAS equip with ADS-B (Out) and meet position and other data quality requirements, regardless of the class of airspace in which they are operating.

4.6.2 Collaborative Air Traffic Management Technologies (CATMT)

CATMT provides capabilities and processes to improve traffic flow management system-wide as well as at the tactical, or location-based, level by delivering services to accommodate flight operator preferences to the maximum extent possible. CATM supports a more flexible air traffic system capable of in-flight adjustment to alternate, more favorable routings and altitudes as well as the ability to shift traffic operations to match airspace and airport capacity. UAS operators actively participate in these TFM processes alongside manned operations whenever their flights use resources being allocated by TFM.

As with manned aircraft, UAS operators experience reduced delays and preferred routes, to the degree that they are able to submit timely information on trajectory intentions and preferences to the traffic flow management system. See the Flight Planning and Traffic Flow Management sections for additional details.

4.6.3 Data Communications

Data communication applications enable controllers to send digital instructions and clearances to pilots, and to exchange more complex 4D (four dimensional, comprising latitude, longitude, altitude, and time) trajectory data, including position, navigation and timing information. Initially, data communications capabilities are available at select airports and en route airspace as a secondary means of communications. Voice is always used for time-critical communications and in airspace where data communications is not available. For UAS that elect to equip, ATC messages and instructions are exchanged via data communications to the PIC.

4.6.4 Integration of Weather into Decision Making

NextGen technologies improve the quality of weather forecasting and the integration of weather information into controller decision support tools. Network-enabled weather data provides operators of the NAS with access to the same accurate weather information to foster a common weather picture that enhances safety and supports collaborative decision-making. NextGen weather services reduce the effects of adverse weather on UAS operations by informing the flight planning process.

Furthermore, enhanced weather services may provide information of specific interest to UAS (e.g., determining turbulence, icing conditions, effect of solar flares on control link). UAS-collected weather data can also serve as an input to the common weather picture.

4.6.5 Voice Switching

A voice communications system with flexible networking capabilities allows greater flexibility for developing and using airspace/traffic assignments in all airspace. NextGen voice communication paths provide opportunities for the air-to-ground voice communications system to be available over ground-to-ground communications, which improves the efficiency and reliability of exchanges between the UAS flight crew and ATC. Additionally, the "party line" requirement integral to NAS Voice System (NVS) requirements adds to the overall situation awareness of UAS flight crews.

4.6.6 Network-Enabled Information Sharing

Network-enabled information access to more timely and improved information throughout the NAS serves as a major enabler for future NAS operations. All information about a given flight (e.g., capabilities, constraints, preferences) is contained within the flight object and made available to system stakeholders and ATM service providers based on information needs and security protocol.

Information on Special Activity Airspace and other airspace status is contained in ground automation systems and is available to the FAA and operators to improve the speed, efficiency, and quality of collaborative decision-making. These improvements provide information for all airspace operators, including UAS, to better plan flights. Improved situation awareness from net-enabled information sharing facilitates the collaborative decision-making (CDM) process needed to mitigate potential adverse effects of weather, Special Activity Airspace status, and infrastructure status on UAS and other NAS operators.

4.6.7 Position, Navigation, and Timing Services

Navigation becomes increasingly performance-based. With these enhancements, aircraft use RNAV and Required Navigation Performance (RNP) to fly more efficient and repeatable trajectories. Operators have the ability to define their desired flight paths based on their own objectives. Increased use of area navigation capability and precise adherence to assigned trajectories enable aircraft to fly user-preferred routes while airspace designers are able to reduce route spacing where needed. UAS operating in performance-based airspace and on performance-based routes must meet the specific requirements for that route. However, UA performance envelope limitations (speed, climb, turn) that are significantly different from those of other users may limit access to some routes during peak periods.

4.7 UAS Operations

To integrate into the NAS, all UAS operations are conducted under IFR. UAS must also file a flight plan so that the ATM system is informed of the intent and location of each operation. Once the flight plan is filed, the ATM system determines whether the UAS operation will be conducted under an ATC clearance, with attendant separation and traffic services, or whether the UAS may be delegated the responsibility for maintaining safe separation using its Sense and Avoid capability.

The operating rules and procedures used may be an adaptation of those currently prescribed for IFR operations, or new rules, some of which may be specific to UAS. These new rules allow UAS to use their Sense and Avoid capability to perform “safe-separation,” a function that all manned aircraft must satisfy in VMC under existing “see and avoid” requirements. New rules allow UAS to use technology to conduct operations wherein the requirements to “remain well clear” and “avoid collisions” are most predominant.

The rules address alternatives to visual separation so that UAS operations do not reduce capacity at airports during VMC, and provide methods of adhering to prescribed traffic patterns at both controlled and uncontrolled airports. Operating rules also address specific NextGen capabilities (e.g., flight deck interval management) that support UAS integration. Some rules require changes to the ATC handbook and to the specific phraseology controllers use to issue clearances and instructions.

From an air traffic control perspective, these new IFR rules do not necessarily translate into the need for ATC separation services. In controlled airspace, ATC may delegate separation responsibility, provided the PIC accepts. This is analogous to VFR operations, but is based on instruments and technology. In uncontrolled airspace, ATC services are not normally provided and the operator is responsible for safe separation. In these instances, separation is typically delegated as part of the flight planning process. Procedures enable UAS to operate IFR in uncontrolled airspace providing self-separation without ATC involvement. These new IFR rules allow the UAS to achieve a VFR-like flexibility without creating a paradigm shift for ATC responsibilities in uncontrolled airspace. These new rules also ensure that ATC provides a level and type of service to UAS that is similar to that which they provide to manned aircraft today in each airspace class.

The remainder of this section describes integrated UAS operations in the NAS in the context of strategic traffic management services, (including flight planning), surface operations, and operations in each class of airspace.

4.7.1 Strategic Traffic Management

The ATM system exists primarily to manage the movement of people and goods by air transport. ATC is the service that provides that capability through the safe, orderly, expeditious, and timely control of the flow of aircraft in the NAS. The introduction of UAS flight profiles that are different from those typically served by the ATM system has the potential to affect that primary function. Those effects, however, are mitigated through the application of strategic traffic management.

Strategic traffic management is an iterative process through which users and ATM service providers collaborate to ensure the efficient flow of traffic within the capacity limitations of the NAS. Decisions related to UAS access to the NAS and the equitable distribution of ATM services for UAS operations are guided by a definitive set of policies and rules with established criteria. These policies and rules address prioritization and equity of access not only for point-to-point trajectories, but also operations using volumes of airspace. Advanced communication and information-sharing systems between the service provider and the user enable precise trajectory planning, accommodation of user preferences, efficient allocation of resources, and ultimately reduced delays and increased system throughput.

Both the service provider and the user community make timely, effective, and well-informed decisions. Users are able to plan flight trajectories with a full understanding of NAS operational status and constraints in a manner that best meets their objectives and priorities. In addition, users who provide early information concerning flight plan intent receive feedback on constraints associated with the planned trajectory and are able to negotiate alternatives.

Traffic management automation assists traffic managers with balancing demand against capacity. As with manned aircraft, traffic management tools and personnel incorporate UA operating parameters, such as climb rates and cruising speed, in the assessment and optimization processes.

Table 1 highlights the changes to strategic traffic management that result from UAS integration.

4.7.1.1 Traffic Flow Management

Balancing the competing needs of all users and ensuring equitable access to airspace and other NAS resources are key concerns for TFM processes. While the determination of priority for a flight or flight segment may be established by agency policy, many of these decisions are developed case-by-case by TFM in collaboration with the users, based on minimizing the disruption to the flow of traffic in the NAS. For example, a UA surveillance mission during a specific national security threat will have a higher priority over commercial operations than a UA conducting a highway traffic survey would, even though the flight profiles may be similar.

UA increasingly share route segments with manned aircraft based on their ability to integrate into the airspace and flows. Procedures and policies resolve competition for resources in a predictable, efficient, and equitable manner. Automation takes into consideration the number of flights and flight segments and manages traffic flows based on flight or segment priority.

TFM employs various traffic management initiatives (TMIs) to handle excessive demand or mitigate emerging constraints such as severe weather. UAS operations are subject to the same restrictions as other aircraft when demand exceeds capacity either in a volume of airspace or at a destination airport. The UAS operations most susceptible to TMIs are those that intend to operate along high-demand routes or within weather-constrained airspace. These operations incorporate their priorities into a set of re-route preferences.

The priorities and preferences of UAS operators may differ from those typical of manned aircraft. For example, if operations in a particular constrained area are essential to the flight objectives, UAS operators may elect to abort or cancel the operation. Similarly, an excessive delay or inefficient re-route may be an acceptable option when the flight has no time constraint.

Table 1. Strategic Traffic Management Improvements

Past Practice	Change with Integration	Improvements
ATC often segregated airspace for UAS operations through temporary flight restrictions and special use airspace.	Route segments are increasingly shared by both UA and manned aircraft.	UAS operations are less disruptive and airspace utilization becomes more efficient.
Traffic flow management (TFM) resolved UAS requests for airspace on a case-by-case basis.	TFM automation assists with assessing the impact of UAS operations. Procedures and policies resolve competition for resources in a predictable, efficient, and equitable manner.	Prioritization is understood and incentives are created for submission of timely and accurate operator intentions.
UAS were not subject to traffic management initiatives (TMIs).	UAS are subject to TMIs in the same manner as manned aircraft.	Integration provides an improved picture of the traffic complexity and demand to Traffic Flow Managers when assessing capacity constraints and selecting the TMIs to apply.
Strategic traffic management did not incorporate UA performance limitations and flight characteristics.	Automated assessments during flight plan negotiation consider UA performance limitations into the impact on overall NAS operations.	NAS capacity constraint predictions are more accurate by incorporating UAS operations and associated performance envelopes.
Flight plans under the COA/special airworthiness approval processes did not provide a near-term flight plan feedback mechanism.	UAS operators file flight plans and receive feedback in parallel with other users.	Flight plan feedback allows UAS to negotiate routing with ATC.
ATC automation was limited in its ability to accept complex and extended duration flight plans.	FAA flight plans can accommodate longer flight durations and complex UAS operations.	ATM has access to comprehensive and accurate information for UAS flights.
The COA/special airworthiness approval processes addressed contingency operations as part of the approval process, but they were not easily accessible to ATC flight plan automation.	UAS contingency procedures are predetermined and are described in the flight object and/or described into ATC standard operating procedures (e.g., JO 7110.65).	Contingency procedures are known and available to controllers in real time.

4.7.1.2 Flight Planning

With integrated operations, flight planners for both civil and public UAS participate in the same flight plan submission and feedback process as manned aircraft, using the same international or domestic flight plan forms, software applications, and filing processes as other NAS users. All UAS must file and fly an IFR flight plan regardless of where they are operating.

Filing a flight plan as early as practical is encouraged. Early filing enables flight planners and ATM to collaborate on approval of the 4D flight plan based on other filers' requests to use routes and/or airspace. Planned trajectories are modified as needed to ensure they do not negatively affect the NAS. Due to the potential of competing interests between manned aircraft and UAS, FAA policy and guidelines assist ATC in resolving demand and capacity imbalances. Flight planning processes that address user intent and trajectory negotiation include recommendations for alternative routes that can be accommodated.

A set of trajectory options allows users to pre-specify conditions under which they would be willing to accept alternate routes or departure times. Users have many options they can select: accepting a pre-negotiated alternative, altering some trajectory parameters (e.g., schedule, timing), or proposing additional work-around options that have been adapted to known constraints. The flight plan becomes more detailed until finalized prior to departure.

While early flight plan filing and the trajectory negotiation processes comprise the preferred method for preparing to fly in the NAS, there will be situations and circumstances when these steps cannot be completed in advance. In such situations, operations are accommodated, commensurate with FAA policies and operational priorities.

For normal UAS flights – those that do not feature "unique" routes or performance envelope characteristics – the flight planning process is the same as for normal manned flight operations. "Unique" refers to any operation, manned or unmanned, that is not typical of those normally conducted in the airspace; for these flights, filing is encouraged at least 48 hours prior to departure to allow for a more extensive coordination effort. Many UAS operations are classified as unique due to vehicle performance envelope characteristics or flight profiles. This may necessitate additional planning and adaptation to satisfy TFM requirements. While unique profiles do not necessarily take priority over other aircraft, TFM techniques may be devised and implemented to enable unique flights without adversely affecting other aircraft operations.

Examples of unique features include:

- Performance envelope – Unusual airspeed range, climb/descent rate, turn rate/radius; for example, a speed envelope of less than 100 knots with intent to operate in Class A airspace.
- Flight profile – Anything other than transit from origin to destination, such as loitering, grid pattern, or racetrack pattern; for example, a grid pattern in Class E airspace that is normally used for point-to-point transit along published routes.

To assess whether a unique flight plan can be accommodated, ATM automation must accurately project the trajectory of the flight. For flights with unique profiles, other means may be needed to describe the route. For instances in which a flight segment cannot be described as a trajectory (e.g., a random or unplanned reactive search pattern), the relevant portion of the trajectory may be described by a volume of airspace.

Figure 8 provides examples of unique UAS operations, and how they may be represented in flight plan filing and automation.

In Case A, the unique flight is a repeatable racetrack or grid pattern. For this type of flight profile, a complete 4D flight plan is filed with the repeatable trajectory known to the automation and used for conflict detection and resolution (CD&R).

In Case B, the unique flight profile contains a segment that is undetermined as to location. For this operation, the known flight segments are filed as a partial 4D flight plan with determined entry and exit points in the search area. For the undetermined search area, the flight segment can be represented as a "volume of airspace" in which the unplanned flight movements take place.

UAS flight plan submissions may require data including:

- Contingency operations (e.g., "lost link" mitigation procedures, flight recovery in the event of system failure, procedures for loss of control) not specifically described in 14 CFR Part 91 and FAA Order 7110.65
- Candidate alternate airports or suitable landing sites along the route of flight
- Flight priority (when assigned), and the segment(s) to which such priority applies
- Unique profiles (e.g., extended duration) or limiting aircraft performance envelope characteristics
- Flight segments where delegated separation is requested.

This information is captured to the greatest extent possible during the flight planning process, becoming part of the flight object, which is then parsed for the specific trajectory data needed by ATM automation and decision support tools for managing the flight.[10]

A detailed description of flight planning and strategic traffic management of UAS operations is provided in the Flight Planning Scenario (see section 5.1).

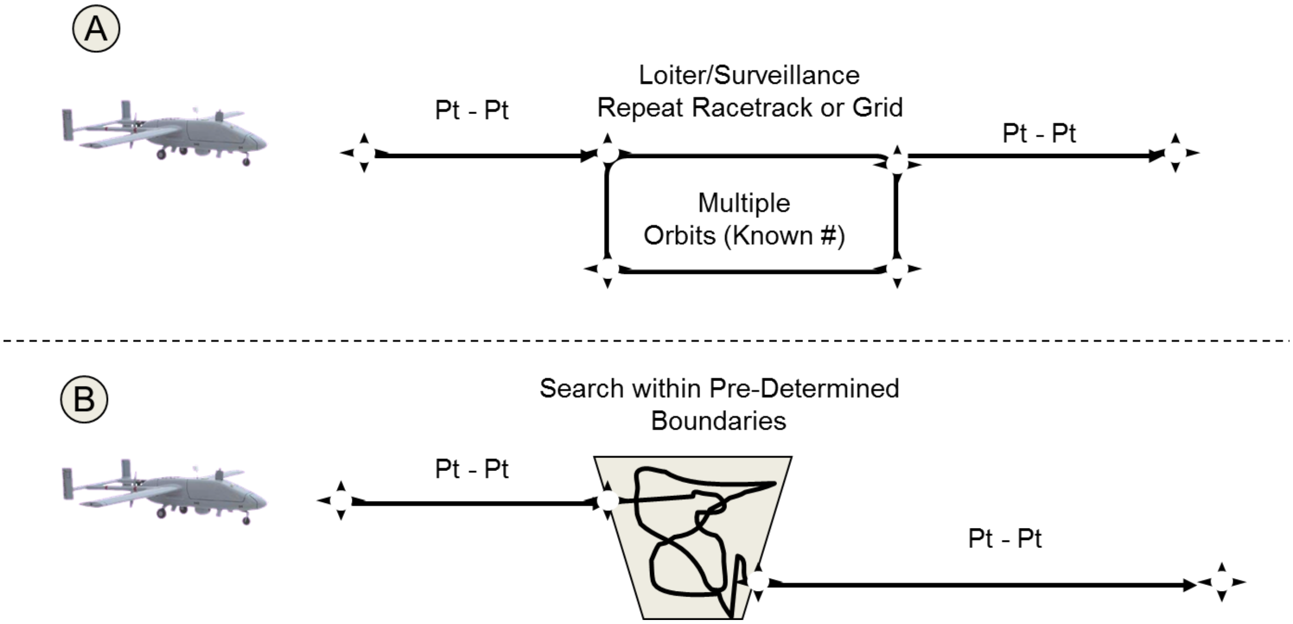

Figure 8. Methods of describing flight plans

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[10] See the Glossary of Terms for the definition of "flight object."

4.7.2 Surface

UAS surface operations may be conducted at towered airports, ranging from low to high density, non-towered airports, or any suitable landing sites consistent with the capabilities of the UAS. Common to surface movements on airports are inherent requirements that UAS flight crews are able to detect and maintain a safe distance from other aircraft, airport vehicles, and personnel, "observe" and comply with surface signage and warning lights, and avoid obstructions. This allows UAS to use common taxi routes where feasible.

Similarly, UAS flight crews must be responsive to instructions issued for lost communications or other off-nominal events on the airport surface. All aircraft, including UAS, comply with controlled departure times that result from the strategic flow management services described in Section 4.7.1.

Table 2 highlights the changes to surface operations that result from UAS integration on the airport surface.

Table 2. Airport Surface Operations Improvements

Past Practice	Change with Integration	Improvement
Surface movement of UA was generally segregated from manned aircraft.	UA and manned aircraft use common taxi routes where feasible.	Airport surface movement areas are used more efficiently. Visual observer requirements are reduced.
Surface operations required a visual observer.	Surface operations use surveillance technology (augmented as required by a visual observer) to provide sufficient imagery to safely navigate the airport surface.	

4.7.2.1 Airports with Surface Management Systems

UAS operations at high-density airports (e.g., civil cargo carriers) are limited to those UAS who can comply with all instructions and procedures in this complex environment. UAS use traditional aircraft-powered taxi techniques. Similarly, the flight crew establishes and maintains two-way radio communication with the ATC facility responsible for providing clearance delivery, ground control, and tower services. Use of data communications for purposes of clearance delivery is an option for those UAS that elect to equip. Non-visual taxi operations are limited by the flight crew and UAS capabilities. UAS operations are managed at these busy airports, as follows:

- UAS flights are integrated into surface management systems that provide timing and guidance for taxi instructions.
- Segregation of UAS operations via taxiway routing, runway assignment, or time of day may be necessary at some airports depending on runway configuration and limitations of UAS performance.

When surface management systems are scheduling runway and taxiway operations, ATC provides aircraft with instructions to meet those schedules. UAS accept taxi instructions that allow them to meet the schedules.

