Unmanned Aircraft Systems (UAS) Traffic Management (UTM)

UTM Pilot Program (UPP)

UPP Phase 1 Technical Report

Version 1.0

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Executive Summary

The Unmanned Aircraft Systems (UAS) Traffic Management (UTM) Pilot Program (UPP) was established in April 2017 per the Federal Aviation Administration (FAA) Extension, Safety, and Security Act of 2016 Pub. L. 114-190 § 2208 (July 15, 2016) as an important component for identifying the initial set of FAA and industry capabilities required to support UTM operations. The FAA, in coordination with the National Aeronautics and Space Administration (NASA), established the UPP in April 2017.

The primary goal for the UPP Phase 1 was to enable the development, testing, and demonstration of a set of UTM capabilities. These capabilities will support the sharing of information that promotes situational awareness and deconfliction (i.e., cooperative separation) [1]. Some of the UTM capabilities successfully demonstrated in the UPP Phase 1 included sharing of operational intent between operators and the ability for a UAS Service Supplier (USS) to generate a UAS Volume Reservations (UVR). A UVR is a capability providing authorized USSs the ability to issue notifications to UAS operators regarding air or ground activities relevant to their safe operation and share it with stakeholders.

On January 14, 2019, U.S. Department of Transportation Secretary, The Honorable Elaine L. Chao, announced the FAA's selection of three test sites to partner with the agency in the UPP Phase 1 (shown in Figure 1):

- The Virginia Tech, Mid-Atlantic Aviation Partnership (MAAP)
- The Northern Plains UAS Test Site (NPUASTS)
- The Nevada Institute for Autonomous Systems (NIAS)

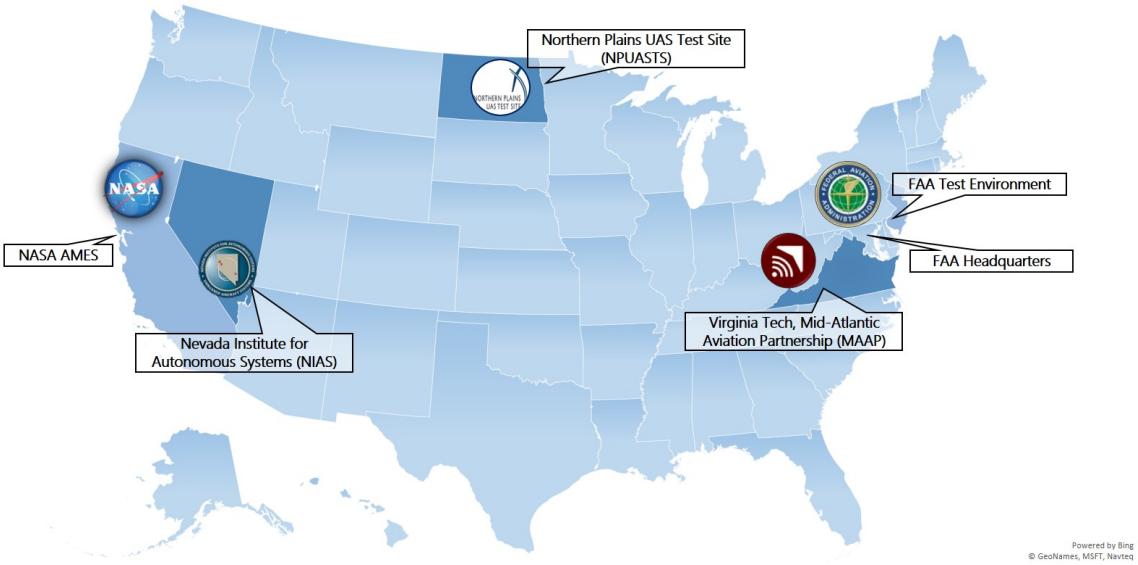

Figure 1: UPP Phase 1 Selected Test Sites

This report discusses how the UPP Phase 1 demonstrations were planned, what the results were, and what lessons were learned. This report concludes with a discussion of the plan for capability implementation and the next steps in demonstration of more complex capabilities.

Version History

Date	Revision	Version #
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1 Introduction

1.1 Purpose

The Federal Aviation Administration (FAA) Extension, Safety, and Security Act of 2016 Pub. L. 114-190 § 2208 (July 15, 2016) directs the Administrator, in coordination with the Administrator of the National Aeronautics and Space Administration (NASA), to establish an Unmanned Aircraft Systems (UAS) Traffic Management (UTM) Pilot Program (UPP).

