



NextGEN

Concept of Operations

v2.0

Foundational Principles

Roles and Responsibilities

Scenarios and Operational Threads



**Unmanned Aircraft System (UAS)
Traffic Management (UTM)**

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U.S. Department
of Transportation
**Federal Aviation
Administration**

Office of NextGen

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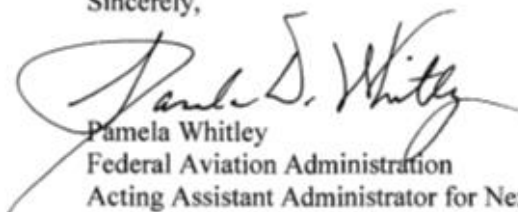
Dear Reader:

Attached for distribution is Version 2.0 of the Unmanned Aircraft Systems (UAS) Traffic Management (UTM) Concept of Operations. This concept documents the continued maturation of UTM through use case development, insights on rulemaking, and the evolution of UTM Technology Capability Level (TCL) and Pilot Program (UPP) demonstrations. It reflects the collaborative efforts across the FAA, including the Office of NextGen (ANG), the Air Traffic Organization (ATO), and Aviation Safety (AVS) organization, as well as the ongoing inter-agency research efforts with NASA. The concept also reflects the inputs and participation of industry partners as part of NASA's research community.

Subsequent versions of this concept will be developed to encompass the continued development and implementation of UTM into the National Airspace System (NAS). An immediate need is to expand and address the role of UTM in supporting our security partners. Security is a key focus area that will support the full implementation of Remote ID (RID) and will lay the foundational elements for future expansion of UTM operations and associated rules.

Thank you for your attention and please share with interested parties.

Sincerely,

A handwritten signature in black ink, appearing to read "Pamela S. Whitley".

Pamela Whitley
Federal Aviation Administration
Acting Assistant Administrator for NextGen, ANG-1

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Document Change Record

Published Date	Document Version	Section Impacted	Revision Description (substantial only)
5/23/2018	1.0	Baseline Document	
3/2/2020	2.0	Throughout	Expanded document to address more complex operations within and across both uncontrolled (Class G) and controlled (Classes B, C, D, E) airspace environments
		2.3	Updated Notional Architecture figure and reorganized section to address components of the architecture diagram (Figure 3)
		2.3.2	Expanded discussion of types of UTM services
		2.4.1	Updated Participation requirements, accounting for Remote ID
		2.4.2	Updated Performance Authorization description
		2.4.3	Added Airspace Authorization description and associated requirements
		2.4.5 2.7.1.2 2.7.3.2 Scenario V2.2	Updated Dynamic Restriction concept to UAS Volume Restriction (UVR) concept
		2.4.6 2.7.1.3	Updated ATM/UTM contingency management notification approach
		2.6	Added Remote Identification description and associated requirements
		2.7.2	Expanded Security section to address data management and access, networked systems, and aircraft systems
		3	Updated and added new Operational Scenarios
		Throughout/ Appendix D	Updated USS Services categories and definitions throughout body of document and Appendix D
		Appendix E	Updated FAA/NASA UTM RTT Use Case/Scenarios list to include Technology Capability Level (TCL 3) addendum and TCL use cases

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Executive Summary

In 2018, the Federal Aviation Administration (FAA) NextGen Office released an initial overarching Concept of Operations (V1.0) for Unmanned Aircraft Systems (UAS) Traffic Management (UTM) that presented a vision and described the associated operational and technical requirements for developing a supporting architecture and operating within a UTM ecosystem. UTM is defined as the manner in which the FAA will support operations for UAS operating in low altitude airspace. UTM utilizes industry's ability to supply services under the FAA's regulatory authority where these services do not currently exist. It is a community-based traffic management system, where the Operators and entities providing operation support services are responsible for the coordination, execution, and management of operations, with rules of the road established by FAA. This federated set of services enables cooperative management of operations between UAS Operators, facilitated by third-party support providers through networked information exchanges. UTM is designed to support the demand and expectations for a broad spectrum of operations with ever-increasing complexity and risk through an innovative, competitive open market of service suppliers. The services provided are interoperable to allow the UTM ecosystem to scale to meet the needs of the UAS Operator community.

The FAA updated this Concept of Operations (ConOps) to document the continued maturation of UTM and share the vision with government and industry stakeholders. UTM ConOps V2.0 continues to focus on UTM operations below 400 feet above ground level (AGL), but also addresses increasingly more complex operations within and across both uncontrolled (Class G) and controlled (Classes B, C, D, E) airspace environments. V2.0 updates and expands the set of operational scenarios, describing more complex operations in denser airspace, including beyond visual line of sight (BVLOS) operations in controlled airspace. V2.0 includes updated descriptions of/approaches to several UTM components, including UAS Volume Reservations (previously referred to as Dynamic Restrictions), Performance Authorizations, data archiving and access, USS service categories, UTM/ATM contingency notification, and security aspects associated with UTM operations. V2.0 also introduces new topics including Airspace Authorization for BVLOS flight within controlled airspace, UTM architecture support to remote identification of UAS Operators, and standards development efforts with industry as an integral part of enabling UTM operations.

FAA UTM ConOps documents do not prescribe solutions or specific implementation methods, unless for example purposes. Rather, they describe the essential conceptual and operational elements associated with UTM operations that will serve to inform development of solutions across the many actors and stakeholders involved in implementing UTM. They also support a spiral implementation approach – maturing the concept through analysis of more complex airspace environments, tested and validated by field demonstrations, including National Aeronautics and Space Administration (NASA) Technology Capability Level (TCL), FAA UTM Pilot Program (UPP), and UAS Integration Pilot Program (IPP) demonstrations. Future versions will continue to be developed as needed to reflect the progress of research and continued concept maturation resulting from collaboration with the FAA, NASA, and industry partners.

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1 Introduction

The commercial applications and opportunities for unmanned aircraft system (UAS) operations, particularly at low altitudes, across a myriad of sectors from inspection, to survey, to monitoring, to package delivery, present enormously enticing incentives and business cases for an operating construct that allows for these operations within the regulatory, operational, and technical environment that comprises the National Airspace System (NAS). UAS operational needs and expected benefits are driving public and private stakeholder partnerships, led by the Federal Aviation Administration (FAA) and National Aeronautics and Space Administration (NASA), to develop and continually mature a Concept of Operations (ConOps) for UAS Traffic Management (UTM). This vision for UAS operations engenders a common desire to realize innovative solutions through public-private partnerships and the leveraging of technologies in support of emerging opportunities while ensuring safety, security, efficiency, and equity of the NAS are maintained to the highest of standards.

1.1 Need for UTM

Integration of low-altitude UAS operations into the NAS presents a variety of issues and novel challenges. The predicted volume of small UAS (sUAS) operations across both controlled and uncontrolled airspace, which could be on a scale comparable, if not greater, to that of present-day manned air traffic, compounds these challenges. Currently, recreation and licensed commercial UAS Operators can fly within visual-line-of-sight (VLOS) under 49 U.S.C. 44809(c), and 14 Code of Federal Regulations (CFR) Part 107, respectively; a limited number of commercial entities are also receiving approval to operate under Parts 135, 137, and 91 when they have demonstrated they can safely fly in a specified operating environment. Other UAS operations occur today via waivers that require an individualized assessment on a case-by-case basis. As detailed in Figure 1, the combined recreation and commercial fleet is projected to reach 2 to 3 million by 2023, up from less than 1.5 million in 2018.¹ This increase in fleet size will bring with it a considerable increase in the expected volume of operations

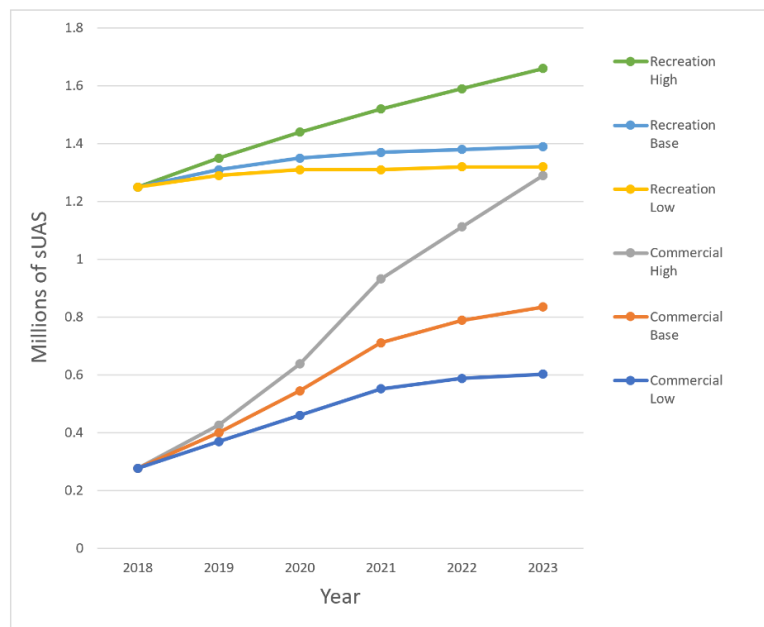


Figure 1. Projected UAS growth

¹ Federal Aviation Administration. (n.d.). *FAA Aerospace Forecast, Fiscal Years 2019-2039 (TC19-0002)*. Retrieved from www.faa.gov/data_research/aviation/aerospace_forecasts/media/FY2019-39_FAA_Aerospace_Forecast.pdf

and, in turn, potentially, demand for airspace services. With commercial UAS conducting multiple flights a day to support business needs, such as deliveries and infrastructure inspections, the number of daily operations could potentially reach into the millions, taxing the NAS well beyond its current service requirements.

The FAA expects that the full gamut of low-altitude UAS operations will encompass everything from those that are fully contained in uncontrolled airspace, to those that require transit across the boundary between controlled and uncontrolled airspace, to those that originate and operate exclusively within controlled airspace. Given the number, type, and duration of UAS operations envisioned, the existing Air Traffic Management (ATM) System infrastructure and associated resources cannot cost-effectively scale to deliver services for UAS. Further, the nature of most of these operations does not require direct interaction with the ATM system. To enable safe management of the expected rapid influx of UAS operations in the NAS, solutions that scale beyond the current ATM infrastructure and Air Traffic Control (ATC) personnel resources are necessary. Solutions that extend beyond the current paradigm for manned aircraft operations, to those that promote shared situational awareness among Operators, are needed.

It is the FAA's responsibility to develop a means for safely enabling new types of UAS operations. This includes establishing a regulatory framework, developing operating rules to ensure accountability of Operators and other actors, and promoting efficient and equitable airspace access for all Operators, manned and unmanned. The FAA acknowledges the need to develop and mature a concept for UTM, a separate set of services to those traditionally provided to airspace users.

1.2 UTM Evolution

A conceptual framework for UTM was first conceived by NASA in 2013 and was initially presented at a NASA-Industry workshop in 2014. In 2015, NASA hosted a UTM Convention where NASA and UAS Operators highlighted the need for UAS traffic management at low altitudes. In response to the Convention, the FAA articulated its principles for managing that airspace, which moved the NASA conceptual framework from individual third-party managers operating in delegated airspace to a focus of third-party support services for Operators. With the FAA's clarification that the airspace is managed by the FAA and that operations would be done cooperatively by Operators and their supporting services, NASA's research has evolved to support the development of both the FAA and Operators' systems, procedures, and policies needed to implement UTM.

The FAA and NASA formed a UTM Research Transition Team (RTT) in 2016 to jointly undertake the development and eventual implementation of UTM, a step that demonstrated the FAA's commitment to building this community-based traffic management system. The FAA has been working with NASA and the UAS community on concept development and prototyping activities to ultimately enable a UTM ecosystem that provides management services to large-scale UAS operations in airspace where air traffic services are not provided (see Appendix A for more information on the UTM RTT).² To support future

² 'UTM ecosystem' refers to the network of actors/participants, services, capabilities, information flows, and other supporting architecture elements (as depicted in yellow shaded area in Figure 3).

operational requirements beyond the current Part 101 and 107 regulations, NASA and the FAA have developed an architecture that supports a federated set of services to enable cooperative management of low-altitude UTM operations between UAS Operators, facilitated by third-party support providers through networked information exchanges. Included in this architecture is the Flight Information Management System (FIMS). FIMS supports information exchanges and protocols between UTM participants and FAA systems, and is a core component of the UTM ecosystem. The UTM architecture supports common situational awareness among all UTM stakeholders (e.g., Operators, FAA, and other government agencies).

In April 2017, the FAA and NASA UTM RTT established the UTM Pilot Program (UPP) in accordance with the FAA Extension, Safety and Security Act of 2016. Following a series of outreach efforts with the UAS industry, the FAA released a request for information to the FAA's designated UAS test sites, and in January 2019, the Secretary of Transportation announced the FAA's selection of three UAS test sites to test and demonstrate an initial set of UPP capabilities. The FAA, NASA, test sites, and industry partners moved forward with the goal of developing, demonstrating, and showcasing enterprise services, using a cloud service infrastructure to support UTM operations. During the summer of 2019, UTM services demonstrated in the UPP included Airspace Authorizations, airspace activity notifications, and the collaborative sharing of intent and other flight information between UAS Operators, the FAA and other UTM stakeholders. Upon completion of all tests and demonstrations at the FAA's designated UAS test sites, the results were compiled into a report to provide a proof of concept for UTM capabilities currently in research and development that will serve as the basis for expanded deployment of UTM capabilities.³

In October 2017, the FAA's initial application within the UTM ecosystem - the UAS Low Altitude Authorization and Notification Capability (LAANC) - was deployed for prototype testing, and then officially rolled out in 2018. LAANC provides Part 107 UAS Operators access to controlled airspace near airports through near real-time, automated processing of Airspace Authorizations below approved altitudes, facilitated by industry service suppliers who provide government-qualified services. LAANC is now available at approximately 400 air traffic facilities, covering about 600 airports.

In October 2018, Congress passed an FAA Reauthorization Act that called upon the FAA to expedite the development and implementation of a UTM system, as well as assess remote identification (RID) capabilities to safely integrate UAS into the airspace and address security concerns. RID is the ability of a UAS in flight to provide identification information that can be received by other parties. RID will help facilitate more advanced operations for UAS, and will also assist the FAA, law enforcement, and federal security agencies when a UAS appears to be flying in an unsafe manner or where the UAS is not allowed to fly.⁴ UTM will provide the supporting architecture for information exchanges related to RID.

³ Federal Aviation Administration, Office of NextGen. (2019). *Unmanned Aircraft Systems (UAS) Traffic Management (UTM), UTM Pilot Program (UPP), UPP Summary Report*.

⁴ U.S. Department of Transportation, Federal Aviation Administration. (2019). *UAS Remote Identification*. Retrieved from www.faa.gov/uas/research_development/remote_id/

The FAA is supporting several organizations in the development of standards to permit, authorize, or allow the use of UTM services – including, but not limited to, ASTM International, the American National Standards Institute (ANSI), and the Joint Authorities for Rulemaking on Unmanned Systems (JARUS). ASTM International’s Committee on Unmanned Aircraft Systems (F38) is developing UTM standards for remote identification, USS interoperability and performance for strategic deconfliction, and surveillance services. ANSI’s UAS Standardization Collaborative (UASSC) is drafting a Standardization Roadmap for Unmanned Aircraft Systems. JARUS is developing a work plan to address UTM aspects from a regulator perspective, including the division of responsibility between actors, organizational oversight, and holistic risk modeling. One specific activity already underway is the development of a specific operational risk assessment (SORA) methodology that will identify standardized areas of operational risk mitigation that a service provider may choose to build and market to Operators. The FAA is also a member of the Global UTM Association (GUTMA). GUTMA serves as an industry voice and advocate for UTM technologies. GUTMA creates working groups to address UTM issues and drives a common understanding across its membership.

1.3 ConOps Scope

This ConOps V2.0 focuses on UTM operations below 400 feet above ground level (AGL) and addresses increasingly complex UTM operations within and across both uncontrolled (Class G) and controlled (Class B, C, D, E[surface]) airspace environments (in comparison to ConOps V1.0).⁵ It introduces scenarios that include beyond visual line of sight (BVLOS) operations in controlled airspace.

Class G airspace is the portion of airspace in the NAS that has not been designated as controlled airspace (i.e. Class A, B, C, D, or E). It is, therefore, designated uncontrolled airspace. ATC has no responsibility to provide separation services in Class G airspace; rather, manned aircraft cooperatively manage their operations predominantly through visual means based on specified principles and rules of operation. In order to provide UAS with the same access as manned aircraft, UTM is designed to provide a similar means of cooperative traffic management for UAS and other participating aircraft in uncontrolled airspace.

Controlled airspace includes airspace that has been designated as Class A, B, C, D, and E. While ATC provides varying levels of services to manned and unmanned aircraft in these airspace classes, they do not provide services to unmanned aircraft operating under 400 ft AGL. UAS operations are cooperatively managed by those conducting flight, and interaction with ATM systems is limited (as discussed in Section 2.7.1.3). See Figure 2 for UTM in the context of airspace classes and Appendix B for detailed airspace class descriptions.

⁵ FAA NextGen Organization. (2018). *Unmanned Aircraft System (UAS) Traffic Management (UTM) Concept of Operations v1.0*. Washington, DC: Federal Aviation Administration

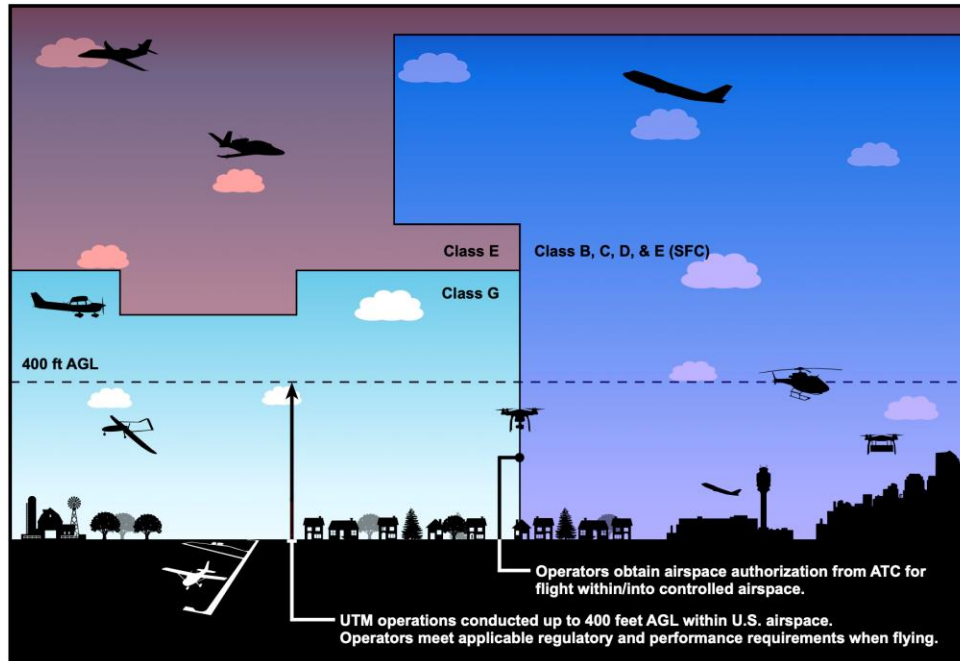


Figure 2. UTM Operations in context of airspace classes

1.4 ConOps Objectives

The objectives of this ConOps are to present a vision and describe the associated operational and technical requirements for developing and operating within the UTM ecosystem. This ConOps does not prescribe solutions or specific implementation methods, unless for example purposes. Rather, it describes the essential conceptual and operational elements associated with UTM operations that will serve to inform development of solutions across the many actors and interested parties involved in implementing UTM. It is possible, and in fact, expected, that additional capabilities, services, and offerings, although non-essential, may be available within the UTM ecosystem. These should adhere to the principles and conceptual elements described here.