4.7.2.2 Other Towered Airports

UAS operations at small and mid-sized airports with a control tower are conducted in much the same manner as those for manned aircraft. Operations are conducted with direct or relayed visual reference that may include a visual observer. At these airports, controllers generally work flights into traffic on a first-come, first-served basis. Depending on the destination of the flight, the controller may delay the departure clearance until approval is granted from an upstream facility to release the departure. Taxi operations are conducted without the help of surface management systems.

The taxi route to the assigned runway requested during flight planning is confirmed or amended by ground control and considers current traffic demand and UAS taxi performance limitations. There may be “preferred” routes for UAS, and in some cases, a “preferred” runway that minimizes impact on other users and concurrently serves UAS objectives. As with manned operations, the flight crew maintains two-way radio communication with ground control during taxi.

The PIC taxis the UA to the active runway (including hover-taxi for rotorcraft) in accordance with ATC instructions, including yielding to other traffic, holding short of active runways, and other specific instructions that reference aircraft or vehicles. Transport via methods other than self-taxi is authorized by exception.

UAS use airport markings and signage to determine their location and navigate on the airport surface. On takeoff and landing, ATC and PICs have a shared responsibility to ensure that the runway is clear of traffic, and there are no conflicting aircraft on final approach.

An example of surface operations at a towered airport is given in the Surface Scenario (see section 5.2).

4.7.2.3 Non-Towered Airports

Non-towered airports do not have ATC to manage movement on the surface. Aircraft are responsible for their own taxi, takeoff, and landing. IFR flight plans are activated prior to departure, and closed following the arrival. ATC provides specific departure instructions at the time the flight plan is activated.

During taxi, the PIC observes and reacts appropriately to signage and lighting, other aircraft, ground vehicles, obstructions, and wildlife. Any method of transport across the surface, including alternatives to self-taxi, may be used, as long as it is agreeable to the airport manager. UAS taxi performance limitations may dictate assignment to specific taxi routes or taxiways.

Responsibility for maintaining safe distances from other aircraft and vehicles rests collectively with the PICs of all aircraft in the vicinity. Taxi intervals are the responsibility of the PIC, and take into consideration other aircraft ahead on the same taxiway, or aircraft transiting through taxiway intersections.

Before taxiing onto the active runway, the flight crew is responsible for ensuring that both the runway and approach path are clear of traffic.

If extra time on the runway is necessary during takeoff and landing, due to non-traditional launch and recovery techniques, UAS operators notify ATC in advance.

4.7.2.4 Suitable Operating Sites

Just as rotorcraft have procedures for landing at a suitable operating site, some UAS operations lend themselves to landing and take-off locations away from conventional airports. These sites have the advantage of avoiding the integration issues with other traffic on the airport surface, and should be considered when operationally suitable to the UAS operator and consistent with UAS take-off and landing characteristics.

4.7.3 Class A

ATC is responsible for providing separation between all aircraft. ADS-B (Out) is mandatory for all aircraft in Class A airspace. With the majority of aircraft capable of RNAV, both manned and unmanned aircraft benefit from greater flexibility available through both published routes and non-restrictive routing options.

Many UA operations in Class A airspace are point-to-point flights, with aircraft whose performance characteristics and PBN flight management capabilities are similar to manned aircraft. Since all aircraft in this airspace are on IFR flight plans and are receiving ATC separation services, the UAS PIC should not have to perform a self-separation maneuver (analogous to remain well clear). However, the PIC may request such maneuvers in response to the Sense and Avoid capability recommendations, which may be approved or modified by ATC. The UAS has an active collision avoidance capability.

Some UAS operations use this airspace for purposes such as environmental monitoring that involve loitering or flying grid patterns while remaining in a volume of airspace, to include changing altitudes within that volume. In situations wherein ATM automation is unable to process these unique trajectories, ATC may temporarily "assign" a block of airspace to the UA, and accommodate the UA for that flight segment, vectoring other participant traffic to avoid that airspace.

UA performance characteristics (e.g. airspeed and turn rates) are contained in ATM automation in order to generate an accurate 4D trajectory. If a UAS PIC determines that there is weather in which the aircraft cannot operate, ATC is contacted to request changes in the 4D trajectory. ATC uses decision support tools to determine if the request can be accommodated, and approves or modifies the request. When the request is modified, the UAS PIC re-evaluates the new 4D trajectory and determines if it is consistent with the mission objective and UAS performance, and accepts the clearance or makes a modified request.

ATC issues instructions through voice and/or data communications to appropriately equipped aircraft. Data communications can be used between ATC and the UAS for negotiating adjustments to the 4D trajectory. Reroutes from ATM are communicated to the UAS PIC via the controller.

Decision support tools are adapted to account for the flight characteristics of the UA. CD&R automation notifies ATC of conflicts that have been detected and presents rank-ordered resolutions, which the controller chooses from and provides to the appropriate PIC.

Table 3 highlights the changes to Class A operations that result from UAS integration.

Table 3. Class A Operations Improvements

Past Practice	Change with Integration	Improvements
COA/special airworthiness approval processes were used to accommodate UAS operations.	UAS operators meet performance and equipage requirements established for airspace with IFR-only operations, to include high performance airspace and associated routes.	ATC provides services to UAS and manned aircraft based on common performance and equipage criteria.
NAS automation did not contain UA performance envelope characteristics.	En route automation incorporates UA performance envelope characteristics into flight data processing, trajectory analysis, and conflict detection and resolution analysis.	Improved information about and knowledge of UA performance limitations reduces ATC workload and requires less disruptive trajectory changes to manage traffic flows and maintain separation.

Time-based flow management (TBFM) is used to space and sequence aircraft into a constrained airport or merge point. ATC issues instructions to meet TBFM requirements. When the UAS is flying to a location where TBFM is being used to sequence and space aircraft, the UAS follows all instructions to meet the required delays.

Domestic RVSM reduces required vertical separation from 2,000 feet to 1,000 feet in designated airspace between Flight Level (FL)290 and FL410, and requires aircraft to carry specially qualified altimeters and navigation equipment. UAS operators that are not RVSM compliant must obtain authorization from ATC to use RVSM airspace, even if the planned operation includes only a transit through the designated airspace.

Examples of Class A operations are given in the Loiter for Surveillance Scenario (in section 5.3) and the Vertical Transit Scenario (section 5.4).[11]

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[11] "Vertical Transit" refers to a flight profile and is defined in the Glossary of Terms. While not a term normally used by ATC, it will become familiar as more UAS operations are integrated into the NAS.

4.7.4 Class B

UAS that meet the airspace-specific performance and equipment requirements of 14 CFR Part 91 may be granted access to Class B airspace. Unique UAS flight profiles through Class B airspace are assessed through the flight planning process for impact to overall operations. UAS communications latency meets the timely response requirements for this high-density airspace. ADS-B (Out) is required for all aircraft in Class B airspace.

ATC is responsible for providing separation to all aircraft in Class B airspace. Separation minima between IFR aircraft, whether in IMC or VMC, are generally 3 miles laterally or 1,000 feet vertically, although situations may arise in VMC in which different minima may be applied. The separation minima generally used for IFR-to-VFR and VFR-to-VFR is 1.5 miles laterally or 500 feet vertically. The UA Sense and Avoid capability may not be able to determine whether another aircraft is operating IFR or VFR. The PIC considers these multiple separation criteria in selecting appropriate Sense and Avoid parameters to support maneuvering in response to system recommendations.

Since all aircraft in this airspace are receiving ATC separation services, the UAS PIC should not have to perform a self-separation maneuver (analogous to remain well clear). However, the PIC may request such maneuvers in response to the Sense and Avoid capability recommendations, which may be approved or modified by ATC. The UAS has an active collision avoidance capability.

Among the most challenging aspects of UAS operations in Class B airspace is departing and arriving at high-density airports during VMC weather. ATC typically issues visual clearances for IFR aircraft to maximize airport throughput and efficiency. For UAS, other methods supported by emerging technologies that function similar to those enabled by visual means are used to approach VMC-level throughput (e.g., flight deck interval management techniques) in the airspace.

RNAV arrival and departure routes and optimized profile descents (OPDs) are used to manage flows into and out of airports within Class B airspace. UAS file routes through the arrival/departure airspace that are compatible with these routes. UAS operating in integrated arrival/departure airspace around major metropolitan areas are able to comply with assigned routes and follow predefined procedures, to include those issued for a missed approach. Transitioning aircraft maneuver through the Class B airspace on overflight routes that are separated from arrival and departure routes. ATC sequences aircraft on the routes and applies wake turbulence separation, specific to UA, if appropriate.

Table 4 highlights the changes to Class B operations that result from UAS integration.

Table 4. Class B Operations Improvements

Past Practice	Change with Integration	Improvements
COA/special airworthiness approval processes were used to accommodate UAS operations.	UAS operators meet performance and equipage requirements for operating in high-density terminal airspace without disrupting operation of manned aircraft.	ATC provides services to UAS and manned aircraft based on common performance and equipage criteria, including the ability to comply with performance-based operational procedures (e.g., flight deck interval management).
UAS had limited access to Class B airspace.	UAS may operate in high-density Class B airspace.	UAS have access to high-density airspace and associated airports.

UAS that are appropriately equipped can perform paired procedures and accept merging and spacing instructions. Aircraft with data communications capabilities exchange 4D trajectories and are handed off automatically. Those with PBN capability fly routes consistent with the prescribed level of navigational performance for the airspace or route; appropriately equipped UAS are able to fly high-precision approaches, to include those supported by augmented GPS signals (ground- or space-based). UAS performance and flight priorities by segment are considered by the automation. UAS pilot/operator preferences are also considered.

Many large airports within Class B airspace apply constraints to UAS arrival and departure operations, and selective segregation by runway assignment and arrival time is described in section 4.7.2.1.

Although UAS operations at major airports may be limited, smaller airports exist within the same airspace. Therefore, specific procedures and equipment for entering, exiting, and transiting Class B airspace may be required for UAS that intend to operate within these areas.

UAS are capable of transitioning from an instrument approach procedure to a safe landing, either by visual reference of a flight crewmember at the airport or other means suitable to the UAS. These fundamental requirements extend to all airport operations, including those discussed in subsequent sections.

An example of a transition through Class B is given in the Grid Pattern Scenario (section 5.5). An example of a UA arriving at a high-density airport in Class B airspace is given in the Oceanic Point-to-Point scenario (section 5.8).

4.7.5 Class C and D

Manned aircraft flying in Class C and D airspace can be either IFR or VFR, while UAS operate under IFR only. Most traffic departs from or arrives at primary airports. However, the airspace can also be used by aircraft arriving and departing other airports underneath the airspace, as well as other aircraft transiting through the airspace. Separation is managed by ATC typically without the use of CD&R tools.

In Class C airspace, ATC is responsible for separating IFR traffic, including all UA, from all other traffic. ATC is not responsible for separating VFR from VFR. All aircraft maintain two-way communication with ATC and are equipped with ADS-B (Out). In Class D airspace, ATC is responsible for separating IFR traffic only from other IFR. The UAS flight crew uses its Sense and Avoid capability to provide safe separation from VFR aircraft within these classes of airspace in accordance with an approved airborne separation standard, but requires ATC approval if deviating from an ATC clearance. The UAS has an active collision avoidance capability.

Integrating UAS operations into Class C and D airport traffic patterns is a significant change from past practices. The most significant challenges to integrating UAS operations in these airspace classes is the mix of IFR and VFR traffic, variations in aircraft equipage and performance, and a less-structured airport operating environment.

ATC cannot provide traditional visual instructions (e.g. reporting traffic in sight, following identified traffic) or use traditional airport traffic pattern techniques (extending the downwind leg or making a short approach) to manage UAS traffic. However, procedures developed to make use of emerging technologies may provide UAS with capabilities similar to those used in response to visual clearances and thereby improve UAS access to more towered airports.

ATC clears aircraft to fly established arrival and departure routes sequenced with other aircraft on those routes. UAS are capable of following published arrival and departure routes, control instructions, and missed approach procedures. ATC applies wake turbulence separation, specific to UAS, if appropriate.

An example of Class C arrival and departure operations is given in the Loiter for Surveillance Scenario (section 5.3). An example of Class D departure operations is given in the Point-to-Point Scenario (section 5.6).

Table 5 highlights the changes to Class C and D operations that result from UAS integration.

Table 5. Class C and D Operations Improvements

Past Practice	Change with Integration	Improvements
COA/special airworthiness approval processes were used to accommodate UAS operations.	UAS operators meet aircraft performance and equipage requirements established for operations near towered airports.	ATC provides services to UAS and manned aircraft based on common performance and equipage criteria, including the ability to comply with clearances enabled by emerging technologies and new operating rules.
UAS terminal operations were segregated from manned operations.	UAS are integrated into terminal sequencing of operations.	UAS have access to more towered airports.
UAS arrivals and departures occurred at towered civil airports by exception.	UAS may land and depart from towered civil airports.	
UAS were not routinely supported by a Sense and Avoid capability.	UAS flight crews use Sense and Avoid capability to support mixed equipage operations in a terminal environment.	

4.7.6 Class E (below Class A)

Manned aircraft operations in Class E airspace can be IFR or VFR, while UAS operate under IFR only. ATC provides separation services for IFR traffic, including all UA. The UAS flight crew uses the Sense and Avoid capability to provide self-separation from VFR aircraft (analogous to remaining well clear) in accordance with an approved airborne separation standard, but requires ATC approval if deviating from an ATC clearance. The UAS has an active collision avoidance capability.

UAS flight crews fly the cleared route and follow all ATC instructions, including transfer of communications. ATC uses CD&R tools to assist in identifying potential conflicts for all known flight trajectories. When ATC determines that a course change is required to maintain separation, the controller issues an instruction to the aircraft.

Table 6 highlights the changes to Class E operations that result from UAS integration.

Table 6. Class E Operations Improvements

Past Practice	Change with Integration	Improvements
COA/special airworthiness approval processes were used to accommodate UAS operations.	UAS operators meet performance and equipage requirements for operations at non-towered airports.	UAS use operating rules and procedures supported by emerging technologies to maintain flexibility and efficiency similar to visual operations, leading to better use of the available capacity of this airspace.
NAS automation did not contain UA performance envelope characteristics.	En route automation incorporates UA performance envelope characteristics into flight data processing, trajectory analysis, and conflict detection and resolution analysis.	Improved information about and knowledge of UA performance limitations reduces ATC workload and requires less disruptive trajectory changes to manage traffic flows and maintain separation.
UAS were not equipped with a Sense and Avoid capability.	UAS flight crews use Sense and Avoid capability to support mixed equipage operations in a complex environment.	Sense and Avoid capability provides for integrated UAS operations while preserving safety of the NAS in a complex mixed IFR and VFR environment.

All aircraft, including UAS, comply with ATC instructions for maneuvers or changes to the approved route of flight. Route changes may be exchanged via voice or data communications for appropriately equipped aircraft. ATC provides additional separation that may be required to mitigate wake turbulence to which UA are susceptible.

Maneuvers that were not planned during pre-flight require real-time coordination with ATC. The amount of coordination varies according to the size and complexity of the affected airspace, and anticipated traffic demand. In such instances when a clearly defined description of the flight trajectory is not possible, ATC may elect to exclude other IFR traffic from the airspace volume in which the unplanned operation is occurring. ATC uses the tools available to evaluate the unplanned maneuvers and provides acceptance, rejection, or modification of the maneuvers depending on the priority of the mission.

ATC provides separation services for manned and unmanned IFR arrivals and departures to non-towered airports in Class E airspace using “one-in, one-out” procedures. ATC may offer to delegate separation responsibility to the UAS PIC, who may accept that delegation or not. In choosing to accept delegation, the PIC assumes responsibility for safe separation from all other aircraft in the vicinity, or from a specific aircraft as assigned by ATC, using the Sense and Avoid capability.

For departures, ATC issues IFR clearances to aircraft on the ground prior to takeoff. The UAS departs within a prescribed window of time following the issue of the clearance. Once airborne, the UAS logs into data communications service for that airspace, if so equipped, and contacts ATC via data communications or voice, as appropriate for that airspace. The ATM automation detects the UAS position and updates 4D trajectories based on the actual departure time.

For arrivals, ATC clears the aircraft for the approach.[12] UAS are equipped for one or more published approaches into the airport, including RNAV with vertical guidance, when applicable. While executing the approach, ATC generally terminates radar service prior to the aircraft reaching the final approach fix. When operating near the airport, UAS communicate intent to other airport traffic through standard communications on the airport common traffic advisory frequency (CTAF). UAS also receive intent information from other aircraft through the same communications channel. The UAS flight crew provides self-separation from VFR aircraft (analogous to remaining well clear) operating in the terminal area. Once the UAS flight crew determines the runway is clear of traffic, the aircraft lands. Closing of the IFR flight plan is accomplished over a communications link with ATC or the flight service station serving that airport.

One of the most significant operational challenges to the UAS in the class of airspace is the requirement to comply with established arrival and departure traffic patterns and procedures for the airport. This involves obtaining information typically gathered with visual cues to perform the routine flight activities at these non-towered airports consistent with the applicable CFR part for operations near a Class E airport. This information includes, but is not limited to:

- Determining the active runway
- Assessing winds against UAS landing and takeoff limitations
- Acquiring the landing airport/runway to execute a straight-in landing or circle the field to land
- Maintaining safe distances from other aircraft in the airport traffic area, and aircraft and vehicles on the airport surface
- Joining the traffic pattern and sequencing with other aircraft in the airport traffic area.

The PIC is responsible for detecting and avoiding obstacles and terrain in VMC.

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[12] While CFR Part 91 provides for the possibility of a manned control tower at an airport within Class E airspace, such situations are rare in practice. In such instances, however, UAS meet equipage requirements for Class E airspace, but comply with operations as described under Class D airspace, section 4.7.5.

Examples of Class E arrival operations are given in the Point-to-Point Scenario (section 5.6), the Grid Pattern Scenario (section 5.5), and the Vertical Transit Scenario (section 5.4). Examples of Class E departure operations are given in the Vertical Transit Scenario (section 5.4) and the Grid Pattern Scenario (section 5.5). Examples of Class E en route operations are in the Grid Pattern Scenario (section 5.5), the Point-to-Point Scenario (section 5.6), and the Loiter for Surveillance Scenario (section 5.3). An example of en route high altitude operation (above FL600) is given in the Vertical Transit Scenario (section 5.4).

4.7.7 Class E (above Class A)

Manned aircraft operations in Class E above Class A can be conducted under either IFR or VFR rules, while UAS operate under IFR only. Although there are few airspace requirements, UA operating in this airspace have the equipment and navigation performance capability necessary for transitioning through Class A. They are capable of flying 4D trajectories that are negotiated to avoid high-density areas while in transit due to any widely varying UA performance characteristics (see Section 4.7.3 - Class A).

The UAS flight crew uses the Sense and Avoid capability to provide self-separation from VFR aircraft (analogous to remaining well clear) within this class of airspace, but requires ATC approval if deviating from an ATC clearance. The UAS retains an active collision avoidance capability.

