Concept of Operations

V1.0

Foundational Principles

Roles and Responsibilities

Use Cases 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

800 Independence Ave., SW.
Washington, DC 20591

May 18, 2018

Dear Reader:

Attached for distribution is Version 1.0 of the Unmanned Aircraft Systems (UAS) Traffic Management (UTM) Concept of Operations. This concept documents what we have learned thus far through our use case development, insights on rulemaking, and the evolution of UTM Technical Capability Levels (TCLs). It reflects the collaborative efforts across the FAA, including ANG, ATO, and AVS, as well as the ongoing inter-Agency research efforts with NASA. The concept also reflects the input and participation of Industry partners as part of NASA's research community.

The NASA UTM Research Transition Team (RTT) serves as the inter-Agency forum to collaboratively explore concepts, develop prototypes, and demonstrate a possible future UTM system to enable large-scale low altitude UAS operations.

Through the UTM RTT effort, we will continue to develop subsequent versions as this UTM concept matures to encompass increasingly complex operations and environments.

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

Sincerely,

Steve Bradford
Chief Scientist, Architecture & NextGen Development
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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 refine 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 to that of present-day manned air traffic, compounds these challenges. Currently, hobbyists and licensed UAS Operators can fly within Visual Line of Sight (VLOS) under 14 CFR Parts 101(e) and 107. Other UAS operations occur today via waivers; a manual and case-by-case process. As detailed in Figure 1, the combined hobbyist and commercial fleet is projected to reach 3 to 6 million by 2021, up from less than 1.5 million in 2016[1]. This increase in fleet size will bring with it a considerable increase in expected volume of operations and, in turn, potentially, demand for airspace services. With commercial UAS conducting multiple flights a day to support business needs, such as deliveries (once enabled), the number of daily operations could potentially reach into the millions, taxing the NAS well beyond its current service requirements.

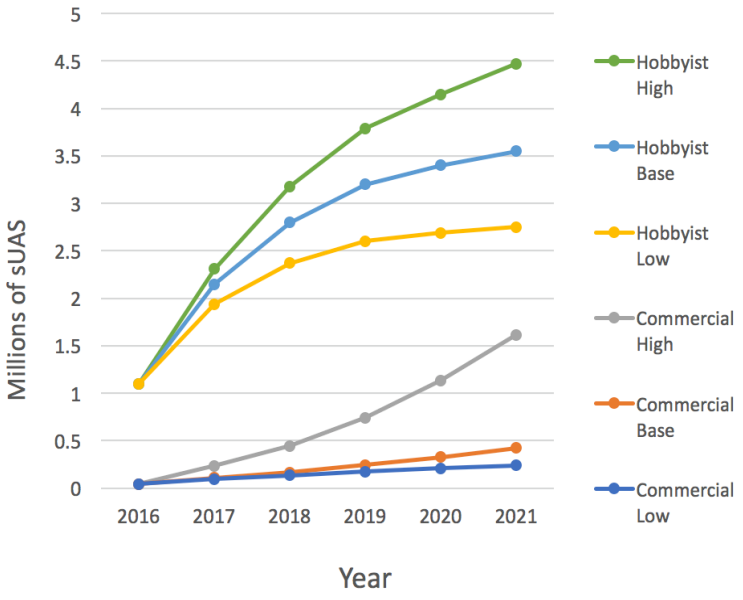

Figure 1. Projected UAS Growth

[1] Schaufele, Ding, Miller, et al, "FAA Aerospace Forecast, Fiscal Years 2017-2037", 2017

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, and finally to those that originate and operate within controlled airspace. Given the number and type of UAS operations envisioned, it is clear that the existing Air Traffic Management (ATM) System 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 this historically underutilized airspace, solutions that scale beyond the current ATM infrastructure and Air Traffic Control (ATC) manpower 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 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 a concept for unmanned traffic management, or UTM, that is separate from, but collaborative with the ATM system, and provide the means to support the management of UAS operations in uncontrolled airspace; where no air traffic separation services are provided.

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 sUAS 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 of 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 support, NASA's research project 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 2015 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).

In 2017, the FAA's initial application within the FAA's UTM ecosystem - the sUAS Low Altitude Authorization and Notification Capability (LAANC) - was deployed to provide UAS Operators access to controlled airspace near airports through near real-time processing of airspace authorizations below approved altitudes in controlled airspace. To support future operational requirements beyond

the current Part 101 and 107 regulations, NASA, in collaboration with FAA, is developing the prototype Flight Information Management System (FIMS). FIMS supports information exchanges and protocols for Operators to cooperatively share information and to access needed FAA-provided information for common situational awareness among all UTM stakeholders (Operators, other government agencies, and the FAA) and will be a core component of the overall UTM ecosystem.

1.3 ConOps Scope

This ConOps focuses on UTM operations ***below 400 feet above ground level (AGL).*** Most of the information presented will apply to UTM operations in any airspace under 400 ft, but operational and technical requirements may vary due to unique characteristics and implications of the airspace class in which UAS are operating. In this Version 1.0, the *use cases* presented are mostly specific to Class G operations. 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 (see Figure 2). ATC has no responsibility to provide separation services in Class G airspace, rather, manned aircraft cooperatively manage their operations based on specified principles of operations. 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 this airspace.

The FAA will develop subsequent ConOps versions that coincide with concept development of increasingly more complex UTM operations and environments across all airspace classes (see Appendix B for airspace class descriptions). The scope will be expanded to cover a range of operations in controlled airspace, as well as those that transit to and from a UTM environment and the ATM environment.

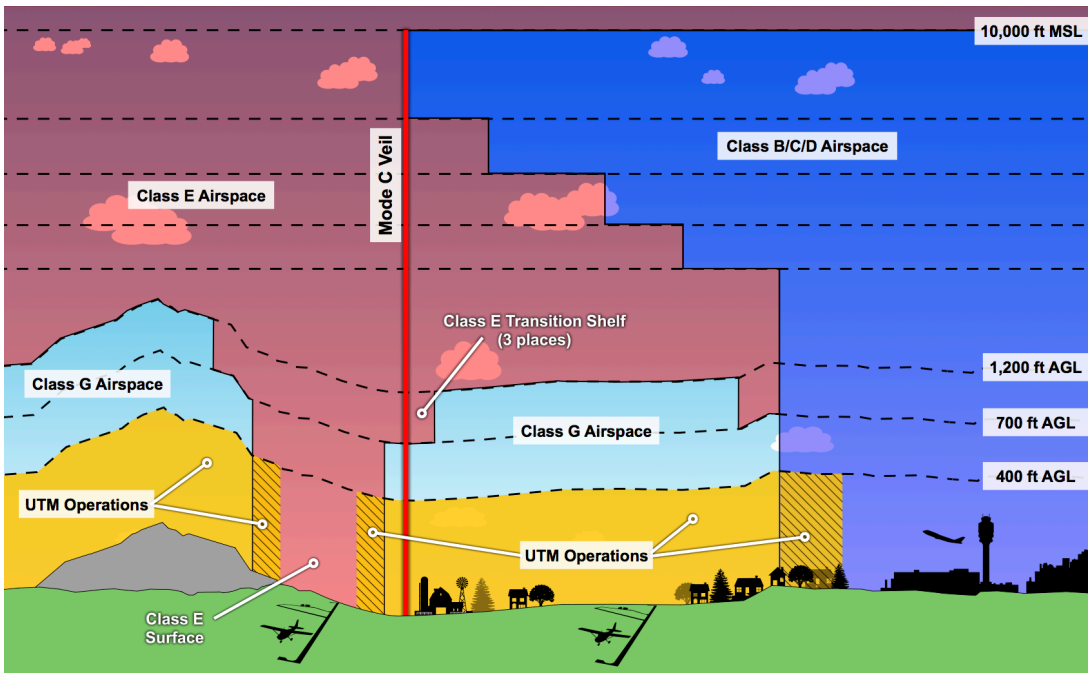

Figure 2. UTM Operations in Context of Airspace Classes

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 a UTM environment. 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 construct. 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 predominantly sUAS operating in low altitude airspace. 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 traffic management system, where the Operators are responsible for the coordination, execution, and management of operations, with rules of the road established by FAA. UTM is designed to support the demand and expectations for a broad spectrum of operations with ever-increasing complexity and risk.

The term 'UTM' refers to a set of federated services and an all-encompassing framework for managing multiple UAS operations. These services are separate, but complementary to those provided by the ATM system, and are based primarily on the sharing of information between Operators on flight intent and airspace constraints. UTM can offer services for flight planning, communications, separation, and weather, among others. Appendix C provides a more comprehensive, but not exhaustive, list of UTM services.

UTM is predicated on layers of information sharing and 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 FAA has on-demand access to UTM operational information when needed. UAS are required to meet the requirements established for the type of operation and associated airspace volume/route in which they are operating - including the ability to contain operations within a specified airspace volume or remain clear of a specified volume.