The ConOps document presents the following:

- ❖ UTM operational concept, which provides the foundational principles around which UTM is based, a description of a conceptual architecture and associated UTM actors, and the concepts and operational requirements envisioned to provide a comprehensive set of traffic services,
- ❖ Roles and responsibilities of the various actors and entities that interact with UTM, and
- ❖ High-level use cases and operational threads that demonstrate the conduct of UTM operations.

2 UTM Operational Concept

2.1 Overview

UTM is the manner in which the FAA will support operations for UAS operating in low altitude airspace.⁶ UTM utilizes industry's ability to supply services under FAA's regulatory authority where these services do not currently exist. It is a community-based, cooperative traffic management system, where the Operators and entities providing operation support services are responsible for the coordination, execution, and management of operations, with rules of the road established by FAA.

UTM is predicated on layers of information sharing and data exchange - from Operator to Operator, vehicle to vehicle, and Operator to the FAA - to achieve safe operations. Operators share their flight intent with each other and coordinate to de-conflict and safely separate trajectories. The primary means of communication and coordination between Operators, the FAA, and other stakeholders is through a distributed information network, and *not* between pilots and air traffic controllers via voice. The FAA makes real-time airspace constraints available to UAS Operators, who are responsible for managing their own operations safely within these constraints without receiving ATC services from the FAA. The FAA does have, however, have on-demand access to UTM operational information when needed.

UTM includes a set of federated services and an all-encompassing framework for managing multiple UAS operations.⁷ The services are separate, but complementary to ATC separation services, and are based primarily on the sharing of information between Operators on flight intent and airspace constraints. They are paramount to supporting the safe and secure conduct of UTM operations, providing support for flight operations planning, communications, separation, and weather, among others. UAS Operators may choose to use third party UAS Service Suppliers (USSs) to support their operations, or they may choose to provision their own set of services. USSs provide services to support the UAS community, to connect Operators and other entities to enable information flow across the USS Network, and to promote shared situational awareness among UTM participants. Some services provided by USSs require qualification by the government in order to support Operators in meeting applicable regulations and policies.

UTM is designed to support the demand and expectations for a broad spectrum of operations with ever-increasing complexity and risk. It encompasses all infrastructure, policies, procedures, services, and personnel required to support low altitude UAS operations. UTM requires the establishment of regulatory frameworks, development of new operating rules and performance requirements commensurate with demands of the operation, and a data exchange and information architecture that provides shared

⁶ FAA UTM ConOps V1.0 referred to 'sUAS' as the primary participants in UTM. V2.0 drops that designation recognizing that 'sUAS' was a size designation and not the manner in which the aircraft operates within the NAS. V2.0 removes that designation and is applicable to all UAS operating within UTM airspace management.

⁷ The term 'federated' in this document refers to a group of systems and networks operating in a standard and connected environment.

situational awareness among participants.⁸ UTM Operators are responsible for meeting the requirements established for the type of operation and associated airspace volume/route in which they are operating and complying with all FAA regulations.

As the federal authority over operations in all airspace, and the regulator and oversight authority over commercial operations, the FAA ensures that UTM aligns with agency goals and meets the requirements for safe and efficient operations.

To establish UTM, the FAA is:

- ❖ Developing a UAS regulatory and traffic management framework that is compatible with the evolution of the technology required to support UTM. UTM infrastructure will evolve so that the use of a mature UTM ecosystem will support planned commercial operations. An example of this is LAANC, which supports the requirements for commercial operations under 14 CFR Part 107 and recreation operations under 49 U.S.C. 44809, Subpart C, and is considered an initial UTM capability.
- ❖ Adopting an “authorize and assess” philosophy to meet the core concerns of this nascent industry. The operational use of UTM capabilities can be event-based, dictated either by density concerns, changes in the nature of allowed operations, or other, yet unknown, external factors.
- ❖ Evolving UTM technology in a time-based fashion with a development plan that provides tested products to meet FAA and community needs, and/or provides insight and opportunity as the industry matures. UTM requirements will evolve with the march to expanded operations, as foreseen in already-submitted Operator waiver requests, cooperative research initiatives, and BVLOS rulemaking.

The FAA expects that industry will develop standards and seize opportunities to innovate and develop solutions that will assist in the management of increasing numbers of UAS operations now, and into the future.

2.2 Benefits

UTM federated services collectively enable the management and safe operation of large scale UAS operations in low altitude airspace. UTM provides:

- ❖ An innovative approach to meeting service requirements, leveraging commercial services that greatly accelerate the provision of capabilities due to market forces and business incentives to meet consumer demand, while placing a much smaller infrastructure and manpower burden (cost) on the government to implement.

⁸ The FAA intends to create new flight rules to support UAS operations that will be complemented by UTM service offerings.

- ❖ A safe and stable environment for Operators to operate and meet business needs through shared situational awareness and an operational framework consisting of standards, regulations, and common protocols that reduce risk and maintain stability.
- ❖ A flexible and extensible construct that can adapt and evolve as the trade space changes and matures.
- ❖ A construct that allows the FAA to maintain its authority over the airspace, while allowing industry to manage operations in areas authorized for low altitude UAS flight.

2.3 Notional Architecture

Within the UTM ecosystem, the FAA maintains its regulatory and operational authority for airspace and traffic operations; however, the operations are not managed by ATC. Rather, they are organized, coordinated, and managed by a federated set of actors in a distributed network of highly automated systems via application programming interfaces (APIs). Figure 3 depicts a notional UTM architecture that visually identifies, at a high level, the various actors and components, their contextual relationships, as well as high-level functions and information flows. The gray dashed line in Figure 3 represents the demarcation between the FAA and industry responsibilities for the infrastructure, services, and entities that interact as part of UTM. As shown, UTM comprises a sophisticated relationship between the FAA, the Operator, and the various entities providing services and/or demonstrating a demand for services within the UTM ecosystem. The illustration highlights a model, which heavily leverages utilization of third-party entities to support the FAA and the Operator in their respective roles and responsibilities. Sections 2.3.1 and 2.3.2 describe elements of this notional architecture.

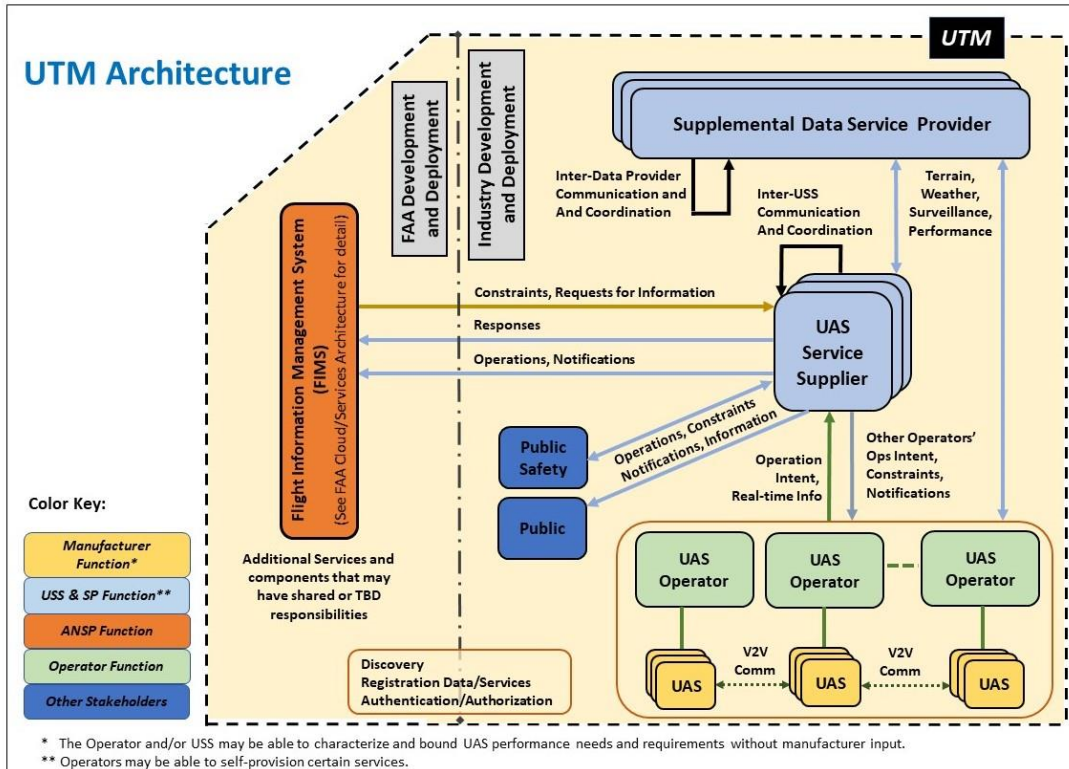


Figure 3. Notional UTM architecture

2.3.1 Participants

2.3.1.1 FAA

The FAA is the federal authority over aircraft operations in all airspace, and the regulator and oversight authority for civil aircraft operations in the NAS. The FAA maintains an operating environment that ensures airspace users have access to the resources needed to meet their specific operational objectives and that shared use of airspace can be achieved safely and equitably. The FAA develops rules, regulations, policy, and procedures as required to support these objectives.

With UTM, the FAA’s primary role is to provide a regulatory and operational framework for operations and to provide FAA-originated airspace constraint data to airspace users (e.g., airspace restrictions, facility maps, active Special Activity Airspace [SAA]). The FAA interacts with UTM for information/data exchange purposes as required, and has access to data at any time, via FIMS, to fulfill its obligations to provide regulatory and operational oversight.

2.3.1.2 Operator

The Operator is the person or entity responsible for the overall management of their operation. The Operator meets regulatory responsibilities, plans flight/operations, shares operation intent information, and safely conducts operations using all available information. Use of the term ‘Operator’ in this

document is inclusive of airspace users electing to participate in UTM, including manned aircraft Operators, except when specifically referred to as a manned or UAS/UTM Operator.

2.3.1.3 Remote Pilot in Command/RPIC

The remote pilot in command (RPIC) is the person responsible for the safe conduct of each UAS flight. An individual may serve as both the Operator and the RPIC. The RPIC adheres to operational rules of the airspace in which the unmanned aircraft (UA) is flying; avoids other aircraft, terrain and obstacles; assesses and respects airspace constraints and flight restrictions; and avoids incompatible weather/environments. The RPIC monitors the flight performance and location of the UA. If safety of flight is compromised, due to system/equipment degradation or environmental vulnerabilities, the RPIC is aware of these factors and intervenes appropriately. More than one RPIC may take control of the aircraft during the flight, provided one person is responsible for the operation at any given time.

2.3.1.4 Other Stakeholders – Public Safety and General Public

Other stakeholders can also access information and/or utilize UTM services via the USS Network. Stakeholders include public safety entities and the general public. Public safety entities, when authorized, can access UTM operations data as a means to ensure safety of the airspace and persons and property on the ground, security of airports and critical infrastructure, and privacy of the general public. Data can be accessed through dedicated portals or can be routed directly by service providers to public safety entities, local/tribal/state law enforcement agencies, and other relevant federal agencies (e.g., Department of Homeland Security (DHS)) on an as-needed basis. The general public can access data that is determined or required to be publicly available.

2.3.2 Services and Supporting Infrastructure

UTM services are modular and discrete, allowing for increased flexibility in the design and implementation of new services. This modular approach allows the FAA to provide tailored oversight of services in order to strike a balance between providing government oversight and spurring industry innovation.

At the most basic level, services can be characterized in one of the following ways:

- 1) Services that are required to be used by Operators due to FAA regulation and/or have a direct connection to FAA systems. These services must be qualified by the FAA against a specified set of performance rules.
- 2) Services that may be used by an Operator to meet all or part of a FAA regulation. These services must meet an acceptable means of compliance and may be individually qualified by the FAA.
- 3) Services that provide value-added assistance to an Operator, but are not used for regulatory compliance. These services may meet an industry standard, but will not be qualified by the FAA.

For the remainder of this document “UTM Operations” are considered any operation that utilizes services from the first and second groupings.

2.3.2.1 UAS Service Supplier/USS

A USS is an entity that assists UAS Operators with meeting UTM operational requirements that enable safe and efficient use of airspace. A USS (1) acts as a communications bridge between federated UTM actors to support Operators' abilities to meet the regulatory and operational requirements for UAS operations, (2) provides the Operator with information about planned operations in and around a volume of airspace so that Operators can ascertain the ability to safely and efficiently conduct the mission, and (3) archives operations data in historical databases for analytics, regulatory, and Operator accountability purposes. In general, these key functions allow for a network of USSs to provide cooperative management of low altitude operations without direct FAA involvement.

USS services support operations planning, intent sharing, strategic and tactical de-confliction, conformance monitoring, RID, Airspace Authorization, airspace management functions, and management of off-nominal situations. They exchange information with one another over the internet to enable UTM services (e.g., exchange of intent information, notification of airspace changes, and automated query exchanges). USSs work with local municipalities and communities, as needed, to gather, incorporate, and maintain airspace reservations into airspace data repositories that may be accessed by Operators.

USSs may provide (1) Services that enable authorized UTM stakeholders to discover active USSs and their available services within the USS Network, (2) Services that provide the ability for vehicle owners to register data related to their UAS, (3) Services for USS registration, and (4) Services for message security to ensure data is secured and exchanged only with the authorized users. USSs may also provide other value-added services to support UTM participants as market forces create opportunity to meet business needs. See Appendix C for a more detailed description of a USS, and Appendix D for examples of UTM services.

2.3.2.2 USS Network

The term 'USS Network' is the amalgamation of USSs connected to each other, exchanging information on behalf of subscribed Operators. The USS Network shares operational intent data, airspace constraint information, and other relevant details across the network to ensure shared situational awareness for UTM participants. In the UTM construct, multiple USSs can operate in the same geographical area. The USS Network must implement a shared paradigm, with industry agreed upon methods for de-confliction and/ or negotiation, and standards for the efficient and effective transmission of intent and changes to intent. This reduces risk to Operators and improves the overall capacity and efficiency in the shared space. The USS Network is also expected to facilitate the ready availability of data to the FAA and other entities as required to ensure safe operation of the NAS, and any other collective information sharing functions, including security and identification.

2.3.2.3 UAS Supplemental Data Service Providers

Operators and USSs can access Supplemental Data Service Providers (SDSPs) for essential or enhanced services - including terrain and obstacle data, specialized weather data, surveillance, and constraint information. SDSPs may connect to the USS Network or directly to Operators through other means (e.g., public/private internet sites).

2.3.2.4 Flight Information Management System/FIMS

FIMS is an interface for data exchange between FAA systems and UTM participants. FIMS enables exchange of airspace constraint data between the FAA and the USS Network. The FAA also uses this interface as an access point for information on active UTM operations. FIMS also provides a means for approved FAA stakeholders to query and receive post-hoc/archived data on UTM operations for the purposes of compliance audits and/or incident or accident investigation. FIMS is managed by the FAA and is a part of the UTM ecosystem.

2.3.2.5 National Airspace System/NAS Data Sources

FAA NAS data sources are connected to the UTM ecosystem through FIMS. This allows for data flow between the UTM community and FAA operational systems, and data access for authorized users, as required. The FIMS interface between the FAA and UTM stakeholders external to the FAA acts as a gateway such that external entities do not have direct access to FAA systems and databases. NAS data sources that FIMS may be connected to for data exchange purposes include sUAS registrations, Airspace Authorizations, operational waivers, and constraints.

2.4 Operations

UTM Operators are expected to abide by the appropriate operating rules, regulations, and policies for their operations. The Operator, vehicle, and USS services are required to perform at levels sufficient to maintain separation at all times from hazards in a fully accountable manner. UTM Operators are supported by a suite of services designed to provide, through information exchanges, the analogous shared situational awareness that visual cooperative operations have always required. The UTM operational framework supports the management and safe conduct of operations through (1) the issuance of Performance Authorizations that ensure Operator performance requirements are met, (2) Airspace Authorizations - required for operations in controlled airspace, (3) Operation Planning that supports the sharing of flight intent (4) airspace constraint and advisory information dissemination, and (5) the use of services, technologies, and equipage to de-conflict operations. Sections 2.4.1 through 2.4.6 further discuss these operational elements.

2.4.1 Participation

All UAS Operators not receiving ATC separation services are required to participate in UTM at some level using applicable services to meet the performance requirements of their operations (see Figure 4 for UTM in the context of ATM operations). The number and type of services required varies based on the type and location of the intended operation and the associated communication, navigation, and surveillance (CNS), and other operational needs.

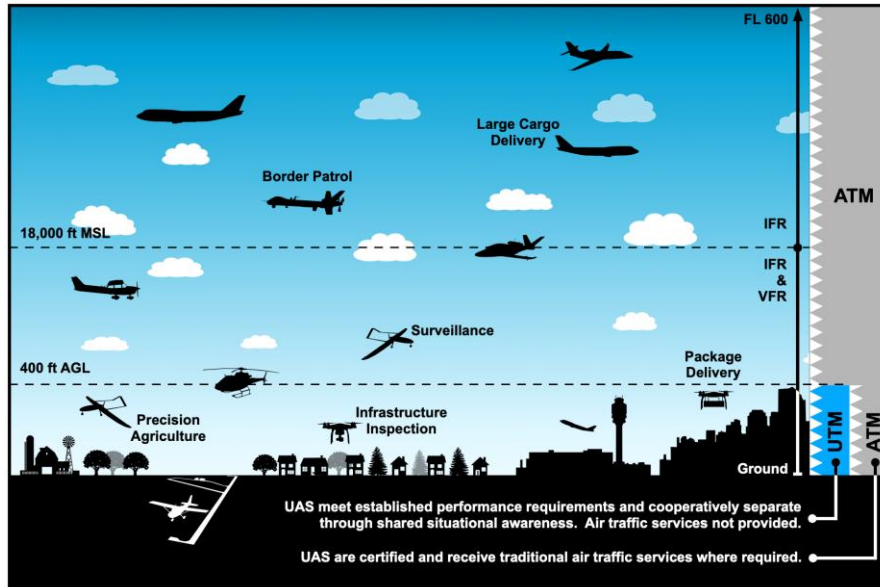


Figure 4. Operational context of UTM services

2.4.1.1 BVLOS UAS Operators

BVLOS UAS Operators are not able to visually separate from other UAS and manned aircraft. As such, they are reliant on various technologies to safely operate in the NAS. While UAS technologies can satisfy certain CNS performance requirements, they are not able to handle the gamut of CNS and other associated safety considerations for operation, including information exchanges with other Operators, with the FAA, and with other stakeholders. As such, BVLOS Operators must utilize UTM services to enable their operations – including, but not limited to: Registration, Airspace Authorization, identification of other nearby UAS Operators for data exchanges, RID transmission, strategic de-confliction through the sharing of flight intent and negotiation, monitoring of conformance to flight intent, notification/alerts of in-flight conflicts, in-flight reroute, weather, surveillance, and navigation.

2.4.1.2 VLOS UAS Operators

VLOS UAS Operators are able to visually separate from other UAS and manned aircraft. Given that the ability to safely operate VLOS is not predicated upon data exchanges with other UTM participants (e.g., strategic de-confliction), the primary UTM services they must use relate to meeting applicable regulatory and policy requirements. Recreation and commercial Operators performing flight per 14 CFR Parts 101 and 107 (respectively) must meet requirements related to aircraft registration, obtaining Airspace Authorization for flight in controlled airspace, and RID. They satisfy such requirements through use of FAA services, including those found in DroneZone or via a USS that has been qualified by the government to provide certain services (e.g., LAANC USS or RID USS).⁹

⁹ FAA DroneZone. (2019, October). Retrieved from <https://faadronezone.faa.gov/#/>

VLOS UAS Operators may voluntarily use services not required of them, such as those applicable to BVLOS Operators. Use of such additional services enhances the situational awareness of the VLOS Operator, as well as that of other Operators and stakeholders within the system.