In summer 2019, the FAA, NASA, and their Industry Partners successfully completed the UPP Phase 1 demonstrations. This report documents the approach, development, execution, and findings from the UPP Phase 1. The initial set of UTM capabilities were successfully demonstrated, highlighting both FAA and Industry UTM capabilities and the technical feasibility for advancement of the UTM operational environment. This report also provides considerations for future research and implementation aspects required for future UTM operations.

1.2 Background

Operators of small UAS (sUAS) are continuously exercising new, beneficial applications for their operations, such as goods delivery, infrastructure inspection, search and rescue, and agricultural monitoring. Currently, there is limited infrastructure available to manage the widespread expansion of sUAS operations within the NAS. A safe and efficient UTM system is needed to help ensure that this rapidly growing industry can integrate into the NAS safely and efficiently [1].

Integration of UAS operations in the National Airspace System (NAS) presents a variety of issues and novel challenges, particularly in low-altitude, uncontrolled airspace. The FAA and NASA have joint interests in identifying innovative and transformative integration solutions that can effectively respond to these challenges without compromising safety or efficiency of the NAS. In 2015, a UTM Research Transition Team (RTT) was formed between the FAA and NASA to jointly develop and enable a UTM framework to manage UASs operating in airspace where air traffic services are not provided [3].

UTM is a community-based, cooperative traffic management system where sUAS operators are responsible for the coordination, execution, and management of operations, with rules of the road established by the FAA. Many UTM services to manage sUAS traffic will be provided by commercial UAS Service Suppliers (USSs). These USSs will offer services to sUAS operators such as flight planning, communications, separation, and weather. The UTM framework will initially provide the capability to exchange information among USSs and the FAA in support of airspace constraints, with Remote Identification (RID) and prioritized operations being supported after future demonstrations.

1.3 UTM Pilot Program Phase 1

The UPP is an important component for defining and expanding the next set of industry and FAA capabilities required to support UTM. Established in April 2017, the scope for the UPP Phase 1 was to enable the development, testing, and demonstration of additional UTM capabilities, and to provide an infrastructure to allow for future testing of new UTM capabilities.

The primary goal for the UPP Phase 1 was to enable the development, testing, and demonstration of a set of UTM capabilities. These capabilities will support the sharing of information that promotes situational awareness and deconfliction (i.e., cooperative separation) [1]. Some of the UTM capabilities successfully demonstrated in the UPP Phase 1 included sharing of operational intent between operators and the ability for a USS to generate a UVR. A UVR is a capability providing authorized USSs the ability to issue notifications to UAS operators regarding air or ground activities relevant to their safe operation and share it with stakeholders.

As an initial step in completing the UPP Phase 1 demonstration, the Flight Information Management System (FIMS) prototype, developed by NASA in collaboration with the FAA, was transitioned to the FAA NextGen Integration and Evaluation Capability (NIEC) Laboratory at the William J. Hughes Technical Center (WJHTC) for integration and testing. FIMS is a central component of the UTM ecosystem that provides the FAA and other airspace stakeholders with access to UTM data. The FAA also uses this interface as an access point for information on active UTM operations.

The UPP Phase 1 demonstrated several fundamental capabilities of the UTM framework. Demonstration of these capabilities was carried out at the UAS test sites and at the NIEC Lab. These capabilities included, but were not limited to:

- UAS operator to USS data exchanges
- USS to USS communication
- Access to FAA enterprise services via application programming interfaces (API)
- UVR submission and viewing (sharing via API)

Specific metrics and information were captured and used to analyze the effectiveness of the UTM capabilities and infrastructure, and to identify areas that have the potential for further refinement. The progress achieved with the UPP Phase 1 is critical to public and private sector entities, as it provides data to support future activities and the implementation of the UTM ecosystem and supporting capabilities. The results from the UPP Phase 1 will contribute to the expansion of UTM framework and serve as the foundational elements for continued UTM infrastructure and concept development [4].

2 Program Approach

Research, development, and deployment of a robust UTM ecosystem will employ a phased approach for system definition, refinement, and expansion. This phased approach will also supply the required information for the development of policies and standards. Individual phases will consist of moving from a business or operational need to a deployed capability or capability set. This phased approach relies on active collaboration between government and industry to progress from an identified need through prototyped capabilities leading to demonstration and deployment of UTM capabilities. As regulations and technology allow, capabilities that enable complex operations will be deployed, building on the foundational capabilities [2]. The UPP provides the mechanism for phased development, testing, and demonstration of UTM capabilities.

