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

Office of the Administrator

800 Independence Ave., S.W.
Washington, DC 20591

July 31, 2023

The Honorable Maria Cantwell
Chair, Committee on
Commerce, Science, and Transportation
United States Senate
Washington, DC 20510

Dear Chair Cantwell:

The Federal Aviation Administration (FAA) submits the attached Unmanned Aircraft Systems Traffic Management (UTM) Implementation Plan in accordance with Section 376(i) of the FAA Reauthorization Act of 2018 (Pub. L. No. 115-254).

Section 376(i) requires that, 1 year after the date of conclusion of the UTM pilot program, the FAA complete, submit to Congress, and publish on the FAA website, a UTM Implementation Plan.

A similar letter has been sent to the Ranking Member of the Senate Committee on Commerce, Science and Transportation, and the Chairman and Ranking Member of the House Committee on Transportation and Infrastructure.

Sincerely,

Polly Trottenberg
Acting Administrator

Enclosure

U.S. Department
of Transportation
Federal Aviation
Administration

Office of the Administrator

800 Independence Ave., S.W.
Washington, DC 20591

July 31, 2023

The Honorable Ted Cruz
Ranking Member, Committee on
Commerce, Science, and Transportation
United States Senate
Washington, DC 20510

Dear Ranking Member Cruz:

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800 Independence Ave., S.W.
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July 31, 2023

The Honorable Sam Graves
Chairman, Committee on
Transportation and Infrastructure
U.S. House of Representatives
Washington, DC 20515

Dear Chairman Graves:

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800 Independence Ave., S.W.
Washington, DC 20591

July 31, 2023

The Honorable Rick Larsen
Ranking Member, Committee on
Transportation and Infrastructure
U.S. House of Representatives
Washington, DC 20515

Dear Ranking Member Larsen:

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Enclosure

FAA Aviation Safety

Unmanned Aircraft Systems (UAS) Traffic Management (UTM) Implementation Plan

Version 1.8

FAA Reauthorization Act of 2018 (Pub. L. No. 115-254) – Section 376

Version History

Date	Revision	Version
3/13/2020	Initial Draft	0.1
9/14/2020	Revised Outline	0.2
9/28/2020	Draft for Review	0.3
11/16/2020	Revised following executive guidance	0.4
2/12/2021	Workshop revisions to service approval concepts	0.5
7/6/2021	Editorial review. Provided for staff coordination.	0.6
7/28/2021	Adjudicated staff coordination comments. Updated gender-neutral language (e.g., “uncrewed”). New Sections 3.1, 3.1.1 on Congressional requirements. Provided for ESG Review.	0.7
8/13/2021	Updates throughout Sections 7 and 9.	0.8
8/17/2021	Technical edit	0.9
8/18/2021	Provided for coordination	1.0
3/18/2022	Reorganized and condensed	1.1
4/5/2022	Provided for informal staff coordination	1.1.1
8/20/2022	Revised by cross-LOB workgroup	(1.2)
9/12/2022	Revised by AGC	1.3, 1.4
11/10/2022	Revised by AUS	1.5
12/2/2022	Adjudicates AGC comments from EDMS	1.6
12/8/2022	Incorporates ATO and APO redlines	1.7
12/15/2022	Incorporates final AGC and ATO redline cleanups	1.8

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Executive Summary

Section 376 of the *FAA Reauthorization Act of 2018*, Public Law No. 115-254 ("Sec. 376" throughout this document), requires the Federal Aviation Administration (FAA) to develop and submit to Congress "a plan to allow for the implementation of unmanned aircraft systems traffic management (UTM) services that expand operations beyond visual line of sight, have full operational capability, and ensure the safety and security of all aircraft" [1].The FAA submits this unmanned aircraft systems (also known as drones) UTM Implementation Plan in response to that Congressional mandate. This Plan addresses FAA's efforts to make UTM a reality, specifically its near-term and long-term plans, and the gaps in policy that must be resolved to have "full operational capability."

Drone operators have found it difficult to operate beyond visual line of sight (BVLOS) because the required mitigations to ensure safety of flight are often too technically difficult and expensive for each operator to achieve on their own. UTM services, properly regulated by the FAA, may help BVLOS drone operators ensure safe and scalable operations by mitigating risks and managing large numbers of flights up to 400 feet above ground level (AGL) covering operations where traditional air traffic control (ATC) services are not possible or appropriate.

This Plan is divided into sections that closely follow the order of requested information in Sec. 376. The introduction summarizes some of the key definitions and policy decisions in the FAA's 2020 UTM Concept of Operations (ConOps) Version 2. The introduction also enumerates several broad unsettled policy areas related to UTM implementation; highlights lessons learned from research efforts, such as the UTM Pilot Program (UPP); and summarizes a range of efforts underway within the agency that are related to implementing UTM.

Section 2 describes the relationship between industry standards for UTM services, and the "safety standards," or criteria, the FAA must develop to help enable the UTM ecosystem.

Section 3 begins by delineating, at a high level, some of the differing roles and responsibilities that FAA and industry have to implement and deploy UTM services. It continues with an overview of FAA's current regulatory framework, and the inherent gaps to regulating UTM services that drive the need for rulemaking and a new regulatory pathway for UTM services.

Section 4 describes the safety benefits, risk reductions, and associated implementation and policy considerations related to a number of expected UTM capabilities.

Finally, Section 5 provides a brief overview of the near-term approval process that the FAA is currently refining in an effort to recognize and enable UTM services in connection with operational waivers and exemptions, in order to inform rulemaking and to satisfy Sec. 377.

1 Introduction

Drones represent the fastest growing sector in aviation today. Over the last decade, the sector has seen exponential growth, with approximately 900,000 registered drones as of August 2022 [2]. Every day, commercially-owned drones contribute to our economy—inspecting infrastructure, supporting agriculture, assisting public safety agencies. Most of those operations occur under visual line of sight (VLOS), with a growing minority leveraging ground-based visual observers to conduct beyond visual line of sight (BVLOS) missions with waivers and exemptions. Many drone operators seek easier, more cost effective, and sufficiently safe solutions to lower the barriers to true BVLOS operations that do not require visual observers.

The concept of UTM is being developed to support and enable advanced, scalable and safe BVLOS drone operations. Third-party services that are regulated by the FAA are intended to provide effective ways to manage communications links, coordinate flight operations amongst many drones, assist with detection of nearby conventional aircraft, and mitigate a variety of other risks.

The UTM Concept of Operations (ConOps) Version 2, published in early 2020, established a number of concepts and definitions that are leveraged throughout this Plan [3]. This Plan summarizes some of the work that is already underway, as well as some of the challenges and policy issues that make developing the UTM ecosystem a complex undertaking. It also proposes a number of solutions that would enable various parts of the FAA to regulate UTM services to ensure that they function in ways that support safe and equitable access for all users of the National Airspace System (NAS).

1.1 Terms and topics addressed in UTM ConOps V2

In early 2020, the FAA published Version 2 of the UTM ConOps, which contained a number of important definitions and settled several policy topics related to UTM. Specifically, the UTM ConOps specified that UTM is for managing drones at altitudes up to 400 feet AGL, which is often referred to as “low altitude airspace” [3, Page 4]. UTM services could exist in controlled airspace, which includes Class B, C, D, or E airspace; or in uncontrolled Class G airspace [3, Page 4]. UTM is distinct from, but complementary to, traditional air traffic control separation services [3, Pages 4, 6]. Class G airspace generally lacks the surveillance and communications infrastructure to provide traditional traffic management services, especially as the density

Common Terminology

Additional definitions in Appendix B

- UTM: A collection of services that supports and enables BVLOS drone operators, and that is separate from, but complementary to, FAA air traffic separation services.
- Third-party service: A distributed service provided by an entity other than the drone operator or the FAA. The two types of third party service providers envisioned for UTM are UAS Service Suppliers (USS) and Supplemental Data Service Providers (SDSP). These service providers could include companies, state/local/tribal government entities, or other organizations.
- UAS Service Supplier (USS): A third party providing UTM services that reduces the risk of UAS operations through capabilities such as strategic conflict detection, strategic deconfliction, conformance monitoring, and constraint management. USSs may need to share with and receive data from FAA systems.
- Supplemental Data Service Provider (SDSP): A third party providing UTM services that supply specialized data to USSs, or to drone operators, for a variety of uses. SDSPs may provide information that is used for flight planning, weather avoidance, traffic awareness, terrain and obstacle avoidance, or other functions. SDSP UTM Services may receive data from but not share data with FAA systems.
- Strategic deconfliction: A function provided by USSs to reduce the likelihood of collision between two drones by adjusting the operational intents (routes) of at least one of those aircraft; or be alerting drone operators when their operational intent intersects with another drone’s operational intent.

of drone operations increases over time [3, Page 4] [4, Sec 2-1-1]. UTM services may support both VLOS and BVLOS operations, with an emphasis on enabling safe BVLOS operations at a scale that would not otherwise be achievable based on each individual drone operator's level of technical capabilities [3, Page 13]. The FAA expects that UTM will be implemented first in lower-complexity environments, with the gradual deployment of services in areas with increasing complexity, including greater numbers of conventional aircraft [3, Page 53].