2.4.1.3 Manned Aircraft Operators

Manned aircraft Operators are *not* required to participate in UTM, but may, and are encouraged to voluntarily do so to obtain the safety benefits that are gained from shared awareness among airspace users. Manned aircraft Operators have access to information regarding the conduct of UTM operations, and can *voluntarily* participate at different levels:

- ❖ *Passive participation* – Manned aircraft Operators utilize information from the USS Network (flight intent of UAS Operators) to gain situational awareness of nearby operations and plan their activities, but do not make available their flight intent information to UAS Operators.
- ❖ *Active participation* – Manned aircraft Operators make their flight intent available to UAS Operators/RPICs participating in UTM via the USS Network, fostering situational awareness for other participants with active operations near their own. They can also voluntarily equip with capabilities (e.g., ADS-B, RID) to provide additional data about their operations.

2.4.2 Performance Authorization

2.4.2.1 Rationale

NAS safety has always been predicated on the successful correlation of aircraft Operator CNS capabilities with the overall safety and efficiency needs of the airspace. Traditionally, the needs of the airspace were promulgated by both regulation (e.g., instrument approach procedures) and air traffic management discretion. These needs were specified against certain technologies, for example, Victor routes based on the VOR infrastructure or HF communication requirements for oceanic operations. More recently, these needs have been specified in a performance based framework, for example, RNAV/RNP routes and oceanic Required Communication Performance (RCP). With this approach, the regulatory side of the FAA ensures consistency in CNS approval through policy and guidance to the various certificate holders in the system (e.g., airworthiness certificate of an airframe, operating certificate). This construct ensures accountability for all the actors and flexibility to meet airspace needs.

Operations in UTM will need to rely on a similar construct through the issuance of Performance Authorizations. UAS operations are expected to vary greatly in CNS performance considering the many vehicle types and intended operations. The expectation is that the variance in performance will be managed by the USSs when providing different services. The USSs will need to account for the variance while maintaining safety and equity in the airspace.

The regulatory side of the FAA - Flight Standards, Aircraft Certification, others as needed - will have a role in approval of UAS operations in UTM.¹⁰ Generally, it is not expected that the regulator will dictate specific CNS performance for airspace that is not under ATC control. These CNS performance requirements will either be a product of the Operator-specific safety case or determined more agilely by the USSs to effectively perform the offered services. It is also expected that there will be general principles of efficient airspace use.

In UTM, the regulator has a role to ensure interoperability of the system actors. Interoperability in UTM focuses on how data is exchanged and interpreted by the actors involved. A common understanding of CNS requirements between actors is critical to the overall safety case. Depending on the overall risk of the underlying operation, substantiating data may be required of the applicant.

2.4.2.2 Obtaining a Performance Authorization

UTM Operators are required to obtain a Performance Authorization prior to conducting a class or type of UTM operation, in which they substantiate their ability to meet flight performance capabilities in their intended area of operation. Performance Authorizations are envisioned to provide credibility, stability, uniformity, and accountability to Operators participating in UTM.

To obtain a Performance Authorization, an Operator submits a Performance Authorization request to the FAA for evaluation.¹¹ The Operator's proposal demonstrates compliance of the overall system (inclusive of air/ground assets, USS/SDSP services, personnel, training, and procedures) and associated capabilities to applicable performance standards - not to individual, equipment-specific requirements, such as the ability of the system to maintain the aircraft within a specified Operation Volume during flight.

The FAA evaluates the request with respect to the Operator's ability to meet the CNS performance standards within the intended airspace. The FAA may scale their direct regulatory involvement according to the complexity of a proposed operation. For lower risk operations (e.g., VLOS, rural, low traffic density, and/or sparse population/property on the ground), Operators could self-declare compliance to standards - and USSs could assist with formulating these declarations - to ease direct FAA oversight. The FAA grants a Performance Authorization when the desired performance can be achieved.¹²

¹⁰ FAA regulator involvement may vary with time and understanding of the proposed operations. They may be more involved initially, and less as time goes on - similar to manned aviation where novel concepts are more heavily scrutinized until the approvals become routine.

¹¹ Performance Authorization requests must be submitted by the Operator, not a USS/SDSP. A service provider can, however, assemble, or supply material to support an Operator's Performance Authorization request.

¹² Performance Authorizations could be available in a standardized digital format to provide assurance to the operating community that the Performance Authorization is valid. Digitization would also enable USSs to provide compliance monitoring services to a subscribing Operator.

Once granted a Performance Authorization, the Operator conducts flights within the Authorized Area of Operation (AAO), which is a geographical area with discretely-defined boundaries. It is possible to have more than one AAO under a single Performance Authorization. Separate AAOs under an Operator’s Performance Authorization may have different levels of performance based on the underlying infrastructure. An example of multiple AAOs is shown in Figure 5.¹³

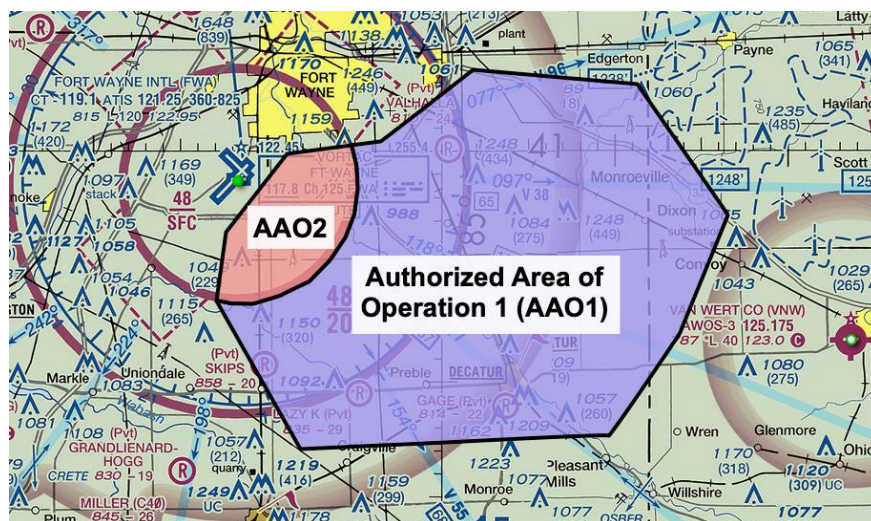


Figure 5. Examples of multiple authorized areas of operation for a UAS Operator

Industry stakeholders, through activities that include the FAA and NASA (e.g., TCL, UPP, IPP), are developing requirements and standards for services that are necessary to enabling UTM operations of increasing scope and complexity. It is expected that USSs will be qualified by the appropriate authority prior to providing a specified service, such that stakeholders have assurance of interoperability and reliability according to applicable standards.

2.4.3 Airspace Authorization

All UAS Operators conducting UTM operations must obtain FAA authorization when operating within the bounds of controlled airspace, including Class B/C/D/E[surface]. This authorization is referred to as an Airspace Authorization and is separate from a Performance Authorization.¹⁴ A Performance Authorization substantiates an Operator’s ability to meet flight performance capabilities in their intended area of operation, while an Airspace Authorization grants access to operate in controlled airspace and provides the air traffic facility with jurisdiction over the airspace access to information about operations being conducted. An Airspace Authorization grants an Operator access to controlled airspace for a period of

¹³ For illustration purposes only; other factors beyond controlled/uncontrolled airspace boundaries could impact the delineation of performance requirements between AAOs (e.g., population density, airspace activity).

¹⁴ Per FAA DroneZone Application, “An Airspace Authorization is the mechanism by which an Operator may seek Air Traffic Control (ATC) approval to operate in controlled airspace. Authorizations can be for a specific location or for broad areas governed by a single ATC jurisdiction.”

time (typically less than 24 hours). UTM Operators can apply for Airspace Authorizations directly through FAA systems (i.e. DroneZone - a predominantly manual process for provisioning FAA Airspace Authorizations services), or they can use a government-qualified USS to provision automated authorization services (e.g., LAANC).

USSs qualified to provide Airspace Authorization services identify operations that require Airspace Authorization (i.e. identify any portion of operation intent that lies in controlled airspace), notify Operators of the need for ATC authorization, and support development and submittal of ATC authorization information. To obtain Airspace Authorization on the Operator's behalf, USSs check the Operator-submitted Operation Volumes (see Section 2.4.4) against the ceilings of UAS Facility Map (UASFM) grids. UASFMs are composed of grids with ceilings, and cover the entirety of an airport's surrounding airspace (first shelf of Class B/C, and the bounds of Class D/E[surface]). The ceiling for each grid indicates areas under which operations are available for automated approval by ATC. Government-qualified USSs can access UASFMs to determine when an operation is available (or not) for automated approval by ATC.

2.4.4 Operation Planning

With UTM, flight intent is submitted and shared among Operators for situation awareness in the form of an Operation Plan – as distinguished from a 'flight plan' that is propagated through NAS/ATC automation systems for aircraft operations managed by ATC. The Operation Plan is developed prior to the operation and indicates the four-dimensional (4D) volume of airspace within which the operation is expected to occur, the times and locations of the key events associated with the operation, including launch, recovery, and any other information deemed important (e.g., segmentation of the operation trajectory by time). While a single volume can be used, segmentation of that 4D volume promotes the efficient use of the airspace and reduces the likelihood of overlapping operations.

The Operation Plan as proposed may be impacted by other planned operations (e.g., overlapping airspace volumes), airspace constraints (e.g., airspace restrictions, special use airspace, NOTAMs, UVRs), or ground constraints (e.g., public gatherings, sensitive areas, obstacles), therefore the Operator should assess all appropriate information affecting the planned operation and make amendments to the plan as applicable. The Operator identifies operational conflicts and strategically de-conflicts, potentially via USS-provided capabilities (e.g., Operator collaboration and de-confliction algorithms) designed to provide fair access to the airspace.

Once the Operation Plan is finalized, the Operator, via their USS (if not self-provisioning services), makes their operation intent available to the USS Network.¹⁵ Following this sharing of intent to the USS Network, the Operator's USS continues to offer de-confliction support up to the start of the operation.¹⁶

2.4.5 Constraint Information & Advisories

UAS Operators are responsible for identifying unexpected operational conditions or flight hazards that may affect their operation. This information is collected and assessed both prior to and during the operation in order to ensure the safe conduct of the operation. USSs may support this Operator responsibility by supplying airspace constraint and advisory information, weather, and other relevant data. Near real-time advisories are provided through the USS Network, and are made available to affected users regarding:

- Traffic (e.g., aircraft known and unknown to the USS Network, non-conforming flights)
- Weather and winds (e.g., unexpected wind gusts or storm)
- Other hazards pertinent to low altitude flight (e.g., unexpected obstacles such as a crane or power-line Notice to Airmen [NOTAM], bird activity, local UAS restrictions, and other UAS-specific hazard information).

Although USSs are likely to be the primary distributors of information, Operators are responsible for gathering these data. Operators may pull from other sources (e.g., SDSPs) or their USSs may pull data from other sources in support of the Operator. Operators may also support distribution of advisory information by reporting phenomena encountered during flight to their USS for network-wide distribution to other potentially impacted Operators. These are referred to as Unmanned Aircraft Reports or *UREPs*, and are comparable to manned aircraft pilot reports (PIREPs).¹⁷

UAS Volume Reservations (UVRs) may be established when activities on the ground, or in the air, present a potential risk to UTM safety interests. UVRs are designed to support operational safety of transient flights (e.g., police activity, emergency response, public safety) by notifying UTM Operators to blocks of airspace in which these activities occur. UVRs are generally short in duration (hours, as opposed to days or weeks), have specified airspace boundaries, and have an established start and end times. A USS that has been qualified by the government to provide UVR services creates and routes UVR data through the USS Network to notify affected Operators, and to applicable FAA stakeholders via FIMS.¹⁸

¹⁵ Operators have the option to act as their own USS, if all requirements for service provision are met (e.g., can communicate with other USSs, can send/receive information from the FAA) and applicable federal and/or industry vetting processes have been conducted.

¹⁶ Industry bodies (e.g., ASTM) are working to standardize how the operation volumes will be created, shared, and used.

¹⁷ Rios, J., Smith, D., & Smith, I. (2017). *UAS Reports (UREPs): Enabling Exchange of Observation Data Between UAS Operations* (NASA/TM–2017–219462). Retrieved from trs.nasa.gov/archive/nasa/casi.ntrs.nasa.gov/20170003878.pdf

¹⁸ UVR scope, functions, and procedures will evolve as needed to adapt to UTM needs and considerations.

2.4.6 Separation

UTM Operators are ultimately responsible for maintaining separation from other aircraft, airspace, weather, terrain, and hazards, and avoiding unsafe conditions throughout an operation. Separation is achieved via shared intent, shared awareness, strategic de-confliction of airspace volumes, vehicle tracking and conformance monitoring, technologies supporting tactical de-confliction, and the establishment of procedural rules of the road (e.g., right-of-way rules).

Operators (RPICs if separate entity) are responsible for remaining within the bounds of their flight volume(s) and tracking the aircraft location during all phases of flight, while meeting required performance criteria for the operation performed. Operators monitor for vehicle non-conformance and on-board equipment failures or degradation (e.g., lost link, engine failure). For situations where corrections cannot be made, Operators are responsible for notifying affected airspace users as soon as practical and executing a predictable response. USSs can assist the Operator in providing tracking and conformance monitoring capabilities and notifying affected airspace users when an event occurs. For off-nominal situations that pose sufficient risk to manned aircraft operations, and where actionable, timely FAA/ATC intervention is achievable, the Operator (through the USS) notifies the FAA and sends data required to manage the event via FIMS.¹⁹

The Operator is responsible for in-flight coordination with other Operators, and can utilize services of a USS to facilitate this coordination. The Operator's Performance Authorization may require on-board communications, navigation, and detect and avoid (DAA) equipment to maintain separation tactically. In the event intent needs to be updated in-flight, USSs accommodate Operator updates.

USSs and/or SDSPs support the Operator by supplying weather, terrain, and obstacle clearance data specific to the area of operation during the pre-flight planning phase to ensure strategic management of the UTM operation as well as in-flight updates ensuring separation provision. The USS maintains and provides near real-time and forecast weather information for the region to UAS Operators. Operators monitor weather and winds throughout flight; in the event their aircraft performance is inadequate for flight in current or forecasted weather, Operators take appropriate action to safely land as soon as practical. Using in-flight connection capabilities, Operators also monitor terrain and obstacle data to ensure the aircraft does not collide with the ground, wires, terrain, mountains, or other obstacles. Data providers maintain and provide the most current terrain/obstacle databases in order to develop accurate avoidance information for UTM Operators.

¹⁹ Off-nominal situations that pose sufficient risk to manned aircraft operations are identified through USS-integrated risk assessment algorithms.

2.5 Allocation of Responsibilities

Table 1 summarizes roles and responsibilities of the UAS Operator, USS, and FAA associated with a UTM operation.

Table 1. Allocation of Responsibilities for UTM Actors/Entities

Function		Actors/Entities		
		✓ = Primary responsibility S = Support		
		UAS Operator	USS	FAA
Separation	UAS from UAS (VLOS and BVLOS)	✓	S	
	VLOS UAS from Low-Altitude Manned Aircraft	✓	S	
	BVLOS UAS from Low-Altitude Manned Aircraft ¹	✓	S	
Hazard/ Terrain Avoidance	Weather Avoidance	✓	S	
	Terrain Avoidance	✓	S	
	Obstacle Avoidance	✓	S	
Status	UTM Operations Status	S	✓	
	Flight Information Archive	✓	S	
	Flight Information Status	✓	S	
Advisories	Weather Information	✓	S	
	Alerts to Affected Airspace Users of UAS Hazard	✓	S	
	Hazard Information (e.g., obstacles, terrain)	✓	S	
	UAS-Specific Hazard Information (e.g., Power-Lines, No-UAS Zones)	✓	S	
Planning, Intent & Authorization	Operation Plan Development	✓	S	
	Operation Intent Sharing (pre-flight)	✓	S	
	Operation Intent Sharing (in-flight)	✓	S	
	Operation Intent Negotiation	✓	S	
	Controlled Airspace Authorization		S	✓
	Control of Flight	✓		
	Airspace Allocation & Constraints Definition		S	✓

¹ Manned aircraft pilots share some responsibility for separation with UAS BVLOS operations (see Section 2.7.1.2).

2.6 Remote Identification

RID provides a means to address public concerns and protect for public safety vulnerabilities associated with low altitude UAS operations, including privacy and security threats. RID allows electronic identification of a UA/Operator through use of a unique identifier (similar in concept to an automobile license plate). RID enables accountability and traceability, particularly for BVLOS operations, where an Operator and vehicle are not co-located. USSs that provide RID services process and distribute RID data to the general public, law enforcement, the FAA, and other public officials according to FAA-established protocols. Public officials, with a need to know, have credentials that enable access to an expanded set of data.

RID uses a combination of technology and services to identify UAs and associated Operators who may pose safety, security, and/or privacy concerns to the public. As a federated system of independent service providers exchanging information across a common network, the UTM architecture supports RID through various means, including: (1) providing the architecture, infrastructure, and services by which Operators transmit RID information through network publishing, and (2) providing services by which authorized persons may obtain information relevant to public safety concerns.

RID is predicated upon transmission of a set of information that enables a recipient to determine location and establish traceability back to a UAS Operator/RPIC responsible for a specific aircraft. It is assumed that there is a minimum set of information that Operators transmit that it is publicly accessible - termed an *RID Message*. For the purposes of this document, it is assumed that the RID Message elements include, at minimum, (1) a unique identification number - or *UAS ID*, (2) UAS location, and (3) a timestamp.²⁰ The information in the publicly accessible RID message may be used by authorized entities to obtain additional information relevant to public safety concerns.

While rules regarding RID for UAS are still in development, the RID Aviation Rulemaking Committee (ARC) Report released in September of 2017 recommends two methods for UAS to transmit RID and tracking information:²¹

- *Direct Broadcast* – transmission of data in one direction only with no specific destination or recipient. Data can be received by anyone within broadcast range.
- *Network Publishing* – transmission of data to an internet service or federation of services. Clients can access published data to obtain UAS ID and tracking information.

²⁰ Regulations have not yet been released detailing what must be transmitted by UAS to satisfy RID requirements. This ConOps leverages recommendations within the RID ARC Report (2017) to establish a reasonable minimum set of elements, and then explores the ways in which the UTM architecture can support stakeholder needs using this information.

²¹ This ConOps examines the ways in which UTM supports stakeholder interests with respect to RID transmissions by either method proposed in the RID ARC Report.

An Operator transmitting via network publish sends an RID Message to a USS that has been qualified by the FAA to provide RID services - termed an *RID USS*. The RID USS makes the RID message available to all other RID USSs, and vice versa, such that the complete set of messages held by these various USSs comprises a distributed database. The general public may utilize services provided by RID USS; an example of a potential service would be a cell phone application supporting queries to publicly-accessible data. Any query through a single RID USS results in a return of all transmitted RID messages that conform to the bounds of the query, regardless of the original RID USS that received each transmission. Additionally, the FAA is able to query RID USSs via the USS Network for relevant RID Messages when such information is needed.

Authorized public safety entities that need to obtain information beyond the publicly-accessible RID message elements are able to query the USS Network. A USS that has been qualified by the FAA to provide public safety services - a *public safety USS* - may have increased access-to-information privileges within the USS Network, compared to USSs not providing public safety services. For example, an authorized law enforcement officer may subscribe to a public safety USS, which could support queries to the USS Network for information relating to a submitted UAS ID. USSs that have, or are servicing the Operator tied to the UAS ID, provide information back to the public safety USS commensurate with the level of information access associated with the requesting law enforcement officer, which could include Operator name and contact information.