The primary means of communication and coordination between Operators, the FAA, and other stakeholders is through a distributed network of highly automated systems, and *not* between pilots and air traffic controllers via voice. The FAA makes real-time airspace constraints available to UAS Operators, via FIMS, and they are responsible for managing their own operations safely within these constraints without receiving ATC services from the FAA. UAS Operators may choose to use UAS Service Suppliers (USSs) to meet these obligations, or they may choose to provision their own set of services to meet these obligations. USSs provide UTM 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.

UTM encompasses all infrastructure, policies, and procedures required to support low altitude UAS operations. UTM requires the establishment of regulatory frameworks, development of operating rules and performance requirements commensurate with demands of the operation, and a data exchange and information architecture that provides shared situational awareness among participants. UAS Operators are responsible for ensuring compliance 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. Generally stated, the FAA will require increasing levels of UAS Operator engagement/interaction with UTM services as the complexity of the operations increases.

To establish UTM, the FAA expects to:

- Develop an 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 initiation of planned commercial operations. An example of this is LAANC, which supports the requirements of 14 CFR Parts 101(e) and 107 rules and is considered an initial UTM capability.

- Adopt 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.

- Evolve 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 system requirements will evolve with the march to expanded operations, as foreseen in already-submitted Operator waiver requests, cooperative Pathfinder research initiatives, and BVLOS rulemaking.

The FAA expects that the industry will seize opportunities to innovate and develop solutions to assist in the management of the 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 place a much smaller infrastructure and manpower burden (cost) on the Government to implement, while greatly accelerating the provision of capabilities due to market forces and business incentive to meet consumer demand. This is consistent with the FAA's approach for manned aircraft operations in Class G airspace.

- 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

With UTM, the FAA maintains its regulatory and operational authority for airspace and traffic operations; however, the operations are not managed via the ATM system. 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 black line in Figure 3 represents the demarcation between the FAA and industry responsibilities in 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 environment. 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.

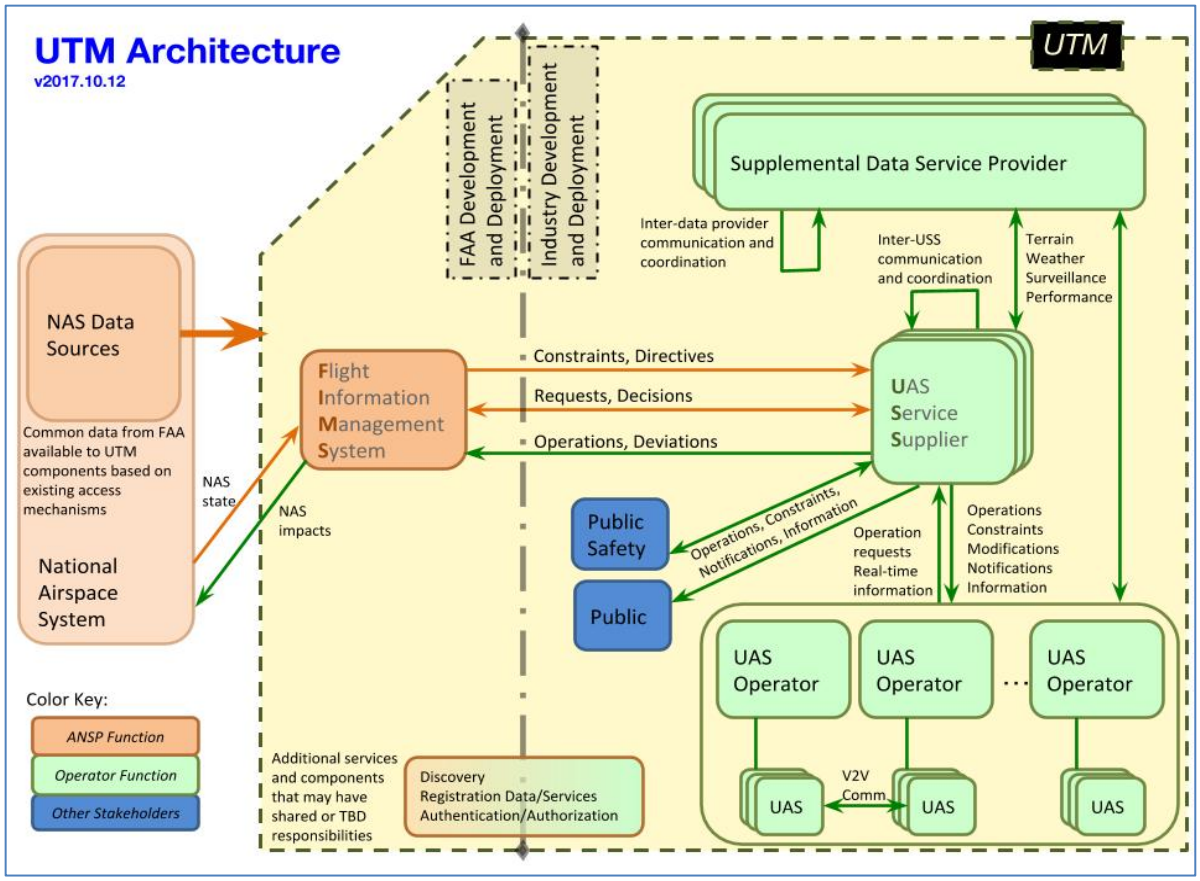

Figure 3. Notional UTM Architecture

2.4 Actors/Entities

The UTM actors and entities are introduced in this section. Sections 2.5 and 2.6 further describe their roles and responsibilities in the overall airspace management approach to UTM and the specific operational elements that comprise the UTM construct.

2.4.1 Operator

The Operator is the person or entity responsible for the overall management of his/her UTM operations. 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 called out as a manned or UAS Operator.

2.4.2 Remote Pilot in Command/RPIC

The 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 UA is flying, avoids other aircraft, terrain and obstacles, assesses and respects airspace constraints and flight restrictions, and avoids incompatible weather/environments. The RPIC is capable of monitoring the flight performance and location of the UA. If safety of flight is compromised, due to sensor degradation or environmental vulnerabilities, the RPIC is aware of these factors and intervenes appropriately. More than one RPIC may take control of the aircraft at different, but sequential times during the flight, provided at least one person is responsible for the operation at any given time.

2.4.3 UAS Service Supplier/USS

A USS is an entity that provides services to support the safe and efficient use of airspace by providing services to the Operator in meeting UTM operational requirements. 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, and (2) provides the Operator with demand forecasts for a volume of airspace so that the Operator can ascertain the ability to efficiently conduct their 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, aircraft de-confliction, conformance monitoring, and emergency information dissemination. USSs may also work, if applicable, with local municipalities and communities to gather, incorporate, and maintain airspace restrictions and local airspace rules into airspace constraint data (e.g., preemptive airspace). USSs may also provide other value-added services to support UTM participants as market forces create opportunity to meet business needs. See Appendix D for a more detailed description of a USS.

2.4.4 USS Network

The term 'USS Network' refers to an amalgamation of shared UAS Operator data, or the mechanism by which Operators and mostly likely their supporting USSs share data or interact with one another (e.g., USS makes intent (or other) information available to all of the other USSs). In the UTM construct, multiple USSs can and will operate in the same geographical area and thus may support "overlapping" operations that require orchestration. In this environment, the USS network shares operational intent and other relevant details across the network to ensure shared situational awareness for UTM participants. Given this need for USSs to exchange a minimum set of data, the USS network must implement a shared paradigm, with methods for de-confliction or negotiation, and standards for the efficient and effective transmission of intent and changes to intent. This reduces risk to each USS 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.

2.4.5 UAS Supplemental Data Service Suppliers

USSs can access Supplemental Data Service Providers (SDSPs) via the USS network for essential or enhanced services (e.g. terrain and obstacle data, specialized weather data, surveillance, constraint information). SDSPs may also provide information directly to USSs or Operators through non-UTM network sources (e.g., public/private internet sites).

2.4.6 Flight Information Management System/FIMS

FIMS is a gateway for data exchange between UTM participants and FAA systems, through which the FAA can provide directives and make relevant NAS information available to UAS Operators via the USS Network. The FAA also uses this gateway as an access point for information on operations (as required) and is informed about any situations that could have an impact on the NAS. FIMS provides a mechanism for common situational awareness among all UTM participants and is a central component of the overall UTM ecosystem. FIMS is the UTM component the FAA will build and manage to support UTM operations.

2.4.7 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, Special Use Airspace (SUA) Special Activity Airspace (SAA) activity). 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.