One of the most challenging aspects of UAS operations in this airspace class is applying different separation minima established for the airspace. For example, IFR aircraft are vertically separated by 2,000 feet, with some exceptions:

- If the operations are in Oceanic Class E above Class A airspace and one or both aircraft are supersonic, the vertical minimum is 4,000 feet.
- If one or both aircraft are military, the vertical minimum is 5,000 feet.

The UA Sense and Avoid capability may not be able to determine whether a specific aircraft encounter is IFR or VFR, or the aircraft type. The PIC must consider these differences before determining an appropriate separation standard, and when evaluating a self-separation maneuver recommendation.

Table 7 highlights the changes to Class E above Class A operations that result from UAS integration.

Table 7. Class E above Class A Operations Improvements

Past Practice	Change with Integration	Improvements
COA/special airworthiness approval processes were used to accommodate UAS operations.	UAS meet performance and equipage requirements for the airspace, for mixed IFR and VFR operations.	UAS use operating rules and procedures supported by emerging technologies to maintain flexibility and efficiency similar to visual operations, leading to better use of the available capacity of this airspace.
NAS automation did not contain UA performance envelope characteristics.	En route automation incorporates UA performance envelope characteristics into flight data processing, trajectory analysis, and conflict detection and resolution analysis.	Improved information about and knowledge of UA performance limitations reduces ATC workload and requires less disruptive trajectory changes to manage traffic flows and maintain separation.
UAS were not equipped with a Sense and Avoid capability.	UAS flight crews use Sense and Avoid capability to support operations in an environment with large variations in aircraft performance envelopes.	Sense and Avoid capability supports additional aircraft operations at these altitudes, while preserving safety in the NAS.

ATC continues to provide separation services using radar, where available. Where radar surveillance is not available, ATC uses procedural separation techniques (course divergence, time over fixes). UAS report their position using either air-to-ground communications through the aircraft, or ground-to-ground communications directly between the control station and ATC.

The mix of manned and unmanned aircraft and their often disparate performance characteristics need to be taken into account within this airspace, to include wake turbulence considerations for very light aircraft. CD&R algorithms in en route automation account for this variability in aircraft performance.

The variability in aircraft performance characteristics has implications on the UAS capability to provide safe separation from other aircraft in the vicinity. UAS must account not only for limitations of speed, turn, and climb performance of the UA, but also for characteristics of other participant aircraft such as supersonic speeds, aircraft with unusual profiles (e.g., balloons), or unusual flight paths (e.g., aerial space launch).

Thus, the requirement for the UAS flight crew to provide safe separation from other traffic may be more complex compared to operations in other airspace classes. Finally, the UAS technologies used to meet "sense and avoid" requirements may ultimately extend to manned aircraft in instances wherein the requirements of 14 CFR Part 91 become increasingly difficult to achieve using visual cues.

UAS operations above Class A airspace may be significantly longer in duration than those at lower altitudes (aircraft that are optimized for endurance over speed). En route automation handles flight plans and trajectories for the full duration of these extended missions. In the course of an extended duration operation, PIC-to-PIC transfers of responsibility are seamless and transparent to ATC, and ensure continuity of the PIC function. As with operations in all airspace, UAS with unique performance envelopes and/or flight profiles are encouraged to file flight plans early.

4.7.8 Class G

ATC services in Class G (uncontrolled) airspace are limited and identical to the same type of services offered to manned aircraft. Title 14 CFR Part 91 and other applicable rules for the airspace continue to apply, including meeting the operational requirements for integration. ATC may delegate separation responsibility to the UAS PIC, which can occur during flight planning, which the PIC may either accept or not. Where such delegation of responsibility is accepted, the PIC uses the capabilities of Sense and Avoid for safe separation from all aircraft in the vicinity, or from a specific aircraft as assigned by ATC.

UAS have position reporting requirements when procedure-based separation services are provided, similar to those for manned aircraft operating IFR. The UAS flight crew provides self-separation from VFR aircraft (analogous to remaining well clear). The UAS has an active collision avoidance capability. Maintaining safe distances from terrain, obstacles, and clouds is also required where applicable. The UAS flight crew must also be able to obtain information typically gathered from visual cues to perform the routine flight activities at non-towered airports. These include, but are not limited to:

- Determining the active runway
- Assessing winds against landing and takeoff limitations
- Acquiring the landing airport/runway to execute a straight-in landing or circle the field to land
- Maintaining safe distances from other aircraft in the airport traffic area, and aircraft and vehicles on the airport surface
- Joining the traffic pattern and sequencing with other aircraft in the airport traffic area.

ATC may clear UAS operating in Class G airspace to enter adjacent controlled airspace, provided the equipage and reporting requirements can be satisfied for that airspace class.

Table 8 highlights the changes to Class G operations that result from UAS integration.

Table 8. Class G Operations Improvements

Past Practice	Change with Integration	Improvements
COA/special airworthiness approval processes were used to accommodate UAS operations.	UAS operators meet performance and equipage requirements for operating in uncontrolled airspace.	UAS use operating rules and procedures supported by emerging technologies to maintain flexibility and efficiency similar to visual operations.
UAS were not equipped with a Sense and Avoid capability.	Sense and Avoid capability allows UAS flight crews to provide safe separation (analogous to remaining well clear) from other aircraft.	In the absence of ATC separation services, UAS use Sense and Avoid capability in uncontrolled airspace, preserving NAS safety.

4.7.9 Oceanic Operations

Manned aircraft flying in Oceanic flight information regions (FIRs) can be IFR, VFR, or DVFR, while UAS operate under IFR only. The International Civil Aviation organization (ICAO) delegates oceanic control responsibility over much of the North Atlantic and the Pacific to the FAA. ATC provides procedural separation for IFR traffic. Oceanic airspace consists of Classes A, E, and G, and appropriate equipage and communications requirements apply.

UAS operators file ICAO flight plans with the appropriate ANSPs. Flight plans are shared between US and international ATM automation systems. In addition, appropriate manifests are filed as required by international law (e.g. crew, passenger, cargo).

Separation standards in Oceanic Class A airspace are based on the available CNS capabilities for the airspace. Since all aircraft in this airspace are on IFR flight plans and are receiving ATC separation services, instances requiring the UAS to initiate a self-separation maneuver (analogous to remain well clear) do not occur. However, as with manned aircraft, PIC requests for trajectory changes are approved or disapproved by ATC. Within Oceanic Classes E and G airspace, the UAS flight crew provides self-separation from VFR aircraft, but requires ATC approval if deviating from an ATC clearance. The UAS has an active collision avoidance capability.

Table 9 highlights the changes to Oceanic operations that result from UAS integration.

Table 9. Oceanic Operations Improvements

Past Practice	Change with Integration	Improvements
COA/special airworthiness approval processes were used to accommodate UAS operations.	UAS meet ICAO performance and equipage requirements established for all airspace classes within oceanic airspace.	ANSP provides services to UAS and manned aircraft based on common performance and equipage criteria, reducing ATC workload.
UAS communicate by telephone to ATC oceanic control centers to make position reports.	UAS use ground-to-ground and data methods of communicating with ATC in addition to voice.	UAS have continuous communication connectivity with ANSP for the entire flight.

Communications with ATC may be performed via data link, voice (HF radio), or through a ground-to-ground network from the control station. When voice communication methods are used, communications are routed to ATC through a third-party service provider and meet communications latency requirements established specifically for UAS.

Navigation is conducted using the Global Navigation Satellite System (GNSS) to performance standards (RNP) prescribed for the airspace.

During overseas transit flights, UAS may require a transfer of the PIC responsibility from an overseas to a domestic location. These changes are seamless and transparent to ATC, and ensure continuity of the PIC position. Individual UAS operators may constrain the timing of PIC transfers (such as during high crew workload), as prescribed in individual operator's standard operating procedures.

The UAS Sense and Avoid capability may provide for the possibility that "state" aircraft are able to exercise "due regard" in accordance with internationally approved (ICAO) standards and recommended practices.

4.8 Contingency Operations

UAS design standards and approval processes ensure that the likelihood of loss of critical functions is acceptably low. If a UAS failure or uncontrollable environmental event that degrades UAS operations does occur, however, a contingency operation goes into effect. The goal of any UAS contingency operation is to preserve NAS safety and efficiency.

UAS operators develop contingency responses based upon established FAA guidelines and pre-defined procedures as part of the approval process, consistent with operational requirements.

UAS operators develop contingency responses based upon established FAA guidelines and pre-defined procedures as part of the approval process, consistent with operational requirements. UAS operators provide the contingency information and procedures during flight planning, which are then accessible to ATC through automation and associated decision support tools. Contingency responses may apply uniformly for the entire flight trajectory, or may change for each discrete flight segment.

Regardless of the reason for the contingency operation, the UAS response is known, predictable, and benign to the greatest extent possible in its impact to ATC and other air traffic.

The UAS contingency operations described in this section address the loss of certain aspects of UAS functionality, including the control link, communications link, and Sense and Avoid capability. Contingency operations for other sub-system failures – engine failure, for example – are contained in operating manuals for each type of UAS.

4.8.1 Loss of Communications Links

If the control link or communications link is interrupted or lost completely, the UA executes a known and predictable response. PIC and ATC training ensures that UAS contingent responses are executed at the appropriate time and that both the PIC and ATC can predict the UA flight trajectory. For specific missions, pre-briefs between the UAS PIC and ATC may also be necessary.

4.8.1.1 Loss of Control Link

The UAS alerts the PIC when the link used to control the UA has been lost. If the duration of the control link loss exceeds established requirements (e.g., for class of airspace, phase of flight, proximity to other aircraft), the contingency is communicated to ATC, either by the PIC or automatically by the UA, and the flight trajectory reverts to the pre-coordinated contingency trajectory. If appropriate control link connectivity is restored, the PIC requests and receives a revised ATC clearance before the UAS flight trajectory is changed from the contingency trajectory to the desired trajectory.

4.8.1.2 Loss of Communications Link to ATC

The UAS alerts the PIC when the communications link used to provide two-way communications between the UAS and ATC has been lost. If the duration of the communications loss exceeds requirements for the current class of airspace, the PIC establishes an alternate communications method with ATC.

If the PIC cannot establish alternate communications, the PIC ensures that the UA flies its pre-coordinated contingency trajectory and squawks the appropriate transponder code. If the PIC establishes satisfactory alternate communications, ATC may allow the UA to continue on its original route.

If ATC considers the alternate communications method insufficient to continue normal operations, ATC and the PIC coordinate an alternate trajectory, which may either be the pre-coordinated contingency trajectory, or another trajectory required by ATC due to airspace and workload requirements.

4.8.2 Loss of Sense and Avoid Function

Sense and Avoid is a safety-critical function with minimum performance requirements for each class of airspace. When either a total loss or loss of required performance occurs, the PIC immediately notifies ATC. A new route may be negotiated between ATC and the PIC that represents minimal risk to other traffic. If a degraded Sense and Avoid function is still available, it continues to augment safety while flying the new route.

4.8.3 Other Contingencies

Like any other aircraft, UAS experience other system failures or environmental effects. Coordination with ATC, when required, is conducted in the same manner as for manned aircraft. Actual responses, however, may be very different. For example, a flight termination in a controlled manner (over unpopulated areas) may be a prudent response to a particular UAS system failure, but would be unacceptable for manned aircraft.

4.9 Enterprise Services and Infrastructure

Enterprise services address the contributions of UAS safety, security, and environmental performance to overall agency goals. UAS operators are full participants in achieving these objectives.

4.9.1 Safety

Safety programs in general, and those specific to UAS, evolve from reactive data analysis to predictive safety risk evaluation and mitigation. Aviation information exchanges enable operators to perform focused inquiries and search an extensive warehouse of safety data. Decision support tools identify trends from historical data that facilitate the planning of appropriate actions and procedures to increase safety. This helps ensure that all NAS systems, including UAS, continually contribute to safety and hazard risk reduction.

UAS operators participate in the FAA National Aviation Safety Strategic Plan to promote this continuous improvement in system safety. UAS operators and pilots support the Safety Management System (SMS) process, fostering widespread sharing of safety-related data and information. Such data sharing is particularly important during the early stages of NAS integration.

4.9.2 Security

Physical security of UAS assets – control stations, communications link hardware – is an important concern, and is therefore certified in a manner similar to other aircraft. Similarly, compliance with information system security (ISS) requirements protects the confidentiality, integrity, and availability of information systems and the processing, storage, and transmission of information by UAS in the same manner as manned aircraft. The UAS control link is certified to be secure from unauthorized use. Control communications occur within a frequency spectrum that is reserved for UAS operations.

Airports will evaluate site-specific security issues and any new practices or regulations needed to preserve airport security while integrating UAS into surface movements and arrival/departure operations.

4.9.3 Environmental Impact

UAS development and integration into the NAS may serve as a research platform to advance engine design and other aircraft technologies. For example, long endurance flights using solar power offer the potential to explore alternatives to petroleum-based energy sources in aviation. For some operations that are assumed by unmanned aircraft, the NAS experiences a reduction in overall fuel consumption, noise, emissions, and overall environmental impact. However, changes in UAS operation in loiter time and flight altitude, relative to manned operations that would be replaced, and the potential for increased overall aircraft operations (UAS plus manned aircraft) could result in increased noise and emissions. Regulatory requirements contained in 14 CFR (or modified as appropriate) that define specific environmental certification standards for noise and emissions apply to UAS aircraft and engines.

4.9.4 UAS Maintenance

Unmanned aircraft system maintenance – including established maintenance intervals, inspection requirements, recordkeeping, and technician qualifications – becomes part of the aircraft certification process, as it is for manned aircraft.

4.9.5 ANSP Training

ATC and TFM personnel receive training on integrating and managing UAS operations. This includes UAS-specific topics, such as the range of UA performance envelope characteristics, typical operational profiles, communications latency, contingency procedures (e.g., lost link), and automation support tools. In addition to an appropriate module during entry level training at the FAA Academy, UAS training may include daily briefings or sessions tailored to specific controller positions and traffic characteristics at each ATC facility.

ATC facilities may create site-specific training materials tailored to specific UAS operations in their airspace. Refresher training occurs as the NAS integrates new UAS capabilities and operational types.

4.9.6 UAS Crew Training and Qualification

As with manned aircraft, the path to flight crew qualification includes not only a practical demonstration of skills appropriate to the crew position, but also knowledge of the UAS flying qualities and its systems, navigation and communications requirements for the airspace, and emergency procedures. Additionally, the PIC and all crewmembers maintain valid medical certificates issued under 14 CFR Part 67. An understanding of ATC phraseology and FARs for the airspace is also required for the PIC.

Requirements for a pilot certificate depend on a variety of factors such as the type of operation, whether or not the operation is conducted within or beyond visual line-of-sight, location of the planned operations, flight profile, and size of the UA. In all instances, the PIC must be familiar with accident and incident reporting requirements.

New training and qualification may be needed if a new crewmember position is required, such as a dedicated person supporting safe separation of the UAS from other traffic using the Sense and Avoid function.

5 Operational Scenarios

This section contains a set of scenarios that illustrates some of the integrated UAS operations described in the Section 4 narrative. The scenarios include a variety of UAS performance envelope characteristics and operations, as well as airspace environments.

The Flight Planning scenario is a NextGen Mid-Term Scenario (available on the NAS Enterprise Architecture website) modified to be applicable to both manned and unmanned aircraft operations. The Surface Operations and Search Pattern in Class G scenarios are derived specifically from this ConOps narrative. The remainder of the scenarios are based on the Operational Services and Environmental Definition (OSED) scenarios developed by RTCA, but modified to include ATM operations and interactions with UAS in each class of airspace.

Table 10 shows a high-level summary of each scenario.

Specific procedures, technologies, and techniques are described in scenarios as potential solutions for accomplishing an operational need. These solutions are examples only, used to augment the scenario descriptions.

Each scenario has the following format:

- Overview: The overview provides a description of the flight, including the purpose of the operations and the type of aircraft. A map shows the airspace where the flight is to take place.
- UAS Description: The UAS description contains a brief description of the UA, including a photo of a representative UA, and includes a table specifying the performance envelope characteristics of the UA.
- Description of the UAS scenario: The remainder of the scenario is a description of the activities that take place during the flight, with an emphasis on the UAS/ATM interaction.

Table 10. Summary of Scenarios

Scenario Name	Airspace or Airport	Purpose	Aircraft	Highlights
Flight Planning	All	N/A	All	Negotiation of flight plan and 4D trajectory prior to departure and updates during flight. Description of prioritization and access equity decisions.
Surface Operations	Airport in Class C or Class D	N/A	All	Ground movement on towered airports. Interaction with other traffic and ATC on the surface.
Loiter for Surveillance	Class C arrival/ departure, aerial work in Class A, E	Border patrol	Predator-B	Planned maneuver on 4D trajectory and unplanned maneuver. Negotiated delay in return to airport. Go-around.
Vertical Transit and Operations Above Class A	Class A, Class E high altitude	Environmental sensing	HALE	Slow transition through Class A. Long-endurance above FL600. Encounter with supersonic traffic and ATC separation assurance.
Grid Pattern	Class E with Class B transition	Monitor coal plant air emissions	Aerosonde	Class B transition, operations in Class E. 4D trajectory operations. Early termination for weather.
Point-to-Point	Class D departure, Class E en route and arrival	Cargo delivery	Cessna Caravan	ATM weather reroute and pilot weather deviation.
Oceanic Point-to-Point	Class A oceanic, Class B arrival	International cargo	B747	Oceanic high altitude point-to-point operations. In-trail climb procedure. High-density airspace operations to include OPD/CDA.
Maneuvering in High-Density Airspace	Class D departure, Class B aerial work	Media and traffic reporting	Fire Scout helicopter	Transit between pre-determined major highway intersections. Loitering operations. Delegated separation.
Search Pattern	Class G	Search and rescue	Scan Eagle	Search operations in Class G airspace. Delegated separation.

5.1 Flight Planning

5.1.1 Overview

UAS will be able to file flight plans and fly, much as their manned counterparts, in the targeted timeframe. However, some UAS operations and flight characteristics differ widely from normal operations conducted within a corresponding piece of airspace. UAS that fly these unique operations are encouraged to file their intent further in advance to allow for coordination that is more extensive. They file an *early intent* of the anticipated flight operation at least 48 hours in advance of the anticipated departure time. This *early intent* information provides ATM with a high-level overview of what to expect in the actual flight plan. As time progresses, the flight plan becomes more detailed until fully completed prior to departure. During this time, the Flight Operations Center (FOC) and ATM collaborate to allow for updates to the 4D flight plan that ensure the UAS flight does not negatively impact the NAS.

5.1.2 Scenario Description

This scenario applies to any UAS filing an IFR flight plan.

The FOC of a unique flight files the early intent of the flight 48 hours in advance. This filing process results in an initial 4D flight plan (Figure 9) and satisfies the requirement for the ATM system to know where the UA intends to operate, and any pre-determined priority that has been agreed upon by the operator and the FAA. ATM automation assesses the impact of the flight on the NAS and determines that an ATC clearance and separation services will be required for part of the flight.