UTM services are sometimes referred to as "third-party services," indicating that the service is provided by an entity other than the drone operator or the FAA [3, Page 6]. Today, drone operators remain responsible for safely separating themselves from other drones, and from conventional aircraft, even if those operators are subscribed to services that assist with strategic deconfliction, detect and avoid, or other traffic management functions [3, Page 20].

Just as it does for conventional aircraft today, the FAA will remain responsible for airspace access, as well as developing plans and policies for the use of navigable airspace and assigning airspace [3, Page 20].

The FAA expects the UTM ecosystem will consist of a number of distinct elements and services, each with specific functions:

- UAS Service Suppliers (USSs) provide cooperative traffic management among drones, including assistance with flight planning, strategic deconfliction, alerts about airspace changes, conformance monitoring, and contingency management [3, Page 11].
- The FAA's Flight Information Management System (FIMS) is a clearinghouse for data exchange with authorized UTM participants, including airspace constraint data and incident/accident investigation [3, Page 12].
- Supplemental Data Service Providers (SDSPs) are UTM services that connect to USSs and operators to share information such as weather, terrain, and non-NAS surveillance data [3, Page 11].
- Low-Altitude Authorization and Notification Capability (LAANC) USSs provide an industry-built service in support of the FAA's airspace authorization responsibilities under Part 107. Despite the "USS" designation adopted by the FAA, these services are not equivalent to USSs as described in the first bullet [3, Page 38].

Unless otherwise required by the FAA, drone operators will be able to choose whether to use a third-party service, or whether to provision their own set of services [3, Pages 6, 10]. UTM is not equivalent to detect and avoid (DAA), but certain services may support an operator's collision avoidance requirements, such as by providing surveillance information or conflict alerts and guidance [3, Page 25]. Whereas DAA typically refers to hardware and software that enables the avoidance of conventional aircraft, today strategic deconfliction is intended for managing interactions between drones [3, Pages 27, 28]. Further, DAA may not be required by the FAA depending on the location and mission profile, and the drone operator's other collision avoidance mitigations; this continues to be an open policy topic within the FAA [3, Page 28].

1.2 Policy Decisions Affecting UTM Implementation

There are many unresolved policy issues that the FAA must resolve so that many of the complex technical and oversight topics related to UTM implementation can be addressed. This section highlights several of those policy topics, but it should not be read as a comprehensive list of all currently identified open policy issues and questions, as there may be other policy questions that will emerge with time.

No Currently Available Near-Term Approvals Process (NTAP): The FAA is working to implement a process to assess UTM services in accordance with Section 377 of the 2018 FAA Reauthorization. The process, as described in Section 5, requires executive-level approval, as well as a decision as to the exact mechanism of approval or recognition that would be used.

Uncertain Criteria for use of UTM Services in Controlled Airspace: Similar to the previous policy issue, UTM services may need to be evaluated and regulated by FAA differently if they are used to support BVLOS operations in controlled airspace, versus exclusively in Class G airspace. Since each specific UTM service may perform different functions (including providing risk mitigations that are unrelated to traffic management), the degree of Air Traffic Organization (ATO) involvement may vary from one case to the next. Additionally, some UTM services, such as USSs that provide strategic deconfliction, may have an eventual need to share information (e.g. about drones experiencing an emergency) with NAS air traffic management systems. These exact interactions have not been defined, and expectations related to air traffic controller involvement or notification have not been established.

Future LAANC Requirements and Capabilities Have Not Been Finalized: The Low Altitude Authorization Notification Capability currently streamlines airspace authorizations for Part 107 drone operations in controlled airspace [19]. At present, the FAA ATO permits specific companies to provide this service under a contractual arrangement. Companies are not compensated by FAA for deploying LAANC services (as they are formally named), but those companies must meet a multitude of software requirements set by ATO. A specific plan around the future of LAANC has not been determined.

No Definition of Low-Risk Areas and Airspace: In Sec. 377 of the *FAA Reauthorization Act of 2018*, Public Law No. 115-254, Congress directed the FAA to provide "expedited" procedures for making assessments and determinations for services used in low-risk settings. [1] The exact definition of these areas, regions or types of airspace is an unsettled policy decision. There are many possible definitions, including those proposed by external entities such as ASTM standards workgroups and described in the Joint Authorities for Rulemaking of Unmanned Systems (JARUS) guidelines on Specific Risk Assessment (SORA). An agreed definition of low-risk areas is foundational to helping the FAA ensure that UTM implementation follows the desired trajectory, from low-risk and low-complexity settings, to areas with greater risk that must be addressed with more robust services and other mitigation measures.

1.3 No Requirement for Drone Operators to Avoid Collisions with Other Drones: Currently, the FAA expects drone operators seeking waivers and exemptions for BVLOS operations to explain how the mitigations they use reduce the risk of midair collision with conventional aircraft, and reduce the risk of crashing into people and property on the ground. However, the FAA does not necessarily expect drone operators to account for the presence of other nearby drones, nor to mitigate second-order effects, such as harms resulting from two drones colliding in midair and falling onto people or property on the ground below. Without such a requirement, there is not an immediate incentive for drone operators to use USSs that provide strategic deconfliction, or to adopt any other means to reduce this potential risk. Lessons Learned from the UTM Pilot Program

Several efforts by the National Aeronautics and Space Administration (NASA), as well as the FAA, helped establish the early concepts of UTM and advanced initial testing and technical development. NASA first articulated the need for UTM in 2015 [5], and released a concept of operations the following year [6].

Between 2019 and 2020, the FAA, in collaboration with selected UAS Test Sites and a variety of industry participants, conducted the UTM Pilot Program (UPP) in two phases of live and simulated flight tests to evaluate a variety of UTM services. UPP Phase 1 included the exchange of flight intent among operators; the generation of notifications to UAS operators regarding air and ground activities, known as UAS Volume Reservations (UVRs); and the ability to share UVRs with stakeholders, including other UAS Service Suppliers (USS) and FIMS [7]. UPP Phase 2 included testing of Remote Identification (RID) technologies and increasing volumes and densities of drone operations, as well as use of strategic deconfliction to reduce conflicts between drones [8].

The UPP2 final report contains a number of specific recommendations based on the program's results and findings. Some have not been acted on, because they related to specific technical aspects that will arise as implementation activities progress. Others, particularly related to Network Remote ID, are not immediately relevant for FAA to act on, since compliance with the Remote ID rule is achieved through Wi-Fi or Bluetooth broadcast [9].

Several recommendations point to issues that will need to be addressed during early phases of implementation. In particular:

1. UPP2 found that operators and UTM services used different altitude reference points. These differences, including measurement in height above geoid versus barometric altitude, introduced possible errors in conflict avoidance.
2. USSs shared limited information about conflicts with drone operators, making it more difficult and time-consuming for operators to find another conflict-free route.
3. Some drone operators took up to 2 minutes to respond to and correct the paths of flights after a conformance alert was generated by the USS. However, most USSs expected corrective action to be complete in a quarter of that time, 30 seconds..
4. UPP2 did not test time-based (temporal) strategic deconfliction but did find that route-based adjustments limited overall airspace capacity. As a result of these findings, FAA conducted a series of simulation tests with Johns Hopkins University Applied Physics Laboratory in 2022 to better characterize the capabilities, limitations, and tradeoffs of different forms of strategic deconfliction. This research is still underway, and is expected to inform future industry standards, as well as FAA policy and rulemaking.

There are multiple avenues for resolving the above issues, which may include updating industry consensus standards, rulemaking, and others. These remain open questions for consideration both within the FAA and the wider UTM stakeholder community.

1.4 Current Work Supporting UTM Implementation

In addition to publicly announced demonstrations, such as Phase 1 and 2 of the UTM Pilot Program (UPP and UPP2, respectively) and the UTM Field Test (UFT), the FAA has undertaken a number of other efforts to advance UTM implementation and development. These range from ongoing standing meetings with a wide range of agency stakeholders, to specific projects to improve internal processes, as described in this section.