2.4.8 Ancillary Stakeholders

Other stakeholders, such as public safety and the public, can also access and/or provide UTM services as an SDSP or via USSs/USS network. As a means to ensure safety of the airspace and persons and property on the ground, and ensure security and privacy of the public, public entities can access UTM operations data. This data can be routed directly to public entities such as the FAA, law enforcement, Department of Homeland Security, or other relevant government agencies on an as-needed basis. To accomplish this, a USS must be (1) discoverable to the requesting agency, (2) available and capable to comply with an issued request, and (3) a trusted source as mitigation actions may be taken as a result of the information provided.

2.5 Operations

All UAS Operators are expected to abide by the appropriate operating rules, regulations, and policies for the intended operation. With UTM, operations are supported by an environment designed to promote, through information exchanges, the analogous shared situational awareness that cooperative operations have always required. Thus, participation in UTM by aircraft Operators to the greatest extent possible is desired to achieve maximum benefit. As with classic operations, within UTM - the Operator, vehicle, and USS services are required to perform at a level sufficient to maintain separation at all times from all hazards in a fully accountable manner. The UTM operational framework ensures the safe conduct of aircraft operations through the issuance of performance authorizations that ensure operational and performance requirements are met, the sharing of flight intent and airspace constraint information among Operators, and the use of services, technologies, and equipage to de-conflict operations. Sections 2.5.1 through 2.5.6 further discuss these operational elements.

2.5.1 Participation

BVLOS UAS

Participation in UTM is *required* for BVLOS UAS operations not participating in ATM. All BVLOS Operators are required to share intent and are encouraged to provide any additional data that can be used by USSs and other Operators to safely conduct their own operations, including, for example, in-flight position information, advisory reports, and contingency plans.

Other Airspace Users

UAS VLOS Operators and manned aircraft Operators have access to information regarding the conduct of UTM operations and are encouraged to participate in UTM to the extent possible to increase the breadth of situational awareness across Operators in shared airspace. Airspace users can *voluntarily* participate, at different levels:

- *Passive participation* – Operators utilize information from the USS Network (Operation Intent of other Operators) to gain situational awareness of nearby operations and accordingly plan their activities, but do not make available any Operation Intent information to other Operators.

- *Active participation* – Operators make their Operation Intent available to the USS Network, and thereby all other Operators/RPICs participating in UTM, fostering situational awareness for other participants with active operations near their own.

VLOS UAS. UAS VLOS Operators are *not* required to participate in UTM, but may, and are encouraged to, voluntarily do so, through sharing of operation intent information, to obtain the safety benefits that are gained from shared awareness among airspace users. UAS VLOS actors also may participate in UTM by utilizing LAANC to meet their regulatory requirements (Part 101

notifications/Part 107 authorizations). These requirements may be met through other means that do not involve use of UTM services (e.g., online FAA authorization request form).

Manned Aircraft. Manned aircraft are *not* required to participate in UTM, but may, and are encouraged to, voluntarily do so as to obtain the safety benefits that are gained from shared awareness among airspace users. At minimum, manned aircraft Operators should access UTM shared intent data to gain awareness of UAS operations planned along their route of flight. More active manned aircraft participation, such as sharing of flight intent and/or sharing and receiving in-flight position information, would provide additional safety benefits for both manned and unmanned operations.

2.5.2 Performance Authorization

All BVLOS Operators are required to obtain a *Performance Authorization* from the FAA prior to conducting a UTM operation. A Performance Authorization is a FAA regulatory approval for BVLOS Operators to perform a specific type of operation in a specified geographical area. The FAA grants a Performance Authorization when a UAS Operator's proposed ground and air assets are sufficient to meet an established level of performance in the airspace in which they intend to operate.

An Authorized Area of Operation is a geographically defined area, which can be spatial and temporal, that is contained within the Performance Authorization for UTM operations. This airspace is not intended to be 'blanket coverage' nor devoid of manned aircraft operations (e.g., helicopters transiting the airspace, manned aircraft conducting agricultural operations). It is airspace where manned aircraft should anticipate a higher density of intended (and perhaps prioritized) use by UAS. The FAA would ensure, though, that certain operations, such as those conducted by Emergency Medical Services (EMS) or first responders, are given priority access to this airspace as required. Rather than develop a universal definition of this airspace, the FAA would consider the addition of commercial UAS Operators and evaluate their proposals, considering the overall effect on safety in various locations.

To obtain a Performance Authorization, an Operator, using his/her own or shared resources, submits a Performance Authorization request to FAA Regulators for evaluation. Performance Authorization requests must be submitted by the Operator, not a USS/SDSP or other entity, regardless of whether the USS/SDSP will provide services or capability/technology packages to support the Operator's ability to meet the performance requirements. USSs/SDSPs can, however, assemble, or supply material to support an Operator's Performance Authorization request.

The FAA evaluates the requests to ensure the requesting Operator can meet established performance levels for navigation, communications, sharing of intent, avoiding other vehicles, and connecting to the FAA near real time, in the airspace in which they intend to operate. If the performance level can be met, the FAA grants a Performance Authorization.

Initially it is expected that Performance Authorizations will require a case-by-case analysis, however, over time, as more are granted, USSs and/or industry may analyze submitted packages to identify specific sets of services and technology capabilities that resulted in approvals in different geographical areas. Industry may then begin to compile packages specific to those locations for Operators, streamlining Performance Authorization Requests, and possibly leading to the establishment of minimum performance standards for geographical locations over time.

2.5.3 Authentication

UAS must be registered in accordance with FAA rules and regulations prior to operating in the NAS. UTM expects an Operator's registration is valid and may audit should conditions warrant. Operators are required to certify, register, and/or obtain all appropriate authorizations and to demonstrate compliance with performance and capability requirements per regulatory policy prior to performing UTM operations. USSs are required to demonstrate the minimum set of capabilities to support UTM operations for subscribing Operators.

2.5.4 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/ATM. The operation plan is developed prior to the operation and should indicate the 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). How the operation plan is shared - full route, partial segments with another Operator - is still to be determined.

The operation plan as proposed may be impacted by other planned operations (e.g., overlapping airspace volumes) or other constraints (e.g., FAA airspace restrictions), therefore the Operator should assess all appropriate information affecting the planned operation and make amendments to his plan as applicable. The Operator gathers this information and strategically de-conflict, potentially via USS-provided capabilities designed to develop equitable solutions (e.g., Operator collaboration and de-confliction algorithms); as well as access to FIMS to gather FAA provided airspace constraints and self-provisioned preemptive airspace restrictions that could affect the proposed flight.

Once the operation plan is finalized, the Operator submits it via a USS (if not self-provisioning services[2]). USSs then share that intent with other Operators via the USS Network. Following submission, USSs continue to offer de-confliction support up to and during the intended operation.

[2] An Operator has the option to act as their own USS, if they meet all requirements for service provision (e.g. can communicate with other USSs, can send/receive information from the FAA, etc.) and have gone through applicable federal and/or industry vetting processes.

The Operator considers USS provided information and chooses to submit intent, or alters his plan in favor of better operational conditions, understanding that he is responsible for ensuring separation at the time of operation, not the USS. In the event of an airspace conflict during the intent sharing process, Operators unable to separate from other aircraft by another means (e.g., detect and avoid) are encouraged to de-conflict their operation by shifting temporal or spatial elements of their plan or negotiating solutions with Operators whose volume(s) overlap via their USS.

2.5.5 Constraint Information & Advisories

Central to UTM is a shared situational awareness based on knowledge of all available constraint and advisory information in the UTM network. Advisories, weather information, other UTM participant observations, and a variety of other information may be made available through the UTM network and should be factored into the Operator's planning and execution to ensure safe conduct of UTM operations.

UAS Operators within UTM 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 their operation. USSs may supply airspace constraint and advisory information through services to support the Operator responsibility. Near real-time advisories are provided by authoritative sources and information providers through the USS network and made available to affected users regarding:

- Traffic (e.g., aircraft unknown to the USS network, non-conforming flights), and
- 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 NOTAM or power-line construction, bird activity, local UAS restrictions, and other UAS-specific hazard information).

Although USSs are likely to be primary distributors of information, Operators are responsible for gathering these data. It is possible Operators may pull from other sources (e.g., SDSPs) or that USSs may pull data from other sources in support of the Operator. Operators may also support advisory information distribution by reporting phenomenon 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'[3], and are comparable to manned aircraft pilot reports (PIREPs).

The Operator maintains a communication with the USS, in compliance with performance authorization criteria and regulatory requirements, to support data exchange that assists with meeting requirements for the operation (e.g., real-time aircraft tracking, airspace restrictions).