2.7 Airspace Management

UTM is designed to ensure UAS operations are authorized, safe, secure, and equitable in terms of airspace access. UTM imposes requirements on operations and performance commensurate with Operator, vehicle, services, operational environment, and airspace class considerations. Airspace management is predicated on a layered approach to safety, security, and equity of airspace access through the following:

- Performance Authorizations and certifications that ensure Operators, equipment, and USSs meet the appropriate capability and performance requirements for the operations planned,
- Airspace Authorizations that provide situational awareness to ATM stakeholders of UTM operations in controlled airspace,
- Strategic traffic management of operations through interactive pre-flight planning,
- Separation provision through de-confliction services and in-flight conflict alerts to UTM participants; including aircraft intent, airspace constraints, and hazards using DAA for well clear guidance,
- Contingency management through operation planning, coordinated procedures and response protocols, and pre-programmed system or vehicle responses to flight anomalies,
- Near real-time notifications of airspace constraints and advisories that safeguard the safety of the airspace,
- Aircraft and obstacle avoidance through the use of appropriate ground-based or onboard equipment, including DAA/collision avoidance logic, and
- Identification of aircraft and UAS Operators/RPICs through RID information exchanges.

In addition, security of the airspace is ensured through NAS data and system protections, as well as through the collection, maintenance, and provision of identity information for UTM operations, vehicles, and Operators via RID, vehicle registration, Operator logs, USS services, and appropriate vehicle identification mechanisms. Finally, equity of airspace access for UTM operations is fostered through operation orchestration/Operator negotiation to optimize airspace use among the participants.

2.7.1 Safety

Safe operations pertain to the safety of people and property on the ground, as well as in the air. UTM has multiple layers of separation assurance to ensure the safe conduct of operations, from strategic flight planning and management tools to tactical aircraft and obstacle avoidance capabilities.

2.7.1.1 Strategic Management of Operations

UTM operations can be strategically managed through interactive planning and orchestration of intent information as well as relevant environmental considerations that enable strategic de-confliction for multiple UAS operations. Operation intent sharing, strategic de-confliction, airspace constraint evaluation, weather reporting and forecasting capabilities, and other key supporting features of UTM reduce the need for tactical separation management and reduce the likelihood of in-flight intent changes due to weather or airspace restrictions.

Operators planning to fly BVLOS are required to share operation intent with other Operators/airspace users via the USS Network. Intent data predominantly consists of the spatial and temporal elements of an operation. At a minimum, operation intent includes Operation Volume segments that make up the intended flight path. Operation Volumes are 4D blocks of airspace that have specified entry and exit times for the Operator's UA. These volumes may be stacked in sequence such that one volume's exit time coincides with the entry time of an adjacent volume along the flight path; the result is that each Operation Volume in the sequence comprises a segment of the overall flight profile.

Operation Volumes are contained within the Operator's AAO, as defined in their Performance Authorization. UAS performance capabilities will typically determine the size of Operation Volume segments, with UAS of higher navigational performance being able to maintain flight within smaller volumes as compared to lower-performance UAS. Navigational performance requirements may be more stringent in certain airspace during periods when traffic density/operational tempo is high. USSs assist in managing and minimizing overlap of Operation Volume segments when necessary, with the goal of maintaining separation through strategic de-confliction. Tactical de-confliction methods – the next layer of separation - are necessary when strategic de-confliction alone is not adequate to support the safety of operations (e.g., operations in areas with dense air traffic) or people/property on the ground.²²

Intent data serves several primary functions. It (1) informs other Operators, manned and unmanned, of nearby operations to promote safety and shared awareness, (2) enables de-confliction of Operation

²² Tactical de-confliction methods/requirements for an operation are addressed in the Performance Authorization as necessary.

Volumes (i.e. strategic separation), and (3) supports conformance monitoring and tracking. USSs can also utilize elements of operation intent (e.g., Operation Volume(s) location and entry/exit times) to enable automatic distribution of spatially and temporally relevant advisories, constraints, weather, and supplemental data (e.g., data relevant to planning and flight execution needs).

Intent information is made available by Operators to UTM participants and other airspace users via the USS Network to promote situational awareness and support cooperative interactions. Manned and unmanned Operators (e.g., Part 107/101(e) VLOS Operators) not required to share intent, but operating near or below 400' AGL, are encouraged to, at minimum, utilize services to identify operations that could impact their route of flight as part of their pre-flight responsibilities.

Other data is likely required during the intent sharing process, some of which may be shared with the USS Network to support USS service provisions, some of which may be confidential - proprietary information is shared only between an Operator and the Operator's respective USS. From a service provision perspective, pre-programmed vehicle responses and other data required to support separation management functions and contingency handling during nominal and off-nominal events is available for sharing with the USS as appropriate (e.g., RPIC contact number, planned response to loss of command and control link).

Operator data submitted during the planning stage does not need to be pre-verified with agency records for compliance at the time of submission (e.g., compliance with Performance Authorization stipulations - AAOs, pilot certifications, use of specified equipment/technologies) but Operator accounts and records are subject to FAA auditing at the agency's discretion.

Real-time NAS airspace constraint data is available to the USS Network via FIMS to separate aircraft from flight restrictions, SAA/Special Use Airspace (SUA) activity, or other airspace management decisions that affect UTM operations. The Operator has the option to alter flight intent to ensure de-confliction with these airspace constraints. USSs work with FAA, state, municipalities, and other entities as required to define airspace reservations (i.e. UVRs) in support of first responder activities. These are incorporated into the USS Network, and affected Operators are alerted to these areas during intent sharing processes.

USSs continue to monitor for, and notify Operators of, changes or conflicts leading up to and including flight that could affect the safety of the operation. This includes analysis of FAA airspace constraint data on airspace changes/UVRs, SUA/SAA status, and published emergencies. Operators assess the potential impacts to their operation and choose whether to make changes to their operation based on their assessment.

Weather and supplemental data sharing assists Operators with determining whether environmental conditions or other factors are suitable for flight in the intended location at the specific date and time being submitted (e.g., weather and wind prediction, planned obstacles). This data assists Operators with determining whether they can meet their responsibilities (e.g., weather, hazard/obstacles awareness) for safe flight or successfully complete their intended mission (e.g., sensor sensitivities) given the predicted conditions.

Strategic management services alone may be sufficient to ensure the safety of low risk, low complexity UAS operations. For example, a BVLOS Operator conducting a flight in a rural/remote area (where UAS/manned activity at low altitudes is sparse) shares intent via the USS Network, providing others the information necessary to maintain separation. Due to the low density of operations at these low altitudes, those who become aware of this operation via a USS, plan around that operation - or when objectives result in a potential overlap, spatial or temporal adjustments are made to ensure strategic separation. Conversely, higher risk, higher complexity operations, such as over densely populated areas with manned aircraft activity, would likely require additional separation assurance capabilities beyond strategic management.

2.7.1.2 Separation Provision/Conflict Management

UTM services/capabilities support a range of UAS operations from rural areas with minimal manned aircraft activity and no people or property on the ground, to urban vicinities with considerable manned traffic, terrain, and surface obstructions. The corresponding requirements for separation provision - in terms of data exchange, tracking and conformance monitoring, equipage, and Operator responsibilities - are commensurate with the risks to people and property. Aircraft/capability requirements are addressed in the Performance Authorization obtained by the Operator prior to the operation.

UAS Operators share separation responsibility with other UAS Operators (BVLOS and VLOS) and other airborne traffic. UAS Operators desiring to operate in areas with high density or heterogeneous traffic may be required to equip with DAA technologies to meet these responsibilities. Low altitude manned aircraft operating in both uncontrolled and controlled airspace have access to, and are encouraged to utilize UTM Operation Planning services to de-conflict their aerial work; low-altitude manned aircraft pilots share some responsibility with BVLOS UAS Operators for maintaining separation from each other (though they do not share responsibility for separation from VLOS UAS Operators).²³ Because UAs can be difficult to identify when small in size, certain UAS may be required to comply with conspicuity requirements designed to increase visibility.

During flight, the Operator is responsible for complying with all rules and regulations associated with the operation, including avoiding other aircraft, complying with airspace restrictions, and avoiding terrain and obstacles. Commercial services, or third-party providers, can provide assistance to Operators in meeting responsibilities. For operations in areas with minimal air traffic, advisories regarding known or uncooperative traffic (e.g., USS alerts on non-conforming aircraft, UREPs) may assist Operators with maintaining separation. The Operator maintains a connection with the USS to support data exchange pertaining to aircraft tracking and monitoring, terrain and obstacle clearance data, weather, and/or notifications and advisories regarding airspace constraints, traffic, or other hazards that could affect the flight. In the case of a notification or advisory, the RPIC responsible for the overall safety of the flight acts accordingly.

²³ As flight rules evolve, it is expected that manned aircraft Operators will share some responsibility for separation when operating in the UTM ecosystem.

When UAS operate in areas where manned aircraft are more prevalent, Operators are responsible for maintaining separation from all aircraft, including both UTM participants and non-participants. This may be done using USS in-flight de-confliction services designed to identify and alert Operators of airborne traffic or through ground-based or airborne technological solutions (e.g., position sharing, vehicle-to-vehicle (V2V) equipment, ground-based surveillance data, airborne surveillance data, and DAA capabilities). USSs can further assist with in-flight separation responsibilities by providing services that assist Operators with staying within the bounds of their volume (e.g., aircraft tracking and conformance monitoring services), disseminating information that facilitates avoidance of flight hazards (e.g., weather/wind information, terrain and obstacle data, UREPs), and coordinating with affected airspace users to facilitate effective airspace management responses in the event of a contingency.

All low-altitude aircraft sharing airspace do so with a clear understanding of responsibilities, rules, and procedures, regardless of whether they are participating in/receiving services from UTM or ATC. Right-of-way rules, established procedures, and safe operating rules enable harmonized interaction when aircraft encounter one another. Though low altitude operating manned aircraft and VLOS unmanned aircraft (e.g., 14 CFR Part 107 and 101[e] operations) are not required to share intent, they are encouraged to, at minimum, utilize UTM services that enable them to identify UAS operations that may affect their route of flight to increase the likelihood they identify UAS.

UTM BVLOS Operators must be capable of tracking their vehicle and remaining within the bounds of their shared intent volumes. USSs can assist Operators in meeting this requirement through vehicle tracking and conformance monitoring services whereby UAS transmit near-real time tracking data to the USS, so the USS can provide services that enable Operators to monitor the UA's position and conformance to applicable system-based Operation Volume boundaries during BVLOS portions of flight. USSs may also use conformance monitoring to track Operator conformance to the geographical boundaries specified in the Performance Authorization.

The FAA makes real-time NAS constraint data available to the USS through FIMS to support airspace management services, but it does not receive data – intent data or otherwise - from the USS during nominal operations. During off-nominal situations, the USS notifies the FAA of an event via FIMS (per established USS policy) only if the situation meets the criteria for FAA/ATC attention that takes into account the ability of ATC to take action in a timely manner.

If a UVR goes into effect, an automatic notification is sent to the USS Network so that affected UTM participants can be identified and informed of the UVR. If impacted by a UVR, Operators/RPICs exercise discretion when deciding to take action, understanding they are responsible for the overall safety of the flight. The Operator/RPIC can (1) proceed with the operation if confident it is safe to continue (e.g., has onboard detection and/or V2V capabilities), (2) avoid or exit the airspace, or (3) land. The FAA also receives information pertaining to UVRs via FIMS and publishes the data to a public portal for airspace user access, routes prescribed data to internal FAA stakeholders, and archives records according to FAA policy and procedures.

Operators receive data for weather, wind, terrain, obstacle, and other supplemental service-provided data pertinent to flight to assist them in meeting their responsibilities. Weather services equip the Operator with information regarding winds, temperatures, pressure, precipitation, and visibility. Operators are encouraged to submit UREPs on observed weather phenomena and other aviation information (e.g., uncooperative traffic) so that this information can be shared across the USS Network with other affected Operators.

Operators are responsible for ensuring endurance and/or fuel levels are adequately maintained to remain compliant with rules or regulations, or to support safe operations. Endurance/fuel levels (actual or reserves) may be provided to the USS to enable monitoring and alerts for endurance level checks and/or enable estimates of endurance levels in the event of a contingency (e.g., estimation of fuel/endurance levels when aircraft is not expected to return to conformance).

2.7.1.3 Contingency Management

In the event of a contingency, the Operator is responsible for notifying affected airspace users. A USS can assist the Operator in meeting this obligation by establishing and maintaining communications with affected UAS Operators, FAA entities (as required), and other airspace users as appropriate, via the USS Network. If an Operator/RPIC determines that safety is compromised, the USS must be notified as soon as practical of the compromised condition, and relevant operational information provided to the USS. If an active flight is: (1) experiencing a critical on-board equipment failure or degradation (e.g., lost link, engine failure), (2) not tracking, or vehicle position is unknown for some period of time, or (3) not conforming to flight intent and/or conformance is not expected to be restored, USS-assisted response protocols are in place to support the Operator/RPIC in mitigating potential for damage or injury.²⁴

Contingency procedures or protocols, such as pre-programmed vehicle loss of command and control link responses, shared with the USS during the operation planning process, or updated in-flight, facilitate USS Network-wide de-confliction of affected flights. USSs actively work to contain their supported operations within Operation Volumes despite uncertain conditions (e.g., USSs update the operation intent of the compromised operation by modifying or creating Operation Volumes that reflect a new path; if RPIC has limited/no control of the UA, USSs generate new Operation Volume(s) based on the UA's projected path). USSs supporting compromised operations notify (and update) the USS Network of potentially hazardous situations according to established UTM guidelines, notification standards, and messaging protocols. Impacted Operators are notified/alerted and respond accordingly.

USSs also notify potentially impacted, connected non-UTM users of off-nominal or potentially hazardous situations, providing relevant data to assist with managing the situation effectively (e.g., position data, contact information). Non-UTM users could include public/private/commercial entities (e.g., balloon Operators, the Department of Defense (DOD), non-towered airport) and, if warranted, the FAA.

²⁴ USSs providing health checks services or tracking and conformance monitoring services may detect off-nominal events prior to Operator notification. For example, if vehicle endurance level anomalies are identified, there is prolonged lapse in vehicle tracking data, or non-conformance to Operation Volumes is detected, a USS may automatically invoke response protocols when prescribed criteria is met.

Vehicle capabilities also support notification to impacted airspace users during contingencies. If a UA is equipped with V2V communication capability (e.g., V2V broadcast capability), it broadcasts relevant information (e.g., position) to nearby vehicles with cooperative equipment, allowing for affected stakeholders (e.g., nearby Operators in four dimensional proximity to the compromised UA) to gain awareness of the situation and respond accordingly.

In the event an off-nominal event poses a threat to the ATM system (e.g., accidental or non-conforming “rogue” UA), UTM participants must be able to notify the FAA with timely and actionable information. ATC’s role is to provide safety mitigations to aircraft receiving ATC services from a hazardous UAS operation that poses a credible safety risk. The FAA FIMS gateway provides a connection through which the USS Network can send pertinent UTM operations data, including flight status, aircraft location (if known), and intent information until the hazard no longer poses a credible risk. USSs or Operators acting as their own USS send notification of errant flights, along with required data, to FIMS for routing to the appropriate ATC facilities/entities.

During a contingency event, impacted Operators act in accordance with rules and regulations to avoid the UA. Once a contingency event is over, the USS provides notice of recovery to affected entities, including the USS Network, for distribution to airspace users. The USS Network also notifies the FAA via FIMS (if necessary), providing data required to restore nominal ATM operations and comply with FAA facility/agency archiving requirements, reporting requirements, and procedures. FIMS routes the data according to established protocols. Operators, USSs, and other stakeholders are encouraged to track and share performance and operational issues with the UTM community to identify and improve aircraft, systems, procedures, and services associated with the operational environment.

2.7.1.4 Aircraft and Obstacle Avoidance

BVLOS and VLOS UAS Operators are responsible for separating from and remaining well clear of all other aircraft. Because the risks associated with different areas of operation can vary, the requirements for onboard DAA systems for UAS also vary. In airspace where risk to life in the air and on the ground is low, a relatively higher risk of UAS-to-UAS collision may be accepted, and thus the FAA may not require DAA technologies. Conversely, operations in more heterogeneous environments (e.g., mix of manned and unmanned aircraft, controlled airspace) could impose increased risk to manned aircraft due to the higher criticality of collision, therefore, increased performance requirements may be imposed (e.g., onboard systems, real-time avoidance equipment, network-based solutions).

Geographical area, proposed airborne and ground DAA assets, and other criteria will be taken into consideration during the Performance Authorization process, and DAA requirements will be tailored to each operational situation. Data communications between UAS and manned aircraft could allow the exchange of position information from the manned aircraft to support DAA at intervals appropriate to the aircraft and operation per the Performance Authorization and appropriate regulatory requirements.

All UTM stakeholders using IATF policies use an IATF compliant Registration Authority (RA) to perform the vetting and proofing of the identities. In addition, all UTM stakeholders using the IATF policies use an IATF compliant Certificate Authority (CA). The RA and CA can be implemented by commercial entities. Identities issued by different CAs under IATF policies are interoperable and can trust each other. The trust relations between identities can be managed by the individual stakeholders and by application domain.

UTM supports requisite security and accountability functions. The UAS operating community meets security requirements that are levied by appropriate authorities (e.g., FAA, DOD) and designed to guard NAS systems and architectures against security threats. UTM meets applicable security requirements through data collection, archival, and provision protocols within the IATF, ensuring operations data is available to support stakeholder needs.

2.7.2.1 FAA

The FAA establishes requirements and response protocols to guard NAS systems and the public against associated security threats. The FAA uses UTM data (e.g., intent, RID messages) as a means of traceability to (1) ensure Operators are complying and conforming to regulatory standards, (2) identify and hold accountable those who are responsible during accident/incident investigations, and (3) inform other NAS users, if needed, of UAS activity in the vicinity of the airspace in which they are operating. The FAA can use near-real time data from UTM to address security needs with respect to operations conducted under ATM, including managing off-nominal and exigent circumstances. They use archived data as a means to analyze UTM operations and ensure NAS needs and safety objectives are being met. The FAA can also use UTM data to notify federal entities of security threats. The FAA leverages the GRAIN and the IATF policies to ensure the integrity and authenticity of the information received from all UTM stakeholders.

2.7.2.2 Public Stakeholders

Local, state, tribal and federal entities (e.g., state police, Federal Bureau of Investigation, DHS) require access to UTM data to inform responses to local or federal complaints and safety/security incidents, and the conduct of investigations. Appropriate data access limitations are set by the FAA for individual federal and public/public safety entities (e.g., public information, classified information). Depending on the nature of the safety or security situation, historical or near-real time information may be needed. UTM data deemed publicly-accessible (e.g., RID messages) may be obtained by the general public through third-party services/applications and/or the government. UTM data that is not publicly-accessible (e.g., Operator contact information) is managed and provided based on the need to know, the credentials, and the level of access-to-information authorized for the requestor using identities issued compliant to the IATF policies.

2.7.2.3 Data Management and Access

Operators must satisfy FAA-stipulated data archiving and sharing requirements to support safety and security. Stakeholders may need information on active UTM operations for the purposes of aircraft separation and identification of UAS affecting air/ground activities, among other things, such that Operators respond to requests from authorized entities in near-real time; an example of such information is RID messages. Operators are required to archive certain data to support post-flight requests by

authorized entities with a need to know (e.g., FAA, public entities), as previously noted; examples of such data may include operation intent, 4D position tracks, reroute changes to intent, and off-nominal event records (e.g., rogue UAS).

USSs providing services to Operators satisfy applicable data management requirements set by the FAA, such as responding to authorized requests for Operator data that must be provided in near-real time. USSs may also support authorized historical information requests of an Operator when providing data archiving services. USSs use IATF compliant network communications and identities to communicate.

The FAA retains information obtained from Operators and USSs relevant to regulatory and policy needs, such as Operator registration information, Airspace Authorization records, and operational waivers. In some situations, information may be requested by the FAA to address a situational need, but is not retained after the need has passed. A notional example is the FAA requesting network-published RID messages in real time to assist authorized federal public safety personnel in identifying a UAS Operator. From the messages obtained from the USS Network, the Operator identity is discerned. The set of RID messages, however, is not retained as the situational need was satisfied. The IATF compliant UAS and Operator identities are used to ensure the integrity and authenticity of the RID messages in transit and archived.