Coming two years after the conclusion of the UPP2 flight tests, UFT is designed to test new capabilities and industry standards for drone and UTM operations that have been developed over that time [10]. In addition, UFT will explore scenarios that are more complex than those tested in UPP2, such as evaluating how well strategic de-confliction works in settings where not all drones are subscribed to a USS. The scenarios are also expected to validate safe BVLOS drone operations using UTM services at night, and over people.

In 2021, the FAA chartered the BVLOS Aviation Rulemaking Committee (ARC) to make recommendations to normalize certain kinds of BVLOS drone operations at up to 400 feet AGL in Class G airspace [11]. The ARC was comprised of approximately 86 members from the drone, conventional aviation, and UTM communities, as well as a variety of other stakeholders. In its final report, the ARC made several dozen recommendations. Not all members of the ARC supported the recommendations. The totality of information presented to the FAA, both in the report as well as in material provided with non-concurrence votes, is helping the FAA prioritize future policy and rulemaking activities.

As mentioned in the previous section, in FY22 the FAA executed a contract with Johns Hopkins University Applied Physics Laboratory to study the safety benefits of strategic deconfliction through simulation [14]. The research, which is still underway, measured midair proximity events (two drones within 75 feet of each other) and expected ground fatalities for a wide range of airspace, ground population density, shelter factor, and mission factor conditions. The research findings are also being shared directly between the Johns Hopkins research team and the ASTM standards group focused on

USS interoperability. The research has helped establish the importance of overall participation rate (that is, the proportion of drones in a given airspace region that are all subscribed to USSs providing strategic deconfliction) in reducing midair collisions, as well as airspace capacity limits that occur when temporal strategic deconfliction is used.

Over the course of 2022, the FAA defined a near-term approvals process for early UTM services that mitigate BVLOS risks identified in FAA Order 8040.6, Appendix A [25]. This work included proposing an initial set of process steps, and a series of workshops with attendees from across the agency. The workshops not only refined the proposed process, but also identified a variety of programmatic risks and highlighted some of the same open policy questions that were outlined in Section 1.2 [15].

Various parts of the agency hold monthly, biweekly, or weekly meetings to cover topics relevant to UTM implementation. Examples include:

- A weekly meetings with participants from across the FAA that fosters discussion about how to provide oversight of specific UTM services, capabilities and technical aspects.
- Regular FAA participation in industry-led workgroups related to standards development for UTM services, as well as governance mechanisms to ensure interoperability; depending on the specific workgroup meetings occur biweekly or monthly.
- Monthly meetings with international airspace regulators under bilateral agreements to discuss a range of UTM policy and technical implementation topics. These are valuable because while the European U-Space regulations are very different from current regulations in the United States, the same companies intend to operate on both continents, leveraging the same performance-based industry standards.

Finally, FAA supports research, testing and deployment of UTM capabilities through contract awards under the Broad Agency Announcement (BAA) process to specific companies, and also works closely with some UTM companies through Partnership for Safety Program (PSP) agreements [16] and the BEYOND program [17].

2 Development of Performance and Safety Standards

Performance and safety standards must be developed to support various operations flown in a UTM environment to give industry participants an opportunity to show the value and safety benefit of evolving UTM service capabilities. While it continues to be the FAA's role to evaluate how well a service (or other drone technology) performs in reducing operational risk and to ensure that industry standards are used correctly and meet FAA's safety criteria, industry is best positioned to take the lead in creating those standards and show how they can be used safely.

The FAA will consider use of industry consensus standards for implementation of UTM, as applicable, and in compliance with OMB Circular A-119. The FAA participates in the development of UTM industry consensus standards, for both performance and safety, through ongoing workgroup meetings that give the FAA insight into how industry intends to scope and use a given standard. Those meetings, which generally occur monthly or biweekly for each workgroup, also provide a venue for industry participants to gain insight and clarification from FAA subject matter experts. The published standards may be presented to the FAA for consideration as means of compliance (MOC) to regulations that need to be developed. The FAA has also recognized use of specific standards when operators request a waiver or exemption to regulations for their BVLOS operations.

Currently, the FAA is supporting several organizations in the development of policy guidance, strategic harmonization efforts, and standards that set performance requirements for UTM services:

- ASTM International
    - Committee on Unmanned Aircraft Systems (F38) is developing UTM standards for remote identification, USS interoperability and performance for strategic deconfliction, and surveillance services [18]. ASTM also published a standard for detect and avoid performance and is drafting a standard addressing test methods for DAA systems. Finally, ASTM is developing a standard for weather services that would support BVLOS drone operations.
- American National Standards Institute (ANSI)
    - ANSI's UAS Standardization Collaborative (UASSC) created a Standardization Roadmap for Unmanned Aircraft Systems, which it continues to update in new versions.
- RTCA
    - Two specific workgroups within RTCA have published several standards related to detect and avoid. While some of the standards are intended for equipment onboard the aircraft, or for non-UTM drone operations at higher altitudes or in complex terminal airspace, other standards may be useful in UTM. For example, RTCA has developed standards for aircraft avoidance algorithms, and for characterizing non-NAS ground-based radar so that it can be used to support a specific drone's DAA capabilities.
- Joint Authorities for Rulemaking on Unmanned Systems (JARUS).
    - JARUS is developing a work plan to address UTM aspects from a regulator perspective, including the division of responsibility between actors, organizational oversight, and holistic risk modeling. One specific activity already underway is the development of a specific operational risk assessment (SORA) methodology that will identify standardized areas of operational risk mitigation that a service provider may choose to build and market to operators. SORA is not currently invoked in FAA regulations however some drone operators choose to submit their materials in the format of a SORA Comprehensive Safety Portfolio when applying for waivers or exemptions.
- Global UTM Association (GUTMA).
    - GUTMA serves as an industry voice and advocate for UTM technologies. GUTMA creates working groups to address UTM issues and drives a common understanding across its membership.

In comparison to industry consensus standards, the FAA's safety standards development focuses instead on identifying and mitigating risk through a system safety approach, risk-based decision making, and enforcing safety regulations. Some of the agency's most significant functions are regulating aviation safety standards through operations, registration, aircraft inspections, design and production requirements and crew qualification rules. Standards may need complete independent verification and validation at an FAA test site or other approved means prior to being adopted as a MOC.

2.1 Requirement for Mechanisms to Approve and Revoke UTM Services

The language in Section 376 of the 2018 FAA Reauthorization Act requires the Agency to develop "safety standards to permit, authorize, or allow the use of UTM services" Additionally, the section allows the Agency to "revoke the permission, authorization, or approval for the operation of UTM services" if those services are no longer in compliance with the applicable safety standards [1].

In recognition of this statutory language, this Plan uses terms like "approval" and "acceptance" in relation to the future process that will be required during the initial evaluation of UTM services that the FAA determines are subject to Agency oversight. The exact mechanisms of approval and/or acceptance have not been defined yet, and they may vary based on the UTM service assessed – other terminology may eventually be adopted, or future rulemaking could create a regulatory pathway toward certification of services. The first process relates to determining the suitability of a UTM service when a proponent (the service supplier) approaches the FAA. This is the initial approval. Then, the FAA must develop methods of ongoing oversight so that, if necessary, the Agency can revoke a service's approval based on compliance issues.

3 Roles and Responsibilities

In order for the UTM ecosystem to mature, some current operational responsibilities and oversight capabilities will need adjustment. The current regulatory construct must evolve to address changing roles in providing necessary UTM services and establishing performance and safety standards.

3.1 Industry Roles and Responsibilities for Establishing UTM Services

The FAA expects industry to develop the overwhelming majority of services based on market organization, the needs of operators, and other opportunities that arise for them. Therefore, industry will have a substantial role in building and deploying services, as well as developing and maturing the underlying standards to which FAA will expect many of those services to be built to in order to meet FAA safety requirements, if applicable.

The FAA has learned from its experience with the UPP trials, as well as watching the progress of UTM in other countries, that manual service approval processes are slow, cumbersome and not scalable. Therefore, FAA expects there will be a need for automated testing and verification mechanisms. This will enable services to deploy new instances and release feature updates without waiting for a potentially lengthy review process. However, the FAA has not decided whether these technical capabilities, sometimes referred to as test harnesses, will be deployed by FAA, or whether industry should expect to stand up these capabilities on their own.