In order to integrate variety of operations and industry service suppliers, the UPP Phase 1 approach leveraged the experience and capabilities of the UAS test sites and encouraged partnering with

large and small businesses across the UAS industry. The expectation was for the UAS test sites, along with industry partners operating in support of the UPP, to contribute towards and participate in all activities leading up to the UPP Phase 1 demonstration events.

To garner interest with the industry, FAA and NASA hosted a series of workshops to share the goals of the UPP Phase 1 and encourage partnerships between the test sites and industry. To enable the largest number of partnerships in the smallest period of time, the team used the existing UAS test site framework. This reduced the amount of time to bring the industry partners on board. In June 2018, the FAA released a Screening Information Request to seven test sites. In August 2018, the FAA-approved evaluation team, completed its technical and price evaluation and in early 2019, the FAA announced the test sites selected to participate in the UPP [4].

The UPP Phase 1 capabilities outlined in Section 1.3 were chosen by the FAA since they are foundational capabilities serving as a framework for the UTM ecosystem. The requirements for these capabilities cover the current view of the entire UTM ecosystem and identify essential system functional capabilities and performance measures to provide additional UTM services in the NAS. This capability set is not final and is being expanded and updated based on regulation, testing, and stakeholder feedback. [9].

3 Technical Approach

As NAS services evolve and advance, the FAA and NASA are responsible for vetting and maturing the innovations to reduce any risks associated with new technologies. To support these new technologies, as well as new service entrants, updates to FAA automation systems and procedures are necessary. Prototyping efforts for the UPP Phase 1 supported these updates through concept development, requirements engineering, system architecture definition, system design and development, systems integration, and test and evaluation efforts (as shown in Figure 2). There was collaboration between the teams responsible for these activities, which led to refinement of their outputs producing a successful demonstration of the UPP and supporting future implementation activities.

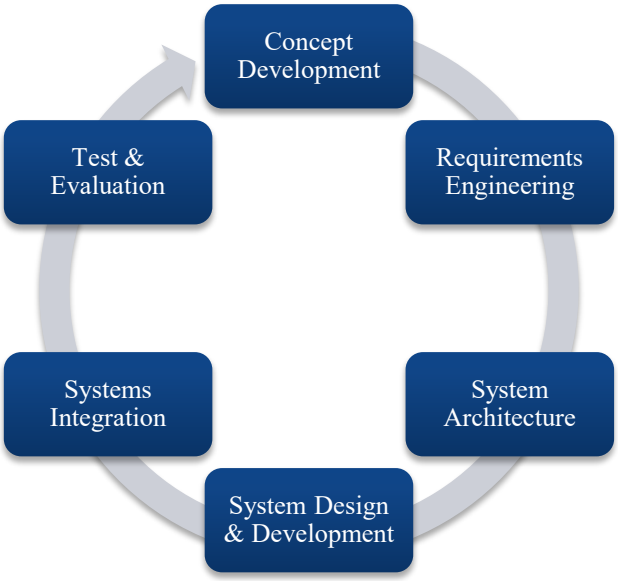


Figure 2: UTM Prototype Development

The initial collaboration between teams responsible for the activities shown in Figure 2 supported requirements development. The UPP Phase 1 requirements were translated into functional requirements, which were then decomposed to lower level functions, and the requirements were allocated to the lower specifications. The results were fed back to the initial requirements and analyzed to verify their compliance or to determine whether updated use cases and operational scenarios should be considered.

The systems architecture, design development, and integration processes operated in parallel with the requirements development. Functional interfaces were established, and functional architectures were defined so that physical system configurations could be developed. As concepts were transformed to hardware and software designs, the design characteristics were analyzed against the allocated requirements. Functional architectures and allocations were re-examined and modified, if necessary.

The final process was the validation of the emerging detailed design against the UPP Phase 1 requirements. Engineering design was validated after systems integration through demonstration, examination, analysis, testing, or a combination of these [5].

3.1 Operational Scenarios and Use Cases

The UPP Phase 1 test scenarios consisted of steps needed to evaluate a use case and its derived functions and requirements against USS services [4]. Test scenario steps include:

- Action – what is happening during this step.
- Actor – which user, service, or component is initiating the action.
- API – which API(s) are used during this step.
- Remarks – expected results or notes for this step.

Test scenarios also include descriptions and any preconditions that need to be in place to execute the test. There should be at least one test scenario per use case. The UPP Phase 1 focused on the demonstration of several capabilities planned for UTM [7].