[3] Rios, Smith, Smith, "UAS Reports (UREPS): Enabling Exchange of Observation Data Between UAS Operations", 2017

Advisories designating *Dynamic Restrictions* on UAS operations may also be originated by authorized entities and routed through the USS Network (where USSs use the information to notify affected subscribers) to FAA infrastructure/associated services - which may include FIMS components, cloud assets, and SWIM services based on allocation of functionality to meet the stakeholder needs. Dynamic Restrictions limit UAS access to blocks of airspace, are generally short in duration (hours, as opposed to days or weeks), are generally smaller in size than a constraint such as a TFR, and can be initiated by approved USSs with appropriate certifications/authorizations. These advisories serve to establish transient restrictions on UAS operations due to police activity, priority operations, public safety, and other conditions that warrant temporary cessation of noncritical UAS operations. Operators receiving advisories take corrective action or respond to the event accordingly and provide confirmation of their compliance with the advisory.

2.5.6 Separation

Although UTM provides traffic management services, Operators are ultimately responsible for maintaining separation from other aircraft, airspace, weather, terrain, and hazards, and avoiding unsafe conditions throughout their operations.

The Operator (RPIC if separate entity) is responsible for remaining within the bounds of his/her flight volume(s) and tracking the aircraft location during all phases of flight with performance criteria appropriate for the operation performed. The Operator monitors for vehicle non-conformance or on-board equipment failures or degradation (e.g., lost link, engine failure). The Operator likely incorporates these monitoring functions into the UAS (vehicle and ground control equipment) such that he is alerted quickly and can take necessary corrective action. 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 (in UTM and ATM environments) when an event occurs. For off-nominal situations requiring FAA attention or intervention, the USS notifies the FAA of, and sends data required to manage, the event via FIMS.

In-flight coordination with other Operators and their RPICs is the responsibility of the Operator. They may utilize services of a USS to facilitate this coordination via the USS network, but may also utilize on-board communications, navigation, and sense and avoid 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 UTM operations as well as in-flight updates ensuring separation provision. The USS shall maintain and provide near real-time and forecast weather information for the region to UAS Operators. Operators monitor weather and winds throughout flight, and act responsibly in the event of environmental or weather phenomena and factors are incompatible with safe flight for their operation/aircraft. Using their in-flight connection, Operators also monitor terrain and obstacle data

to ensure the aircraft does not collide with the ground, wires, terrain, mountains, or other obstacles. The data provider shall maintain and provide the most current terrain/obstacle database in order to develop accurate avoidance information for the subject mission.

2.6 Allocation of Responsibilities

Table 1 summarizes roles and responsibilities of the UAS Operator, USS, and FAA for the various services and functions associated with operating in a UTM environment.

Table 1. Allocation of Responsibilities for UTM Actors/Entities

Service/Function		Actors/Entities		
		✓ = Primary responsibility		
		UAS	USS	FAA
Separation	VLOS UAS from VLOS UAS	✓	S	
	VLOS UAS from BVLOS UAS	✓	S	
	BVLOS UAS from BVLOS UAS	✓	S	
	VLOS UAS from Low Altitude Manned A/C	✓	S	
	BVLOS UAS from Low Altitude Manned A/C *	✓	S	
Hazard/ Terrain Avoidance	Weather Avoidance	✓	S	
	Terrain Avoidance	✓	S	
	Obstacle Avoidance	✓	S	
Status	UTM Operations Status		✓	
	Flight Information Archive	✓	S	
	Flight Information Status	✓	S	
Advisories	Weather Information		S	
	Alert Affected Airspace Users of UAS Hazard	✓	S	
	Hazard Information (e.g., Obstacles, terrain)		S	
	UAS Specific Hazard Information (e.g., Power Lines,		S	
Planning, Intent & Authorization	Priority Status Notification (e.g., emergency	✓	S	
	Operation Plan Development	✓	S	
	Operation Intent Sharing (pre flight)	✓	S	
	Operation Intent Sharing (in flight)	✓	S	
	Operation Intent Negotiation	✓	S	
Operations Management	Demand Capacity Management		✓	
	Airspace Access Management		✓	
	Control of Flight	✓		
	Airspace Allocation & Constraints Definition		S	✓

*** Manned aircraft pilots share responsibility for separation with UAS BVLOS operations.**

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 the associated considerations for Operator, vehicle, services, operational environment, and airspace

class. UTM airspace management is predicated on a layered approach to safety through the following:

- Use of performance authorizations and certifications ensuring Operators, equipment, and USSs meet the appropriate capability and performance requirements for the operations planned,
- Strategic traffic management of operations through interactive pre-flight planning,
- Separation provision through in-flight situational awareness of UTM participant intent and airspace constraints,
- Contingency management through the development of plans and triggers for unexpected operational anomalies, and
- Collision avoidance through appropriate ground based and onboard equipage

In addition, security of the airspace is ensured through the collection, maintenance, and provision of identity information for UTM operations, vehicles, and Operators via vehicle registration, Operator logs, USS services, and appropriate vehicle identification mechanisms. Finally, equity of airspace access for UTM operations is ensured through appropriate performance authorizations and operation orchestration/Operator negotiation to optimize airspace use among the participants. UTM does provide the ability to prioritize use of airspace for operations deemed a public priority through the issuance of Dynamic Restrictions for other UTM operations in the affected airspace.

2.7.1 Safety

While the FAA/ATC does not play a direct role in the provision of separation services to UTM operations, it does establish operational and technical requirements for UTM to ensure safe operations. 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 Management*** to more real-time ***Separation Provision*** and ***Contingency Management***, to real-time ***Collision Avoidance*** capabilities.

Strategic Management

UTM operations are 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. The sharing of operation intent, airspace constraint de-confliction, and supplemental data sharing are key supporting features of UTM that reduce the need for tactical separation management and/or reduce the likelihood of in-flight intent changes due to weather or airspace restrictions.

Operators planning to operate BVLOS are required to share operation intent with other Operators/airspace users via a USS. Intent data predominantly consists of the spatial and temporal elements of an operation. At a minimum, operation intent includes operation volumes and the

associated 'active' times. Operation volumes are four-dimensional (4D) shapes with specified ceilings and floors that encompass the operation's flight profile within an authorized area of operation, as specified in the Performance Authorization. The 4-dimensional (space and time) nature of the volumes enable USSs to de-conflict operations, when possible, prior to, and during flight to maximize safety. Operation volumes can take a variety of forms (e.g. 4D discs, tubes, or complex shapes) and can be stationary or moving. A single or multiple operation volume(s) may be defined for a single operation. The actual requirements on volume shape, size, and time increments will vary based on the types and potential density of UAS operations. Operators unable to provide and maintain operations within their volumes may have restricted access during times of high density UTM operations. Operators should minimize airspace volumes when possible, whether defining a route or area of land, to allow for others to strategically de-conflict, including shifting their time of access. USSs assist with minimizing airspace volume overlap and optimize airspace efficiency and access.

Other data beyond intent 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 that is shared only between an Operator and their 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 do not need to be verified with agency records for compliance at the time of submission (e.g., compliance with Performance Authorization stipulations - Area of Authorization, pilot certifications, use of specified equipment /technologies) but Operator accounts and records are subject to FAA auditing at the agency's discretion.

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 volumes (i.e., strategic separation), (3) enables identification and distribution of known airspace constraints/restrictions for the intended area of operation, (4) enables distribution of weather and supplemental data that affects operations for the intended location and time, and (5) supports cooperative separation management services (e.g., conformance monitoring, notifications/alerts).

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) Operators) not participating in UTM, but operating near or below 400'AGL, are encouraged to, at minimum, identify operations that could impact their route of flight as part of their preflight responsibilities.

Real-time NAS airspace constraint data is available to the USS Network via FIMS to separate proposed operation volumes from flight restrictions, SAA/SUA activity, or other airspace management decisions

that affect UTM operations. The USS makes Operators aware of any NAS constraints or preemptive airspace restrictions that could affect the proposed flight, including:

- NAS Airspace Constraints: The USS accesses the FAA's NAS real-time airspace constraint data, made available via FIMS, to identify whether there are any NAS constraints or restrictions on the airspace at the flight times requested. Known constraints are made available to the Operator who has the option to alter their flight intent to ensure de-confliction of airspace constraints.

- Preemptive Airspace: Many states have passed laws that regulate or prohibit the flight, weaponization, and surveillance use of UAS in select airspace to preserve the rights of its citizens. The USS works with states, municipalities, and other entities as required ensuring local airspace access restrictions, or preemptions, are incorporated into, and maintained in, the USS Network and Operation Volumes are de-conflicted from these areas during the intent sharing processes.

Intent sharing also enables weather forecasting and supplemental data sharing that assists the Operator with determining whether environmental conditions or other factors are suitable for flight in their intended location at the specific date and time being submitted (e.g., weather and wind prediction, planned obstacles). These 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.

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/restrictions, 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.

Strategic management services alone may be sufficient to ensure the safety of UAS operations of low complexity. For example, a BVLOS Operator conducting a flight in a rural/remote area (where UTM and other UAS /manned activity at low altitudes is relatively 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 established to ensure strategic separation.