3.2 FAA Roles and Responsibilities for Establishing UTM Services

The FAA, and the federal government in general, has a wide variety of roles in enabling the UTM ecosystem, through crafting enabling regulations and policies, as well as through eventually creating a regulatory pathway for BVLOS operators to use UTM services. In the future, that may include recognizing applicable industry standards as means of compliance to new regulations that enable BVLOS operations.

The FAA is responsible for ensuring the safety of all users in the NAS. The FAA will also ensure that the UTM ecosystem operates in ways that are equitable to service providers, operators, and other airspace users. The FAA has further responsibility to define specific requirements in several areas, and to build

nation's airspace regulator and its ANSP. The ANSP functions and rules (such as for aircraft separation) are found in documents formally referred to as FAA Orders.[1] Equipage requirements and right of way rules ensure that aircraft can operate safely in certain types of airspace and flight regimes, while training requirements ensure that pilots meet the minimum qualifications to use certain types of air traffic services.

By contrast, operations for compensation or hire, such as carrying passengers, have a lower risk tolerance and must pass a higher bar for ensuring the safety of operations. This has the effect of shifting more responsibilities onto the aircraft and the pilot. Aircraft must meet more stringent certification requirements, such as under 14 CFR parts 25 and 29. Pilots must hold more advanced certificates and may have minimum-hours requirements that must be documented in their training.

UTM fundamentally changes these allocations of responsibilities. The pilot has a decreasingly active role as flight automation increases.. Meanwhile, greater responsibilities are placed on the UAS, and on industry-provided infrastructure and UTM services. New automation and interoperability requirements may be needed to ensure that the UAS interacts correctly with UTM and ANSP services. New ratings and training requirements for humans involved in UTM-supported operations may be necessary in the future.

3.5 Priority of Operations

The FAA's roles are not limited to providing a robust regulatory construct. As the ANSP, the FAA sets the priority of flight operations in the NAS. At present, air traffic operations are managed on a first-come, first-served basis (or in some cases, best-equipped, best-served), with exceptions for emergencies, national security missions, and circumstances in which air traffic controllers have discretion to sequence flights when operationally advantageous [23]. UTM stakeholders have indicated a need for more granular prioritization than is used in traditional air traffic management methods. This granularity is supported in newly developed industry standards for UTM. For example, there may be multiple public safety agencies operating in the same region, or package delivery companies carrying medical payloads that must arrive within precise timeframes or be kept in narrow temperature ranges. While prioritization was not tested in the UPP scenarios, it may be tested in some of the UFT scenarios in 2022. For the purposes of UFT, FAA envisions delineating priority between public safety and commercial operations. UFT will help the FAA understand how best to divide roles and responsibilities for operational prioritization as the UTM ecosystem grows and matures.

3.6 Oversight of Vehicle-to-Vehicle (V2V) Spectrum and Usage

There are emerging concepts and initial standards work underway to enable vehicle-to-vehicle (V2V) communications links for tactical separation and collision avoidance functions, as well as many other possible future use cases [24]. In general, the spectrum that is used by aviation must be carefully managed and allocated internationally, so that interference or oversaturation issues do not impede safety-critical communications links.

The FAA, in collaboration with other U.S. government entities with spectrum equity, may have a future role to work with international partners to understand the emerging spectrum needs for V2V communications and ensure that appropriate spectrum is allocated for those needs. Additionally, there is technical work required to ensure the robustness of those links, and to ensure that messages between aircraft are properly shared and understood. While some of that work can be done by industry, there may be an FAA role in defining and funding research efforts, as well as in determining that a given solution is acceptable and incorporating it into future policy or rulemaking.

4 How UTM Services May Reduce and Mitigate Risks

UTM services hold the potential to help operators address the identified hazards and harms of UAS operations, as detailed in Appendix A of FAA Order 8040.6 [25]. Services may also help operators fulfill other regulatory requirements or address other risks not identified in FAA Order 8040.6. This section is

[1] The prerogative for the creation of airspace and route definitions is captured in 14 CFR part 71.

not meant to be comprehensive. Rather, the FAA expects that industry will continue to innovate in developing novel ways for UTM services to improve the safety of individual operations and outcomes of distributed services.

Before takeoff, UTM services can fulfill a variety of flight planning roles, including making operators aware of threats they may not know exist. These functions might include:

- Recommending flight routes that mitigate ground risk by avoiding high-population areas, terrain, regions with poor GPS or communications link coverage, and so on.
- Providing weather forecasts specific to operations at and below 400 feet AGL.
- Checking aeronautical databases for flight restrictions.

During flight, UTM services may support operations in many ways to prevent unsafe situations from developing, and to help manage unusual situations so that safe outcomes are more likely. These functions might include:

- Ensuring security of UAS operations by comparing remote ID information with registration information about the aircraft and operator, as well as any airspace authorizations that are required for the flight.
- Continuously monitoring the actual flight trajectory against the planned route. This may help prevent controlled flight into terrain, as well as airspace incursions, and proximity events both with crewed aircraft and other UAS.
- Merging traffic information from a variety of surveillance sources to help UAS operators avoid crewed aircraft and other UAS.
- Proposing alternate routings when inflight conflicts, especially with other UAS, are predicted.

4.1 Remote Identification of UAS

Remote ID is the ability of a UAS in flight to provide identification and location information that can be received by other parties. In 2019, the FAA published an NPRM for the remote ID of UAS operating in the NAS, and the final rule was issued in December 2020 [9].

The regulations for Remote ID are focused exclusively on using broadcast technologies, such as Wi-Fi and Bluetooth, to identify nearby UAS. Most drone manufacturers were required to produce aircraft with built-in remote ID compliant capabilities. By the end of 2023, UAS not otherwise excepted will be required to broadcast remote ID information from the UA either by operating a standard remote ID UA or by equipping with a remote ID broadcast module, which enables correlation and traceability to the aircraft owner's registration information. This will support public safety and national security interests, such as determining if a UAS is authorized to fly, distinguishing it from UAS operating in possible violation of local, state, or federal laws and/or regulations.

A separate capability, known as Network Remote ID, is envisioned by industry as a foundational piece for enabling more complex UTM services. The Remote ID Final Rule only requires broadcast remote ID, and does not include any network remote ID requirements. However, the FAA is optimistic that industry will continue to voluntarily develop and adopt solutions that use Network Remote ID to enable other UTM capabilities, in addition to adding Broadcast Remote ID capabilities to meet the requirements of the new rule. Industry has the opportunity to develop network solutions without the need for FAA authorization if they meet the Remote ID broadcast requirements as well. This may help provide the data necessary to validate the sufficiency for network solutions to meet the intent of the rule for future means of compliance or rulemaking considerations.

4.2 Strategic Deconfliction

In the UTM ecosystem, strategic deconfliction is a function provided by USSs to reduce the likelihood of collision between two UAS by adjusting the operational intents (routes) of at least one aircraft. Strategic deconfliction can occur before takeoff or during flight. Most discussions focus on how strategic deconfliction provided by a set of connected USSs adhering to the ASTM USS Interoperability Standard (F3548-21) would achieve this capability [18].

The BLVOS ARC recommended that FAA research the effectiveness and safety benefit of strategic deconfliction, and that work is underway (Section 1.4).

At present, strategic deconfliction is not intended to support separation between UAS and conventional aircraft. Additionally, there are currently no FAA-prescribed separation minima for strategic deconfliction.

4.3 FAA Oversight of UTM Systems Based on Interoperability Considerations

Interoperability takes many forms in the UTM ecosystem and is meant to ensure that there is proper, safe, and scalable coordination between entities, enabling a diversity of aircraft types to use the same airspace. Interoperability also means that functions bundled together by a service provider perform in expected ways and that service providers can identify and coordinate with each other, potentially across jurisdictions and countries. This coordination does not just include data exchanges and message protocols; it is also the ability for UTM services to eventually interface with ATC systems in more complex ways than one-way notifications and alerts.

Interoperability between USSs is critical for ensuring that strategic deconfliction (including collaborative conflict detection, negotiation, and resolution elements) occurs quickly, safely, and equitably. Over time, ensuring that USSs are functioning correctly will become more complicated as each connection between new UTM services may impact the flow of information to other service providers and operators as well. Near-term approvals will focus on relatively straightforward connections between operators and either SDSPs or USSs. In both cases, the flows of information and dependencies can be easily described. However, as the number of operators and supporting USSs grows, the potential number of interactions requiring interoperable connections also increases. It will not be feasible or desirable for the FAA to retest and reapprove each USS whenever a new USS begins operations.