The FAA provides services to certain federal public entities in support of public safety and security needs; services may include provision of portals designed to facilitate automated information exchanges and queries to the USS Network for authorized data. Local, state, tribal and federal public entities may have dedicated portals external to the FAA by which they can request and receive authorized information; USSs meet applicable security requirements and protocols when collecting and provisioning data to such entities. Authorization and authentication between entities, using IATF compliant identities, ensure data is provisioned to those permitted to obtain it. Authorized entities utilize USS Network discovery services to identify individual USSs from which to request and receive data commensurate with access credentials. USSs must be (1) discoverable to the requesting agency, (2) available and capable to comply with issue request, and (3) a trusted source as mitigation/enforcement actions may be taken as a result of the information provided.

2.7.2.4 Networked Systems

UTM introduces new security challenges due to UAS Operator reliance on interconnectivity and integration. USS connections to other USSs, Operators, public entities, general public, and government assets increase overall network complexity and provide opportunities for cyber incidents and attacks - including threats to system security and unintended or malicious degradation of system performance. To protect for these system vulnerabilities, cybersecurity architectures, requirements, and structures are developed and implemented to mitigate the potential for malicious activities and prevent unlawful access to third-party and FAA systems. These cybersecurity architectures, requirements, and structures are defined by IATF network policies. USSs authenticate one another using IATF compliant identities and are ensured of the trust in their respective network capabilities when engaging in information exchanges, through compliance with the IATF network policies. For example, (1) USS ABC confirms that USS XYZ is authentic, the integrity of the message is intact, and is permitted by the government to disseminate UVR

messages to the USS Network, and (2) USS 123 confirms that USS 456 is authentic, the integrity of the received messages is intact, and meets applicable standards and requirements to engage in data exchanges for strategic de-confliction of their respective Operators.

2.7.2.5 Aircraft Systems

UAS design architectures, which vary by manufacturer and/or model, can be manipulated in ways that impact the safety and security of people on the ground and in the air. Command and control link infrastructure, cellular communications, security of GCSs, and global positioning system signal vulnerabilities, create potential for misuse (intentional and unintentional) and malicious interference (e.g., hacking, hostile takeovers) of UAS technologies. The FAA considers security risks and requirements proposed for an operation during the Performance Authorization process and evaluates the adequacy of proposed solutions (e.g., encrypted links). UAS are registered in accordance with FAA rules and regulations prior to operating in the NAS. Although UTM assumes an Operator's registration is valid, Operator records are subject to FAA auditing at the agency's discretion. Operators are required to certify, register, and obtain all appropriate authorizations and demonstrate compliance with performance and capability requirements per regulatory policy prior to performing UTM operations. Aircraft systems, including the vehicle and GCS, are operated in accordance with applicable RID requirements, which may include transmission by the aircraft (via over-air broadcast) or network publish (via a USS qualified by the government to provide RID services). When required for the mission, the FAA may require the RID to be cryptographically protected by an authentication message, ensuring the authentication, non-repudiation, and integrity using an IATF-compliant UAS identity.

2.7.3 Equity

UTM provides an operating environment that ensures airspace users have right of access to airspace needed to meet their specific operational requirements, and that the shared use of airspace by different users can be achieved safely. Within the cooperative rules and processes for the shared UTM enterprise, there is no assumption of a priority scheme that would diminish equity of access for users that have received a Performance Authorization to operate in the airspace. In airspace with moderate demand, equitable access is achieved through Operator collaboration, efficient airspace design, and FAA rules. As demand for a volume of airspace increases, the performance requirements for the Performance Authorization may increase to ensure continued free access. If demand for a volume of airspace becomes too great to maintain safety of flight, or support all types of operations, the FAA may be required to manage the demand for access.

2.7.3.1 Airspace Access

When UTM point-in-space contentions arise, and Operators have already planned and shared their intent with the network, USSs assist with resolving or minimizing the issues via alteration of spatial or temporal elements of the operation intent and/or Operator collaboration and negotiation. Operators adjust plans to de-conflict overlapping airspace according to personal preferences or with USS tools (e.g., operation planning service). USSs' collaborative flight planning capabilities (e.g., route planning functions, airspace configuration options) offer equitable solutions to competing Operators and/or enable Operator negotiation using collaborative USS tools (e.g., real-time Operator exchanges) to identify acceptable

alternate plans that minimize volume overlap. Operators and USSs consider airspace volume efficiency during the intent sharing process to optimize UTM-wide airspace capacity. Operators ensure intent changes are accurate and up to date, pre-empting unnecessary de-confliction of airspace (e.g., an Operator updates intent when a planned operation is cancelled). Business rules ensure that individual Operators cannot optimize their own operations at the expense of sub-optimizing other Operators and the UTM ecosystem as a whole.

2.7.3.2 Priority Flights

Priority access demands for airspace may overlap with UTM Operational Volumes. In the event of a public safety incident (e.g., EMS or first responders must access airspace), FAA-authorized entities (e.g., law enforcement, fire department) can request UVRs to alert UTM participants of the public safety activity. UVRs do not exclude UTM participants from the airspace, however, Operators/RPICs are expected to exercise caution if they continue their operations, as they are responsible for the overall safety of their flight and are accountable for their actions.

3 Operational Scenarios

The scenarios presented in this section focus on different aspects of UTM operations; they expand on, and include updates to, the set of scenarios presented in UTM ConOps v1.0 (see comparison in Table 2. Summary of V2.0 Scenarios).²⁵ They are a subset of those developed under the auspices of the UTM RTT (Appendix E provides a list of all UTM RTT use cases for reference). The scenarios present examples of processes, technologies, and techniques for accomplishing different operational needs – and should not be construed as final UTM implementation requirements or solutions.

Each scenario has the following format:

Overview: Provides a description of the environment, operational objectives, and factors surrounding the use of UTM services in the scenario events.

Scenario Narrative: Provides a storyline of interactions among UTM actors (e.g., commercial UAS Operators, USSs, SDSPs, the FAA, public safety entities, general public), the use of various capabilities within the UTM ecosystem, and high level process flows that enable the actors to accomplish the objectives of the operation.

3.1 Scenario Overview

The operational environment in the scenarios includes both controlled and uncontrolled airspace, 400 feet AGL and below. Operators conduct commercial and recreation operations in rural, suburban, and urban environments. Commercial operations include inspections (e.g., infrastructure, agricultural), scenic photography/videography, medical operations (e.g., organ transport), and package delivery. UTM stakeholders work together to foster shared situational awareness, develop and disseminate notifications to UAS Operators about airspace changes, and support safe UA interactions with manned and unmanned aircraft. Table 2 presents a high-level summary of each scenario.

²⁵ The scenarios presented in UTM ConOps V2.0 are the current set and supersede those presented in V1.0. Readers need only reference V2.0 for the most current information.

Table 2. Summary of V2.0 Scenarios

Scenario	Title	Summary	Relationship to ConOps V1.0
V2-1	Nominal UTM Operations in Uncontrolled and Controlled Airspace	Explores commercial VLOS and BVLOS operations participating in UTM via use of various services, including planning, Operator messaging, de-confliction, and Airspace Authorization.	Encompasses and expands upon Scenarios V1-1 and V1-4
V2-2	UVRs and Associated Operational Impacts	Explores the establishment of a USS providing public safety services to a MedEvac helicopter Operator landing to retrieve a patient in medical distress. The servicing USS generates and distributes the UVR notification to the USS Network and the FAA. Operators with planned or active operations directly impacted by the UVR take appropriate actions to maintain safe flight. Also explores indirect impacts to other operations.	Updates Scenario V1-2. Dynamic Restriction concept replaced by UAS Volume Reservation concept
V2-3	Interactions between UAS and Manned Aircraft at Low Altitudes	Explores various methods by which UAS Operators and low-altitude manned aircraft Operators gain situational awareness of each other, including information sharing via the USS Network, cooperative V2V communications, and DAA technologies.	Based on and similar to Scenario V1-3
V2-4	Use of UTM to Remotely Identify UAS	Explores methods by which a private citizen and public safety entity each gather information about UAS operations occurring over a residence. The citizen uses the services of a RID USS, while the public safety entity uses FAA services to obtain relevant RID information.	New Scenario
V2-5	Federal Public Safety Request for UTM Information	Explores methods by which a public safety entity obtains Operator information not available to the general public, using RID information as a query. The public safety entity uses the services of a federal public safety USS to query the USS Network and the FAA for information relating RID information.	New Scenario

3.2 Scenario V2-1: Nominal UTM Operations in Uncontrolled and Controlled Airspace

Overview

In the Southwest quadrant of Cleveland Hopkins International Airport (KCLE) airport, multiple operations are scheduled in the morning, including construction and rail inspections, package delivery, photography, agriculture spraying, and training. The operations span Class G and Class B airspace, and include VLOS, BVLOS, and UAS operations over people (OOP).

UAS Operators fly under applicable rules and regulations (e.g., VLOS commercial under 14 CFR Part 107).²⁶ Operators obtain Performance Authorizations to enable operating within an AAO, and also obtain Airspace Authorizations for each operation conducted wholly or partially within controlled airspace. The remote pilots responsible for an individual flight obtain appropriate pilot certification to conduct operations per the Operator’s Performance Authorization (the Operator may also be the RPIC).

Operators in the area, depicted in Figure 7, participate in UTM using the services of USSs to meet the requirements of their operation, including, but not limited to, sharing operation intent for situational awareness, strategically de-conflicting to avoid 4D overlap of operations, obtaining Airspace Authorizations, receiving airspace notifications, and meeting applicable RID transmission requirements.

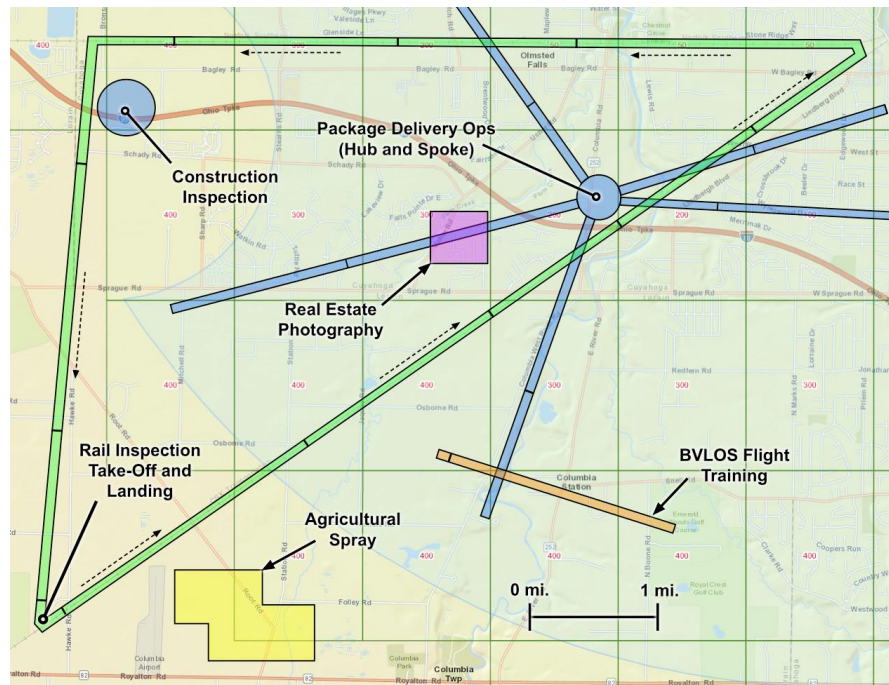


Figure 7. BVLOS and VLOS operations relative to Class B boundaries and UASFM grids

²⁶ Operating Part and regulatory requirements for UTM BVLOS operations are to be determined.

Scenario Narrative

Operation Planning Phase

A BVLOS or VLOS UAS Operator utilizes the services of the USS to which they subscribe for operational support, as well as relevant SDSP services, to gather planning information for an operation.²⁷ The Operator provides initial planning information to their USS, such as an operation area, points of interest, and times. The Operator's USS utilizes USS Discovery services to identify other USSs with active operations in the area of interest during the noted times and requests applicable operation intent information for Operators subscribed to their services; the returned data includes Operation Volume segments relevant to the area. The Operator's USS also retrieves relevant operation intent for its own subscriber base. The Operator's USS and/or SDSPs provide additional supplementary information for planning, such as weather, air and ground obstacles, airspace constraints, and other airspace information (such as UASFMs for controlled airspace).

Using gathered information, the Operator plans out a nominal 4D path for the flight. The Operator's USS applies applicable performance buffers to the nominal flight path to define one or more Operation Volume segments; entry and exit times of each segment are based upon the time of projected occupancy with respect to the 4D flight path. The Operator's USS checks the Operation Volume segments against those of other operations and other operational considerations (e.g., UVR) for any 4D conflicts. If the Operator's volume segment(s) have no conflicts, no additional planning actions are required. If, however, there is a conflict, the Operator strategically de-conflicts the operation from other operations. Strategic de-confliction methods may include: (1) adjustments to one or more volume segment's entry/exit times to separate temporally (with adjustments to the nominal 4D flight path as needed), (2) adjustments to the lateral/vertical boundaries of one or more volume segments to separate spatially, or (3) a combination of both temporal and spatial separation (depicted in Figure 8).²⁸

If strategic de-confliction by an Operator is not possible, the Operator can strategically de-conflict by coordinating with other Operators via their respective USSs. Negotiations may occur in back and forth data exchanges to minimize impacts to the goals of each operation.²⁹

²⁷ VLOS UAS Operators are not required to strategically de-conflict with other UTM participants to conduct operations because they are able to visually separate from other aircraft. However, they may do so voluntarily. Providing operation intent over the USS Network benefits VLOS Operators through increased situational awareness of other activities in the airspace, particularly in areas where there is frequent flight activity or close proximity of operations, or airspace changes (e.g., UVR).

²⁸ Rios, J. (2018). *Strategic Deconfliction; System Requirements Final Report*. Retrieved from <https://utm.arc.nasa.gov/docs/2018-UTM-Strategic-Deconfliction-Final-Report.pdf>

²⁹ USSs may streamline elements of the strategic de-confliction coordination process by instituting operating rules and Operator-indicated preferences.

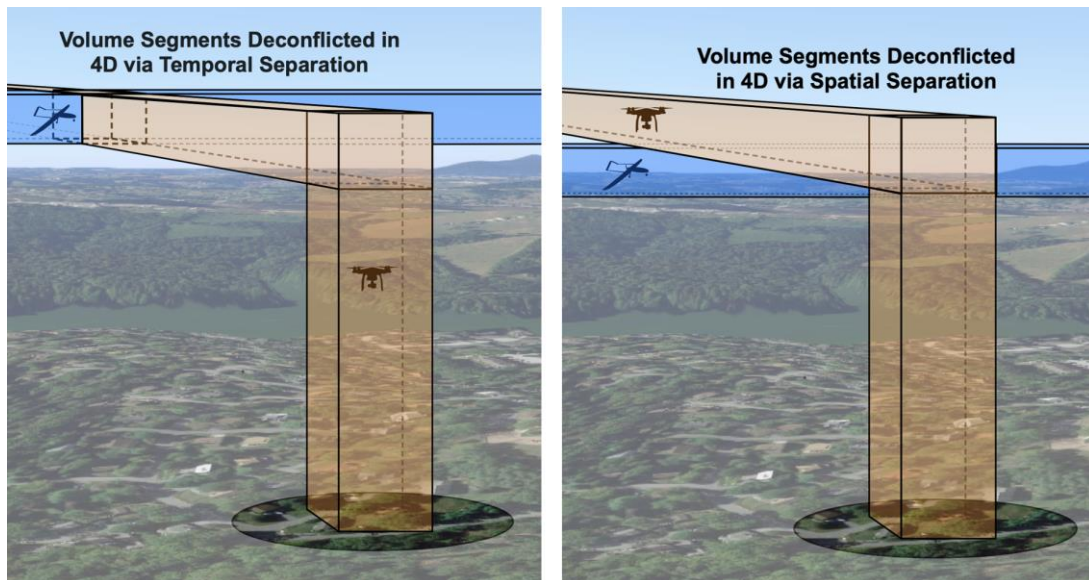


Figure 8. Temporal and spatial separation of Operation Volume segments

A strategic de-confliction process is presented for a notional rail inspection operation, depicted in Figure 7. The Operation Plan splits the flight profile into 11 Operation Volume segments (arrows depict the direction of flight). The use of segmented volumes, with sequenced entry/exit times of adjacent segments, results in more efficient utilization and access to the airspace. Segmentation can also reduce the need for coordinated strategic de-confliction between Operators/USSs. Together, segmentation of an operation into sequential volumes and 4D de-confliction between operations allows Operators and their USSs to more efficiently utilize and access the airspace.

If one or more of the Operator’s Operation Volume segment(s) exist within controlled airspace, in whole or in part, an Airspace Authorization must be obtained by the Operator.³⁰ As depicted in Figure 7, the rail inspection, package delivery, real estate photography, and BVLOS training operations are within the boundaries of Class B airspace, and therefore require Airspace Authorization. The construction inspection and agricultural operations are contained within Class G airspace, and do not require Airspace Authorization.

Using the services of a LAANC-qualified USS, the Operator requests an automated Airspace Authorization from ATC. The USS checks the Operation Volume(s) against the UASFM data for the airspace. If all volume segments are below the ceilings of applicable UASFM grids, the operation is authorized through

³⁰ Scenario V2-1 presumes use of USS LAANC services for automated Airspace Authorizations. An Operator could obtain an Airspace Authorization through another means, such as DroneZone; however, this would require advanced planning due to the longer times associated with more manual authorization processes.

automated processes, and the Operator is notified that the authorization has been granted.³¹ Authorization information is available to the traffic facility (or facilities) responsible for the airspace in which the authorization was granted.

Once planning is complete, the Operator's USS makes the operation intent, which includes the Operation Volume segment(s), available to the USS Network. Other USSs can get this operation information when using applicable services of their own USSs, in similar fashion to that described above, for planning and coordination purposes. The operation is in the "Accepted" state at this point.

Flight Phase

The RPIC, or operation support personnel, arrive(s) at the launch site and prepare(s) the UA for take-off.³² At the scheduled entry time for the first Operation Volumes segment, the UA is powered on and begins sending flight data to the RPIC and the Operator's USS. As part of transmitted information, the UA also transmits RID messages as required by FAA-established RID rules. The operation is in the "Activated" state at this point. The UA takes off and the servicing USS begins monitoring conformance using flight data transmitted by the UAS.³³ The servicing USS monitors the data to ensure that the UA is flying in accordance with its filed operation intent and the parameters of the Operator's Performance Authorization. The RPIC maintains separation from other UAS and manned aircraft. Operation Volume segments become active and close out in sequence, according to their respective entry and exit times.

If airspace changes (e.g., new operations, UVRs) result in operational impacts far enough in the future, the Operator may de-conflict strategically in similar fashion to the description in the planning phase. If the impacts are more near-term, such that strategic de-confliction is not viable (e.g., nearby rogue/fly-away UA), tactical de-confliction methods may be necessary, such as use of transmitted position information (e.g., broadcast or network transmissions), and/or on-board DAA technologies (e.g., light detection and radar [LIDAR]).

Landing and Post-Flight Phase

The UA arrives at the landing area and touches down prior to the exit time of the final Operation Volume segment. At the volume exit time, the operation is over and is in a "Closed" state. Data relevant to archiving requirements is saved by the Operator and/or USS.

³¹ If any volume segments partially or wholly exist above the ceiling for a UASFM grid (e.g., a volume goes up to 400 ft AGL for a grid whose ceiling is 300 ft AGL), the USS gives the Operator the choice to ask the FAA for "Further Coordination". If that option is selected, FAA personnel manually review the authorization request before denying or approving.

³² The RPIC may be remotely located, with representatives supporting any on-site operational needs.