TFM evaluates any traffic flow impact and/or potential conflicts, and determines whether policy and guidance regarding prioritization and equity of access needs to be applied (beyond that which was pre-determined). During the trajectory negotiation process, it is determined that a segment of the operation requires a prioritization or equity decision. ATM automation evaluates the aggregate demand for services considering all traffic and aids the TFM specialist in determining what level of priority should be assigned to that segment. The TFM specialist enters the resultant priority level of the flight segment into automation as part of the flight object. That initial flight object becomes the basic information within the iterative trajectory negotiation phase of flight planning.

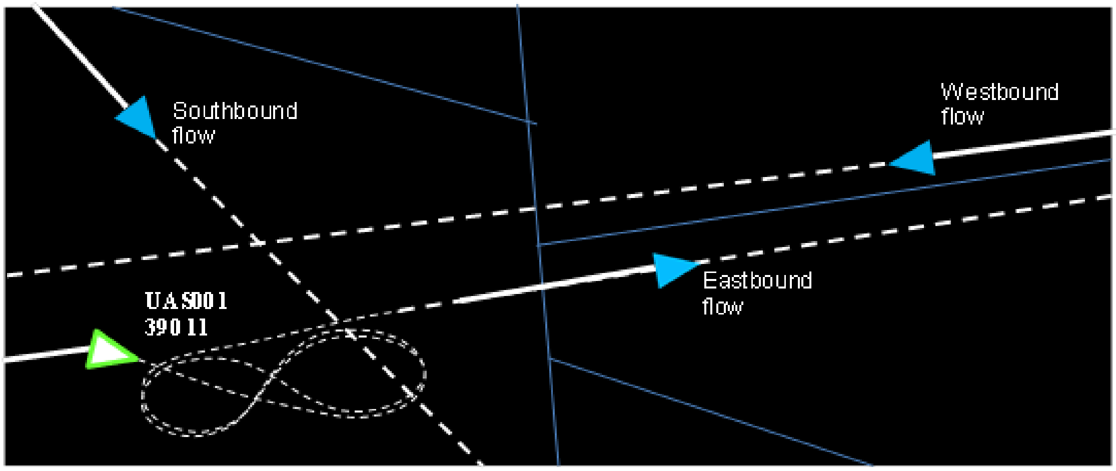

Figure 9. Proposed flight plan profile in relation to other traffic

In instances where the UAS trajectory negatively impacts the workload of an individual sector during the intended time of operation, automation provides recommended alternative trajectories that resolve the heightened sector complexity issue. Once filed, the requested 4D flight plan can be:

- Accepted "as is"
- Accepted after automation selects alternative trajectory options offered by the FOC when filing the flight plan
- Translated into a constraint for other operators
- Amended during negotiation between the FOC and ATC in order to meet the needs of the UAS operator while preserving the efficiency of the NAS
- Rejected

At least 24 hours in advance, ATM automation assesses the likely congestion and constraint volumes of a particular piece of airspace based on several factors. These factors include Special Activity Airspace scheduling, weather, airspace configurations, pre-planned airline routes, and historical flight trajectories of transient aircraft. With the onset of integrated UAS operations, unique operations specified as 4D flight plans with flight critical parameters are also be taken into consideration.

Between 24 and eight hours in advance of departure, flight planners are mainly concerned with airport priorities and the total fleet of aircraft. Users start with stated constraints, weather forecasts, and configuration plans identifying a subset of the RNAV procedures. In doing so, flight planners account for unique operation constraints, as well as weather, when developing the initial flight intent.

Between eight and four hours in advance of departure, automation predicts where flight congestion and other issues may be significant enough to label them as potential constraints in the NAS. This congestion prediction also accounts for unique operations that result in additional sector complexity due to factors such as the trajectory of the intended operation, any prioritization considerations, communications, and/or aircraft performance. The flight planner evaluates multiple options using flight planning tools.

Users have an opportunity to accept alternatives, alter trajectory parameters, or propose additional work-around options that have been adapted to known airspace or routing constraints. As time progresses, the flight plan becomes more detailed until fully completed prior to departure.

UAS not able to adapt to amended flight plan trajectories before the proposed departure time may need to re-file their flight plans or request special handling from ATC.

At four hours from the intended departure time, ATM automation provides feedback based on possible mitigation plans and considerations generated from user-filed inputs, while also updating weather constraint information. Unique flights may be canceled, delayed, or provided with an alternative 4D plan, taking into consideration flight segment priorities.

Within two to four hours of departure, the UAS flight planner responds to ATM automated feedback in the same manner as manned aircraft. ATM automation then provides any updated constraints to the NAS two hours prior to departure. At about 45 minutes prior to planned departure, ATC issues the clearance for the negotiated trajectory. Within 20 minutes of departure, flight planners make adjustments to their flights based on evolving factors such as weather and congestion, which may require an amended clearance. Due to the complex nature of unique operations, requests for changes to the flight plan may be denied by ATC at any point of the flight planning process, as well as when the operation is being performed.

5.2 Surface Operations

5.2.1 Overview

This scenario describes surface operations for any UAS at a towered airport, using standard runways and taxiways, operating under its own power, and integrated into normal traffic sequencing. Those UA that are not self-powered are towed or otherwise accommodated as traffic permits and according to operational priority. (These surface movement alternatives are not covered under the scenario.) The UAS taxis across the surface from a non-movement area to the runway via an ATC assigned route while maintaining two-way communications with ATC. The UAS has the ability to give way to other aircraft, hold short of active runways, and follow detailed taxi instructions. Figure 10 provides a graphical overview of the Surface Operations scenario. References to specific technologies used to emulate functions typically satisfied through visual means are provided as examples only, and have not been verified or validated.

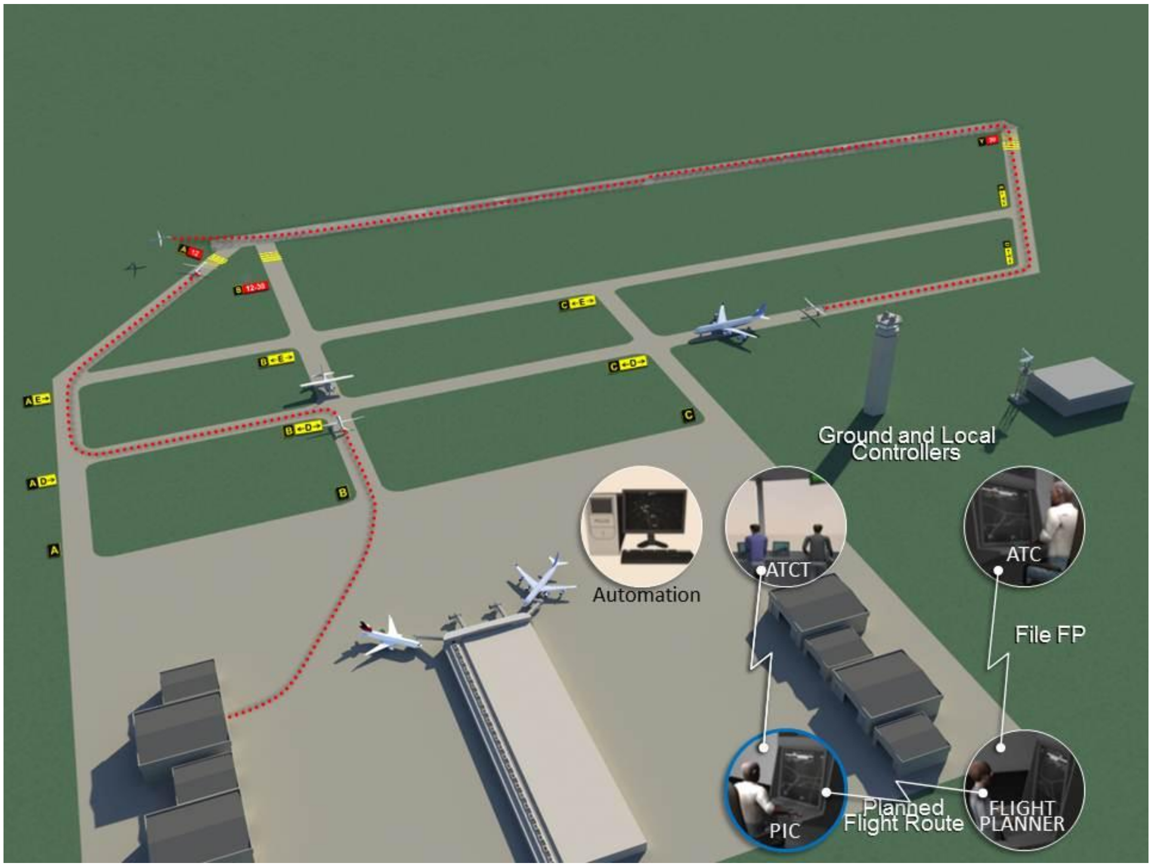

Figure 10. Surface operations overview

5.2.2 Scenario Description

Prior to flight, the FOC files a flight plan which includes a gate-to-gate 4D flight plan, including the intended method of taxi, takeoff, and any ground equipment that will be used during surface movement. If appropriate, initial contingency procedures are also negotiated at this time. Contingency information updates may be provided by the UAS operator during the flight planning phase and/or during flight operations. ATC automation and associated decision support tools are able to access contingency information when required.

To initiate taxi, the PIC contacts ATC ground to request taxi to the active runway via two-way communications. ATC ground identifies the aircraft standing-by on the non-movement area, visually inspects the desired taxi route for any potential conflicts, and approves the UAS to taxi to the active runway as filed.

The PIC initiates the taxi following his pre-planned route and monitors the progress of the aircraft using airport-specific surface data. During taxi, the PIC detects a manned Cessna that is a potential conflict and notifies ATC ground. ATC instructs the Cessna to stop, but the Cessna is unresponsive. The Cessna turns onto the same taxiway as the UAS, so ATC ground instructs the UAS to stop. The UAS comes to an immediate stop on the taxiway. ATC instructs the PIC to turn left onto an adjacent taxiway to avoid the approaching Cessna. The PIC acknowledges the ATC instruction and commands the UA to make a left turn.

ATC ground control clears the PIC to continue taxiing to the active runway via a new taxi route, and instructs the PIC to hold short of the active runway. The PIC confirms the new taxi route, updates the route within the flight management system, and ensures the route is clear of conflicts using a moving map display with traffic information. The PIC continues to monitor the progress of his aircraft, monitors all ground traffic, and complies with airport markings and signage consistent with all local policies and procedures.

Upon completing the pre-takeoff checklist, the PIC taxis the aircraft up to the hold short line. The PIC monitors the final approach airspace to the active runway, and calls ATC local to request takeoff. ATC local observes an arriving aircraft exit the runway, and clears the UAS for takeoff. The PIC acknowledges the clearance, checks the runway with an on-board runway incursion alerting capability to ensure it is clear of obstructions and other aircraft, aligns the UA with the runway centerline, and commences the takeoff roll.

After completing the flight the UAS returns to the airport and the PIC contacts ATC local with a request to land. ATC local clears the UAS to land. The PIC conducts the landing and exits the active runway. ATC local instructs the PIC to change to ATC ground frequency.

The PIC contacts ATC ground for a taxi clearance with progressive ("turn-by-turn") taxi instructions. ATC ground clears the UAS to taxi and provides the PIC with instructions to follow UAL1002 – a departing aircraft – on taxiway B to taxiway L, and then to a non-movement area. The UAS is able to remain a suitable distance from UAL1002 until arrival in the non-movement area.

5.3 Loiter for Surveillance

5.3.1 Overview

This scenario involves a fixed-wing single engine turboprop UA performing surveillance and aerial work along the national border. The intended flight is a routine operation, taking place at night on an IFR flight plan. Weather is VMC with scattered clouds and light wind. The flight departs a Class C airport not far from the northern border. The flight climbs through Class E into Class A airspace, climbing to FL190 while heading north to the border. From there it follows the border to the east until reaching water. The flight includes a loiter at 5,000 feet along the route, and an unplanned excursion along the way. The return route is the same, without the loiter point, back to the Class C airport. The flight out is high priority, but the return portion is low priority. Figure 11 provides a graphical overview of the Loiter for Surveillance scenario. References to specific technologies used to emulate functions typically satisfied through visual means are provided as examples only, and have not been verified or validated.

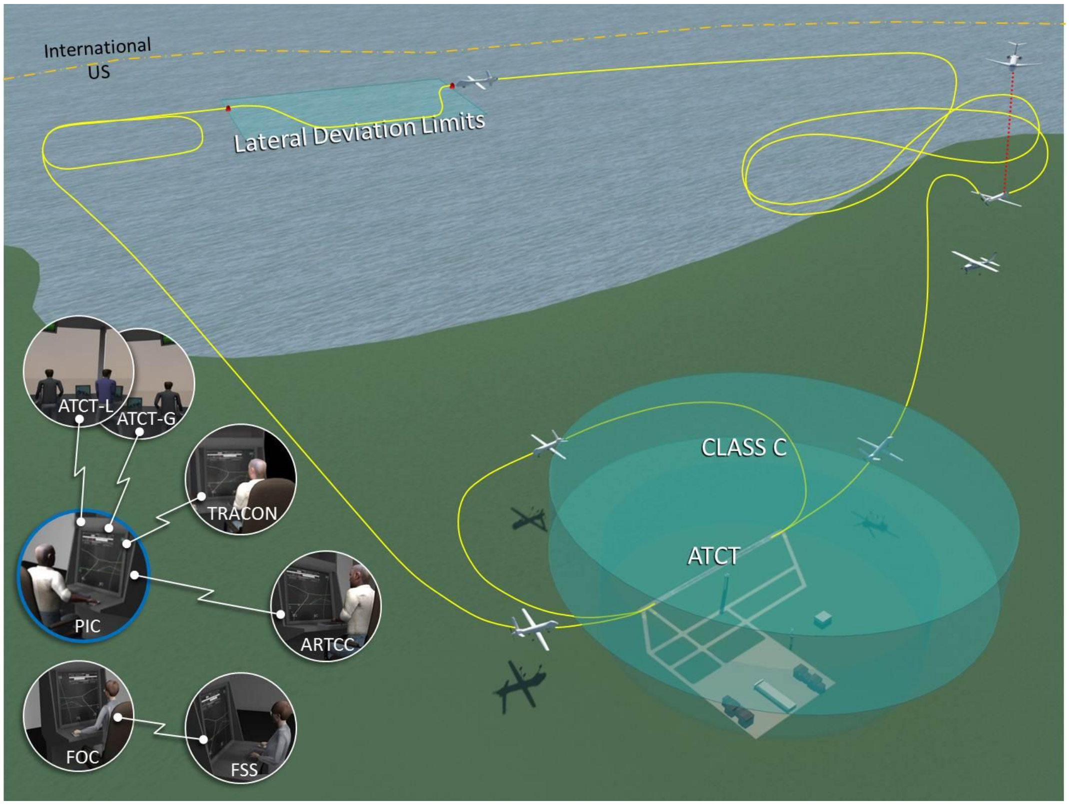

Figure 11. Loiter for surveillance overview

5.3.2 UAS Description

The UA is a turboprop, long-endurance UA. Table 11 shows the aircraft performance characteristics, which are similar to that of the Predator-B (MQ-9), shown in Figure 12.

Figure 12. US Customs and Border Patrol Predator B

Table 11. UA for Loiter Specifications

Specification	**Value**
Endurance	30 hours
Speed	240 knots
Climb rate	2600 feet per minute
Wingspan	50 feet
Weight	7000 pounds
Service ceiling	FL500

5.3.3 Scenario Description

The FOC initiates the flight planning process for the unique flight by filing *early intent* 48 hours prior to the anticipated departure time, as described in the Flight Planning scenario. The 4D flight plan includes a planned loiter maneuver with a designated priority considered for each segment of flight. Initial contingency procedures are also negotiated at this time.

As the early intent is filed, ATM automation begins to factor the intended plan into its calculations, and provides feedback to the FOC. As part of the trajectory negotiation process, the FOC advises TFM that getting the patrol aircraft on-station as expeditiously as possible is critical. Adhering to policy guidance (see Flight Planning scenario), TFM assigns a high-priority to that segment of the flight and makes the appropriate entry into the flight object. ATM feedback determines the predicted level of congestion in the Class C airspace is acceptable for accommodating the UAS flight. As other flights file their flight plans, ATM automation includes the UAS flight in determining sector complexity levels of the corresponding airspace.

Prior to departure, the PIC receives an IFR clearance consistent with with the filed flight plan. After obtaining an IFR clearance, the PIC initiates two-way communication with ATC ground control and receives taxi instructions to the active runway (see Surface scenario). Once the aircraft departs, ATC provides the UAS with separation from both IFR and VFR traffic. The PIC complies with all ATC instructions. The PIC continues to operate using its Sense and Avoid capability for collision avoidance only, since ATC separation services are being provided.

While en route, the flight approaches the initial point of the pre-planned maneuver. The PIC calls ATC with a request to descend to 5,000 feet and begin the loiter pattern as shown in Figure 13.

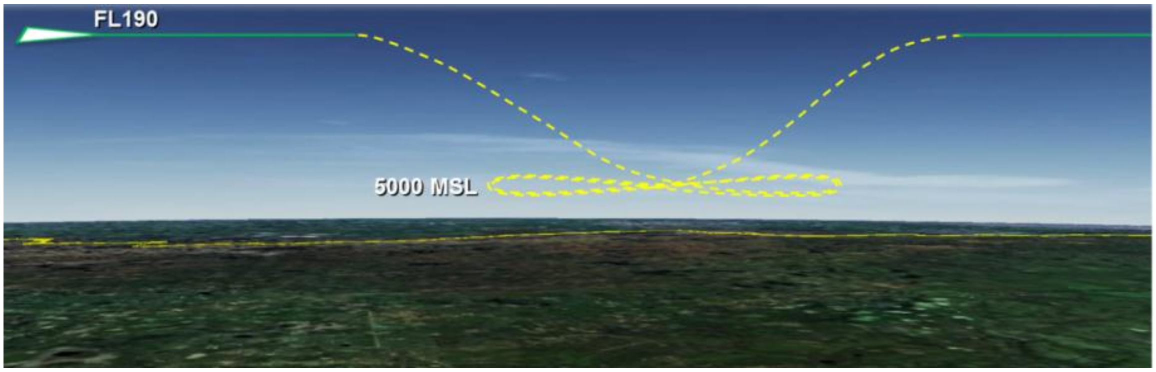

Figure 13. Depiction of pre-planned loiter maneuver

The loiter airspace volume is indicated on the display to remind ATC that the activity is in progress. ATC determines that the UAS trajectory will not conflict with other IFR traffic during the descent and initial entry into the new loiter area, and clears the PIC to descend to 5,000. The PIC descends the aircraft and commences the loitering manuevers. Upon exiting Class A airspace, ATC continues to provide separation from IFR traffic, while the PIC uses the Sense and Avoid capability to remain clear of VFR traffic within the constraints of the IFR clearance. The collision avoidance feature remains active.

After an hour of loitering, the PIC requests to resume the flight path along the border. ATC enters the time for resuming the flight plan into ATM automation, and analyzes the result for potential conflicts and congestion. The ATM automation provides decision support to ATC that the request is conflict free, and ATC approves the request. The PIC climbs back to FL190 and continues flying the border.