The vision for the UTM ecosystem includes the capability for SDSPs to interact directly both with USSs and operators so that various data sources can inform flight planning, routing, and strategic management functions. This introduces new sets of dependencies that may not be obvious to the operator, and it will therefore become important not just to check first-order functionality (e.g., how information flows from one SDSP to one USS), but to understand second-order effects (e.g., how increased latency between two services affects the ability of an operator using those services). This requires understanding what happens when one service fails or enters a degraded performance state. Such a condition may have impacts on other services and operators that may not be directly connected with the service that is not operating normally.

With time, there will be a need for a common testing framework run by trusted entities to address the challenges and questions in the previous paragraph. Such a testbed may provide a simulated environment for USSs and other services to check their performance and verify interoperability in increasingly scalable and automated ways. While this kind of a testbed need not be operated by the FAA, it would most likely need to accept requirements from the FAA and report on testing outcomes to the FAA.

The FAA must ensure that interoperability is maintained on an ongoing basis, since it contributes to overall airspace safety. This includes the future need to evaluate and ensure interoperability between UTM services (as well as the operations they manage) and air traffic services managed by the FAA. The exact needs and means of interoperability are a current topic of research and concept development, so it is premature to speculate on how situations will be handled where there is an emerging conflict between, for example, a UAS managed by UTM services, and a Visual Flight Rules (VFR) or Instrument Flight Rules (IFR) crewed aircraft.

The FAA will be strategic and deliberate in deciding which interactions to oversee. Standards for interoperability between USSs, for example, will be critically important to ensure overall functionality of the ecosystem. However, the implementation details of interactions between a USS and an operator may be left to industry to refine and validate without specific requirements from the FAA. To that end, the FAA expects to have less of a role in certain aspects of interoperability than others. Verifying sufficient interoperability may be addressed in a number of ways:

- Through the appropriate pairing of the operator's capabilities with UTM service approvals.
- By conducting robust analyses to determine and justify which types of UTM services operators will be required to use, based on the need for those services to interoperate with each other.
- By developing appropriate evaluation steps that consider potential modes of interoperation as new services evolve.
- By collaboratively developing test plans and ongoing validation checks of functional connections between deployed UTM services.
- By providing flexible architecture for the mechanisms by which data is exchanged between UTM services and the FAA, particularly in relation to conventional air traffic and ATC services.

4.4 Detect and Avoid Technologies

Tactical collision avoidance includes not only use of DAA systems, but also other mitigations such as visual observers on the ground and use of traffic information displays that increase situational awareness. But there may be situations, based on airspace usage patterns and the use of other mitigations, where using a DAA system would not be required in order to achieve the target level of safety for a given set of UAS operations.

Tactical collision avoidance functions may be allocated in many possible ways between the operator, aircraft, and UTM services. For example, some operators may choose to place all required hardware and software aboard their aircraft, so that it can avoid other aircraft without relying on external systems. Other operators may leverage UTM services that provide surveillance information (either through a USS, or directly), while leaving alerting and avoidance decisions to the operator, GCS, or aircraft. As a third example, a UTM service that receives surveillance information could execute Airborne Collision Avoidance System (ACAS) functions on behalf of subscribed operators or aircraft; the aircraft would then only need to follow commands issued to it by the ACAS UTM service.

The effectiveness of various tactical collision avoidance technologies is an area of active research, both within industry and the FAA. There are multiple research projects underway within ASSURE related to DAA validation, and several FAA-funded Broad Agency Announcement projects by industry are currently determining the suitability of specific DAA technologies in real-world situations.

4.5 Collaboration and Coordination with Air Traffic Control

At present, there are limited means for UAS operators to interact with ATC services. This is largely by design, since ATO has indicated there are certain parts of the NAS, especially at and below 400 feet AGL, where it is not traditionally providing separation services [23]. Once USSs are able to provide strategic deconfliction and conformance monitoring services, the need for more robust interactions may emerge.

Some initial work is being done to identify risk-based thresholds at which alerts about non-conformant operations could potentially be provided to ATC. Therefore, the iterative deployment of USS capabilities provides a prime opportunity to develop these information exchange interactions with ATC. This work would include operational and conformance data to routinely pass to the FAA, defining who is responsible for generating alerts relevant to ATC, and determining which actions, if any, air traffic controllers may need to take in response. If the FAA identifies an operational need for ATC to utilize USS-provided data for safety of flight-related decisions, there will be more stringent cybersecurity requirements in place for those third party providers (described further in Section 4.9). This set of capabilities is the first step in providing an integrated approach to UTM service usage in controlled airspace.

4.6 Data Exchange Between FAA and UTM Service Providers

The UTM ConOps describes FIMS as “an interface for data exchange between FAA systems and UTM participants” [2] that serves as an interface and gateway to a variety of FAA data sources. As the agency has articulated elsewhere, FIMS is best thought of as a collection of cloud services, most of which will have discrete endpoints and access criteria. Cloud services would not be authorized for any sharing of FAA surveillance and flight plan data that includes sensitive data on military, homeland security, or law enforcement flights. It is not a universal, single point of connection for all information that might be exchanged between the FAA and services in the UTM ecosystem. Much of the present-day FIMS functionality addresses needs for LAANC, and some of the needs surrounding airspace and restriction data will continue to exist. LAANC may take on evolving functionality as the FAA deploys new algorithms to assist in calculating UAS Facility Map (UASFM) grid square heights, with certain responsibilities continuing to lie with the LAANC USSs.

Authoritative aeronautical data, including airspace boundaries, airport/heliport locations, temporary flight restrictions, and Notices to Air Missions (NOTAMs) will continue to be provided by the FAA to the UTM ecosystem. Figure shows the FAA Cloud Services, many of which fall under the FIMS umbrella.

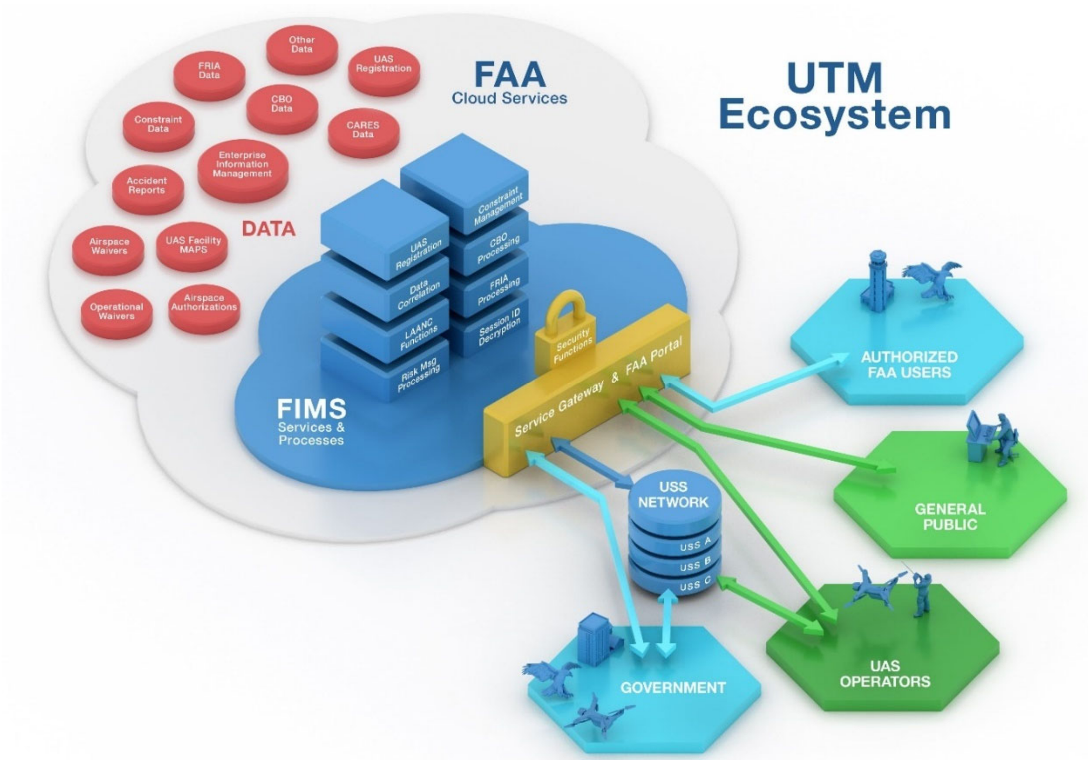

Figure 1: FAA Cloud Services

There are a number of emerging needs related to airspace usage data that the FAA will need to address. Many UTM services will be appropriate only in low- or medium-risk airspace. It is within the FAA’s purview to develop a clear definition of these airspace risk levels, as well as specific metrics that the FAA expects service providers to use when determining or verifying the airspace risk level where they provide coverage. Alternatively, the FAA may resolve these ambiguities by indicating which regions of the NAS fall into different airspace risk levels. Where making such determinations requires analyzing historical or aggregate airspace data, FAA policy should indicate which data sources are acceptable and how to calculate certain metrics.