Separation Provision

UTM services/capabilities support a range of BVLOS UAS operations in authorized areas of operation from rural areas with minimal manned aircraft activity and no people or property on the ground, to vicinities with manned aircraft over moderately populated areas in suburban areas or close to airports. The corresponding requirements for separation provision - in terms of data exchange,

tracking and conformance monitoring, technologies/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 or heterogeneous traffic may be required to equip with sense and avoid 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 services to gain situational awareness of nearby UTM operations; low-altitude manned aircraft pilots share responsibility with BVLOS UAS Operators for maintaining separation from each other (though they do not share responsibility for separation from VLOS UAS Operators). Manned aircraft should be able to see and avoid UAS - which could require UAS comply with cospicuity 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. UAS Operators share separation responsibility with other UAS Operators (BVLOS and VLOS), manned, and other airborne traffic. Commercial services, or third-party providers, assist Operators in meeting responsibilities. For operations in areas with minimal air traffic, alerts regarding known or uncooperative traffic may assist Operators with maintaining separation. The Operator maintains a continuous connection with the USS to support data exchange pertaining aircraft tracking and monitoring, terrain and obstacle clearance data, weather constraints and/or notifications or directives regarding airspace constraints, traffic, or other hazards that could affect the flight. In the case of a notification or alert, the RPIC responsible for the overall safety of the flight acts accordingly.

When UAS operate over people or in areas where manned aircraft are more prevalent, Operators are capable of identifying and 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, V2V equipment, ground-based radar detection data, ADS-B in or out, sense and avoid 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, manned traffic alerts), 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 ATM. 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 participate in

UTM, they are encouraged to utilize UTM services to, at minimum, 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 unmanned aircraft's (UA's) position and conformance to applicable system-based boundaries during BVLOS portions of flight.

For BVLOS operations in uncontrolled, Class G airspace – UAS Operators are not required to notify the FAA prior to or during flights unless they experience an off-nominal event or contingency situation that requires FAA attention and/or intervention (e.g., rogue UAS – threat of entering controlled airspace). 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. In the event that an off-nominal situation requires FAA attention or intervention, the USS notifies the FAA of the event via FIMS.

To ensure pre-emption of airspace when appropriate, authorized USSs are able to designate a Dynamic Restriction for an area/block of airspace, where all UTM/UAS operations must cease (e.g., to allow EMS or first responder access). Dynamic Restrictions can be requested by authorized entities (e.g., law enforcement, fire department) and approved/distributed by these authorized USSs. If approved, an automatic notification is sent to the USS Network so that affected UTM participants can be identified and informed of the constraint; additionally, a notification is sent to the FAA through FIMS so that other relevant NAS stakeholders may have access to information. Operators are responsible for remaining outside the restricted area (unless waived), until it is released. Vehicles following a pre-programmed route and/or with automated vehicle responses that would violate an airspace restriction (e.g., programmed lost link contingency response) must possess some method of intervention capable of preventing intrusion in restricted airspace (e.g., re-program route in flight, manual intervention). USSs provide Operators real-time notifications regarding the restriction and accommodate real-time adjustments to operation intent.

Operators assemble weather and wind data, terrain and obstacle information, traffic alert data, and other supplemental service-provided data pertinent to flight to assist them in meeting their responsibilities for safe flight. 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 subscribers.

Operators are responsible for ensuring actual or reserved endurance and/or fuel levels are 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).

Contingency Management

Operators provide real-time management of their operations and are actively engaged in keeping information updated during their operations to ensure shared situational information among UTM participants. This includes making others aware of mission changes due to Operator prerogative as well as unexpected operational factors that impact the operation. The Operator needs to have continuous interaction with the UTM community to ensure continuity and safe orchestration of operations.

In the event of contingency, the Operator is responsible for notifying the network of a change in status which allows affected airspace users to be alerted. A USS can support/assist the Operator in meeting this obligation through communications with affected UAS Operators, appropriate FAA entities, and other airspace users as appropriate, via the USS network. In the event an active flight is experiencing a critical on-board equipment failure or degradation (e.g., lost link, engine failure); not tracking or vehicle position is unknown for some period of time; not conforming to flight intent and/or conformance is not expected to be restored - the Operator notifies their USS of the contingency event as soon as practical. 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 share data regarding potential hazards with impacted airspace users across the USS network. Impacted parties enact necessary measures to respond to the threat.

The USS also notifies potentially impacted non-UTM users of off-nominal or potentially hazardous situations (e.g., potentially affected public/private entities), providing all known data to assist with managing the situation effectively (e.g., tracking information, pre-programmed contingency procedure, RPIC contact information). Non–UTM users could include public/private/commercial entities (e.g., balloon Operators, the Department of Defense, non-towered airport) and in the event the ATM system could be impacted, the FAA.

UAS Operators within UTM are required to notify the FAA if they experience an off-nominal event or contingency situation that requires FAA attention and/or intervention (e.g., rogue UAS – threat of entering controlled airspace). If an off-nominal situation requires FAA intervention, the FAA has on-demand access to information regarding UTM operations. The FAA FIMS gateway provides a continuous connection through which the USS Network can provide UTM operations data, including flight status, aircraft location (if known), and intent information until the event is contained. USSs send notification of errant flights, along with required data, to FIMS for routing to the appropriate ATC facilities/entities.

Once a contingency event is contained and safety is restored, the USS provides notice of recovery to affected entities, including the USS Network, for distribution to airspace users. The USS Network

notifies the FAA via FIMS, providing data required to restore nominal operations and comply with FAA facility/agency reporting requirements and procedures. FIMS routes the data according to established protocol.

Collision Avoidance

In the UTM environment, BVLOS UAS share responsibility with other BVLOS UAS and manned aircraft for collision avoidance. Because the risks associated with different areas of operation can vary, the requirements for onboard collision avoidance systems for UAS may vary. In airspace where risk to life in the air and on the ground is low, a relatively higher risk of sUAS-to-sUAS collision may be accepted, and thus the FAA may not need to require collision avoidance technologies. Conversely, operations in more heterogeneous (e.g., mix of manned and unmanned aircraft, controlled airspace) environments 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).

It is likely that geographical area, proposed airborne and ground assets, and other criteria will be taken into consideration during the Performance Authorization process, and collision avoidance requirements will be tailored to each operational situation. It is expected that V2V communication between both UAS and manned aircraft will include position of craft and Operator to ensure collision avoidance at intervals appropriate to the craft and operation per the Performance Authorization and appropriate regulatory requirements.

2.7.2 Security

In addition to ensuring safety, security is a priority of UTM, and expectation of the public. Security refers to the protection against threats that stem from intentional acts (e.g., terrorism, or unintentional acts, such as human error or natural disasters affecting aircraft, people, and/or property in the air or on the ground). UTM should therefore contribute to security, and UTM-related information should be protected from external and internal security threats. Security risk management goals include balancing the needs of the members of the UTM community that require access to the airspace with the need to protect UTM participants, the public, and property. In the event of threats to aircraft or threats using aircraft, UTM provides relevant information and assistance to responsible authorities.

UTM goals include ensuring safety, security, and accountability of UAS operations, including the sharing of identification information regarding the operation plans and execution data, Operator, vehicle, and supporting services. Identification data (ID) and appropriate metadata (e.g., Operator and position of aircraft during an operation) are managed and provided based on the need to know and credentials of the entity. The public may access identification information through USS services or broadcast ID if that is required. Law enforcement and other authorized entities may access information such as UAS identification, Operator information, UAS position reported throughout the

operation, V2V broadcast Operator and position data, and other data perhaps protected in short and long-range communication links.

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

NAS Operations

From an FAA *regulatory and safety perspective*, UTM intent data/operation plans provide 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. With UTM, USSs archive data per FAA requirements and ensure that data is available to the FAA as needed to support those objectives. Archived data also provides the FAA a means to analyze UTM operations-and ensure NAS needs and safety objectives are being met.

The FAA has the ability to access stored or archived information related to the UTM operations as required, including information filed with the USSs in the Operation Intents on demand if the situation warrants. USS operations data is available on demand through FIMS, and in Operator/USS data repositories, for FAA access upon request. FAA may require operational data to be logged / archived by Operators in order to support the FAA and other federal entities requesting Operator logs and associated operational information (e.g., safety, security, or post-hoc analysis of events of interest).

NAS Systems

UTM introduces new security vulnerabilities and challenges due to UAS reliance on interconnectivity and integration. These vulnerabilities include the potential for increased threats to system security and unintended degradation of system performance. Third party commercial entities share data with FAA systems in order to enable the UTM system, creating a need for third party networks to link to government assets providing potential opportunities for cyber incidents and attacks. Creation of cybersecurity architectures requirements and structures are developed and in place to mitigate potential for malicious activities and prevent unlawful access to FAA systems.