As the UAS is nearing a body of water, the PIC notifies ATC of the need to deviate from the flight trajectory to pursue a suspicious boat. The PIC requests a trajectory change based upon the direction of the boat and the altitude required (FL190) for adequate observation. ATC enters the requested change into the flight planning function in ATM automation and scans the area where the UAS is requesting to fly. ATM automation determines the requested trajectory is currently free of conflicts, and ATC does not forecast any other aircraft that might conflict, so the change is approved as requested. The pilot flies the new trajectory and tracks the boat on the water, while ATC continues to provide separation services.

Once the UAS has finished tracking the boat, the PIC requests a return to the flight plan route, then back to the airport. ATC enters the return into the trial planning automation. The automation indicates that the UAS will arrive back at the Class C airport during a period of peak demand. Since this is a low priority segment, automation recommends that the UAS loiter an additional 30 minutes prior to resuming the flight plan. ATC notifies the PIC of this constraint. The PIC enters the new loiter duration into the UAS flight management system and determines that the 30 minute delay allows for adequate fuel reserve. The PIC accepts the delay and new arrival time.

The destination airport in Class C airspace is configured for a south-east flow, with runway 14 as the active runway. This runway is served by a published non-precision instrument approach procedure. ATC provides vectors to the final approach course, the approach clearance is issued, and ATC instructs the PIC to remain on approach frequency. At the final approach fix, the PIC is instructed to contact tower. The PIC contacts local with a request to land. ATC clears the PIC to land.

The PIC has access to the specific airport navigational database and determines the UA position on a multi-function display. Following the published procedure, the UA descends to the minimum descent altitude and tracks inbound to the missed approach point. The PIC advises local that he has "acquired" the runway environment for landing.

During the process of landing, the UA crew member responsible for monitoring the Sense and Avoid capability observes a vehicle on the runway through a display image from the nose camera and the PIC notifies the local controller of a go-around. The local controller coordinates with the Terminal Radar Approach Control (TRACON), and then instructs the PIC to contact the TRACON once established on the missed approach procedure.

The PIC contacts the TRACON, and the TRACON provides radar vectors back to the final approach course and clears the UAS for a second non-precisionapproach. The TRACON instructs the PIC to contact tower. The PIC contacts tower and receives a clearance to land. The PIC conducts the landing and exits the runway. Ground control instructs the PIC to taxi to the ramp (see Surface scenario).

5.4 Vertical Transit (and Operations Above Class A)

5.4.1 Overview

This scenario describes a High Altitude Long Endurance (HALE) UAS supporting an agricultural/environmental monitoring operation in the Midwest. The intended flight takes place under an IFR flight plan, with the weather conditions being VMC at departure and arrival. The flight departs from a small, non-towered Class E airport, then flies on course while climbing to FL650, transitioning through Class A into high altitude Class E. The flight remains in high altitude Class E airspace for ten days, flying two large grid patterns between FL600 and FL650. After the grid patterns are complete, the UAS transitions back through Class A to land at the same airport from where it departed. Figure 14 provides a graphical overview of the Vertical Transit scenario. References to specific technologies used to emulate functions typically satisfied through visual means are provided as examples only, and have not been verified or validated.

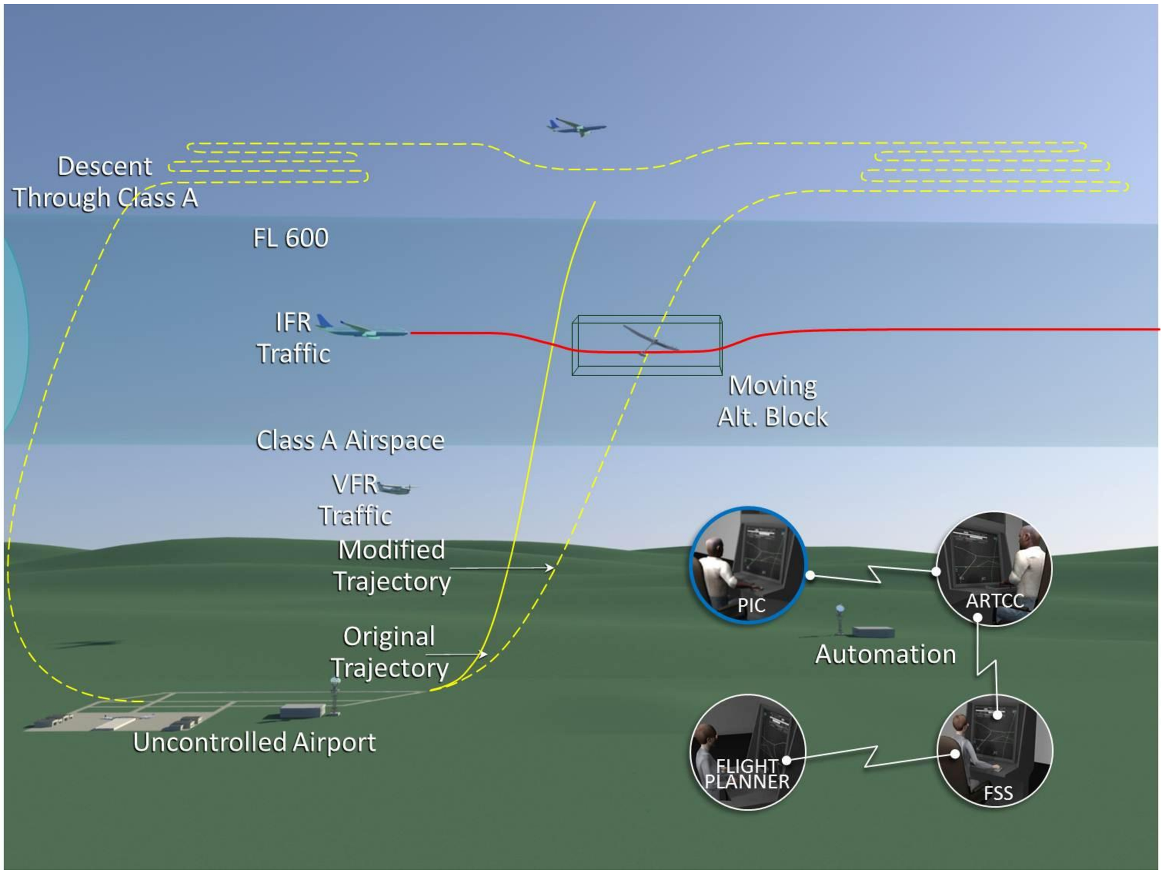

Figure 14. Vertical transit overview

5.4.2 UAS Description

The UA is a HALE with very slow climb rates and cruise rates. Table 12 shows the aircraft performance characteristics, which are similar to that of the HALE Global Observer depicted in Figure 15.

Figure 15. Global Observer

Table 12. UA for Vertical Transit Specifications

Specification	Value
Endurance	12 days
Speed	60-80 knots
Climb rate	100-500 feet per minute
Wingspan	250 feet
Weight	10,000 pounds
Service ceiling	FL750

5.4.3 Scenario Description

The FOC initiates the flight planning process for the unique flight by filing *early intent* 48 hours prior to the anticipated departure time (see Flight Planning scenario). The flight plan includes a 4D plan consisting of a slow climb through Class E and Class A airspace. Initial contingency procedures are also negotiated at this time.

Once the intent is filed, ATM automation begins to factor that intent into its calculations and provides feedback to the FOC. During the trajectory negotiation process, the FOC advises TFM that the commercial sponsor of the operation is not requiring any expeditious handling or priority (see Flight Planning scenario). For this flight, TFM advises the FOC that the predicted level of congestion in the Class A airspace will be too high to accommodate the UAS flight at the requested time, but a delay of two hours would be more feasible. The FOC determines that the amended time is acceptable and agrees to the recommended change. As other flights file, ATM automation includes the UAS flight in determining sector complexity levels in the airspace.

The PIC obtains an IFR clearance prior to departing. Once airborne, ATC separates the UA from other IFR traffic. The PIC uses Sense and Avoid capability to self-separate from VFR traffic within the constraints of the IFR clearance while in Class E airspace. The UAS trajectory is continuously negotiated between ATC and the PIC. During the climb, the PIC requests a modified trajectory which includes a delay. ATC puts the modified trajectory into ATM automation for trial planning, and the automation determines that the new trajectory is free of potential conflicts. ATC clears the PIC for the new trajectory, which the PIC uploads into the flight management system.

During the climb, ATC identifies a potential conflict between the UA and another aircraft. In this situation, the automation has determined that maneuvering the manned aircraft will provide the least disruption to the NAS. (These determinations are made on a case-by-case basis, as described in section 4.7.1.) ATC maneuvers the conflicting aircraft around the UAS trajectory. Once above Class A airspace, ATC offers to the UAS PIC the option to accept delegated separation responsibility, and the PIC accepts. The PIC or his designated crew member modifies and updates the Sense and Avoid settings to be consistent with the range of aircraft types and performance associated with operations in this airspace, and to provide maneuvering recommendations that are suitable considering the approved airborne separation standards. The UAS executes its first grid pattern, using Sense and Avoid to maintain separation from all other aircraft.

After that operation is complete, ATC resumes separation responsibility and clears the UAS to proceed to the starting point of the second grid pattern. As the flight progresses, ATC advises the PIC of opposite direction supersonic traffic about 100 miles away at the same altitude. The PIC responds that the traffic has been detected with the Sense and Avoid capability. ATC vectors the UA to maintain proper separation, and once clear, instructs that UA to rejoin the previously cleared trajectory. Once at the second grid search area, ATC again delegates separation resposnbility to the UAS.

The PIC notifies ATC that the UA will be operating in this grid area for three days. Changes in PIC occur during this flight, but are seamless and transparent to ATC. ATC continues to provide separation from IFR traffic while the UAS uses the Sense and Avoid capability to self-separate from aircraft not being controlled by ATC. The PIC requests clearance from ATC before maneuvering outside of the designated grid area.

Once the surveillance operation is complete, the PIC requests a descent through Class A airspace. ATM automation processes the request and determines that the congestion level is acceptable for a transition through Class A airspace as filed.

ATC provides descent instructions and further clearance to the point where the 4D trajectory resumes, which the PIC evaluates and determines can be executed within the aircraft speed and descent limitations. The PIC commences the descent through Class A airspace, continues through Class E airspace, and lands the aircraft at the origination airport.

5.5 Grid Pattern

5.5.1 Overview

This scenario involves a light, single-engine piston aircraft performing video capture and measuring air quality. The flight is originally planned as two UAs, each with its own PIC, flying in formation, but is reduced to a single aircraft after collaboration between the FOC and ATC. The flight departs a Class E airport and transitions through Class B airspace, prior to re-entering Class E airspace to perform a grid pattern with incrementally stepped altitudes. Weather is VMC. The UAS encounters traffic along the route of flight. The entire mission is filed as a low priority flight. Figure 16 provides a graphical overview of the Grid Pattern scenario. References to specific technologies used to emulate functions typically satisfied through visual means are provided as examples only, and have not been verified or validated.

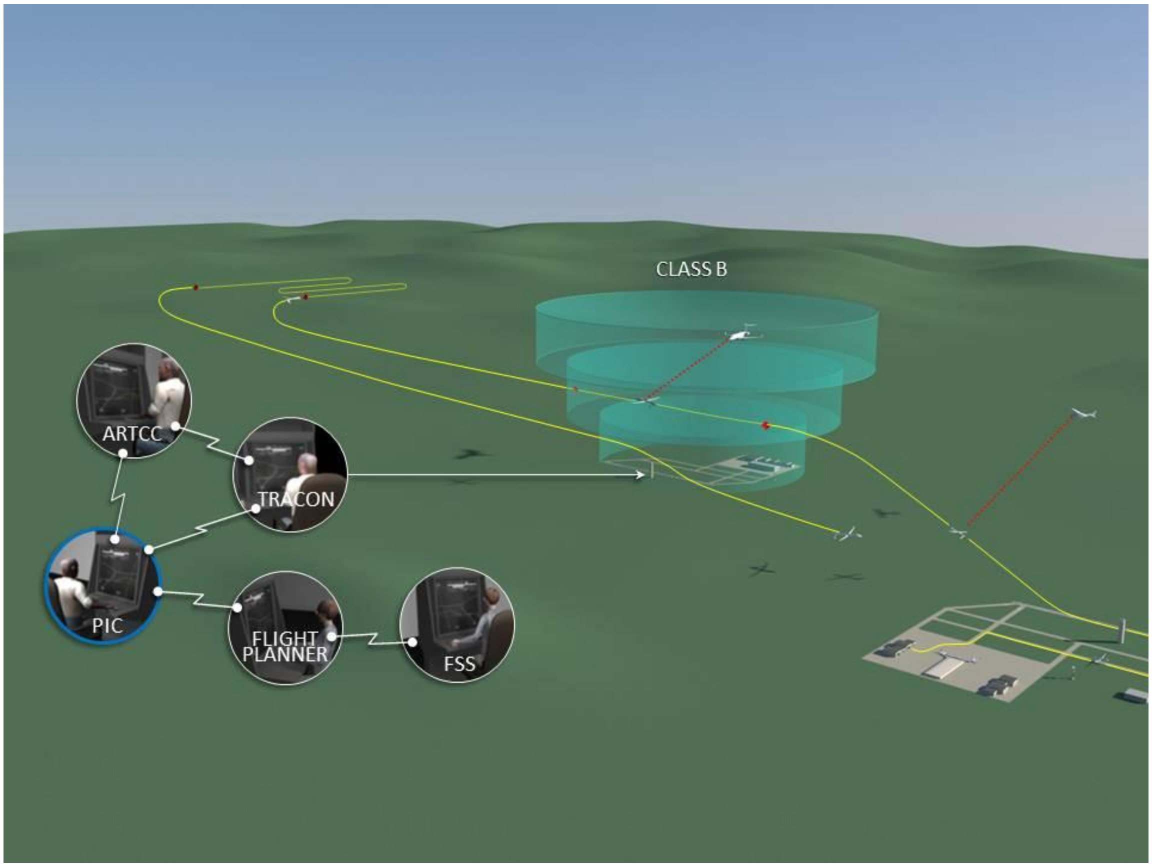

Figure 16. Grid pattern overview

5.5.2 UAS Description

The UA is a lightweight aircraft with limited airspeed and maneuvering performance characteristics. Table 13 shows the aircraft performance characteristics, which are similar to that of the Aerosonde Mk47 depicted in Figure 17.

Figure 17. Aerosonde Mk47

Table 13. UA for Grid Pattern Specifications

Specification	Value
Endurance	14 hours
Speed	40 – 60 knots
Climb rate	500 feet per minute
Wingspan	10 feet
Weight	30 pounds
Service ceiling	15,000 feet

5.5.3 Scenario Description

The FOC initiates the flight planning process for the unique flight by filing *early intent* 48 hours prior to the anticipated departure time. The flight plan includes a 4D plan consisting of a transition through Class B airspace, a planned grid pattern maneuver (with altitude changes), and low priority assigned to each segment of the flight (see Flight Planning scenario). Initial contingency procedures are also negotiated at this time.

ATM automation processes the flight plan and determines that the congestion in Class B and Class E airspace are predicted to be acceptable for the flight operation. However, two UAS operating in close proximity are unacceptable in this instance because of the increased sector complexity, and demand by other users. Only one UA will be allowed at the desired time. The FOC determines that the mission can still be accomplished with a single aircraft and files the amended flight plan.

Once early intent is filed, the ATM automation begins to factor that intent into its calculations, and provides feedback to the FOC that the predicted level of congestion in the Class B and E airspace is acceptable for accommodating the UAS flight. As other flights file their plans, the ATM automation includes the UAS flight in determining sector complexity in the airspace.

Prior to departure, the PIC receives an IFR clearance in accordance with the filed flight plan. After the flight has departed the runway, the PIC establishes communications with ATC, who provides the UAS with separation services from IFR traffic. The PIC uses Sense and Avoid capability to self-separate from VFR traffic within the constraints of the IFR clearance.

While en-route within Class E airspace, the PIC detects VFR traffic that he deems a concern to his route of flight. The PIC contacts ATC to request a deviation to pass behind the VFR traffic. ATC checks his display to confirm that the manuever will not impact other IFR flights in the region, and approves the request. The PIC executes the proposed maneuver and re-establishes the filed 4D trajectory. ATM automation updates the time component of the trajectory and alerts any concerns to ATC.

As the flight approaches Class B airspace, ATC hands the UAS off to the TRACON controller and issues a frequency change to the PIC. ATC manages all traffic within Class B airspace to ensure separation; the PIC continues to use the Sense and Avoid capability primarily to ensure collision avoidance from other aircraft.

While the UA is transiting Class B airspace, ATM automation alerts ATC that there is a potential conflict between the UA and another aircraft. The automation provides ATC with a rank-ordered set of resolutions that accounts for all aircraft trajectories in the local vicinity.

ATC assesses the automated advisory and projects that a loss of separation may in fact occur if one or more aircraft is not issued a manuever for separation. The controller elects to maneuver the UAS in this instance to avoid the conflict, and issues the PIC a changed route of flight to resolve the conflict. The PIC complies, and updates the UAS flight management system consistent with the new trajectory.

Once the UAS enters Class E airspace to conduct the desired operation, ATC hands it off to a TRACON controller and issues a frequency change to the PIC. The TRACON controller provides the UAS separation services from IFR traffic. The PIC continues to evaluate other traffic for appropriate self-separation and to ensure collision avoidance.

As the PIC approaches the planned grid location, ATC clears the PIC to conduct the grid pattern as filed. The PIC commences the intended manuevers, and ATC continues to monitor the UA as the grid pattern is flown. ATC vectors conflicting traffic around the UA grid location.

As the PIC is conducting his flight in the grid pattern, he determines that the remainder of the flight may be compromised due to an approaching rain storm. The PIC revises the flight plan so that the UA can avoid the rain and return to base nearly 30 minutes early. The PIC requests an amendment to the flight plan with ATC, thereby terminating the grid pattern prematurely. ATC uses automation to assess the early execution of the return route of flight, and determines that it does not impact any other IFR flights. ATC approves the request, and the PIC terminates the remainder of the grid pattern operations, and returns to base on the newly established trajectory.

5.6 Point-To-Point

5.6.1 Overview

This scenario involves a fixed-wing single engine turboprop UA performing cargo operations across the state of California. The intended flight is a routine operation, taking place in the morning hours of the day on an IFR flight plan in IMC. The flight departs a Class D airport in Northern California and climbs to 7,000 feet above mean sea level (MSL) while remaining on published airways. During the 440 nautical mile flight, the aircraft transitions across two TRACONs before landing at a non-towered airport in Southern California. Figure 18 provides a graphical overview of the Point-to-Point scenario. References to specific technologies used to emulate functions typically satisfied through visual means are provided as examples only, and have not been verified or validated.