4.7 Requirements on Data Exchange Protocols

At present, the FAA is leaving the requirements for specific UTM implementation topics, such as suitable data exchange protocols, to industry standards development organizations. For example, the ASTM USS Interoperability Standard contains extensive requirements on message formats. Many of these requirements were developed following the UPP2 trials, which uncovered challenges in properly exchanging and interpreting messages between service providers. As an additional example, the draft ASTM Surveillance SDSP standard (WK69690) includes extensive proposed requirements on messages, underlying formats and common data dictionary elements to ensure consistency of information derived from a variety of underlying sensor types.

4.8 Expansion of UTM to Other Operations

Many UTM concepts and philosophies could be applicable beyond the domain of UAS at very low altitudes. Therefore, the rollout of more robust UTM capabilities for operations at and below 400 feet AGL will be an important input to the overall Extensible Traffic Management (xTM) research concepts being explored by FAA and NASA [26, 27]. This umbrella effort will consider how to ensure that disparate entities use the navigable airspace in compatible ways, including larger UAS that operate above 400 feet AGL, and powered lift cargo and passenger Advanced Air Mobility (AAM) operations that take advantage of vertiports, transition through UTM low-level airspace, and cruise as high as 5,000 feet AGL [28].

One of the newest initiatives underway, the AAM BVLOS NAS Evaluation (BNE), explores operational concepts for UAS that include greater complexity and increasing capabilities for UAS integration at mid-altitudes of the NAS [29]. AAM BNE, a research and development project under the FAA's NextGen Portfolio & Management Directorate and conducted through an Other Transaction Agreement with Embry-Riddle Aeronautical University, focuses on large UAS operations such as cargo aircraft that fly longer distances through the NAS. Through a series of data collection activities that exhibit increasing complexity, this project's participants will analyze, test, and evaluate multiple concepts and scenarios aimed at identifying potential gaps and the impact of large BVLOS operations on CNS services. The AAM BNE efforts consider a variety of use cases, including large cargo UAS, as well as optionally piloted AAM aircraft that may eventually carry passengers. At present, the AAM BNE evaluation does not consider use of UTM-like distributed services, and relies instead on leveraging existing legacy infrastructure. However, it is an important steppingstone to define gaps that may be filled by more advanced services, such as the need for Providers of Services for Urban Air Mobility (PSUs), which are part of the AAM concept development work.

Early efforts by FAA's NextGen office are also underway to evaluate which methodologies and approaches for cooperative traffic management may be leveraged and extended from UTM so that they can be applied to Upper Class E Traffic Management (ETM), above Flight Level 600.

UTM services as deployed for UAS operating at and below 400 feet AGL may not be suitable for passenger-carrying AAM missions, though. One key issue is that there is no specific set of concepts emerging in industry of exactly what is needed of services to support AAM. That makes it nearly impossible to derive functional requirements, much less establish requirements in support of safety criticality.

The FAA's near-term UTM service approval concept is predicated on several assumptions, including that UTM services generally support operations for which there are no passengers, and operations that are typically constrained to areas where there is no interaction with ATC services. Therefore, the underlying UTM service architectures may not translate well to the passenger-carrying AAM realm.

At present, some of the most mature AAM concepts involve type-certified aircraft with a human safety pilot onboard. Until the functional responsibilities and roles of the safety pilots are more specifically defined, defining future distributed service needs will be difficult.

4.9 Cybersecurity, Data Integrity, and Reliability

UTM information systems may be subject to threats seeking to exploit any existing vulnerabilities that may result in compromised security. To protect its assets, the FAA's Information Security and Privacy Program and Policy [29] defines the organizational and management responsibilities to ensure information security and privacy policies are consistent with federal statutes (e.g., Office of Management and Budget (OMB) A-130, Federal Information Security Management Act (FISMA), National Institute of Standards and Technology (NIST)). As a mitigation against potential threats and to meet the security requirements of the agency, the FAA has identified the following UTM message security objectives: authentication, data integrity, non-repudiation, authorization, and confidentiality.

It is important that all stakeholders of the UTM ecosystem follow the principles of security by design, which incorporates mitigations against potential threats into hardware and software from early development stages. Not all security threats can be pre-determined, therefore, cybersecurity initiatives need to be holistically designed, continuously evaluated, and improved iteratively in order to respond to emergent threats. Constantly evolving threats require constantly evolving defenses. As shown in **Error! Reference source not found.**, a layered approach to implementing cybersecurity measures can effectively protect the UTM ecosystem from a variety of known and emergent threats.

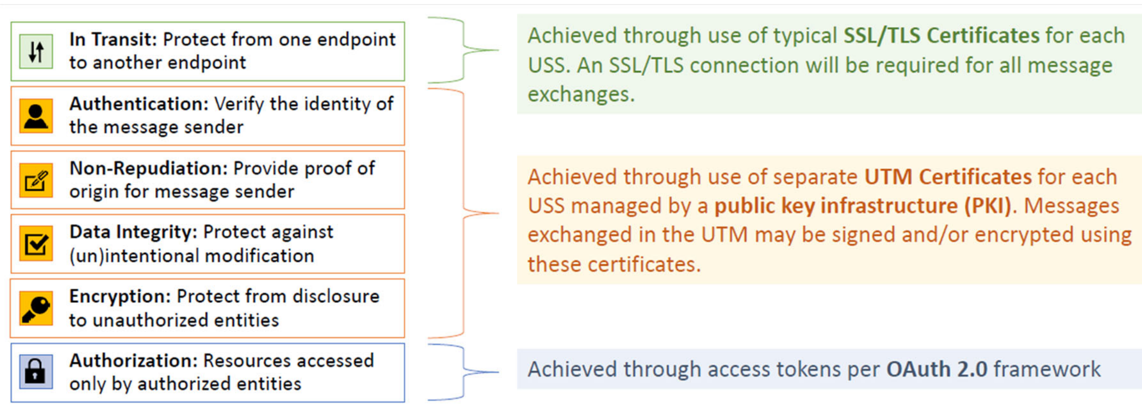

Figure 2: Layered Approach to Cybersecurity

While information sharing in UTM is primarily for situational awareness, messages are also exchanged to facilitate strategic deconfliction and communicate off-nominal situations. In these contexts, USSs and FIMS must be confident that the entities with which they are exchanging information are properly authenticated and that the exchanged information retains its integrity (See Section **Error! Reference source not found.** for more detail about FIMS and FAA Cloud Services). If messages are intentionally or unintentionally altered, intercepted, impersonated, or withheld, the repercussions to UTM may be severe, with potential impacts to deconfliction or off-nominal events. As a baseline layer of security, UTM plans to require Transport Layer Security (TLS) protections for all communications, providing point-to-point authentication, data integrity, and confidentiality. To move toward a successful and scalable implementation of UTM, FIMS and the UTM service providers must be able to trust the identity of UTM entities and be assured that other service providers are able and approved to perform their tasks, enabled by authorization through Identity and Access Management (IAM).

To provide stronger end-to-end authentication, UTM will likely need to leverage a Public Key Infrastructure (PKI) using certificate authorities [e.g., International Aviation Trust Framework (IATF)] to manage the use of digital certificates. A trusted certificate authority verifies the identity of the certificate holder to ensure that all parties receiving a certificate can be certain of the holder's identity. To achieve both authentication and data integrity, the FAA proposes that UTM interactions require that digital signatures be applied to message exchanges. In addition, the use of digital signatures achieves end-to-end non-repudiation for messages, preventing a message sender from denying the communication. This strategy also facilitates the FAA's historical data access needs, such as data correlation, auditing, and post-incident investigations.

IAM, with a centralized and federated authorization mechanism, has been exemplified by early NASA demonstrations, other FAA implementations, and standards in development by ASTM International, which use an OAuth 2.0 authorization framework that assigns permissions to UTM service providers based on their roles.[2] During onboarding, USSs will demonstrate their technical ability to perform USS functions and will be given pre-defined roles based on the level of service they have been qualified by the FAA to provide. In order to successfully gain access to Application Programming Interface (API) endpoints, the USSs will then need to provide proof of permission obtained from a centralized authorization server. In this way, the authorization strategy implemented in UTM restricts the access of UTM resources to appropriately authorized service providers. The use of Role-Based Access Control (RBAC) defines each entity based upon their role in the system and provides them the minimum permissions required to perform their role. In addition to preventing unauthorized UTM participation, this authorization strategy provides a layer of mitigation against damaging denial of service attacks on the system to ensure system reliability and availability.