Distributed UAS architectures can be manipulated in ways that can impact the safety and security of people on the ground and in the air. Command and control link infrastructure, security of ground control stations, GPS signal vulnerabilities, among other things, create potential for misuse (intentional and unintentional) and malicious interference (e.g., hacking, hostile takeovers) of UAS technologies. UAS accessibility, flexibility, and payload potential also give rise public privacy and safety concerns (e.g., ability to surveil citizens in situations where they could otherwise reasonably expect privacy). 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). When unlawful activity is detected, response protocols are enabled through UTM data transmission capabilities (e.g., via USS Network access to public entities). A communication, navigation, and surveillance tracking technology, coupled with the information service of legally operating commercial UAS, supports identification of illegal operations. These same capabilities, and others, may be used by law enforcement to track vehicle registration data and identify geographical positioning of perpetrator(s).

2.7.3 Equity

UTM provides an operating environment that ensures all 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. The FAA ensures that within the cooperative rules and processes for the shared UTM enterprise, there is no assumption of priority that would diminish equity of access for users that have received a Performance Authorization to operate in the airspace. In airspace with moderate airspace demand, equitable access is achieved through Operator collaboration, efficient airspace design, and FAA rules. 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 provide demand management of access, but only for that purpose.

Airspace Access

When UTM demand/capacity imbalances arise, and Operators have already planned and shared their intent with the network, USSs assist with resolving/minimizing the issues via alteration of spatial or temporal elements of the operation intent and/or Operator collaboration/negotiation. Operators adjust plans to de-conflict overlapping airspace according to personal preferences or with USS tools. USSs collaborative flight planning capabilities (e.g., route planning functions, airspace configuration options) offer equitable solutions to competing Operators or Operators negotiate with one another via USS collaborative tools (e.g., real-time Operator exchanges) to identify acceptable alternate plans that minimize volume overlap. FAA right of way rules are imposed when collaborative de-confliction cannot successfully resolve demand issues. Operators and USSs consider airspace volume efficiency during the intent sharing process to optimize UTM-wide airspace capacity. Operators and USSs also facilitate prompt release of unused airspace (e.g., notify USS network airspace is released when a flight ends earlier than projected). In the event that demand for UTM airspace makes safety or equity no longer achievable through Operator coordination and USS-assisted operation orchestration, the FAA may issue directives/protocols limiting access to UTM airspace to resolve capacity/demand issues.

Priority Flights

Priority access demands ensure preemption of airspace when appropriate. The FAA is able to identify an area where all UAS operations must cease to ensure that certain operations, such as EMS or first-responders, can be given priority access to this airspace when necessary. Temporary flight

restrictions (e.g., Dynamic Restriction) are enacted to clear all unwaived flights from the restricted airspace.

3 UTM Use Cases

This section contains a set of use cases that illustrate operations in predominantly uncontrolled airspace and interactions within the UTM environment. They are a subset of the total inventory developed under the auspices of the UTM RTT. For a full list of use cases developed in support of V1.0, see Appendix E.

The use cases presented here focus on different aspects of unmanned operations: multiple actors work together to foster shared situational awareness between Operators/RPICs, creation and dissemination of airspace constraints that affect UAS Operators and interactions with manned aircraft. Table 2 shows a high-level summary of each use case.

Table 2. Use Case Summary

Use Case	Title	Summary
1	BVLOS Operations in Uncontrolled Airspace: *Mandatory* UTM Participation	BVLOS Operators (not Part 101e or 107 applicable regulations in development) flying in uncontrolled airspace participate in UTM by sharing operation intent, thereby gaining shared situational awareness.
	Dynamic Restriction in Uncontrolled Airspace	An authorized USS approves a request for and creates/distributes a Dynamic Restriction affecting UAS operations in uncontrolled airspace. UTM participants receive alerts when in or near the restriction via the USS to which they are subscribed. VLOS UAS Operators and other NAS stakeholders not participating in UTM gain knowledge of the restriction through other channels.
3	BVLOS UAS and Manned Aircraft Interactions in Uncontrolled Airspace	Multiple scenarios explore methods by which UAS and manned aircraft gain situational awareness of each other - including information-sharing via the USS Network, cooperative V2V communications, and SAA technologies.
4	VLOS Operations in Uncontrolled and Controlled Airspace: *Voluntary* UTM Participation	Part 101e and/or Part 107 VLOS Operators flying in uncontrolled and controlled airspace (not near an airport) voluntarily participate in UTM, thereby gaining shared situational awareness.

3.1 BVLOS Operations in Class G (Uncontrolled) Airspace: *Mandatory UTM Participation*

This use case assumes that BVLOS operations occur in uncontrolled airspace, are not near an airport, and are limited to flight under 400 feet AGL. BVLOS Operators are required to *actively* participate in UTM, in which they make their Operation Intent available to the USS Network (and thereby all other

Operators/RPICs participating in UTM), fostering situational awareness for other participants with active operations near their own.

The Operator must have a Performance Authorization from the FAA, which grants an Authorized Area of Operations (geographic location in which the Operator is allowed to perform types of operations that fall under the constraints of the authorization). In uncontrolled airspace, authorization for individual operations is not required; as many operations as desired can be performed while the Performance Authorization is valid (i.e., before it expires).

BVLOS RPICs are required to have any applicable airmen's certificate when conducting BVLOS flights.

Planning

The Operator submits his operation intent for a flight he wishes to conduct, using tools provided by the USS to which he is subscribed. The Operator receives information from his USS on known UTM operations that need to be considered during planning of his own; this information is shared by other Operators subscribed to his USS, as well as by Operators subscribed to different USSs (via the USS Network), who will be conducting operations in the same area during similar times.

Upon completion of developing his operation intent, the USS, the USS sets the operation status (part of the operation intent) to "Accepted" and makes the operation intent available to the USS Network. Other USSs are now aware of this new operation; they provide notice/alerts to other Operators and RPICs who may need to know of it.

Flight

The UAS is prepared for take-off, and the immediate airspace is evaluated for safe launch. With preparations complete, the RPIC notifies his USS he is about to take off; the USS sets the Operation Status to "Activated" and makes the update available to the USS Network (alerting other Operators of the newly-active operation near them).

The RPIC receives an acknowledgement of activation from the USS and takes off. The operation volume(s) is/are considered active per scheduled times (provided in the operation intent).

The RPIC may be required to share position data from his UAS with his USS, allowing the USS to provide conformance-monitoring services. The RPIC flies in accordance with his operation intent, maintaining separation from other UAS and manned aircraft.

NOTE: *Should the UAS be in a state incongruent with his shared operation intent, the Operation Status may be changed to either "Non-Conforming" or "Rogue" by the USS and shared with the USS Network; in the event the non-conforming situation could affect manned operations, the USS may alert the FAA through FIMS.*

Landing

The RPIC returns his UAS to the landing area; he then alerts his USS of the landing and the completion of the operation. The USS sets the Operation Status to "Closed" and makes the updated operation intent available to the USS Network.

3.2 USS Approval/Distribution of a Dynamic Restriction

This use case examines an authorized entity sending a Dynamic Restriction Request to a USS. The approved restriction limits access of UAS to a block of airspace due to a low-altitude manned aircraft that is operating in the airspace to support emergency response personnel on the ground. It is assumed that the entity requesting the constraint has been approved, authorized, or has some level of authority to make the request. This use case assumes the USS handling the request has the ability to approve a request, create a Dynamic Restriction, distribute it to the USS Network, and notify the FAA.

The scenario is set in a rural area, around and near an interstate highway; the airspace above this area is uncontrolled. A medical emergency occurs at an accident location on an interstate in this rural area. Emergency responders on the ground have requested a MedEvac for one of the victims of the accident. The MedEvac company knows that UAS operations occur in the area to support farms and other needs; due to the hazard sUAS can present a to manned aircraft operations and people and property on the ground, the company prefers the airspace around the landing site be sanitized of UAS operations while the helicopter is flying at low-altitudes.

The MedEvac company subscribes to a USS that is authorized by the FAA to create and distribute Dynamic Restrictions. The company sends a Dynamic Restriction Request to the USS. Included in the request is the defined airspace volume requested for restriction, the duration of the restriction, and any aircraft that should be waived from the restriction (e.g., aircraft supporting the operation).

The USS utilizes business rules that conform to the FAA regulatory framework regarding Dynamic Restrictions when evaluating the request. USS automated processes determine if the request is approved, or if it needs further review by USS personnel. In this case, the request conforms to applicable business rules, and it is automatically approved.