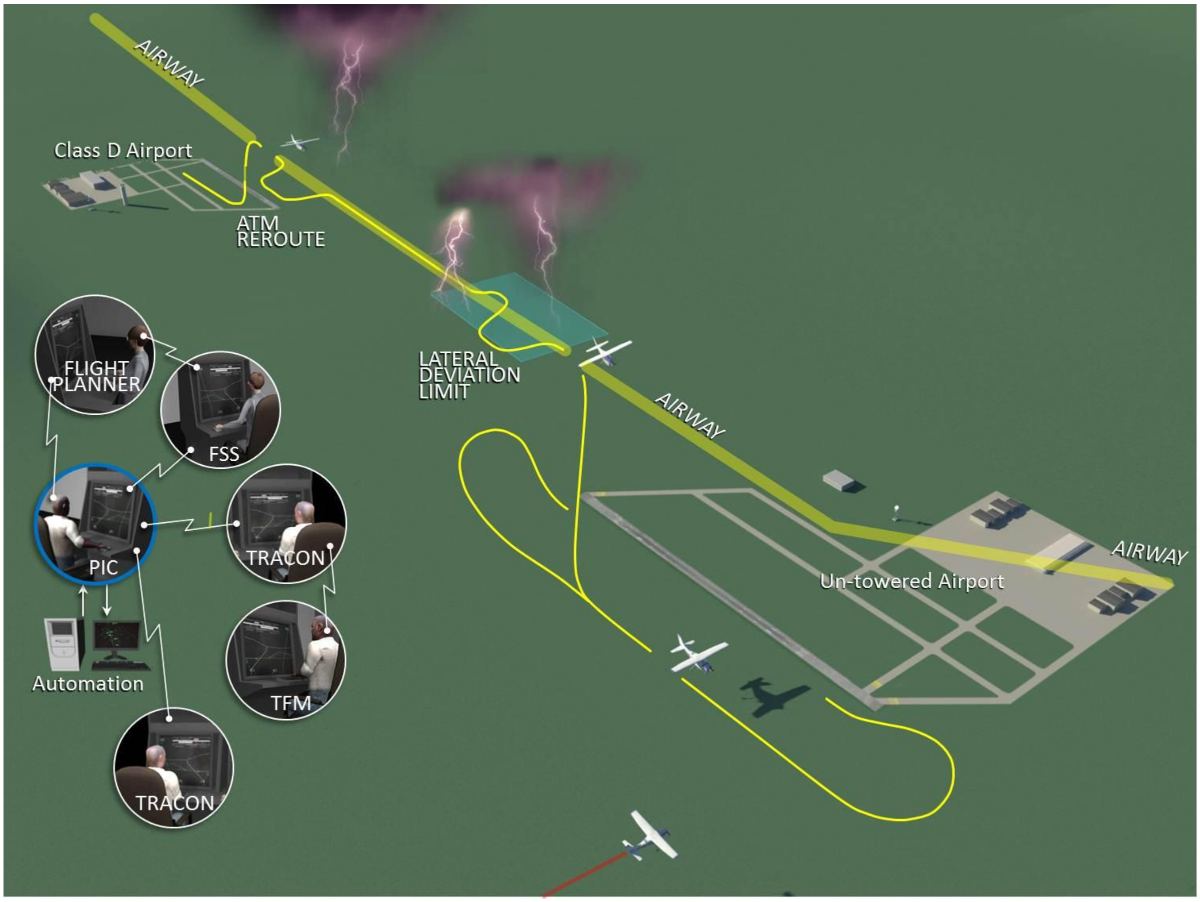

Figure 18. Point-to-point overview

5.6.2 UAS Description

The UA is a modified manned aircraft similar to a Cessna Caravan certified for Utility Category flights pertaining to cargo operations, as depicted in Figure 19. Table 14 shows the aircraft performance characteristics which are identical to the manned aircraft equivalent.

Figure 19. Cessna Caravan converted to UA

Table 14. Point-to-Point UA Specifications

Specification	Value
Endurance	5 hours
Speed	170 knots
Climb rate	950 feet per minute
Wingspan	52 feet
Weight	8,750 pounds
Service ceiling	23,000 feet

5.6.3 Scenario Description

Prior to the flight, the FOC files a flight plan for the daily itinerant trip. The same flight plan is used every day. Initial contingency procedures are also negotiated at this time. Once the intent is filed, ATM automation begins to factor that intent into its calculations, and provides feedback to the FOC that the predicted level of congestion in the Class D and E airspace is acceptable for accommodating the UAS flight at the proposed time.

As other flights file their plans, the ATM automation includes the UAS flight in determining sector complexity levels in the airspace along the route of flight. The fully detailed flight plan is filed prior to departure, and ATM provides feedback of any time or route modifications that are necessary to accommodate the UAS flight plan.

Prior to departure, the PIC receives an IFR clearance in accordance with the filed flight plan. The PIC establishes communication with ATC ground control and receives taxi instructions to the active runway (see Surface scenario). Once the flight has departed the runway, ATC provides separation services from IFR traffic. The PIC follows all instructions concerning other traffic. The PIC monitors Sense and Avoid capability for collision avoidance. ATM automation updates the trajectory of the UAS as the flight progresses.

While en route, TFM detects areas of congestion due to severe weather along the planned route of flight. ATM automation provides ATC with a re-route solution around the area of severe weather. ATC reviews the automated re-route of flight, and determines that it is currently free of conflicts with other aircraft. ATC issues the new 4D trajectory to the PIC. The PIC verifies that he can accept the new route of flight and accepts the clearance. The UA manuevers around the weather and intercepts the amended flight path, as shown in Figure 20.

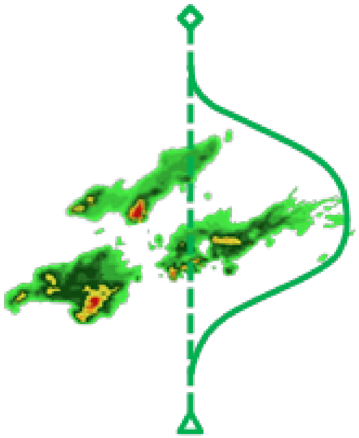

Figure 20. Flight trajectory deviation by ATM automation

Nearly an hour after re-establishing the intended flight path, the PIC detects more weather ahead, and requests to deviate around it. ATC uses automation and determines that the course is clear of traffic, but instructs the PIC not to deviate more than 20 degrees from originally assigned course.

The PIC uses automation inside of the control station to derive a flight path free and clear of hazardous weather, while adhering to the 20 degree constraint. The PIC manuevers the aircraft through areas of concern, as shown in Figure 21. The PIC contacts ATC to verify that he is clear of weather and requests clearance to resume the intended 4D trajectory. ATC uses automation to verify that there are still no potential conflicts along the modified 4D trajectory, now accounting for the time differential, and clears the PIC to return to the original route of flight. The PIC complies and reestablishes his route of flight.

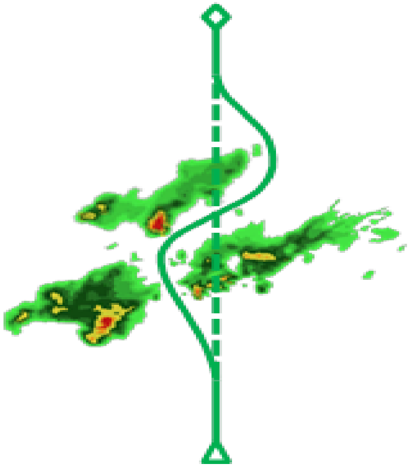

Figure 21. PIC-initiated deviation for weather

With approximately 40 miles remaining in the flight, the weather ahead is forecast to be VMC. ATC has identified a VFR aircraft operating at 6,500 feet MSL about 8 miles ahead of the UA and on a converging course. ATC advises both pilots of traffic, informing the UA PIC that the opposite direction aircraft is VFR. The UAS crew member responsible for monitoring the Sense and Avoid capability reports to the PIC that the system is recommending a turn to the left to avoid the traffic. The PIC relays that information to ATC, who replies that at 7,000 feet, the UA is sufficiently separated by altitude from the VFR traffic.

As the distance closes to 4 miles, the PIC repeats his information to ATC and requests a 20 degree turn to the left. ATC authorizes the turn as requested, while reinforcing that the altitude separation is sufficient. The UA makes its 20 degree turn away from the airway centerline, while the VFR traffic also changes course and is now flying a similar heading.

The VFR pilot, when asked about his course change, informs ATC that he is maneuvering based on ground references, and expects to be on his current course for another ten minutes. Because the Sense and Avoid recommended maneuver is not necessary to maintain separation, the UA PIC elects to disregard the recommendation, and advises ATC he is turning to the right to re-join the airway as cleared.

Nearing the airport, the UA PIC requests to begin his descent for the RNAV (GPS) runway 26 approach. ATC first confirms that the UA meets the RNP requirement for this approach, and then clears the UA "present position direct to the initial approach fix, descend to cross that fix at or above 2,900 feet, cleared for the RNAV (GPS) runway 26 approach." The UA leaves 7,000 feet for 2,900 feet and turns direct to the initial approach fix.

The PIC is able to determine the UA position with reference to the RNAV procedure using an overlay of the procedure on a primary flight display that also incorporates terrain images and aircraft traffic information provided by the TIS-B service. As the UA passes through 4,000 feet, ATC advises that radar services are terminated and to change to CTAF, requesting that the PIC cancel his IFR flight plan within 30 minutes after arrival. The PIC acknowledges that request and changes frequencies, continuing on the approach procedure as published.

As the PIC initiates the final portion of the approach, he broadcasts his location and intentions on CTAF, and listens for other traffic in the vicinity. Following the route using symbology on a heads-up display, the PIC "acquires" the assigned runway on the primary flight display that depicts the airport and the surrounding terrain. However, conflicting traffic reports on CTAF indicate that the opposite direction runway (08) is active, and the PIC determines he must terminate the approach, and circle to land on the active runway. The PIC turns the UA to the right (north) and joins the traffic pattern prescribed for the runway. The UA circles to line up for runway 08 while broadcasting on CTAF his position in the traffic pattern consistent with local course rules. Once the PIC determines that the runway is clear, the aircraft lands and taxis to the parking area (see Surface Operations). The PIC closes the IFR flight plan with the flight service station serving the airport.

5.7 Oceanic Point-to-Point

5.7.1 Overview

This scenario describes an unmanned aircraft carrying cargo through oceanic airspace. The flight is conducted on an IFR flight plan, with VMC forecast at the destination airport. The flight departs an international airport, flies through the oceanic FIR in Class A, and arrives at a Class B airport in the United States. Figure 22 provides a graphical overview of the Oceanic Point-to-Point scenario. References to specific technologies used to emulate functions typically satisfied through visual means are provided as examples only, and have not been verified or validated.

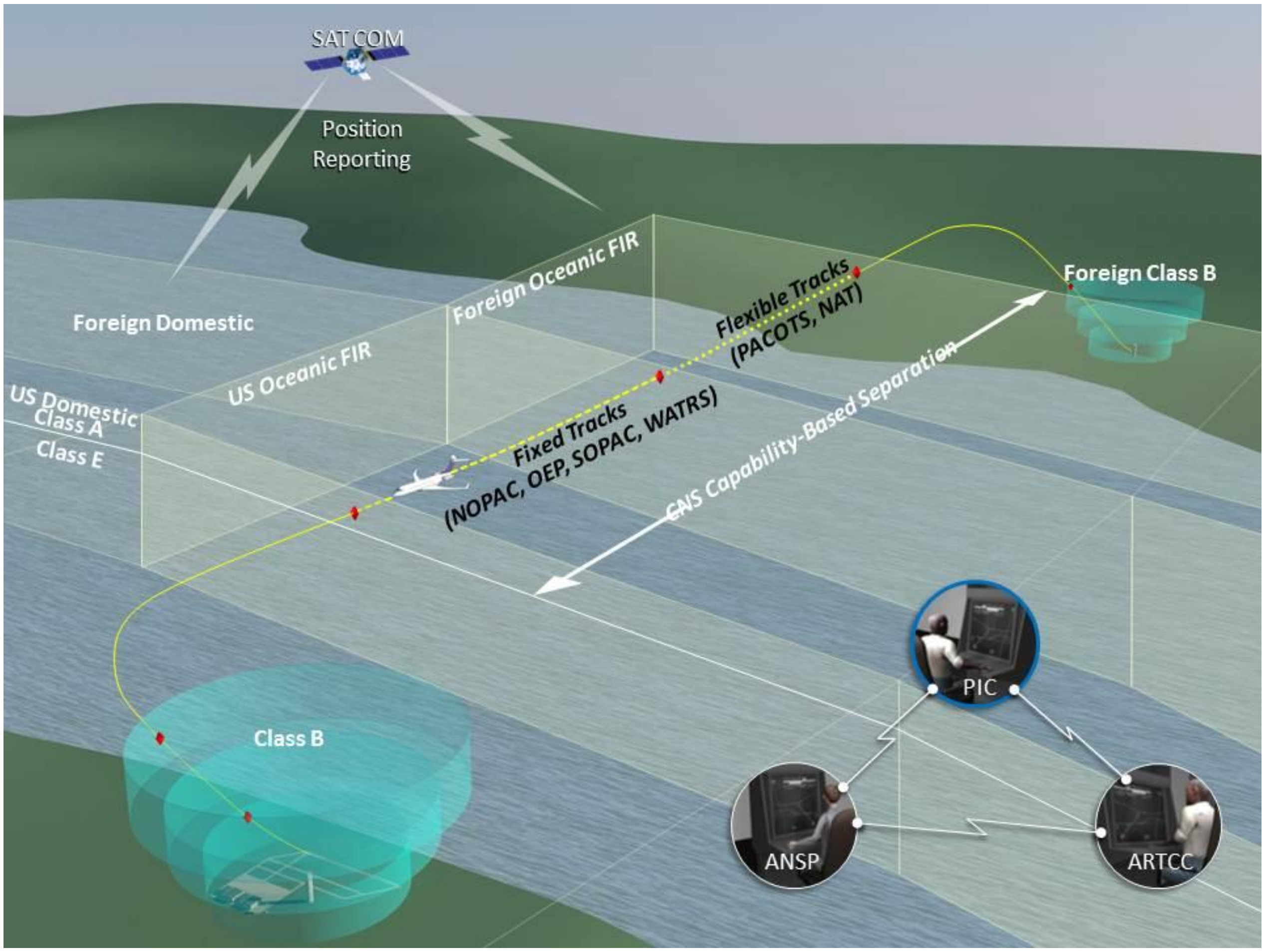

Figure 22. Oceanic point-to-point overview

5.7.2 UAS Description

The UA is a modified large jet aircraft similar to that of a Boeing 747 (Figure 23). Table 15 shows the aircraft performance characteristics, which are identical to the manned aircraft equivalent.

Photo credit:Tim Beach

Figure 23. Oceanic UA

Table 15. Oceanic UA Specifications

Specification	**Value**
Endurance	13 hours
Speed	500 knots
Climb Rate	1800 feet per minute
Wingspan	210 feet
Weight	900,000 pounds
Service Ceiling	FL430

5.7.3 Scenario Description

Prior to flight, the flight planner files an ICAO flight plan with each FIR along the route. The fields in the ICAO flight plan include the CNS capabilities available on the UA, indicating that this flight will be able to take advantage of the advanced operational improvements in ATM developed and implemented under the NextGen/SESAR harmonized framework. These CNS capabilities include services available as part of the Future Air Navigation Systems (FANS) avionics package, such as Controller-Pilot Data Link Communications (CPDLC), Automatic Dependent Surveillance – Contract mode (ADS-C), and Required Navigational Performance qualifications for precise navigation in oceanic airspace (RNP-4). Additionally, the aircraft has ADS-B (In and Out) enabled.

On-line data interchange enables different ANSPs involved in the flight planning process to negotiate the optimum trajectory for this flight, including scheduling for access to the oceanic tracks and Required Time of Arrival (RTA) planning at selected waypoints along the trajectory.

The UAS departs an international airport and flies toward the oceanic track entry point. About 45 minutes before entering oceanic airspace, the PIC establishes a data communication link with the oceanic ANSP. Until this point in the flight, VHF communications and ATC radar surveillance have been used for separation services. The ANSP establishes a "contract" with the UA avionics for ADS-C position reports. ATC thus specifies a time interval for automatic periodic position reports and a set of events such as crossing a waypoint that will trigger additional automatic position reports. Without further pilot action, the UAS sends position data as specified in the agreement.

Once the aircraft departs and estimated times are updated, that information is passed to the FAA/ATC. During the oceanic transit, all PIC and ground control station changes are determined by operator procedures and are seamless and transparent to ATC.

While operating in routine cruise on the Oceanic track, ATC informs the PIC that his trajectory will overtake another aircraft on the same track at the same altitude, and suggests a new altitude. The UA PIC obtains the flight identification, altitude, position, and ground speed transmitted by the leading aircraft on its ADS-B (Out). After conferring with the FOC, the PIC makes an In-Trail Procedure (ITP) altitude change request to ATC to climb from FL390 to FL410 to pass the slower aircraft ahead. ATC clears the PIC for an ITP climb to FL410. The UA crewmember responsible for monitoring the Sense and Avoid capability enters the flight information and ITP interval constraint into the system (initiated no closer than 15 nautical mile (NM) and no more than 20 knots of closure).

As the UA begins its climb, the slower traffic is detected by the Sense and Avoid capability, but the system offers no maneuver recommendation because the other aircraft is still sufficiently far ahead of the parameter that is set for the required oceanic separation (the 15 mile minimum required by ATC for this operation).

As the UA passes through FL400, the crewmember monitoring the Sense and Avoid system reports to the PIC that the traffic has been detected just over 30 miles ahead. To make certain that they do not violate the 15-mile in-trail requirement, the PIC increases his rate of climb, and the UA reaches its cleared altitude of FL410 20 miles in trail of the slower aircraft.

Once across the oceanic FIR boundary, FAA/ATC assumes control of the flight and updates the traffic flow plan for the destination airport. As the UA approaches domestic airspace, ATC instructs the PIC to change frequencies. When the UA reaches the domestic en route airspace boundary, ATC establishes radar contact with the UA and begins to provide radar separation.

As with a manned aircraft on a similar trajectory, the UAS and the ATM system negotiate the Top-of-Descent (TOD) and RTA at that waypoint, and ATC issues a clearance for a Continuous Descent Approach (CDA) to the destination airport. As the UA passes its TOD waypoint and begins descent, TFM advises ATC that a 12-mile interval between that aircraft and a previous arrival already on descent is needed. ATC issues traffic identity information to the PIC, and using ADS-B (In), the UAS crewmember responsible for monitoring the Sense and Avoid capability detects the traffic on the system display.

The PIC relays that information to ATC who instructs the PIC to maintain 12 miles in trail of that traffic until further advised. The flight management system of the UA adjusts airspeed to take station 12 miles in trail.

After the UA passes the initial approach fix, ATC instructs the PIC to contact TRACON. The UAS changes frequency and the PIC checks in with the TRACON. ATM automation calculates how to merge the UA with other arrivals to the airport and ATC provides route and delay clearances to meet time-based flow management restrictions.

ATC clears the UAS for an RNAV arrival to runway 1R. The PIC acknowledges the clearance and intercepts the final approach course. Prior to the final approach fix, ATC instructs the PIC to contact tower.