5 Next Steps: Proposed Near-Term Process for Evaluating UTM Services

An approval basis for a UTM service is only useful in the broader UTM context if many different aircraft and operators can leverage that service, and without the service having to be reevaluated for each application. This is fundamentally different from other FAA approval mechanisms, like waivers and exemptions, whereby approvals are tied to a specific aircraft or operator. The concepts in this section should be taken as notional and broadly illustrative. Absent a final rule that includes a regulatory pathway for UTM services, it is premature to infer specific business rules, approval processes, and mechanisms.

Recognizing that changes to regulations will be required to provide comprehensive and performance-based oversight of the UTM ecosystem, this section provides details of a generalized process that may be used for the initial approval of UTM services. At its essence, this process helps the FAA understand the delineation of roles and responsibilities between an operator and a service provider. The FAA envisions this approach would be applied in slightly different ways for SDSPs and for USSs based on the Agency's emerging understanding of differences in information flows and potential interoperability requirements.

The phased approval concept is not intended to address the possible future need for approval mechanisms that may leverage delegated authority between service providers and operators without direct FAA oversight. Those mechanisms would flow from a mature regulatory construct, once the capabilities of all participants are already well understood and validated through experience.

Figure 3 illustrates a theoretical UTM architecture that presents the various actors and components, their contextual relationships, and high-level functions and information flows. The red dotted line represents the demarcation between the FAA and industry responsibilities for the infrastructure, services, and entities that interact as part of UTM.

[2] Other authorization solutions and implementations may also be acceptable. OAuth 2.0 was used by participants in UPP Phase 2 trials and was found to meet the security requirements of those scenarios.

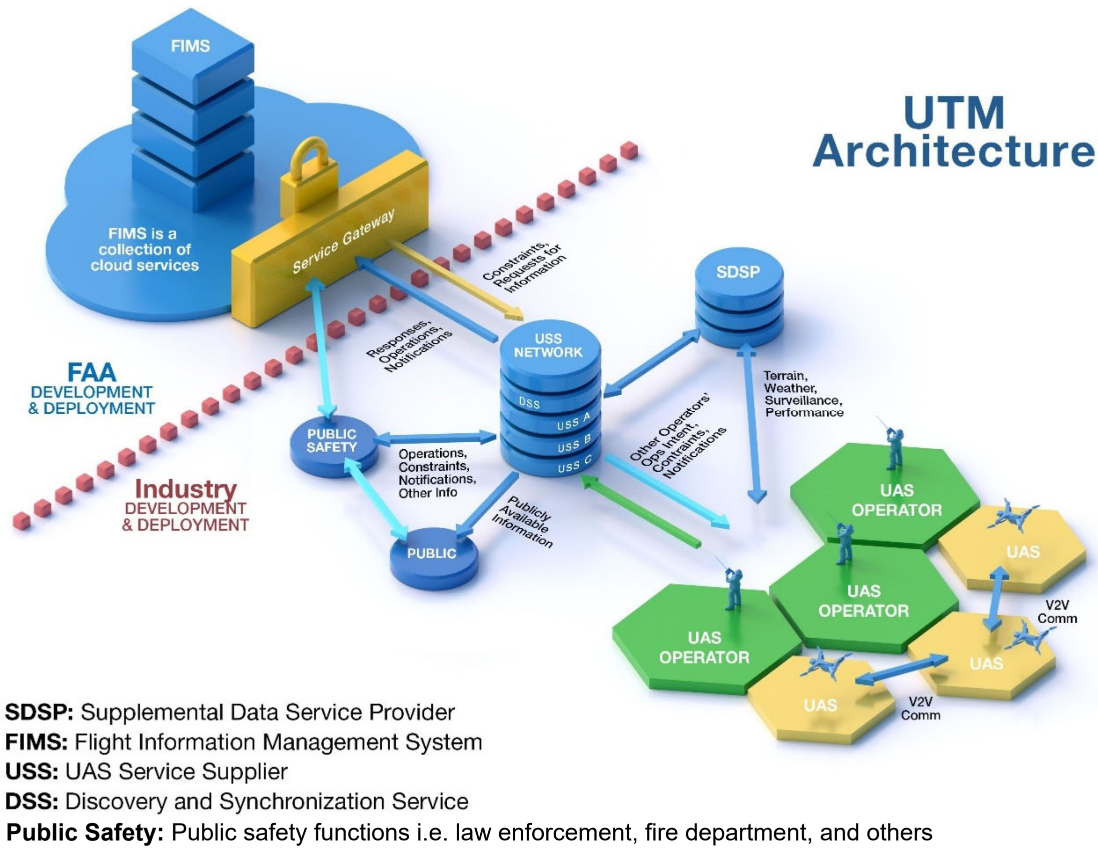

Figure 31: High-Level UTM Architecture

5.1 A Phased Approach

The FAA will initially focus on an approval process for interactions between the operator and a SDSP. The FAA recognizes that industry would also desire a near-term approval pathway for USSs as well. The FAA has not yet determined whether this process will be used to evaluate such an applicant. The FAA has identified the need for slightly different approval mechanisms for SDSPs and USSs based on predominant information flows. SDSPs generally process data in a single direction, from sensors and sources to the operator.[3] USSs, on the other hand, exchange information in both directions with the operator, and have additional requirements to correctly exchange information with other USSs. Over time, there will be a need to evaluate interoperability between dependent services.

This process would provide a path for the FAA to gain experience and confidence in service providers. This can be likened to FAA processes that may now seem commonplace but started with little to no means to evaluate or provide oversight to new roles and responsibilities.

Consider the course for approving new kinds of avionics. When Global Positioning System (GPS) technology was in its infancy, approvals were challenging, requiring very close scrutiny of the avionics themselves, flight crew procedures, and requirements for backup instruments that relied on legacy ground-based navigation equipment. As GPS technology matured and gained wider adoption, FAA approvals also became more straightforward through use of Technical Standard Orders (TSOs). Today, those avionics may now be installed across many different aircraft platforms by trained Airframe and

[3] Note that while Figure 3 also depicts information flows from SDSPs to USSs, that particular interaction may be out of scope of the earliest efforts to evaluate UTM services.

Powerplant (A&P) technicians, whose record of the approved work done is via a logbook entry and is not closely monitored by the FAA.

5.2 Standards for Independent Private-Sector Validation and Verification

In most avionics and aircraft matters outside of UTM today, the FAA specifies the types of testing the applicant must perform, as well as the data and documentation to be provided to the FAA. There is a general desire to follow a similar framework for UTM, but this will require a series of transitions.

The FAA recognizes that the current process it uses to onboard and refresh LAANC providers (e.g., during initial approval and in updates that occur approximately annually) is not scalable because it requires the FAA to manually design and run many of the test scenarios with each provider's LAANC service.

As proposed by the Remote ID Cohort in early 2020, industry desires a highly automated, asynchronous series of test workflows that would allow individual service providers to update, test, and deploy new service versions and features on their own schedules, sometimes as frequently as daily or weekly. Achieving this will require architecting and deploying a testbed that allows for the FAA to monitor test behavior and inject new test scenarios, but without necessarily requiring the FAA to host the testbed infrastructure. This is a new way of testing for the FAA, though similar frameworks are widely used in other types of software development, and it will take time for the FAA to gain trust in such automated onboarding systems. There are open questions about how such a framework would be hosted and funded as well. These capabilities, sometimes referred to as test harnesses, are provided by NASA in the context of demonstrations such as UFT. However, test harnesses for deployed UTM services need not be hosted by a government agency – this responsibility could lie with another entity, such as a consortium funded by industry participants. The FAA has not committed to any specific path or implementation to address this topic.

Appendix A Congressional Requirements Table

Table 1 provides a cross-reference of each of the topics from the legislative language in Section 376 of the 2018 FAA Reauthorization Act [1], the FAA's understanding of what each topic entailed, and citations to relevant sections of this document that address each of those topics.