The USS, using services, automated business rule execution, and pre-defined scenario templates, automatically generates a Dynamic Restriction that adheres to the constraints of the request, activates the restriction, and sends it to the USS Network. The USS also sends details on the restriction to the FAA via FIMS; the FAA may also automatically distribute this information through other channels, such as an FAA Public Portal or to applicable ATM stakeholders. All USSs are now aware of the restriction; automatic processes within each USS identify any potentially affected subscriber UAS operations (VLOS or BVLOS) by checking against known operation intent - those affected receive notification of the restriction from their respective USSs. Once notified, affected Operators/RPICs take necessary actions to vacate the airspace and, if necessary, update their

operation intent to account for needed changes due to the restriction (e.g., intent, contingency responses that would violate the restricted airspace). The start time for the active state of the restriction accounts for time to allow UAS currently within the affected airspace to evacuate or land in a safe manner. The helicopter enters the airspace after the restriction becomes active with the knowledge that UTM participants are aware of the requirement to vacate the airspace.

The helicopter eventually enters the restricted airspace and lands, retrieves the accident victim, and proceeds to a nearby hospital. The helicopter completed its mission earlier than expected, and the USS updates the restriction time to end earlier than the originally defined time. The update is dispersed as noted above, and is no longer active once the new end time is reached. Normal UTM operations in the area recommence.

3.3 BVLOS UAS and Manned Aircraft Interactions in Class G (Uncontrolled) Airspace

This use case is subdivided into scenarios; each of which examines a different way in which UTM-participating UAS and manned aircraft can interact in low-altitude, uncontrolled, shared airspace. The scenarios assume that BVLOS UAS provide ID and position information. Manned aircraft act in accordance with existing rules of the road, procedures, and regulations.

3.3.1 Scenario 1 – UAS On-Board Sense/Detect

In this scenario, a UAS utilizes on-board equipment to scan the environment around it continuously for potential airborne objects. When an object is identified, the UAS on-board systems relay the information to the UAS Ground Control System (GCS), which communicates the potential conflict to the RPIC. 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 upon detection of a manned aircraft, without the input of the RPIC from the GCS.

3.3.2 Scenario 2 – Ground-Based Sense/Detect

In this scenario, an entity employs ground-based equipment to either identify airborne objects via sensors (radar, for example), or by receiving signals transmitted by an aircraft (ADS-B, for example). While it is possible individual Operators could set up such equipment, the need for equipment over a large area to support BVLOS operations indicates this role would likely be fulfilled by a third party, such as a USS or a SDSP; in this scenario, we assume the latter. We also assume that USSs subscribe to information services provided by the SDSP.

The SDSP ground system identifies an airborne object/aircraft; subscribing USSs have access to this information, and use it to identify any active or planned subscribers that may need to know about the object/aircraft. Messages/alerts are provided to affected Operators and/or RPICs, who take appropriate actions to maintain a safe operation.

3.3.3 Scenario 3 – UAS and Manned On-Board Cooperative Equipment

In this scenario, an Operator has installed equipment onto the UAS that can interact with on-board equipment of manned aircraft (e.g., ADS-B). The equipment may transmit/receive information, or may just receive information (receiver-only equipment is assumed more lightweight).

While in flight, the UAS obtains information about equipped aircraft in the area; this information is relayed to the RPIC via their associated GCS. The RPIC takes appropriate actions, if required, to stay clear of the manned aircraft. If the UAS is capable of transmitting information, the manned aircraft's equipment relays known information about the UAS to the pilot, who would also act in accordance with prescribed rules of the road/procedures to keep clear.

3.3.4 Scenario 4 – Manned Aircraft *Voluntary Passive* UTM Participation

In this scenario, manned aircraft Operators that fly at low-altitudes are aware that UTM operations occur in their area. They voluntarily subscribe to information services provided by a USS or an SDSP; both of which have access to the shared UTM operation intent data for the area in which they operate. The manned aircraft PIC uses the information about local UTM operations, either during pre-flight or in-flight, to gain situational awareness of UAS operating near him. The PIC is not assumed to provide any flight information to the USS. By using information about UTM operations, the PIC is considered to be *passively* participating in UTM.

NOTE: *VLOS UAS Operators could passively participate in UTM in the same manner as described above for manned aircraft PICs. The Operator would use information available to the USS Network to get situational awareness of other UAS operations in the area but would not provide his/her own intent information to the network.*

3.3.5 Scenario 5 – Manned Aircraft *Voluntary Active* UTM Participation

In this scenario, manned aircraft Operators that fly at low-altitudes (e.g., crop-dusters) are aware that UTM operations occur in their area. Manned aircraft Operators that do not have on-board equipment that either broadcasts information or works cooperatively with UAS equipment may opt to actively participate in UTM by providing their own Operation Intent to the USS Network. Doing so allows UTM participants nearby to be aware of the manned aircraft's intent, and to understand the equipment limitations of the aircraft regarding coordination with UAS. Creation of intent and sharing with the USS Network is assumed to be strategic in nature and is done during the planning phase, and mirrors that of BVLOS UAS Operators as detailed in the first scenario (see §3.1).

3.4 VLOS Operations in Controlled Airspace (Class B/C/D/E): *Voluntary* UTM Participation

This use case assumes that a Part 107 operation is conducted without a waiver and is done so within the boundaries of controlled airspace for a towered airport. The VLOS Operator is required to obtain

authorization from ATC for the operation. The Operator can be a separate entity from the RPIC or can be one entity that fulfills both roles.

Planning and Authorization

The Operator elects to *actively* participate in UTM and develops the operation intent for a flight he wishes to conduct using tools provided by the USS to which he is subscribed. The Operator receives information from his USS on known UTM operations that need to be considered during planning of his own; this information is shared by other Operators subscribed to his USS, as well as by Operators subscribed to different USSs (via the USS Network), who will be conducting operations in the same area during similar times.

During planning, the Operator indicates to the USS that he is conducting a Part 107 VLOS UAS operation. The USS determines that based on the type (Part 107) and location (controlled airspace) of the operation, ATC authorization is required. The USS asks the Operator if he would like to apply for automatic ATC authorization using LAANC services; the Operator responds in the affirmative. The USS is provided UAS Facility Map (UASFM) information for the applicable airspace by the FAA via LAANC systems and checks the submitted intent information (i.e. operation volume boundaries) against the ceilings and lateral boundaries for the UASFM. The USS determines that the Operator's volumes lie entirely within the bounds and under the ceilings for the UASFM, and therefore the operation qualifies to be automatically authorized by ATC. The USS sends an automatic authorization record to the Operator. A copy of the record is also forwarded to ATC via LAANC systems; ATC may utilize information from this record for traffic management purposes.

With operation intent development complete and a Part 107 authorization obtained, the USS, knowing that the operation is VLOS, asks the Operator if he wishes to make the operation intent available to UTM, through the USS Network. As the Operator is actively participating in UTM, he affirms. The USS sets the operation status (part of the operation intent) to “Accepted” and makes the operation intent available to the USS Network. Other USSs are now aware of this new operation; they provide notice/alerts to other Operators and RPICs who may need to know of it.

Flight

The UAS is prepared for take-off, and the immediate airspace is evaluated for safe launch. With preparations complete, the RPIC notifies his USS he is about to take off; the USS sets the Operation Status to “Activated” and makes the update available to the USS Network (allowing other Operators to know of the newly active operation near them).

The RPIC receives an acknowledgement of activation from the USS and takes off. The operation volume (single operation volumes only, given it is a VLOS flight) is considered active per its scheduled times (provided in the operation intent).

The RPIC may elect to share position data from his UAS with his USS, allowing the USS to provide conformance-monitoring services. The RPIC flies in accordance with his operation intent, maintaining separation from other UAS and manned aircraft.

NOTE: *Should the UAS be in a state incongruent with his shared operation intent, the operation status may be changed to either "Non-Conforming" or "Rogue" by the USS, and shared with the USS Network; in the event the non-conforming situation could affect manned operations, the USS may alert the FAA through FIMS.*

Landing

The RPIC returns his UAS to the landing area; he then alerts his USS of the landing, and that he is done with the operation. The USS sets the Operation Status to "Closed" and makes the updated Operation Intent available to the 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. 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: 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 UAS operations. It is anticipated that requirements on airspace users to perform operations will increase commensurately with the complexity of the operations and the environment within which these operations are performed. UTM is expected to continue to mature and encompass increasingly complex operation in heavily populated environments and more heavily utilized and regulated airspace. It is expected UTM will place increasingly demanding requirements for performance and capability on all entities in these situations.