³³ Should the UA be in a state incongruent with the Operator's operation intent, the operation state may be changed from "Activated" to either "Non-Conforming" or "Rogue" by the USS and shared with the USS Network so that impacted Operators and other stakeholders receive notice from their respective USSs. ATC may be notified if a USS integrated risk model determines notification is necessary and timely enough for the FAA to respond.

3.3 Scenario V2-2: UAS Volume Reservations and Associated Operational Impacts

Overview

A medical emergency necessitates patient transport to a nearby medical facility; a MedEvac helicopter is dispatched. Flight operations personnel from the MedEvac company (referred to as the MedEvac Operator) subscribe to the services of a USS that supports public safety operations (referred to as public safety USS, or USS-PS). The USS has been qualified by the FAA to provide UVR services that can notify local UAS Operators of the incoming low-altitude MedEvac helicopter. Three UAS operations are active or planned in the area of the UVR while it is active. Figure 9 provides an overview of the operational environment.

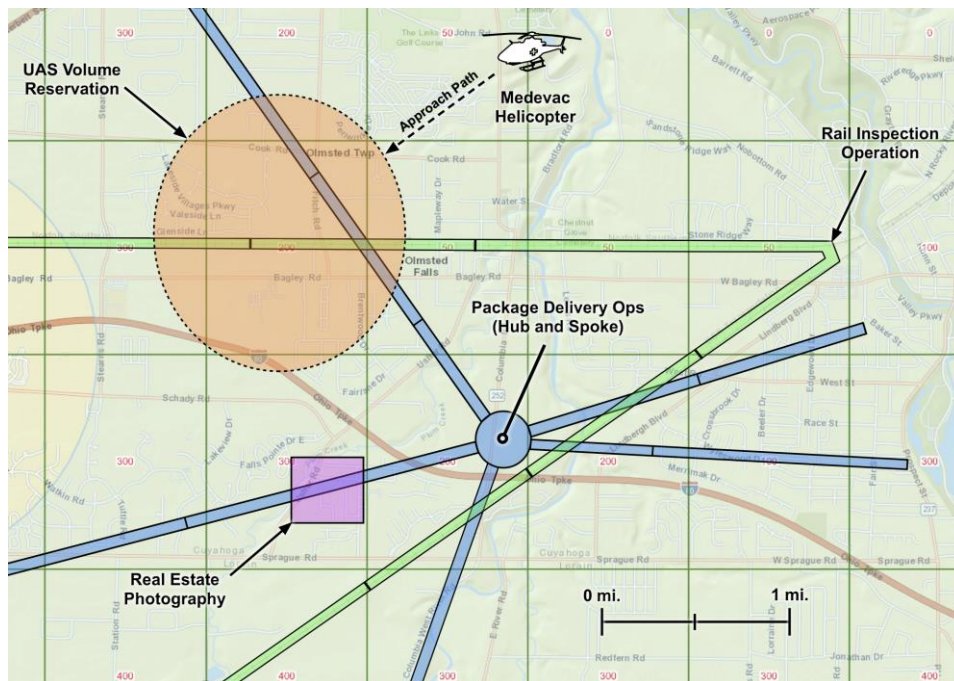


Figure 9. Operational overview relative to UVR

Scenario Narrative

The MedEvac Operator sends a UVR request to USS-PS that includes a defined airspace volume, the active UVR duration, the nature of the activity that will be occurring in the UVR (in this case, MedEvac helicopter activities), and any other relevant information. USS-PS authenticates the MedEvac Operator, confirming that it is a public safety entity permitted to request UVRs for the associated activity.

USS-PS, using automated business rules and pre-defined scenario templates, generates a UVR that adheres to the constraints (defined spatial and temporal boundaries) of the request, and distributes it to the USS Network. The USS also sends information on the UVR to the FAA via FIMS, which makes the information available to applicable FAA systems. See Figure 10 for notional information flows.

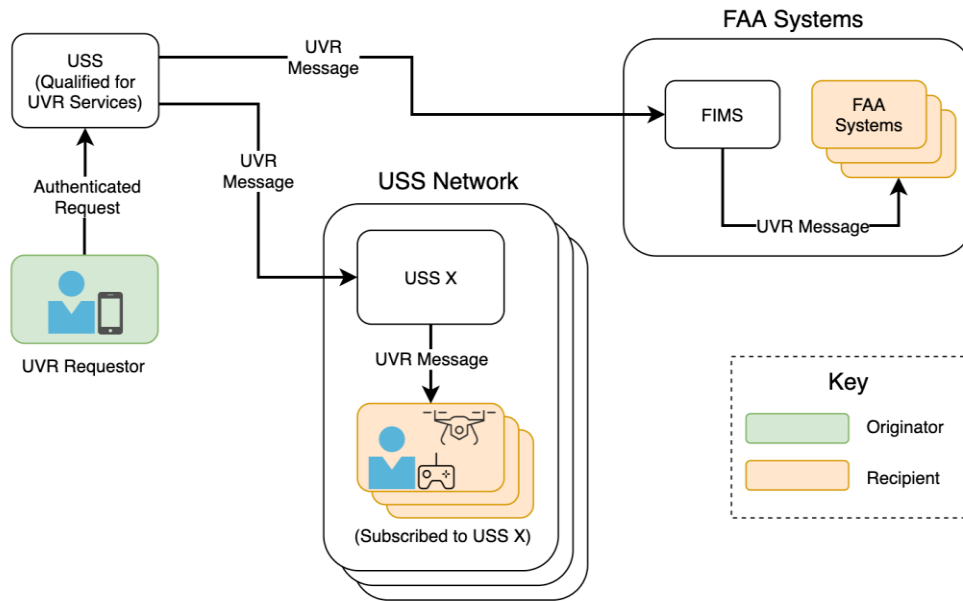


Figure 10. Notional UVR information flows

Upon receipt of the UVR message, other USSs with subscribed Operators in the vicinity of the UVR provide automated notifications in accordance with Operator preferences. For instance, in Figure 9, the delivery and rail inspection Operators would receive automatic notification from their USSs due to the overlap of the UVR with one or more of their respective Operation Volume segments. The real estate photo Operator, on the other hand, might set preferences to be notified when operating within some distance of an airspace event, or may only want notification when such an event overlaps an active or planned volume (see Figure 11).

Once notified, Operators who are impacted by the UVR evaluate whether they can safely operate within its bounds. They adapt their operation as appropriate to maintain safety of flight by, for example, strategically de-conflicting from the overlapping UVR, using DAA technologies to maintain separation from the helicopter while not changing their intent, or landing their UA during the period in which the UVR is active.³⁴ In this scenario, the rail inspection and the delivery operation 4 strategically de-conflict from the UVR, as well as from each other (via coordinated strategic de-confliction enabled by USS Network intent information exchanges). Delivery operation 4 makes necessary adjustments to their volume scheduling to avoid overlap with the UVR and the rail inspection operation. The rail inspection makes similar adjustments, shifting its 4D flight path to an earlier time to avoid the UVR and delivery operation 4.

³⁴ As in the previous scenario, Operator activities may be executed in a quick and/or automated fashion via the services of the USS to which the Operator subscribes, using applicable rules and Operator preferences. The narrative here minimizes references to USS automation to focus on the operational impacts to other Operators.

Note that the adjustments previously described were done in response to a direct impact of the defined UVR on each Operator. The following describes the indirect impacts to other operations due to changes by the rail inspection Operator's response to the UVR.

The shift of the 4D flight path of the rail inspection operation creates new upstream conflicts with delivery operations 1, 2, and 3 (see Figure 11). The rail inspection Operator de-conflicts strategically from the applicable delivery operations, which may include self-provisioned or coordinated de-confliction. The Operators that updated their operation intent as part of the conflict resolution process make the new intent available to the USS Network for situational awareness among Operators. If an Operator's original Airspace Authorization lapses during/before the updated operation times, or they will be operating in new UASFM grids, the Operator obtains a new authorization using LAANC services. The real estate operation and delivery operation 5 are not overlapped by the UVR, therefore neither Operator makes a change to their intent.

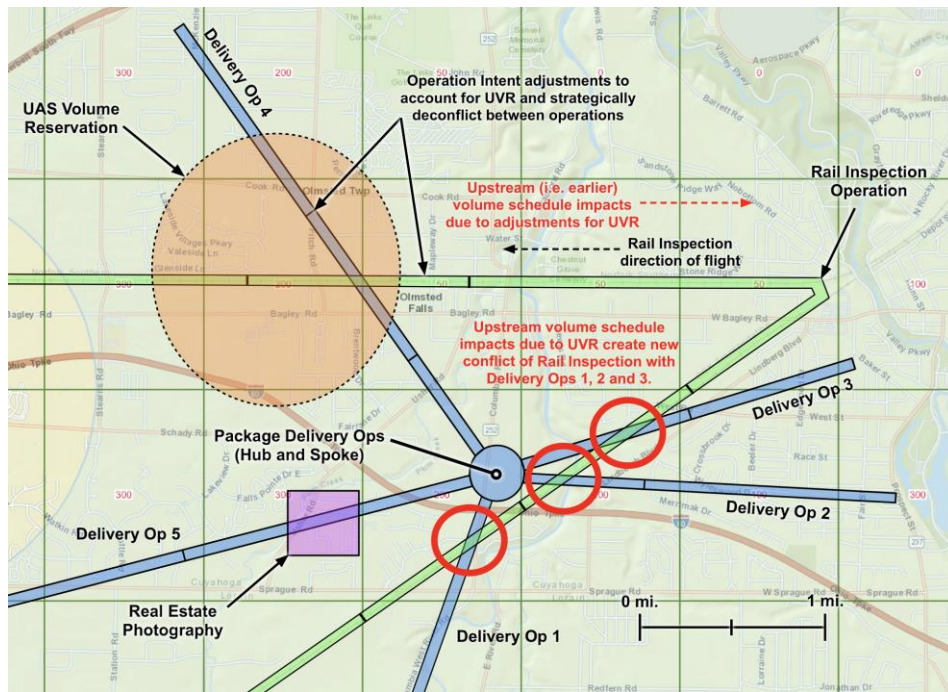


Figure 11. Example of direct and indirect impacts to operations by UVR

The UVR goes into the active state in accordance with its start time. The helicopter eventually enters the bounds of the UVR and lands, retrieves the person requiring medical treatment, exits the UVR, and proceeds to its destination. The UVR reaches its end time and is no longer active.

3.4 Scenario V2-3: Interactions between UAS and Manned Aircraft at Low Altitudes

Overview

Columbia Airport is a privately-owned, public use airport located in uncontrolled airspace approximately 8.3 miles southwest of KCLE. It sees an average of 15 general aviation operations a day, primarily single-engine aircraft. Pilots operating out of the airport are aware that there is significant low altitude traffic. In addition to manned aircraft operating at low altitudes (helicopters, crop-dusters), UAS operations occur regularly in the area (see Figure 12). Manned aircraft pilots in command (PICs) identify unmanned operations in the area prior to and/or during flight to ensure safety. UAS Operators flying near the non-towered airport also take actions to detect manned aircraft so they can maintain separation, particularly when operating BVLOS. This scenario explores different options UAS and manned aircraft Operators have to maintain situational awareness of, or detect, each other so they can safely share the airspace.

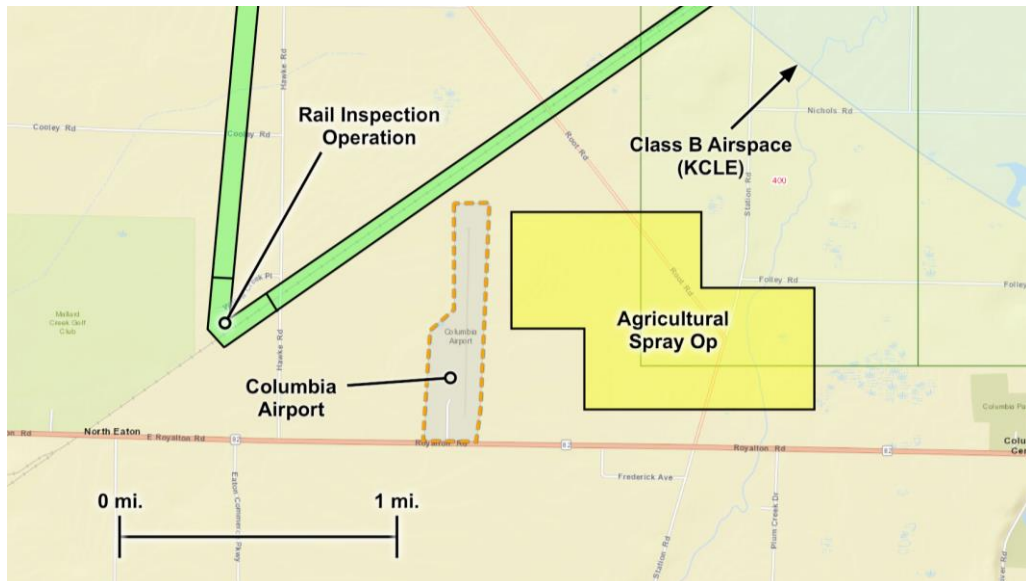


Figure 12. UAS operations near Columbia Airport

Scenario Narrative

Option 1 – UAS On-Board Detection of Manned Aircraft

UAS can use on-board equipment to continuously scan the environment for airborne objects (e.g., visual sensors). When an object is identified, the on-board UA systems relay the information to the GCS, which notifies the RPIC of a potential airborne object. Depending on the type of object, its distance, its trajectory, etc., the RPIC takes appropriate action to stay clear. Additionally, a UAS could be pre-programmed to adjust its heading or enact automatic contingency procedures when an object is detected.

Option 2 – Ground-Based Detection for UAS and Manned Aircraft

An entity can employ ground-based equipment to either identify airborne objects via sensors (e.g., radar, visual sensors), or via signals transmitted by an aircraft (e.g., RID broadcast receiver, ADS-B In). This equipment can be of use to UAS Operators and manned aircraft alike. Examples of each are provided.

UAS Detection for Manned Aircraft Operators: Columbia Airport installs equipment along airport boundaries to detect low-altitude UAS in proximity of the airport. This UAS activity is made known to manned aircraft Operators by airport staff (e.g., flight briefing, radio communications), enhancing situational awareness and safety during take-off and landing.

Manned Aircraft Detection for UAS Operators: While individual UAS Operators can set up detection system capabilities, infrastructure for large scale detection is more likely fulfilled by a third party, such as a USS or a SDSP. In this scenario, an SDSP installs a large-scale ground system in an area with moderate low-altitude manned and unmanned traffic. When the ground system identifies an airborne object/aircraft, it makes the information available to USSs that pay for access to the SDSP service. USSs, in turn, use this information to identify potentially-impacted subscribing Operators of an identified target along with its last known location, heading, and speed. Notified Operators and/or RPICs take appropriate action to maintain safe operation.

Option 3 – UAS and Manned Aircraft On-Board Cooperative Equipment

Equipment installed on the UA can be used to interact with compatible on-board equipment of manned aircraft (e.g., ADS-B In on the UA). The equipment may transmit/receive information, or just receive information (receiver-only equipment is assumed more lightweight). Manned aircraft can likewise have equipment installed that can detect information transmitted by UAS (e.g., RID broadcast signal).

While in flight, the UA can obtain information about equipped aircraft in the area. This information is then relayed to the RPIC via the GCS. The RPIC takes action, if required, to stay clear of the manned aircraft. The manned aircraft's equipment relays known information about the UA to the pilot, who acts in accordance with prescribed rules of the road/procedures to keep clear.

Option 4 – Voluntary Passive UTM Participation

Manned aircraft PICs, as members of the general public, can voluntarily subscribe to a USS and utilize services that enable them to request UTM operation information relevant to their needs (e.g., operation intent, RID messages), providing them with an increased situational awareness of UAS operations that are planned and/or active in the vicinity of their own low altitude operations. Manned aircraft PICs access local UTM operation information during their pre-flight planning period and/or or in-flight. If a manned aircraft PIC gathers information but does not share intent or flight information regarding their own

operations with a USS (one-way USS to PIC information flow only), the PIC is considered to be *passively* participating in UTM.³⁵

Option 5 – Manned Aircraft Voluntary Active UTM Participation

Manned aircraft PICs that do not have on-board broadcast, or other equipment that works cooperatively with UAS equipment, can opt to actively participate in UTM by providing their own operation intent to the USS Network. By participating, nearby UTM participants are aware of the manned aircraft's intent. The manned aircraft PIC does not strategically de-conflict with UAS Operators in the manner that UAS Operators de-conflict operations with one another. Rather, the UAS Operators have increased situational awareness of the manned aircraft and can plan/act accordingly, and the manned aircraft's intent can be used by a USS to provide notification to the PIC of relevant UAS activity near them. The information exchanges are similar to those detailed in previous scenarios.

³⁵ VLOS UAS Operators could passively participate in the same manner as described above. The Operator would use information available via the USS Network to gain situational awareness of other UAS operations in the area, but is not required to actively participate in cooperatively sharing information (e.g., intent) over the USS Network.

3.5 Scenario V2-4: Use of UTM to Remotely Identify UAS

NOTE: This scenario examines operational threads related to network-published RID messages. It is assumed that the UAS in the scenario are transmitting publicly-accessible RID messages via network publish through an RID USS.

Overview

A large party is being held at a private residence in Strongsville, Ohio. Throughout the day, various UA can be seen flying overhead and off in the distance. During the event, partygoers notice an unknown, low-flying UA close to the property. This scenario examines two options: one in which RID information is obtained via direct query of RID USSs by a private citizen (or member of the general public), and one in which RID information is obtained via FAA query of RID USSs as a service provided to authorized entities (e.g., public safety/law enforcement).

Scenario Narrative

Option 1 - Private Citizen Query of RID USSs for RID Messages

The property owner, hereafter referred to as private citizen, becomes concerned about the intentions of the UA. The property owner uses an internet-connected device in an attempt to gather publicly-accessible identification information about the UA so it can be provided to local authorities for investigation. The private citizen previously downloaded a government-qualified RID USS (referred to as RID USS A) application to a smartphone. While the UA in question is still in the air, the private citizen uses the phone app to query RID USS A about any UAs transmitting RID messages via network publish within X radius of the property.

RID USS A checks its subscriber base for RID messages with position information that match the bounds of the private citizen's query. Additionally, RID USS A uses USS discovery services to identify other government-qualified RID USSs that are active in the area in question. RID USS B is identified, and RID USS A sends a request to identify any RID messages currently being transmitted that conform to the bounds of the private citizen's query. RID USS B authenticates RID USS A's request and then responds with the applicable RID messages. RID USS A provides query results to the private citizen via the phone app. The private citizen reviews the information provided by RID USS A, and identifies a transmitting UA near the physical location.³⁶ The private citizen records the UAS ID message element from the RID message and provides it to local authorities as part of a privacy complaint.³⁷

³⁶ The private citizen would get the same results from the query if RID USS B were used (see Figure 10). Additionally, if other RID USSs were active in the area (e.g., RID USS C, D,...,n), the set of messages accessible by the private citizen would also include those from the other RID USSs.

³⁷ In addition to RID messages, a private citizen could obtain other publicly-accessible information and report it to authorities. For example, if a private citizen subscribed to USS services for Operator to Operator messaging, in addition to RID services from an RID USS, the citizen could also obtain information shared between Operators over the USS Network (e.g., operation intent).

Figure 13 provides a visualization of the high-level data exchanges associated with the private citizen query of the USS Network.