Table 1: Congressional Requirements Mapping by Requirements

Requirement No.	Legislative Language	Requirement	Applicable Section(s)
Req 0	in coordination with [NASA], and in consultation with unmanned aircraft systems industry stakeholders	Coordinate with NASA, consult with industry	1.3, 1.4
Req 1	include the development of safety standards to permit, authorize, or allow the use of UTM services,	Define approval/checkout process for qualifying USS Services	2, 2.1
Req 2	outline the roles and responsibilities of industry and government in establishing UTM services that allow applicants to conduct commercial and noncommercial operations	Define roles and responsibilities for implementing new UTM services	3.1, 3.2, 3.3
Req 3	include an assessment of various components required for necessary risk reduction and mitigation including... Remote identification of both cooperative and noncooperative UAS	Describe remote ID service	4.1
Req 4	...deconfliction of cooperative unmanned aircraft systems	Describe strategic deconfliction service	4.2
Req 5	...the manner in which the [FAA] will conduct oversight of UTM systems, including interfaces between UTM service providers and air traffic control	Define methods of USS oversight to include description of interfaces	4.3
Req 6	...the need for additional technologies to detect cooperative and non-cooperative aircraft	Identify additional enabling technologies such as DAA/ Ground-Based DAA (GBDAA)	4.4
Req 7	...management services and technologies to ensure the safety oversight of manned and unmanned aircraft	Describe the strategies for the safe separation of UAS within UTM from traffic receiving ATC services	4.5
Req 8	[FAA] responsibilities to collect and disseminate relevant data to UTM service providers	Define data FAA will provide to ensure the safe separation of UTM operations from traffic receiving services (e.g., constraint information, UASFMs, etc.)	4.6, 4.7
Req 9	the potential for UTM services to manage [UAS] carrying either cargo, payload, or passengers, weighing more than 55 pounds, and operating at altitudes higher than 400 feet AGL	Describe the operational limitations of the UTM system	4.8
Req 10	the potential for UTM services to manage [UAS] carrying either cargo, payload, or passengers, weighing more than 55 pounds, and operating at altitudes higher than 400 feet AGL	Describe the additional work that would be required to accommodate higher risk operations	4.8

Requirement No.	Legislative Language	Requirement	Applicable Section(s)
Req 11	cybersecurity protections, data integrity, and national and homeland security benefits	Define cybersecurity practices used for UTM services	4.9
Req 12	cybersecurity protections, data integrity, and national and homeland security benefits	Define processes used to ensure data reliability and integrity	4.9
Req 13	establish a process for ... setting the standards for independent private sector validation and verification that the standards for UTM services... have been met by applicants	Define process for independent checkout/qualification of UTM services	5.2
Req 14	...accepting applications for operation of UTM services in the national airspace system	Define process for reviewing USS applications for approval/qualification of new services	5, 5.1

Appendix B Definitions

Third-party service: A distributed service provided by an entity other than the drone operator or the FAA. The two types of third party service providers envisioned for UTM are UAS Service Suppliers (USS) and Supplemental Data Service Providers (SDSP). These service providers could include companies, state/local/tribal government entities, or other organizations.

UTM Service: A type of third-party service that specifically supports UAS operations at and below 400 feet AGL in the United States. At a minimum, a UTM service exchanges information with a UAS operator/aircraft (see SDSP); certain UTM services may exchange information with each other, or with FAA Cloud Services (FCS), depending on their functionality and access credentials.

LAANC USS: A service qualified to process airspace authorizations on behalf of the FAA under the Low Altitude Authorization and Notification Capability (LAANC) Program. As distinguished from USS.

Discovery and Synchronization Service (DSS): A UTM service that serves as a real-time directory of flight operations being conducted by all USSs in a given area. Each USS Network needs at least one DSS, which may be provided by a USS, or exist as a separately provisioned service.

FAA Cloud Services (FCS): Includes FIMS (Flight Information Management System) Services and Processes. Also includes a collection of endpoints and gateways for managing access and authentication; as well as FAA-maintained data stores.

Flight Information Management System (FIMS): A subset of FCS that supports UTM-specific functionalities. These include UAS registration information, data correlation, session ID decryption, and LAANC functions.

UTM Service Supplier (USS): A third party providing a UTM service(s) that reduces the risk associated with UAS operations through capabilities such as strategic conflict detection, strategic deconfliction, conformance monitoring, and constraint management. USSs may need to share data with and receive data from FAA systems.

USS Network: The collection of USSs and DSS instances that are connected to each other in a given region or jurisdiction.

Supplemental Data Service Provider (SDSP): A third party providing a UTM service(s) that supplies specialized data to USSs, or to drone operators, for a variety of uses. SDSPs may provide information that is used for flight planning, weather avoidance, traffic awareness, terrain and obstacle avoidance, or other functions. SDSP UTM Services may receive data from but not share data with FAA systems.

Appendix C References

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Appendix D Acronyms

Table 2 provides a list of acronyms used throughout this document and their definitions.

Table 2: Acronyms

Acronym	Definition
AAM	Advanced Air Mobility
AC	Advisory Circular
ACAS	Airborne Collision Avoidance System
ADS-B	Automatic Dependent Surveillance – Broadcast
AGL	Above Ground Level
ANSP	Air Navigation Service Provider
ALR	Acceptable Level of Risk
API	Application Programming Interface
ARC	Aviation Rulemaking Committee
ARTCC	Air Route Traffic Control Center
ASRS	Aviation Safety Reporting System
ASTM	American Standard for Testing and Materials
ATC	Air Traffic Control
ATM	Air Traffic Management
ATO	Air Traffic Organization
AUS	UAS Integration Office
BNE	BVLOS NAS Evaluation
BVLOS	Beyond Visual Line of Sight
C2	Command and Control
CBO	Community-Based Organization
CFIT	Controlled Flight into Terrain
CFR	Code of Federal Regulations
CNS	Communication, Navigation, and Surveillance
ConOps	Concept of Operations
CORUS	Concept of Operations for European UTM Systems
DAA	Detect and Avoid
DAC	Drone Advisory Committee
DHS	Department of Homeland Security
DOD	Department of Defense
DOI	Department of the Interior
DOJ	Department of Justice
DSS	Discovery and Synchronization Service
ETM	Upper Class E Traffic Management

Acronym	Definition
EUROCAE	European Organisation for Civil Aviation Equipment
FAA	Federal Aviation Administration
FCC	Federal Communications Commission
FIMS	Flight Information Management System
FISMA	Federal Information Security Management Act
FOQA	Flight Operations Quality Assurance
FRIA	FAA-Recognized Identification Area
GBDAA	Ground-Based DAA
GBSS	Ground-Based Surveillance System
GCS	Ground Control Station
GPS	Global Positioning System
IAM	Identity and Access Management
IATF	International Aviation Trust Framework
ICAO	International Civil Aviation Organization
ID	Identification
IFR	Instrument Flight Rules
IPP	Integration Pilot Program
ISO	International Standards Organizations
LAANC	Low Altitude Authorization and Notification Capability
METAR	Meteorological Aerodrome Report
MOPS	Minimum Operational Performance Standards
MOR	Mandatory Occurrence Report
MOSAIC	Modernization of Special Airworthiness Certification
NAS	National Airspace System
NASA	National Aeronautics and Space Administration
NIST	National Institute of Standards and Technology
NMAC	Near Midair Collision
NOTAM	Notice to Airmen
NPRM	Notice of Proposed Rulemaking
NTIA	National Telecommunications and Information Administration
OMB	Office of Management and Budget
OPR	Office of Primary Responsibility
OpSpec	Operator Specification
PKI	Public Key Infrastructure
PSP	Partnership for Safety Plan
PSU	Provider of Services for Urban Air Mobility

Acronym	Definition
R&D	Research and Development
RBAC	Role-Based Access Control
RIN	Regulation Identifier Number
RNP	Required Navigation Performance
RNP-AR	Required Navigation Performance – Authorization Required
RPIC	Remote Pilot in Command
RTTA	Reasonable Time to Act
RWC	Remain Well Clear
SBIS	Surveillance and Broadcast Information Services
SDSP	Supplemental Data Service Provider
SLA	Service-Level Agreement
SMS	Safety Management System
SO	Staff Office
sUAS	Small UAS
SWIM	System Wide Information Management
TAF	Terminal Area Forecast
TCAS	Traffic Collision Avoidance System
TFR	Temporary Flight Restriction
TLS	Transport Layer Security
TSO	Technical Standard Order
UA	Unmanned Aircraft
UAS	Unmanned Aircraft System
UASFM	UAS Facility Map
UFT	UTM Field Test
UPP	UTM Pilot Program
USS	UAS Service Supplier
UTM	UAS Traffic Management
V2V	Vehicle-to-Vehicle
VFR	Visual Flight Rules
VMC	Visual Meteorological Conditions
xTM	Extensible Traffic Management