The tower clears the UAS to side-step to the left and land on runway 1L. The PIC acknowledges the change to runway 1L, and modifies the UA flight profile using a lateral offset to align with the assigned runway. The UA continues the modified approach until touching down on runway 1L.

5.8 Maneuvering in High-Density Airspace

5.8.1 Overview

This scenario describes an unmanned helicopter on an IFR flight plan performing media and traffic reporting in a corridor that has been established for the main purpose of VFR aircraft transiting through Class B airspace. Because the flight is routine and conducted under a Letter of Agreement (LOA) with the operator, no prioritization or access-equity determination is required. The flight departs a Class D airport, transitions into Class B airspace and enters the corridor, wherein ATC delegates the responsibility to the UAS PIC to provide safe separation from other aircraft in the corridor, and then returns to land at the airport of origin. Figure 24 provides a graphical overview of the Maneuvering in High-Density Airspace scenario. References to specific technologies used to emulate functions typically satisfied through visual means are provided as examples only, and have not been verified or validated.

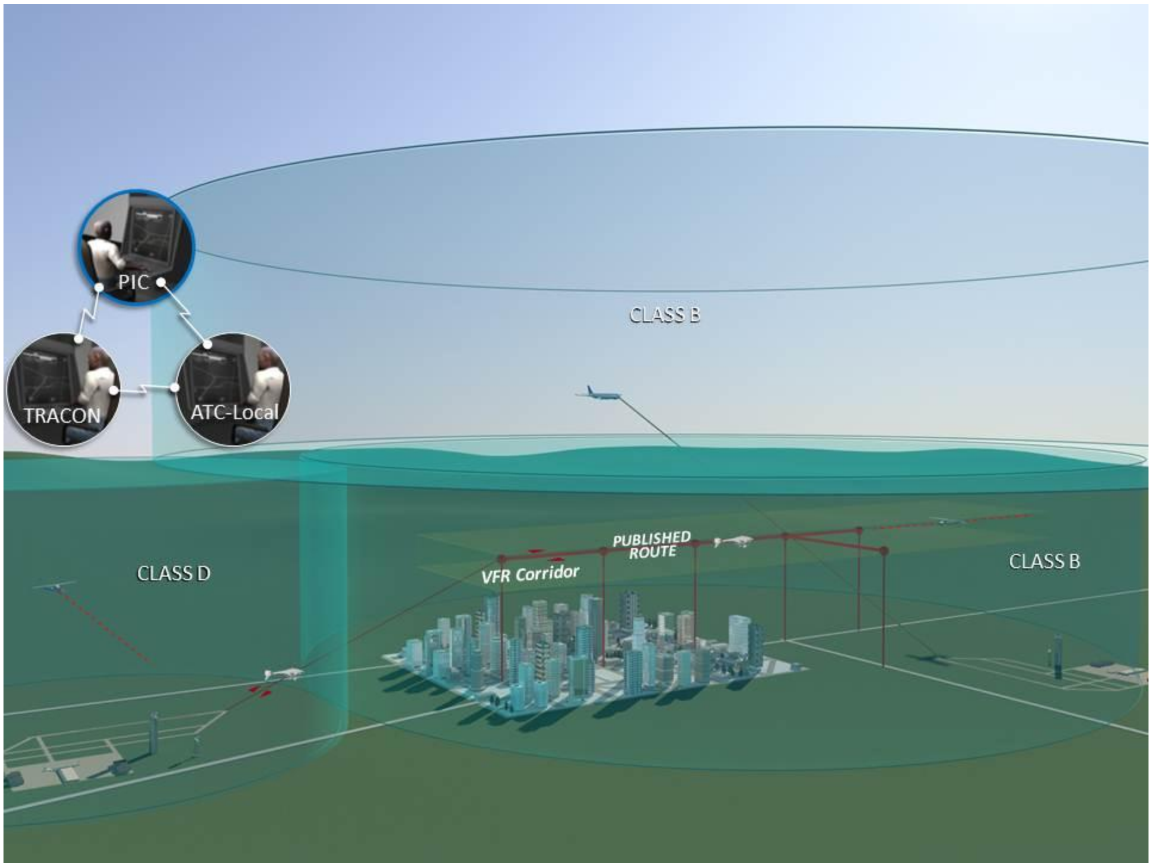

Figure 24. Maneuvering in high-density airspace overview

5.8.2 UAS Description

The UA is a small helicopter similar to that of a Fire Scout (Figure 25). Table 16 shows the aircraft performance characteristics for this type of UAS.

Figure 25. Helicopter UA for traffic monitoring

Table 16. Helicopter UA Specifications

Specification	**Value**
Endurance	6+ hours
Speed	117 knots (may hover)
Climb Rate	Varies
Wingspan	27.5 feet
Weight	3150 pounds
Service Ceiling	20,000 feet

5.8.3 Scenario Description

Prior to flight, the flight planner files an IFR flight plan for the published traffic route the helicopter intends to fly. The route is a corridor through Class B airspace that includes specified dimensions and altitude restrictions. An LOA between the operator and the local ATC facilities includes a pre-assigned discrete beacon code. Notices of UAS operations on the published route are available in the airport directories. During the flight planning and trajectory negotiation process, the local ATC facility determines that separation responsibility should be delegated to the UAS operator/PIC while in the transit corridor. The UAS operator/PIC concurs and accepts that delegation.

When ready to depart, the PIC calls ATC and requests a takeoff clearance from the helipad. Per a local LOA, the tower calls the neighboring TRACON to coordinate entry into the Class B airspace. After receiving approval from the TRACON, local ATC scans the area for other traffic, determines that it is conflict-free, and issues a takeoff clearance to the PIC with an advisory that there are two other aircraft in the departing airport traffic pattern. The UAS departs via a standard helicopter departure route. The UAS uses the Sense and Avoid capability to self-separate from other aircraft in the traffic pattern.

As the UAS approaches Class B airspace, ATC approves a frequency change to the Class B TRACON frequency. The PIC changes frequencies and contacts the controller in Class B airspace with his position, altitude, and intent to fly the published traffic route. ATC radar identifies the UAS and instructs the PIC to remain within the published traffic route boundaries once established. Further, ATC advises the PIC that no other IFR aircraft will be cleared to enter the corridor, and therefore safe separation from VFR aircraft in the corridor will be the responsibility of the PIC. The UAS flight crew sets the "sensitivity" of the Sense and Avoid capability to satisfy their self-separation responsibility within the limits of the assigned corridor, consistent with the performance of the other aircraft in the vicinity and an approved airborne separation standard.

The PIC complies with all instructions and reports entering the published traffic route. After a period of time, the PIC learns of an event at another intersection outside the published route and calls ATC to request a clearance through the Class B airspace to that point. ATC analyzes current workload and denies the request. The PIC acknowledges and remains within the published corridor.

Once the monitoring is complete, the PIC requests clearance off the published traffic route and back to the Class D airport. ATC provides clearance outside the published route back to Class D airspace and resumes separation responsibility for the UA as it transits Class B airspace. Prior to the Class B boundary, the controller issues a frequency change. The PIC contacts the Class D tower when inbound for landing.

The PIC is able to depict the UA current position on a moving map display, as well as local procedures and common reporting points. Tower instructs the PIC to cross the active runway at midfield, and to report a landmark in accordance with local procedures. ATC also advises the PIC to expect the standard helicopter arrival at helipad C. The UAS uses the Sense and Avoid capability to self-separate from other aircraft consistent with right of way rules and local traffic procedures. The UAS uses available sensors and displays to provide adequate clearance from terrain and ground obstructions, and to recognize appropriate landmarks as reporting points.

The UAS continues inbound and the PIC reports abeam the landmark. ATC advises the UAS that there is a Cessna on final. The UAS reports that he has “acquired” the Cessna using the Sense and Avoid capability, and ATC clears the UAS to land at the helicopter landing pad with an advisory to remain clear of the Cessna. The UAS stays clear of the Cessna, verifies that the helipad is clear of obstructions, and lands.

5.9 Search Pattern

5.9.1 Overview

This scenario describes a UAS performing a search pattern in Class G airspace at night. The flight duration is 14 hours in VMC with a dusk launch and daytime recovery the next day. Because the flight will be conducted entirely within Class G airspace, no prioritization or access-equity determination is required. The UAS is rail launched from a site that is close to the area to be searched. The UAS performs a standard search pattern, which includes segments that are beyond line of sight from the PIC and returns to the same field it was launched from for recovery. Figure 26 provides a graphical overview of the Search Pattern scenario. References to specific technologies used to emulate functions typically satisfied through visual means are provided as examples only, and have not been verified or validated.

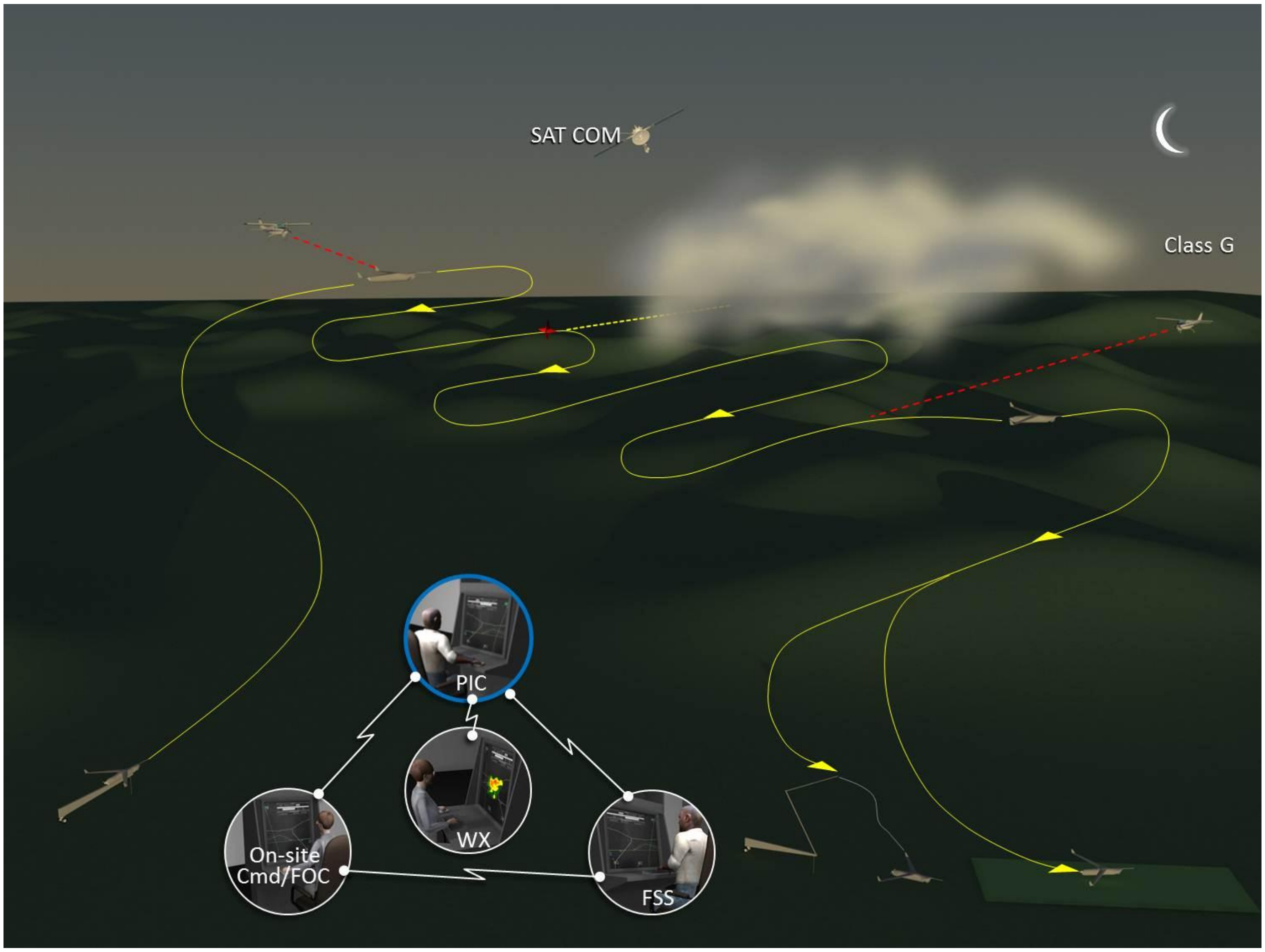

Figure 26. Search pattern overview

5.9.2 UAS Description

The UAS is a ScanEagle type that is rail launched and can land into a net either on or off the airport (Figure 27). Table 17 shows the typical aircraft performance characteristics for this type of UAS.

Figure 27. UA for night search pattern

Table 17. Night Search UA Specifications

Specification	Value
Endurance	24+ hours
Speed	50 knots
Climb Rate	Varies
Wingspan	10 feet
Weight	48 pounds
Service Ceiling	19,500 feet

5.9.3 Scenario Description

This scenario describes a night mission with a launch just prior to dusk that lasts for 14 hours. The FOC files an IFR flight plan with a delay en route for conducting the search. The local ATC facility acknowledges the flight plan and delegates separation responsibilities to the UAS PIC. The FOC and on-site commander have established the specific search pattern for this mission. The on-site commander has checked the weather and the forecast calls for scattered clouds near the search pattern. The crew is briefed on the pattern and the weather conditions and advised to provide PIREPs on the actual conditions encountered.

The UA is rail launched and proceeds to climb on course to its designated cruising altitude and search area. The UAS uses the Sense and Avoid capability to self-separate from all traffic throughout the flight. The PIC checks in with the on-site commander informing him that the UA is about to start the search pattern.

As the operation progresses, weather conditions begin to deteriorate. The PIC is having a problem staying out of the scattered layer of clouds while executing the planned search pattern. Because the Sense and Avoid sensors are unable to see through the clouds, he changes the geometry of the search pattern to avoid any additional clouds. The PIC notifies the on-site commander of the change in the search pattern and weather conditions. The on-site commander calls the FAA to provide a PIREP.

The PIC notifies the on-site commander that the search pattern is complete and that the UA is returning to the landing site. The UAS continues to use the Sense and Avoid capability to provide safe separation from all other aircraft and returns to the landing site for recovery. After recovery, the PIC notifies the local ATC facility that the flight is complete and closes his flight plan.

6 Summary of Impacts

This section contains two “summary of impact” tables.

Table 18 summarizes the anticipated impacts of UAS integration on the NAS, in terms of operational performance and the evolution of NextGen. It addresses several key performance areas, including access and equity, efficiency, safety, security, environmental impact, global interoperability, and flexibility. Impacts are presented from the perspectives of the FAA and NAS users, including both manned and unmanned aircraft operators.

Table 19 identifies other NAS operational concepts that either influence, or are impacted by, UAS integration. These documents identify operational and/or functional requirements that ultimately impact UAS integration. Likewise, a gap analysis may require updates to some concepts to account for the vision of this ConOps. This information will allow all affected organizations to prepare and plan for changes that will be brought about by UAS integration. The table itself provides the name of each concept document, a brief description of the content, and a summary of its connection or relationship to UAS integration.

Table 18. Impacts of UAS Integration on NAS Key Performance Areas

Key Performance Area	FAA	NAS Users
Access & Equity	FAA must formulate an access/equity policy regarding prioritization of UAS in consideration of the needs of other users. "Operational priority" is a factor that is included in access decisions.	**Manned:** Integrating UAS into the NAS as "routine operations" means fewer TFRs or airspace volumes reserved for UAS usage that must be avoided, thus reducing restrictions on the movement of manned aircraft.
		UAS: Increased access to the NAS results from type certification and flight approval in a manner similar to manned aircraft. This also leads to a significant reduction in the use of special processes (e.g., COA) for UAS. However, equity of access to the NAS may be impacted by unique UA performance and flight profiles.
Efficiency	Segregation of operations into different volumes of airspace presents a negative impact on efficiency. Integration removes this impediment to the more efficient use of the NAS. Enhancements to ATM automation and other NextGen improvements enable integration of UAS flight profiles.	**Manned:** UAS integration does not adversely affect manned operations.
		UAS: UAS integration enables UAS to file and fly the desired flight path more frequently compared to the constraints associated with accommodation.

Key Performance Area	FAA	NAS Users
Safety	The overall level of safety in the NAS is preserved through UAS integration, which requires adherence to rigorous airworthiness standards. While these standards apply equally to manned aircraft, they also recognize the distinguishing characteristics of UAS (e.g., wake vortex susceptibility).	**Manned:** Integration of UAS does not compromise the safety of NAS operations.
		UAS: UAS certification ensures that failure events are infrequent and better understood. A certified Sense and Avoid capability satisfies an established collision risk threshold.
Security	Regulations mitigate the potential for security breaches of UAS communications links and control stations, which would otherwise impact air traffic operations in the NAS. Improved inter-agency communications (DOD, DHS, and FAA) ensure rapid and effective handling of unauthorized UAS intrusions in the NAS.	**Manned:** No impact.
		UAS: Some UAS operations enable public agencies to accomplish national and local security objectives more effectively.
Environmental Impact	Although an individual UAS flight may be quieter and produce fewer emissions than a manned flight, it is premature to state whether UAS introduction will decrease or increase overall noise and emissions from aviation.	**Manned:** Certain flight operations that were formerly flown by manned aircraft may be replaced by UAS.
		UAS: Some UAS operations may serve as platforms for environmental applications and research. Long endurance missions may be achievable at less cost and lower emissions compared to manned aircraft or satellite assets.

Key Performance Area	FAA	NAS Users
Global Interoperability	UAS integration in domestic airspace serves to advance the process of developing international standards for civil UAS operations, such as through ICAO and other international working groups.	**Manned:** No impact.
		UAS: Once interoperability standards are adopted and incorporated, UAS operators are able to expand operational objectives and use airspace where they had previously been restricted. International UAS operators are granted access to the NAS.
Flexibility	The implementation of NextGen technologies and capabilities may offer capacity improvements that offset potential adverse effects of UAS integration on the ability of the system to meet users' changing needs or adapt their operations to changing conditions. Operations increase in under-utilized airspace (e.g., Class E above Class A).	**Manned:** UAS may compete for airspace and services with manned aircraft operators. Mitigation/resolution is accomplished through Access/Equity policies.
		UAS: UAS operators may experience constraints on when they are permitted to operate in areas of high traffic density or at peak hours.