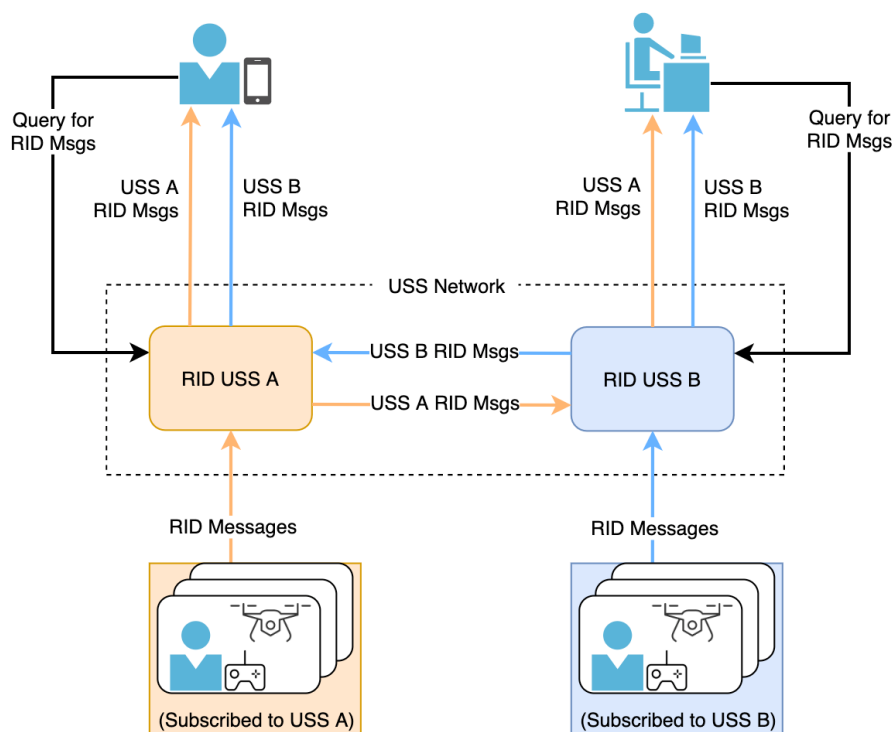


Figure 13. Notional USS Network data exchanges of RID messages

Option 2 - Public Safety query to FAA for RID Messages

The property owner becomes concerned about the intentions of the UA and calls the local police department to file a privacy complaint. An officer is assigned to handle the complaint. In accordance with standard procedures, the officer signs into an FAA service via a work-issued desktop computer. After being authenticated by the FAA service, the officer initiates a query for any UAs transmitting RID messages via network publish within X radius of the property.

The FAA RID Service utilizes FIMS to query applicable USSs. FIMS uses discovery services to identify active government-qualified RID USSs in the area of interest; RID USS A and RID USS B are identified. FIMS sends a request to each USS to identify any RID messages being transmitted that conform to the bounds of the officer's query. RID USS A responds to FIMS with matching RID messages, as does RID USS B.³⁸ The FAA RID Service relays the information obtained to the officer, who saves the data for investigative purposes.

³⁸ It is assumed that in this situation the RID USSs are not making their responses to FIMS available to each other, similar to the Option 1 narrative. Rather, FIMS is connected to each USS individually (point-to-point) and exchanges information one-to-one.

Figure 14 provides a visualization of the high-level data exchanges associated with the public safety query to the FAA RID Service.

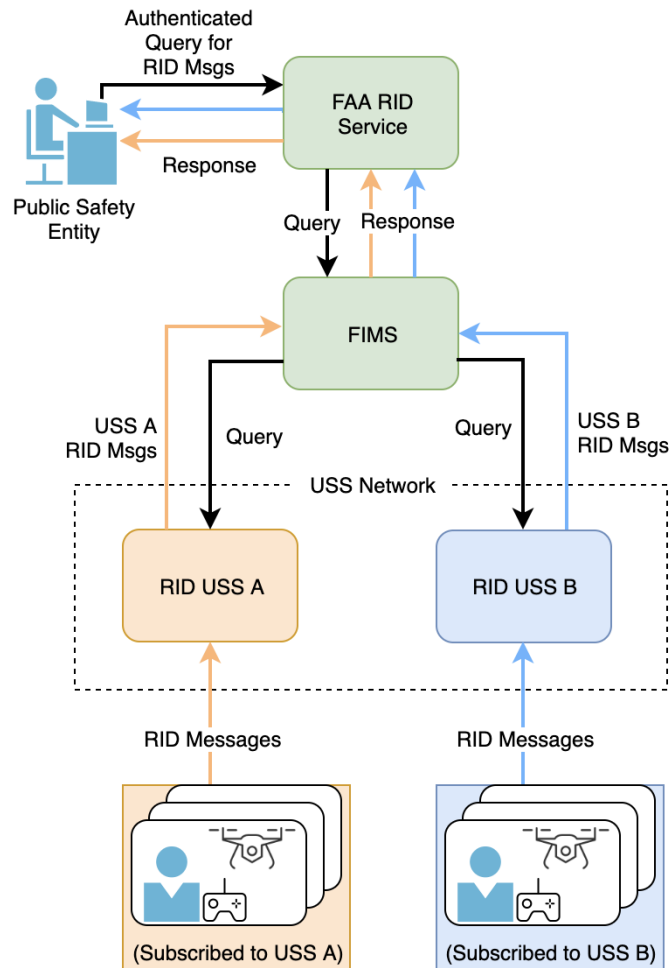


Figure 14. Notional public safety query to FAA for RID messages

3.6 Scenario V2-5: Federal Public Safety Request for UTM Information

NOTE: This scenario examines operational threads related to broadcast RID messages. It is assumed that the UAs in the scenario are transmitting publicly-accessible RID messages via broadcast. These messages are available to anyone within a range of the UA.

Overview

An open-air political rally for a presidential nominee is occurring in the suburbs of Cleveland. As part of the security measures, a Temporary Flight Restriction (TFR) is created in the area. Federal officers take position at various event locations to monitor the crowd and any activity in the air. A UA is spotted near the event, within the bounds of the TFR. The federal officers determine that the UA is not part of media activities that are permitted to fly within the TFR, and the responsible RPIC is not immediately identified in the vicinity of the event.

The officer investigating the UA uses a device capable of receiving broadcasted RID message transmissions (in this scenario, assumed to be a smart phone), and obtains an RID message from the UA in question. From the received message, the officer has the UAS ID associated with the aircraft. The officer then utilizes UTM and FAA services to get information on the UAS and the associated Operator (beyond what is obtained from the publicly-available RID message previously received). This scenario examines two notional options: one in which the officer, using USS services, directly queries the USS Network and FAA for information, and one in which the officer only queries to the FAA, which provides information from its own data sources and facilitates queries to the USS Network as well (an indirect query).

Scenario Narrative

Option 1: Direct Query to FAA and USS Network

The officer uses a phone app to connect to a USS that has been qualified by the government to provide public safety services to authorized entities (referred to as a public safety USS, or USS-PS). Upon logging in, USS-PS authenticates the officer and confirms the type(s) and level(s) of information the officer is requesting is authorized. The officer initiates a query for Operator and UAS information from the USS Network using the UAS ID previously received via RID message broadcast. USS-PS utilizes USS discovery services to identify other USSs active in the area; upon identifying active USSs, USS-PS sends queries to each over the USS Network requesting information associated with the submitted UAS ID.³⁹ Each USS authenticates USS-PS to verify information access privileges and ensure any information provided is consistent with the privilege level of USS-PS (e.g., public vs. sensitive information). Each USS sends a

³⁹ Types of information requested may include operation intent, operation state, Operator contact information, etc. It is assumed that USS-PS establishes individual, point-to-point connections with each identified USS; information that is provided to USS-PS by each USS is not provided to the other USSs during these one-to-one exchanges.

prompt response indicating it does not have data associated with that UAS ID, which USS-PS relays to the officer via the app.⁴⁰

The officer then uses the phone app to initiate a query to the FAA requesting information related to the UAS ID. USS-PS sends the query to FIMS, which authenticates USS-PS and then queries internal FAA systems for related information (e.g., LAANC authorizations, DroneZone registration, authorizations and waivers). Only the UAS registration associated with the UAS ID is retrieved. FIMS relays elements of the registration data to USS-PS, which USS-PS is authorized to receive. The registration data includes the owner's name and contact information. USS-PS provides the results of the query to the officer. The officer contacts the registered owner of the UAS and requests an immediate landing of the UA. Using the information obtained, authorities take appropriate post-incident actions.

Figure 15 provides a visualization of the high-level data exchanges associated with the public safety query of the USS Network and the FAA.

⁴⁰ Information regarding the Operator may not be available from the USS Network for various reasons. For example, if operating VLOS, the Operator would not be required to share intent information with other Operators via a USS. If operating VLOS and in controlled airspace, the Operator might obtain Airspace Authorizations from DroneZone instead of a LAANC provider, such that associated authorization information is only available from the FAA. RID transmission via Network Publish, if required, might not be possible due to internet service issues. If operating BVLOS, then the Operator is not meeting applicable pre-flight and in-flight information sharing requirements with respect to the USS Network.

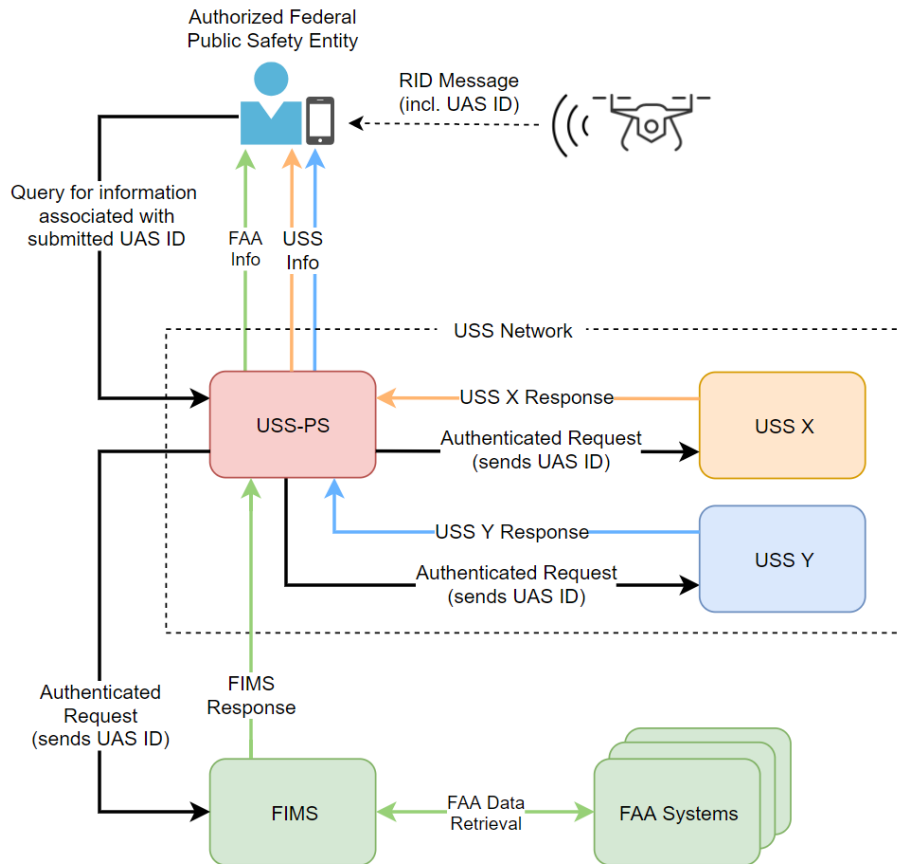


Figure 15. Notional direct queries to USS Network and FAA

Option 2: Direct Query to FAA and Indirect Query to USS Network (via the FAA)

Similar to Option 1, the officer has connected to and been authenticated by USS-PS. Using the USS-PS app, the officer initiates a query to the FAA for Operator and UAS information using the UAS ID previously obtained from the publicly-available RID message. USS-PS sends the query to FIMS, which authenticates USS-PS. FIMS utilizes USS discovery services to identify USSs active in the area and sends queries to each identified USS over the USS Network, requesting information associated with the submitted UAS ID.⁴¹ Similar to the prior narrative, each USS indicates no data associated with that UAS ID is available. FIMS then queries internal FAA systems for related information; the UAS registration associated with the UAS ID is retrieved.

FIMS relays to USS-PS the elements of the registration data which it is authorized to receive; if USS Network information was retrieved, it would have been provided as well. The registration data includes

⁴¹ It is assumed that FIMS establishes individual, point-to-point connections with each identified USS; information that is provided to USS-PS by one USS is not available to the other USSs.

the owner's name and contact information. USS-PS provides the results of the query to the officer. Similar to the previous narrative, the owner is contacted, is requested to land, and authorities take appropriate post-incident actions.

Figure 16 provides a visualization of the high-level data exchanges associated with the public safety query of the FAA.

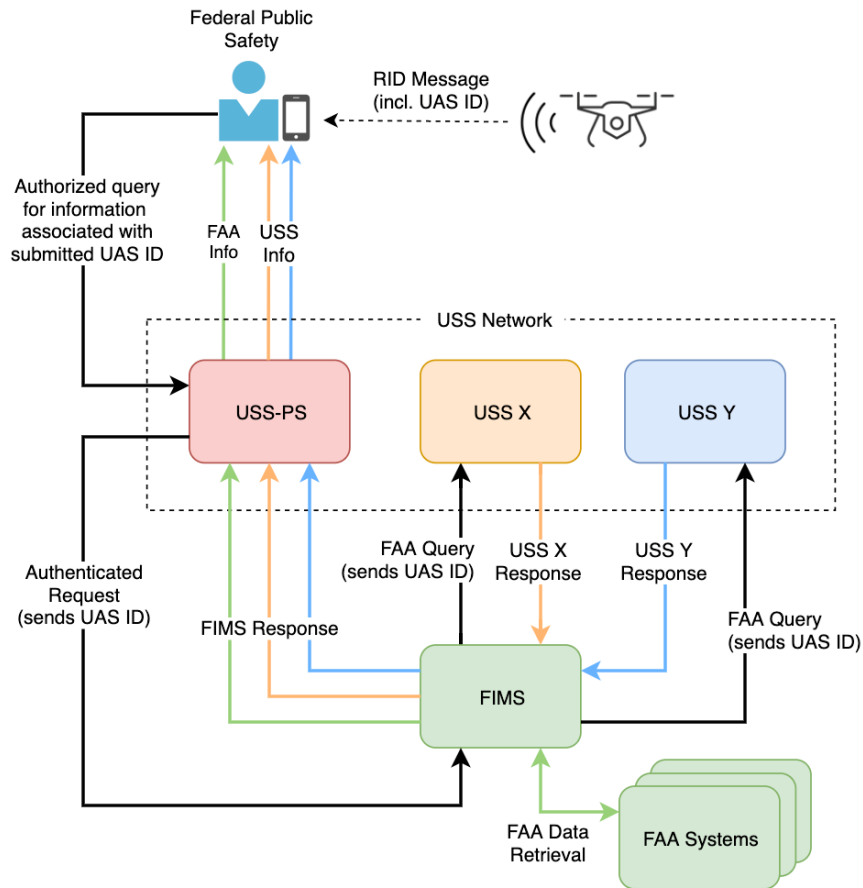


Figure 16. Notional direct query to FAA and indirect query to USS Network

4 UTM Implementation

The FAA, in coordination with NASA, industry, and the greater UTM community, is implementing a spiral development of UTM, starting with low complexity operations and building, in modules, higher complexity operational concepts and requirements. This approach aligns with the UAS rulemaking roadmap. Each new development cycle is designed to mature the UTM architecture and services provided to ultimately support the full range of UAS operations - from remotely piloted aircraft to command-directed UAS and fully autonomous UAS.

Stages of development are based upon three risk-oriented metrics: (1) the number of people and amount of property on the ground, (2) the number of manned aircraft in close proximity to the UAS operations, and (3) the density of UAS operations. It is anticipated that operational requirements on airspace users will increase commensurately with the complexity of the operations and the environment within which these operations are performed (e.g., the density of demand for access to a volume of airspace). UTM is expected to continue to mature, encompassing increasingly complex operations in high density, heavily regulated airspace over densely populated areas, with increasingly demanding requirements for UAS performance and capabilities. Stakeholders will adopt applicable public and private sector standards related to data exchanges, operation protocols, and equipment performance where necessary in order to support the highly automated nature of the envisioned management system.

The goal for initial UTM implementation is to minimize deployment and development time by utilizing current industry-provided technologies and capabilities for operations (e.g., mobile communications, existing ground and air infrastructures) capable of meeting appropriate performance requirements for safety, security (cybersecurity, resilience, failure modes, redundancy), and efficiency while minimizing environmental impacts and respecting privacy and safety of citizens.

This spiral approach to UTM development provides several advantages. First, by initially addressing lower complexity environments, where technological requirements and services should be the least stringent, implementation can be streamlined to these environments using current capabilities that meet performance requirements and do not require a full-scale architecture. Second, developing UTM according to an environmental risk and complexity scale allows for scalable, flexible, adaptable services that are 'right sized' for the environment rather than one size fits all. UTM design must be able to adapt to new technologies and automation, both ground-based and airborne, and increasingly allow for more advanced forms of interaction with the UTM ecosystem, predominantly through interoperable systems capable of digital information and data exchange. Ultimately, UTM must encompass the range of UAS demand, business models, applications, and technologies, and support safe and efficient operations that coexist with manned traffic, and impose as little disruption to the existing ATM system as possible - while maintaining fair and equitable access to airspace.

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List of Acronyms

Acronym or Term	Description
101e	Part 101 Subpart E
4D	Four Dimensional
AAO	Authorized Area of Operation
ADS-B	Automatic Dependent Surveillance - Broadcast
AGL	Above Ground Level
ANSI	American National Standards Institute
API	Application Program Interface
ARC	Aviation Rulemaking Committee
ATC	Air Traffic Control
ATM	Air Traffic Management
BVLOS	Beyond Visual Line of Sight
CFR	Code of Federal Regulations
CNS	Communications, Navigation, and Surveillance
ConOps	Concept of Operations
DAA	Detect and Avoid
DHS	Department of Homeland Security
DOD	Department of Defense
EMS	Emergency Management Service
FAA	Federal Aviation Administration
FIMS	Flight Information Management System
GCS	Ground Control Station
JARUS	Joint Authorities for Rulemaking on Unmanned Systems
KCLE	Cleveland Hopkins International Airport
LAANC	Low Altitude Authorization and Notification Capability
NAS	National Airspace System
NASA	National Aeronautics and Space Administration
NOTAM	Notice to Airmen
OOP	Operations over people
PIC	Pilot in Command
RID	Remote Identification
PIREP	Pilot Report
RNP	Required Navigation Performance
RPIC	Remote Pilot in Command
RTT	Research Transition Team
SAA	Special Activity Airspace

Acronym or Term	Description
SDSP	Supplementary Data Service Provider
SUA	Special Use Airspace
sUAS	Small Unmanned Aircraft System
SRFC	Surface
TCL	Technical Capability Level
TFR	Temporary Flight Restriction
UA	Unmanned Aircraft
UAS	Unmanned Aircraft System
UASFM	UAS Facility Map
UAS ID	UAS Identification
UASSC	Unmanned Aircraft System Standardization Collaborative
UPP	UTM Pilot Program
UREP	Unmanned Aircraft Report
USS	Unmanned Aircraft System Service Supplier
USS-FPS	Federal Public Safety USS
UTM	Unmanned Aircraft System Traffic Management
UVR	UAS Volume Reservations
V2V	Vehicle-to-Vehicle
VLOS	Visual Line of Sight

Appendix A - UTM Research Transition Team

NASA and the FAA formed the UTM RTT to jointly identify, quantify, conduct, and effectively transfer UTM capabilities and technologies to the FAA (as the implementing agency) and to provide guidance and information to UTM stakeholders to facilitate an efficient implementation of UTM operations. The goals of the UTM RTT are to: (1) research and mature increasingly complex UTM operational scenarios and technologies; (2) demonstrate those capabilities through NASA UTM research; and (3) deliver to the FAA technology transfer packages that enable NAS service expectations for low-altitude airspace operations by providing insight and capability requirements for critical services.

The UTM RTT consists of four work groups (WGs) that focus on a range of technological areas to be addressed and further developed, including: (1) Concepts & Use Cases; (2) Data Exchange & Information Architecture; (3) Sense & Avoid; and (4) Communications & Navigation. Each of the WGs has FAA and NASA representation, as well as industry participation where appropriate. Collectively, these WGs will mature the operational concept, and define the services, roles/responsibilities, information architecture, data exchange protocols, software functions, and performance requirements that will enable large-scale, low altitude UAS operations.