The goal for initial UTM implementation is to minimize deployment and development time by utilizing current 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 environment, 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
ADS-B	Automatic Dependent Surveillance - Broadcast
AGL	Above Ground Level
API	Application Program Interface
ATC	Air Traffic Control
ATM	Air Traffic Management
BVLOS	Beyond Visual Line of Sight
C2	Command and Control
CNS	Communications, Navigation, and Surveillance
ConOps	Concept of Operations
DAA	Detect and Avoid
EMS	Emergency Management Service
FAA	Federal Aviation Administration
FIMS	Flight Information Management System
GCS	Ground Control Station
ID	Identification
LAANC	Low Altitude Authorization and Notification Capability
NAS	National Airspace System
NASA	National Aeronautics and Space Administration
PIREP	Pilot Report
RPIC	Remote Pilot in Command
RTT	Research Transition Team
SAA	Sense and Avoid
SAA	Special Activity Airspace
SDSP	Supplementary Data Service Provider
SUA	Special Use Airspace
sUAS	Small Unmanned Aircraft System
TCL	Technical Capability Level
UA	Unmanned Aircraft
UAS	Unmanned Aircraft System
UREP	Unmanned Aircraft Report
USS	Unmanned Aircraft System Service Supplier
UTM	Unmanned Aircraft System Traffic Management
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 on the 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 currently 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 (SAA); 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 UTM RTT WGs are developing products in alignment with NASA's spiral development and evaluation schedule of Technical Capability Levels (TCL), 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.

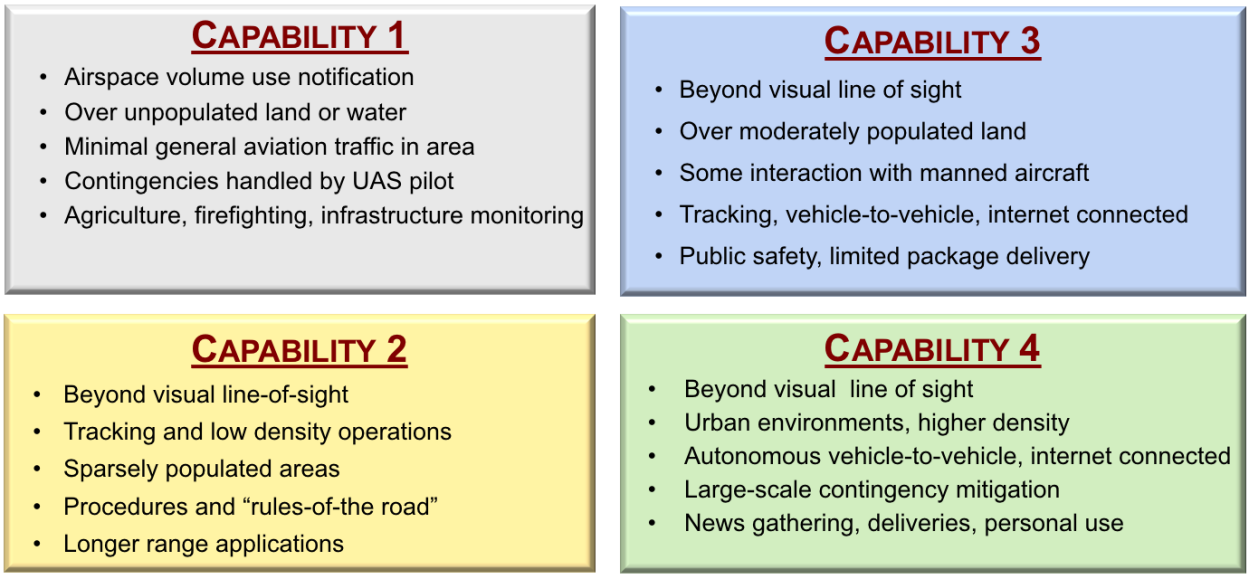

Figure A-1. NASA UTM Technical Capability Levels

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/SAA, and other detailed technical documentation regarding operator-to-operator interaction and operator-to-Air Navigation Service Provider (ANSP) interactions - ***to the FAA and Industry***, and

- A Flight Information Management System (FIMS) prototype (software prototype, application protocol interface description, algorithms, functional requirements) - ***to the FAA***.

Appendix B - NAS Airspace Classification Descriptions[4]

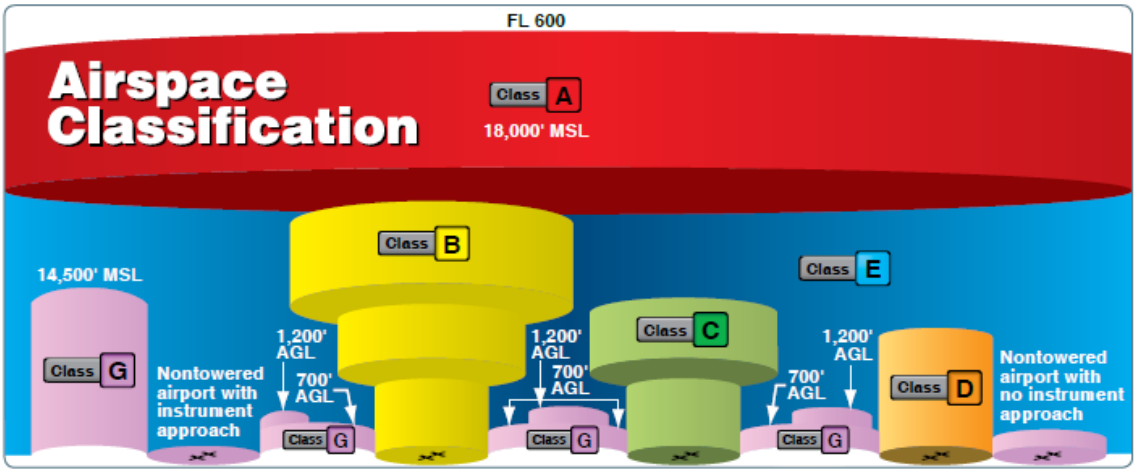

Figure B-1. NAS Airspace Classifications

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 Airspace[5]

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.

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[4] Federal Aviation Administration, *Pilot Handbook*, Chapter 15 – Airspace, Pg. 15-2 and 15-3

[5] Class A airspace is not within the scope of sUAS 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 - UTM Services

Messaging Service	A service which provides on demand, periodic, or event driven information on UAS operations (e.g. position reports, intent information, and status information) occurring within the subscribed airspace volume and time. Additional filtering may be performed as part of the service.
Discovery Service	A service which allows for service suppliers and UAS Operators to be aware of other service suppliers providing specific services of varying levels of capability in a specific geographical region.
Registration Service	A service which provides the ability for vehicle owners to register data related to their UAS and a query function to allow appropriate stakeholder to request registration data.
Airspace Authorization Service	A service which provides airspace authorization from the Airspace Authority/Air Navigation Service Provider to a UAS Operator.
Restriction Management Service	A service which manages and pushes operational restrictions from the Airspace Authority/ANSP to effected UAS operations.
Communication Services	
Command and Control Service	A service which provides infrastructure and quality of service assurance for radio frequency (RF) Command and Control (C2) capabilities to UAS Operators.
Separation Services	
Strategic De-Confliction Service	A service which arranges, negotiates, and prioritizes intended operational volumes/trajectories of UAS operations with the intention of minimizing the likelihood of planned airborne conflicts between operations.
Conformance Monitoring Service	A service which provides real-time alerting of non-conformance to intended operational volume/trajectory to an Operator or another airspace user.
Conflict Advisory and Alert Service	A service which provides real-time monitoring and alerting through suggestive or directive information of UA proximity for other airspace users.
Dynamic Reroute Service	A real-time service which provides modifications to intended operational 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 operational volumes/trajectories of UAS operations while the UAS is aloft.
Weather Services	A service which provides forecast and/or real-time weather information to support operational decisions of individual Operators and/or services.
Flight Planning Service	A service which, prior to flight, arranges and optimizes intended operational volumes/trajectories for safety, dynamic airspace flight rules, airspace restrictions, and mission needs.
Mapping Services	A service which provides terrain and/or obstacle data appropriate and necessary to meet the safety and mission needs of individual UAS operation or support the needs of separation or flight planning service.

Appendix D - UAS Service Supplier[6]

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 the Operator 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 and situational awareness 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) other data critical to safety of flight. This data supports numerous services, including strategic de-confliction, notifications of priority services (temporary flight restrictions), inflight de-confliction/sense and avoid functions, hazard avoidance, and terrain and obstacle clearance, 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, Department of Defense) 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.

[6] Rios, J. "UAS Service Supplier", NASA White Paper, December 2017.

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, Department of Defense) 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 they are meeting ensure 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.

Appendix E – Use Case Inventory: Version 1.0

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 V1.0. The CWG will continue to develop use cases that represent increasingly complex UTM environments. They will be documented in subsequent ConOps versions.

Table E-1. V1.0 Use Case Inventory

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**	• 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**	• 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.
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 environment. • Strategic vs Tactical Deconfliction/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	**UTM Priority Considerations in Uncontrolled Airspace**	• Emergency UAS scenarios; control available and marginal control scenarios • Emergency declaration to USS Network and in-air to nearby UAS • Priority consideration given to UAS in distress
TCL3-8	**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