Table 19. Impact of UAS Integration on Other Operational Concepts

Concept Document	Description	Potential UAS Impact
A Proposed Operational Concept for NextGen Towers (Sept. 2008)	Concept describes a ground-level facility, either fully automated or staffed, from which ATM services will be provided to one or more remote airports.	UAS will have to be sufficiently equipped and able to operate in the remotely-staffed or automated tower environment.
Concept of Operations for Commercial Space Transportation in the NAS (May 2001)	Concept supports evolution of a fully integrated, modernized NAS inclusive of commercial space transportation.	UAS operations will be competing for some of the same airspace that commercial space operations will use (Class E above Class A).
Concept of Operations for En Route Separation Management Enhancements (Sept. 2008)	Concept describes the development of conflict prediction and trial planning automation assistance in the en route domain, to include extension of 3-mile separation minima and wake turbulence mitigation strategies.	Some UA, because of their unique aircraft design characteristics, may require larger wake turbulence minima; conflict prediction and trial planning algorithms need to incorporate those unique characteristics and apply the proper "rules."
Initial Mid-Term Oceanic Trajectory Management on Four Dimensions (Sept. 2008)	OTM-4D allows users to fly close to their optimized trajectory in oceanic airspace and to transit to/from oceanic airspace under different national ANSPs seamlessly.	Oceanic point-to-point UA may be similarly equipped and able to perform advanced 4D trajectories in this domain.
Integrated Surveillance Concept of Operations (Apr. 2009)	Concept describes a net-centric distribution of surveillance data primarily for NAS security purposes.	Some public-use UAS are likely to be "sensors" and "clients" of security-level surveillance data.

Concept Document	Description	Potential UAS Impact
Mid-term Terminal Radar Approach Control Automation Concepts (Apr. 2008)	Concept describes the deployment and use of RNAV and RNP in the terminal approach environment.	Some high-performance UAS will qualify to operate in the high-density terminal environment.
Mid-term End-to-End Flight Data Management Concepts for the NAS (Sept. 2008)	Concept describes the distribution and sharing of flight data across different NAS operators and users.	UAS flight data also needs to be incorporated into ATM automation and shared (to the extent permitted by "public" security missions) with other NAS users in a trajectory-managed environment.
Advanced Merging and Spacing Concept of Operations for the NextGen Mid-Term (Sept. 2009)	Automation defines aircraft metering times in advance so the aircraft can take most of the delays required by implementing smaller trajectory modifications.	Some UAS will be able to use merging and spacing capabilities; ATM automation must be able to recognize and identify unique aircraft performance and flight characteristics.
National Airspace System Surveillance and Broadcast Services Concept of Operations (Aug. 2010)	ADS-B surveillance information (airborne and airport surface) will be used for air traffic control operations and traffic flow management.	One possible method for the Sense and Avoid functions to obtain traffic information necessary for integrating UAS may be through SBS/TIS-B.
Performance-Based Air Traffic Management Terminal Concept of Operations (Aug. 2007)	Concept describes plans to leverage RNAV and RNP, airspace redesign efforts, automation enhancements, and data communications.	Some high-performance UAS will qualify to operate in the high-density terminal and RNP en route environments.
Surface Trajectory Based Operations (STBO) Concept of Operations Overview and Scenarios (Sept. 2009)	Concept describes the functions needed to support tower and surface operations in terms of automation aids, displays, and flight data management and distribution.	ATM automation must be able to recognize UAS and identify unique aircraft performance and flight characteristics.
Terminal Area Required Time of Arrival (RTA) Concept of Operations (Sept. 2008)	Concept describes the application of time-based metering with RNAV and RNP in high-density airport terminal approach environments.	Some high-performance UAS will be able to use FMS with RTA capabilities and be qualified to operate in the high-density terminal and RNP en route environments.

Concept Document	Description	Potential UAS Impact
Tower Flight Data Manager (TFDM) Concept of Operations (Sept. 2009)	Concept describes the functions needed to support tower and surface operations in terms of automation aids, displays, and flight data management and distribution.	ATM automation must be able to recognize UAS and identify unique aircraft performance and flight characteristics.
Wake Vortex Advisory Concept of Operations (Apr. 2003)	Concept describes how to integrate technologies providing reduced spacing for single runway arrivals where wake turbulence may be a factor, including weather sensors, wake sensors, and a wake behavior prediction algorithm.	Some UA, because of their unique aircraft design characteristics, may require larger wake turbulence minima. ATM automation must be able to recognize UAS and identify unique aircraft performance and flight characteristics.
Integrated Arrival/Departure Control Service (Big Airspace) Concept of Operations (Aug. 2005)	Concept aims to improve the services provided to users by integrating Arrival, Departure, and Surface operations. The IADS domain is defined as from the airport surface to top of ascent (TOA) for departures and from the top of descent (TOD) to the airport surface for arrivals.	Some high-performance UAS will qualify to perform integrated arrival and departure operations in the high-density terminal environment.
GBAS Draft Concept of Use (Sept. 2010)	Document details how satellite navigation technologies and ground-based augmentation will enable highly precise approach systems.	Some high-performance UAS will qualify to operate in the high-density terminal environment.
High Altitude Performance Based Airspace (Aug. 2009)	Class A airspace at or above FL340 offers an opportunity to provide tangible benefits to both the FAA and high performance aircraft operators through improved airspace and traffic flow management and service delivery.	Some high-performance UAS will qualify to operate on high performance RNAV/RNP routes.

Concept Document	Description	Potential UAS Impact
NextGen Mid-term Concept of Operations (Sept. 2010)	Document describes, at a high level, the concept of operations for the NAS in the mid-term, as a transitional stage toward NextGen.	This concept describes the NextGen operating environment during a timeframe when UAS will be integrated into the NAS, which sets out the functionality UAS must be able to meet to participate in NextGen-type operations.
Concept of Operations for NextGen Alternative Position, Navigation, and Timing (APNT) (Nov. 2011)	Document establishes requirements on how aircraft operating in PBN airspace will handle the loss or degradation of GNSS services.	Some UAS may be certified to operate in PBN airspace and will be subject to the same system requirements for handling loss of GNSS.
Communications Operating Concept and Requirement for the Future Radio System (May 2007)	Document coordinates between FAA and EuroControl on how engineering requirements for expansion and improvement of radio communications infrastructure will be developed, to include digital voice/data communications.	This document asserts that integration of UAS into controlled airspaces around the world will add to the communication infrastructure load and that there are no estimates yet on what that additional load will be. Document is version 2.0 and future versions will include estimates of UAS demand and bandwidth requirements.
Collaborative Airspace Constraint Resolution Concept of Operations (Mar. 2011)	Document describes CDM processes for handling prioritization and equity issues arising from increasing demand, temporal constraints, and changing user environment.	UAS will participate and be subject to these CDM processes.
Unified Flight Planning and Filing Concept of Operations (Feb. 2011)	Document describes how trajectory negotiation and prioritization/equity resolution will be handled in the flight planning process.	UAS will participate in these flight planning and filing processes.
Concept of Use (ConUse) for Weather in the Next Generation Air Transportation System (NextGen) (Sept. 2008)	Document describes weather's effects and its mitigation on decision-making and operations.	UAS will make use of these mitigation strategies and products.

Concept Document	Description	Potential UAS Impact
NextGen Traffic Management Concept of Operations (June 2011)	Document describes traffic management in mature state NextGen, and provides a comprehensive operational view of traffic management functions including long and near term flight planning, day of flight planning, and day of flight operations.	UAS will participate in these flight planning and traffic management processes.
Operational Concept for Special Activity Airspace (SAA) (June 2011)	Document is focused on improving information pertaining to SAA and overall access to the NAS through enhanced scheduling, tracking, analysis and sharing of data for more efficient flight planning and daily operations.	Many UAS are DOD assets and will be making extensive use of SAA for training.

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4 Appendix A: Glossary of Terms

Terminology	Definition
4D flight plan	A filed flight plan that follows a specific written format for the route of flight, in which planned times for departure, arrival at destination, and at certain waypoints are incorporated.
4D trajectory	The result of a flight plan once entered into ATM automation, which then describes the continuous route of flight in all four dimensions (lateral, longitudinal, vertical, and time), including constraints and tolerances for each route segment where specific performance parameters are prescribed. "Trajectory" also refers to the actual movement of the aircraft in 4D.
Airspace Management (ASM)	The aspect of Air Traffic Management that governs the process by which airspace configuration and allocation options are selected and applied to meet the needs of the users. A planning function with the primary objective of maximizing the use of available airspace by dynamic time-sharing and, at times, the segregation of airspace among various categories of users based on short-term needs.
Air Traffic Control (ATC)	The aspect of Air Traffic Management consisting of the service operated by appropriate authority to perform the safe, orderly, expeditious, and timely flow of air traffic.
Air Traffic Management (ATM)	ATM is the dynamic, integrated management of air traffic and airspace (including air traffic control services, airspace management, and traffic flow management) through the provision of facilities and seamless services in collaboration with all parties and involving airborne and ground-based functions. The ATM system functions to safely, economically, and efficiently move aircraft during all phases of operations.
Airworthiness	The condition in which the UAS conforms to its type certificate and is deemed suitable for safe operation.
Autonomous operations	Any system design that determines and implements changes in operation of the aircraft and precludes any person from affecting the normal operations of the aircraft. Autonomous does not include traditional autopilot, flight management systems, or similar systems where the pilot-in-command can either directly or indirectly affect changes, or where the pilot-in-command must confirm changes to the operations prior to occurring. In addition, contingency actions pre-programmed into a system are not considered under this definition, e.g., actions that occur only during failures of some part of the system.
Certificate of Waiver or Authorization (COA)	An FAA grant of approval for a specific operation.

Terminology	Definition
Civil aircraft	Non-public aircraft purchased and operated for business or personal use.
Class A Airspace	Generally, that airspace from 18,000 feet MSL up to and including FL 600, including airspace overlying the waters within 12 nautical miles of the coast of the 48 contiguous States and Alaska. 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 IFR 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 airspace 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."
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 airspace area is individually tailored, the airspace usually consists of a 5 NM radius core surface area that extends from the surface up to 4,000 feet above the airport elevation, and a 10 NM radius shelf area that extends no lower than 1,200 feet up to 4,000 feet above the airport elevation.
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 appropriate portions of the procedures for conducting that approach.
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 G Airspace	All airspace that is not defined as Class A, B, C, D, or E. Commonly referred to as uncontrolled airspace.

Terminology	Definition
Collision Avoidance	Sense and Avoid function where the UAS takes appropriate action to prevent an intruder from penetrating the collision volume. Action is expected to be initiated within a relatively short time horizon before closest point of approach. The collision avoidance function engages when all other modes of separation fail.
Control link	The communication link and exchange of data between the aircraft and the Control Station regarding the flight operations of the unmanned aircraft. This includes, but is not limited to, flight control and related operational control instructions provided by the PIC to be sent to the aircraft, and status and telemetry information from the aircraft to be sent to the PIC regarding all aspects necessary for safe operations.
Control station	Equipment, not on the aircraft, used to maintain control, communicate, guide, or otherwise operate an unmanned aircraft.
Data communication links	All links between the unmanned aircraft and the control station which include the command, status, communications, and payload links.
Flight object	An extensible and dynamic collection of data elements that describes an individual flight. It is the single common reference for system information about that flight. Authorized system stakeholders and ANSPs may electronically access consistent flight data that is tailored to their specific need and use. The flight object facilitates the sharing of common flight information between current and future systems, enables greater collaboration among system stakeholders and service providers, and provides information (real-time and near real-time) for multiple applications and mission requirements. The flight object will include flight-specific data such as: • Aircraft identifiers and parameters • Current flight plan information (filed, cleared, flown) • Operator preferences, constraints (limitations), SOPs • Flight capabilities, preferences, constraints • Security information
Flight plan	Specified information relating to the intended flight of an aircraft that is filed orally, electronically, or in writing with an FAA or ATC facility.
Fly-away	An interruption or loss of the control link, or when the pilot is unable to effect control of the aircraft and, as a result, the UA is *not* operating in a predicable or planned manner.

Terminology	Definition
Grid pattern	While in a grid pattern, an aircraft flies a back-and-forth route such as north-to-south or east-to-west within a contained area. Grid patterns may occur in any class of airspace, controlled or uncontrolled.
Instrument flight rules (IFR)	Rules governing the procedures for conducting instrument flight. Also a term used by pilots and controllers to indicate a type of flight plan.
Instrument meteorological conditions (IMC)	Meteorological conditions expressed in terms of visibility, distance from clouds, and ceiling, which preclude flight in compliance with visual flight rules (VFR).
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.
Loiter	Loitering occurs when an aircraft remains within a given volume of airspace. Loitering is typically used for search and surveillance operations, which may use random patterns, but may also include flying in a "race-track" or "orbit." Loitering differs from airborne holding in that airborne holding is one of the capacity and/or workload management techniques used by ATC, while loitering is specific to the mission of the flight.
Lost link	An interruption or loss of the control link, or when the pilot is unable to effect control of the aircraft.
Manned Aircraft	Aircraft piloted by a human onboard.
National Airspace System (NAS)	The network of U.S. airspace; airports; air navigation facilities; ATC facilities; communication, surveillance, and supporting technologies; and operating rules and regulations. Its function is to provide a safe and efficient environment for civil, commercial, and military aviation.
Pilot In Command (PIC)	Pilot in command means the person who: 1) Has final authority and responsibility for the operation and safety of the flight; 2) Has been designated as pilot in command before or during the flight; and 3) Holds the appropriate category, class, and type rating, if appropriate, for the conduct of the flight.

Terminology	Definition
Point-to-point transit	Point-to-point transit describes an aircraft whose main purpose of flight is transit from origin to destination, typical of today's traffic. It differs from a "tower-to-tower" flight plan in that a point-to-point transit operation may not necessarily depart or arrive at a towered airport, but might be a volume of airspace or a non-towered launch/recovery point.
Public aircraft	An aircraft operated by a public user that is intrinsically governmental in nature (i.e., federal, state, and local agencies). Examples of public entities are Department of Defense (DOD) and its military branches; other local, state, and federal government agencies; and state universities. See Title 14 CFR Part 1.1, General Definitions, for a complete definition of a public aircraft.
Radar cross-section (RCS)	Radar cross section (RCS) is a measure of how detectable an object is with radar. A larger RCS indicates that an object is more easily detected. An object reflects an amount of energy emitted by a radar, and that amount is affected by a number of different factors, such as: • material of which the target is made; • absolute size of the target; • size of the target in relation to the wavelength of the radar; • the angle at which the radar beam hits a particular spot on the target which depends upon shape of target and its orientation to the radar source; • the angle at which the reflected beam leaves the part of the target hit, which depends on incident angle.
Safe Separation	The result of the UAS flight crew applying sense and avoid technology to separate from other airborne traffic (analogous to the visual requirements for manned aircraft to "see and avoid").
Sense and Avoid	The capability of a UAS to remain well clear from and avoid collisions with other airborne traffic. Sense and Avoid provides the functions of self-separation and collision avoidance to establish an analogous capability to "see and avoid" required by manned aircraft. Collectively, these functions result in "safe separation."
Self-separation	Sense and Avoid function where the UAS maneuvers within a sufficient timeframe to prevent activation of a collision avoidance maneuver while conforming to an accepted airborne separation standard. Any UAS maneuvers will be in accordance with regulations and procedures. The self-separation function is analogous to the requirement to remain well clear of aircraft from which ATC does not provide separation services.

Terminology	Definition
Special Activity Airspace	Any airspace with defined dimensions within the NAS wherein limitations may be imposed upon aircraft operations. This airspace may be restricted areas, prohibited areas, military operations areas, ATC assigned airspace, and any other designated airspace areas. This airspace is designated as either active or inactive.
Traffic Flow Management (TFM)	The aspect of Air Traffic Management that ensures that system capacity is used to the maximum extent possible, and that the traffic demand is compatible with the capacities declared by the ANSP.
Unmanned Aircraft (UA)	A device used or intended to be used for flight in the air that has no onboard pilot. (Note that the use of the term "device" is contained in the official language, but is clearly intended to refer to aircraft, rotorcraft, and airships.)
Unmanned Aircraft System (UAS)	An unmanned aircraft and its associated elements, which may include control stations, control links, support equipment, payloads, flight termination systems, and launch/recovery equipment.
Vertical transit	During vertical transit, an aircraft typically flies through one or more airspace classes for the sole purpose of reaching a higher altitude. It differs from the more familiar term "departure climb-out" in that a vertical transit does not necessarily follow a departure procedure, but may originate from another segment of a flight profile.
Visual Line-of-Sight	Unaided visual contact between a PIC (or designated UAS crewmember) and a UA sufficient to maintain safe operational control of the aircraft, know its location, and be able to scan the airspace in which it is operating to see and avoid other air traffic or objects aloft or on the ground.
Visual Flight Rules (VFR)	Rules that govern the procedures for conducting flight under visual conditions. In addition, it is used by pilots and controllers to indicate a 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.
Visual observer	A UAS crewmember assigned by the PIC to assist in providing the ability to see and avoid other airborne traffic or objects on the ground.

5 Appendix B: Acronym List

UAS Related Acronyms	
4D	Four Dimensional
AC	Advisory Circular
ADS-B	Automatic Dependent Surveillance - Broadcast
ADS-C	Automatic Dependent Surveillance - Contract
AIM	Aeronautical Information Manual
ANSP	Air Navigation Service Provider
ASM	Airspace Management
ATC	Air Traffic Control
ATM	Air Traffic Management
CATMT	Collaborative Air Traffic Management Technologies
CDA	Continuous Descent Approach
CDM	Collaborative Decision Making
CD&R	Conflict Detection and Resolution
CFR	Code of Federal Regulations
CNS	Communication Navigation Surveillance
COA	Certificate of Waiver or Authorization
ConOps	Concept of Operations
CPDLC	Controller Pilot Data Link Communications
CTAF	Common Traffic Advisory Frequency
DHS	Department of Homeland Security
DOD	Department of Defense
FAA	Federal Aviation Administration
FANS	Future Air Navigation Systems
FARs	Federal Aviation Regulations
FIR	Flight Information Region
FL	Flight Level
FOC	Flight Operations Center
GNSS	Global Navigation Satellite System
GPS	Global Positioning System

UAS Related Acronyms	
HALE	High Altitude, Long Endurance
HF	High Frequency radio band
ICAO	International Civil Aviation Organization
IFR	Instrument Flight Rules
IMC	Instrument Meteorological Conditions
ISS	Information System Security
ITP	In-Trail Procedure
LOA	Letter of Agreement
MSL	Mean Sea Level
NAS	National Airspace System
NASA	National Aeronautics and Space Administration
NextGen	Next Generation Air Transportation System
NM	Nautical Mile
NOAA	National Oceanic and Atmospheric Administration
NVS	NAS Voice System
OPD	Optimized Profile Descent
OSED	Operational Services and Environmental Definition
PIC	Pilot In Command
PIREP	Pilot Report
RNAV	Area Navigation or Random Navigation
RNP	Required Navigation Performance
RTA	Required Time of Arrival
RVSM	Reduced Vertical Separation Minimum
SESAR	Single European Sky ATM Research
SMS	Safety Management System
TBFM	Time-based Flow Management
TBO	Trajectory-Based Operations
TCAS	Traffic Alert and Collision Avoidance System
TFM	Traffic Flow Management
TFR	Temporary Flight Restriction
TIS-B	Traffic Information Service – Broadcast mode

UAS Related Acronyms	
TMI	Traffic Management Initiative
TOD	Top of Descent
TRACON	Terminal Radar Approach Control facility
TSO	Technical Standard Order
UA	Unmanned Aircraft
UAS	Unmanned Aircraft System
UHF	Ultra High Frequency radio band
VFR	Visual Flight Rules
VHF	Very High Frequency radio band
VLOS	Visual line of sight
VMC	Visual Meteorological Conditions