To accomplish UTM RTT goals, the WGs are developing products in alignment with NASA's spiral development and evaluation schedule of Technical Capability Levels (TCLs), which are shown in Figure A-1. Spiral development of the UTM research platform is described in terms of four successive UTM TCLs, where each new TCL extends the supporting technological architecture, number of services provided, and types of UAS operations supported. UTM development starts with TCL 1 which represents low risk, low complexity UAS operating concepts and expands to TCL 4, which describes higher risk, more complex UAS operating concepts. As a set, the successive iterations will support development of the range of UAS operations for each operating environment - from remotely piloted aircraft to command-directed UAS and fully autonomous UAS. The TCLs are staged based upon four risk-oriented metrics: the number of people and amount of property on the ground, the number of manned aircraft in close proximity to the UAS operations, and the density of the UAS operations. Each capability is targeted to specific types of applications, geographical areas, and use cases that represent certain risk levels.

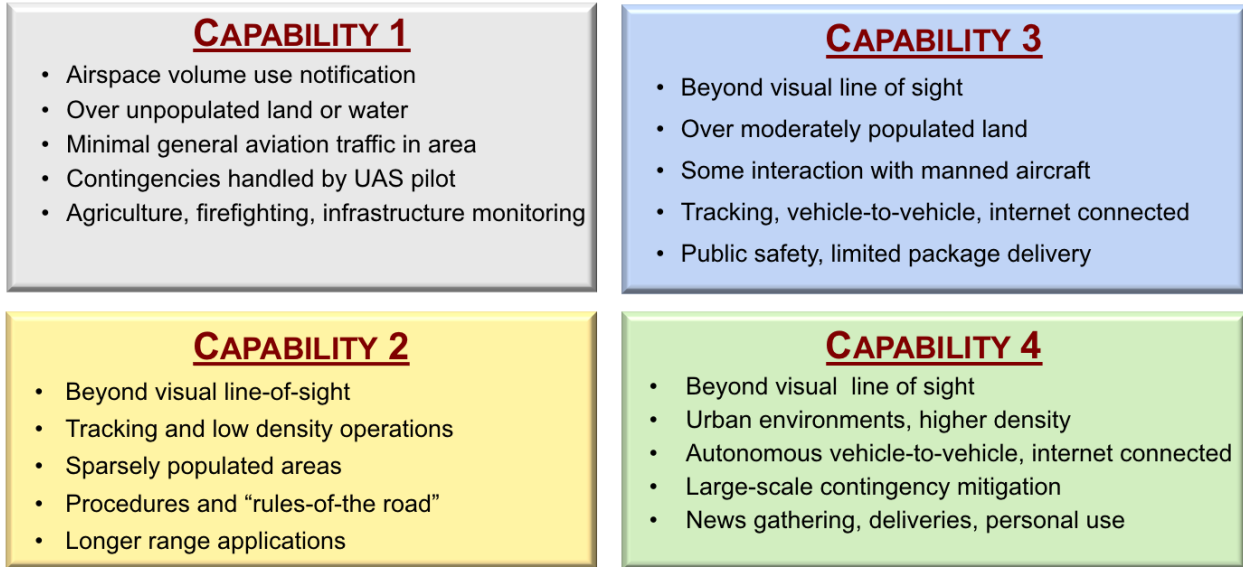


Figure A-1. NASA UTM Technical Capability Levels

The UTM RTT efforts will ultimately result in NASA’s technology transfer of

- UTM concepts and requirements for data exchange and architecture, communication/navigation and detect/sense and avoid, and other detailed technical documentation regarding Operator-to-Operator interaction and Operator-to-ANSP interactions - to the FAA and industry, and
- A FIMS prototype (software prototype, application protocol interface description, algorithms, functional requirements) - to the FAA.

Appendix B - NAS Airspace Classification⁴²

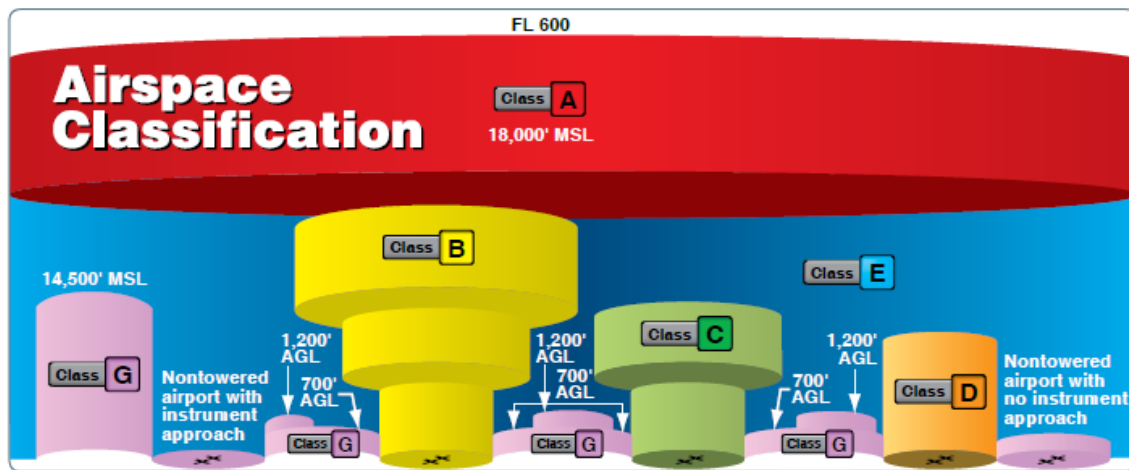


Figure B-1. NAS airspace classifications

Controlled Airspace

Controlled airspace is a generic term that covers the different classifications of airspace and defined dimensions within which air traffic control (ATC) service is provided in accordance with the airspace classification. Controlled airspace consists of Classes A, B, C, D, and E.

Class A Airspace⁴³

Class A airspace is generally the airspace from 18,000 feet mean sea level (MSL) up to and including flight level (FL) 600, including the airspace overlying the waters within 12 nautical miles (NM) of the coast of the 48 contiguous states and Alaska. Unless otherwise authorized, all operation in Class A airspace is conducted under instrument flight rules (IFR).

Class B Airspace

Class B airspace is generally airspace from the surface to 10,000 feet MSL surrounding the nation's busiest airports in terms of airport operations or passenger enplanements. The configuration of each Class B airspace area is individually tailored, 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.

⁴² Federal Aviation Administration. (n.d.). Pilot Handbook: Chapter 15 Airspace (pp. 15-2-15-3). https://www.faa.gov/regulations_policies/handbooks_manuals/aviation/phak/media/17_phak_ch15.pdf

⁴³ Class A airspace is not within the scope of UAS UTM operations; however, its description is included for completeness.

Class C Airspace

Class C airspace is generally 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 have a certain number of IFR operations or passenger enplanements. Although the configuration of each Class C area is individually tailored, the airspace usually consists of a surface area with a five NM radius, an outer circle with a ten NM radius that extends from 1,200 feet to 4,000 feet above the airport elevation, and an outer area. Each aircraft must establish two-way radio communications with the ATC facility providing air traffic services prior to entering the airspace and thereafter maintain those communications while within the airspace.

Class D Airspace

Class D airspace is generally 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 is normally designed to contain the procedures. Arrival extensions for instrument approach procedures (IAPs) may be Class D or Class E airspace. Unless otherwise authorized, each aircraft must establish two-way radio communications with the ATC facility providing air traffic services prior to entering the airspace and thereafter maintain those communications while in the airspace.

Class E Airspace

If the airspace is not Class A, B, C, or D, and is controlled airspace, then it is Class E airspace. Class E airspace extends upward from either the surface or a designated altitude to the overlying or adjacent controlled airspace. When designated as a surface area, the airspace is configured to contain all instrument procedures. Also in this class are federal airways, airspace beginning at either 700 or 1,200 feet above ground level (AGL) used to transition to and from the terminal or en route environment, and en route domestic and offshore airspace areas designated below 18,000 feet MSL. Unless designated at a lower altitude, Class E airspace begins at 14,500 MSL over the United States, including that airspace overlying the waters within 12 NM of the coast of the 48 contiguous states and Alaska, up to but not including 18,000 feet MSL, and the airspace above FL 600.

Uncontrolled Airspace

Class G Airspace

Uncontrolled airspace or Class G airspace is the portion of the airspace that has not been designated as Class A, B, C, D, or E. It is therefore designated uncontrolled airspace. Class G airspace extends from the surface to the base of the overlying Class E airspace. Although ATC has no authority or responsibility to control air traffic, Operators should remember there are visual flight rules (VFR) minimums which apply to Class G airspace. A remote pilot will not need ATC authorization to operate in Class G airspace.

Appendix C - UAS Service Supplier

The USS is an integral part of the UTM ecosystem. The USS serves a support role to Operators participating in UTM. USSs are expected to develop and implement a wide variety of capabilities and services to assist Operators in the safe conduct of their operations. USSs provide infrastructure and services that may be burdensome for individual UTM participants to develop, access, or maintain. By ensuring the sharing of information across the UTM community, USSs play a critical role in maintaining shared situational awareness across participants.

Communications Bridge: USSs act as a real-time or near-real time communications bridge between UAS Operators, the FAA (via FIMS), SDSPs, public entities, and other stakeholders to share information required to manage nominal and off-nominal operations. USSs assist Operators in meeting the requirements set forth for each operation either by acting as a coordination mechanism to relay safety critical information to the Operator and other entities (e.g., distribution of off nominal flight operations data to FAA and other affected airspace users) or provide services that enable efficient, safe operations.

The USS coordinates and distributes to appropriate entities (1) Operator intent, (2) airspace constraint data, (3) weather data, (4) vehicle tracking and conformance data, (5) surveillance data, and (6) RID data, and (7) other data critical to safety of flight. This data supports numerous services, including strategic de-confliction, notifications of UVRs, inflight de-confliction/sense and avoid functions, hazard avoidance, and terrain and obstacle clearance, RID, and other value-added services.

To successfully complete these exchanges, USSs must have discovery to FIMS, other USSs, Operators, SDSPs, and public entities (e.g., law enforcement, emergency services, DOD) either directly or via a central inter-USS communication and coordination capability (e.g., the USS Network). Adherence to a common requirement for information exchange within a USS Network (USS-USS) and/or with other specified entities is necessary, along with standard protocols for publishing flight information and other data, ensures data flow and situational awareness across all participants.

Demand/Capacity Balancing: USSs also support collaborative decision-making and conflict avoidance/de-confliction, which promote safety, equitable airspace access, and efficient operations. When users are competing for airspace, USS Operator negotiation capabilities and flight planning tools (e.g., route planning functions, airspace configuration options) are available to support collaborative decision making and/or offer alternate flight intent options that enable equitable airspace configuration solutions designed to optimize airspace equity and access and resolve demand/capacity imbalances.

To meet these objectives, USSs must develop/procure tools and capabilities that meet these requirements. Exchanges between identified parties require that USSs have discovery to FIMS, other USSs, Operators, SDSPs, and public entities (e.g., law enforcement, emergency services, DOD) either directly or via a central inter-USS communication and coordination capability (e.g., the USS Network). Adherence to an API defined to exchange information within a USS Network (USS-USS) or with other specified entities is also required.

Data Archiving: As the regulator, the FAA monitors Operator compliance with established rules and regulations set forth for the operation; investigates aviation accidents and incidents; collects and analyzes operations data to evaluate whether Operators are meeting agency requirements and goals are being met; and sets the risk for safety and authorizes Operators to operate provided they maintain the established level of safety. USSs will assist the FAA with meeting these responsibilities by archiving requested operations data sets in historical databases for FAA analytics, regulatory, and Operator accountability purposes. USSs must be capable of providing this data upon FAA request.

Remote ID: RID capabilities enhance safety and security by allowing the public, FAA, law enforcement, and other federal security agencies to remotely identify UAS flying in their jurisdiction. Government-qualified RID USSs support RID by receiving and processing network publish RID messages and responding to RID data queries from the general public and authorized officials (e.g., FAA, law enforcement officials).

Appendix D - UTM Services

Table D-1 provides a list of UTM services that have been addressed or identified in this document. This list is not exhaustive. Additional services may be developed as required.

Table D-1. UTM Services

Service Name	Definition
Remote ID	Services related to the identification of UAS in the NAS.
FAA Messaging	Services that provide on-demand, periodic, or event-driven message exchange capabilities with FAA systems to satisfy applicable regulatory/policy requirements.
USS Network Discovery	Services enabling authorized UTM stakeholders to discover relevant active USS providers and operations within a specified geographical area. The network operates in accordance with applicable standards. Each USS's access to the network will be qualified against the performance requirements necessary to be connected with the FAA portion of the network.
Operator Registration	A service which provides the ability for vehicle owners to register data related to their UAS and a query function to allow appropriate stakeholders to request registration data.
Airspace Authorization	A service which provides Airspace Authorization from the Airspace Authority/Air Navigation Service Provider to a UAS Operator.
Constraint Management	A service which supports provision of operational constraint information related to public safety activities, as well as applicable constraint information from the Airspace Authority/ANSP and other non-FAA authorized sources, to UAS Operators.
Operator Messaging	A service that provides on-demand, periodic, or event-driven message exchange capabilities in support of UAS Operator activities. Examples of exchanged information include position reports, intent information, and status information.
Strategic De-Confliction	A service that arranges, negotiates, and prioritizes intended Operation Volumes/trajectories of UAS operations with the objective of minimizing the likelihood of airborne conflicts between operations.
Conformance Monitoring	A service that provides real-time alerting of non-conformance with intended Operation Volume/trajectory to an Operator or another airspace user.
Conflict Advisory and Alert	A service that provides real-time monitoring and alerting through suggestive or directive information of UA proximity for other airspace users.
Dynamic Reroute	A service that provides real-time modifications to intended Operation Volumes/trajectories to minimize the likelihood of airborne conflicts and maximize the likelihood of conforming to airspace restrictions and maintaining mission objectives. This service arranges, negotiates, and prioritizes inflight Operation Volumes/trajectories of UAS operations while the UAS is aloft.
Operation Planning	A service that supports flight planning - accounts for various operational impacts, including other known operations, aircraft performance, weather forecasts, ground constraints, airspace constraints.
Flight Dispatch	A service that supports flight planning of operations requiring certification/special authorization (e.g., flight dispatch under Part 135).

Service Name	Definition
Weather	A service that provides forecast and/or real-time weather information to support operational decisions of individual Operators and/or services.
Mapping	A service that provides airspace constraint (e.g., airspace restrictions, special use airspace, NOTAMs, UVRs) and ground constraint (e.g., public gatherings, sensitive areas, obstacles) data necessary to meet the safety and mission needs of UAS operations and support in-flight and planning-related services.
Communication/C2	A service that provides infrastructure and quality of service assurance for radio frequency (RF) Command and Control (C2) capabilities to UAS Operators.
Surveillance	A set of strategic and tactical services that support air risk assessment for safety case development, flight planning with airspace heat maps based on common traffic patterns, and flight operations by providing real-time tracking information of air traffic for a given geographic area. Surveillance services consist of three primary means of collecting information regarding airborne hazards: terrestrial surveillance, airborne surveillance, and satellite surveillance.
Navigation	A set of strategic and tactical services that provide historical quality of service performance for airspace surveying during the safety development phase, coverage maps during the flight planning phase, and real-time integrity, availability, quality of service, and security monitoring during the operation phase.
UAS System Monitoring (Prognostics)	A service that monitors the health and status of UAS system components (e.g., battery and motors) in real time, and uses the input data to formulate predictions about the components' viability at future time horizons.

Appendix E - Use Case Inventory: Version 2.0

Table E-1 lists the complete set of use cases developed to date by the UTM RTT CWG to support NASA's TCL demonstrations and to serve as a basis for the concept narrative in this ConOps V2.0. The CWG will continue to develop use cases that represent increasingly complex UTM operations. They will be documented in subsequent ConOps versions.

Table E-1. V2.0 Use Case Inventory

Use Case	Title	Summary
TCL1-1	Two VLOS Operations with Voluntary Use of UTM for Coordination	Basic activities involved in sharing intent. Process of in-flight changes to operation intent.
TCL2-1	One BVLOS Operation, One VLOS Operation with Voluntary UTM Participation for Coordination	Introduction of a BVLOS operation. Manned aircraft (low density) at low altitudes near UTM operations.
TCL2-2	Two BVLOS Operations near an Airport in Uncontrolled Airspace	USS de-confliction of Operation Volumes during planning stage. Multiple USSs coordinating across the USS Network
TCL2-3	Priority Operation – Emergency Medical Aircraft in Uncontrolled Airspace <i>*Replaced by 4-4</i>	Introduces the concept of a Dynamic Restriction. Effects of a priority manned operation on UTM participants in uncontrolled airspace.
TCL2-4	BVLOS Operation Conformance Violation from Uncontrolled Airspace into Class D Airspace <i>*Currently being re-evaluated; work underway to consider UTM risk-model support</i>	Effects within UTM of a UTM-participating UAS becoming non-conforming with its shared operation intent. Direct FAA interaction with UTM once a UAS approaches and crosses into controlled airspace (when not authorized previously).
TCL3-1	One-Way BVLOS Flight, Separate Landing/Take-Off Locations	Introduction of Operation Plan development for long distance point-to-point operation in an area of increased airspace demand. De-confliction of Operation Volumes using flight planning tools. Segmentation of Operation Volumes to optimize airspace usage.
TCL3-2	Negotiation versus Prioritization between Operators Due to Dynamic Restriction	Segmented flight operation on long distance, point-to-point route. UAS contingency response to dynamic restriction on a segmented route. Two alternative outcomes of Operator negotiation due to in-flight airspace conflict.

Use Case	Title	Summary
TCL3-3	UAS Interaction with Manned Aircraft in Low-Altitude Uncontrolled Airspace	Heterogeneous operations. Concept level capability requirements for heterogeneous operations. Procedural requirements for manned/unmanned interactions.
TCL3-4	BVLOS Operation Lost-Link Event	UAS on-board contingency procedures during a lost-link event. Communication of Off-Nominal Event to other UTM Participants via the USS Network. Communication of UAS with Unknown Intent to the FAA and other Airspace Users.
TCL3-5	High Density UTM Operations in Uncontrolled Airspace	Many UAS operations managed through the course of a day by multiple servicing USSs. Closer examination of small Operation Volumes used in dense UTM operations. Strategic vs Tactical De-confliction/Separation between UAS operations.
TCL3-6	Last-Mile Rural Deliveries in Uncontrolled Airspace under the Mode C Veil	Simultaneous package deliveries (successful and unsuccessful deliveries). RPIC to UAS ratio of 1:2. Mode C Veil Uncontrolled Airspace UTM Operations.
TCL3-7	UAS Operator Loss of Performance Capabilities in Uncontrolled Airspace	Operator unable to meet Performance Authorization requirements. USS to USS operation hand-off due to loss of USS support for Operator. UAS landing due to inability to continue operating per Performance Authorization.
TCL4-1	BVLOS UTM Operation within UAS Facility Maps	BVLOS operation in controlled airspace. Cooperative separation/strategic de-confliction. Automatic Airspace Authorization.
TCL4-2	Historical UTM Information Queries by Authorized Entities	Public safety, FAA, and Federal interactions with the USS Network. Public safety USSs supporting authorized queries for information. Direct queries of USSs for information. Information categories.
TCL4-3	UAS Urgency/Distress Condition with Alternate Landing and UTM Coordination	Urgency situations with safe landing capability. Distress situation with compromised safe landing capability. Notification to stakeholders of enacted contingencies.
TCL4-4	UAS Volume Reservation in Controlled Airspace	USSs with capability to generate and distribute UVRs. Operator assessment of flight within UVR area and applicable safety mitigations.
TCL4-5	Report to FAA due to UAS Flight Incident	Automated USS transmit of report to FAA via FIMS.