1. **Operation planning for participating UAS operators**. Capability demonstrations include Visual Line of Sight (VLOS) (14 CFR Part 101(e) & Part 107) and Beyond Visual Line of Sight (BVLOS) operations in uncontrolled airspace under 400 feet Above Ground Level (AGL) in remotely-populated areas away from airports, with minimal manned/UAS traffic, and low risk to people and property on the ground. VLOS Part 101(e)/107 operators are not required to share their intent but may voluntarily do so in promotion of shared situational awareness.
2. **Shared situational awareness between participating UAS operators and Remote Pilots in Command (RPICs) through sharing of intent and state information**. Capability demonstrations include the same environmental conditions as above.
3. **Automated airspace authorization for 14 CFR Part 107 operations**. Capability demonstrations include 14 CFR Part 107 operations occurring within controlled airspace at low altitude (under 400 feet AGL).
4. **UVRs and their effect on UAS operations**. Capability demonstrations include VLOS (14 CFR Part 101(e) & Part 107) and BVLOS operations in uncontrolled airspace, as well as Part 107 VLOS operations in controlled airspace, with other environmental conditions similar to those above.

In March 2018, use cases illustrating the breadth of the UPP concepts were developed as a Concept of Use (ConUse). Each use case included an overview, identified information exchanges, narratives, and associated event trace descriptions (OV-6c[1]).

Table 1 provides an overview of the use case elements and interactions included in each use case.

Table 1: Use Case Elements and Interactions (ConUse)

Description		Use Case 1	Use Case 2	Use Case 3
Type of Operation	Part 101(e)		✓	✓
	Part 107	✓	✓	✓
	BVLOS (waivered Part 107)	✓	✓	
Participation	UTM-Participating Operators	✓	✓	✓
	Non-Participating Operators		✓	
Airspace Characteristics	Uncontrolled	✓	✓	

[1] The Department of Defense (DoD) Architecture Framework (DODAF) is a standard used throughout the development of the UPP. Abbreviations for the Event Trace Description is based on the DODAF standard. The OV-6c provides a time-ordered examination of the Resource Flows as a result of a particular scenario. Each event-trace diagram should have an accompanying description that defines the particular scenario or situation. Operational Event/Trace Descriptions, sometimes called sequence diagrams, event scenarios, or timing diagrams, allow the tracing of actions in a scenario or critical sequence of events.

Description		Use Case 1	Use Case 2	Use Case 3
	Controlled			✓
Operation Plan/Intent Development & Sharing		✓	✓	✓
UVR Creation/Dissemination			✓	✓
FIMS query of USS Network for UTM information			✓	

Note: It was understood that many of the functions, communications and decisions occurring in the use case narratives would likely be automated by the USSs and FAA. Explicit callout to automation was avoided to focus on the information exchange and flow of operations.

The objectives of the ConUse were to present a vision and describe the associated operational and technical requirements for developing and operating within a UTM environment. The ConUse does not prescribe solutions or specific implementation methods except where necessary for purposes of clarification. It instead describes the essential conceptual and operational elements associated with UTM operations that will inform the development of solutions across the many actors and interested parties involved in implementing UTM. It is possible and expected that additional capabilities, services, and offerings, although non-essential, may be available within the UTM construct [5].

3.2 NextGen Integration and Evaluation Capability Laboratory Role

The NIEC Lab, located at the WJHTC, focuses on future capabilities across the NAS, including evaluation of FAA initiatives and activities, such as the UPP. Beginning in Spring 2019 and continuing through late Summer of 2019, the NIEC lab integrated and tested industry partners' capabilities in preparation for the UPP Phase 1 flight trials. The NIEC Lab played a pivotal role as the host and test environment for the UPP, leading the following activities:

- Technical transfer point for NASA UTM technologies and prototypes, including FIMS.
- Development, testing, and integration of FAA UTM services and environment.
    - FIMS servers in Amazon Web Services (AWS) Virtual Machines (VMs)
    - Facilitated software operation in AWS VMs
    - Developed visual portals to be used during demos to facilitate the presentation of the demonstration
        - Public Portal
            - Shows UVRs and simulates a potential public facing portal
        - Admin Portal
            - Internal viewing tool used for showing information, such as current operations
    - FIMS and FIMS Authorization (Authz)
    - USS Discovery – used by NIAS
    - InterUSS – used by MAAP and NPUASTS
- Integration of industry partners' systems to the FAA UTM test environment and coordination of technical interchange between industry and the FAA.
    - Worked with partners to onboard USSs and maintain FAA UTM infrastructure for the demonstration.

- Provided partner connections to the test environment.

Figure 3 provides a high-level representation of the NIEC Lab's UPP Phase 1 architecture.

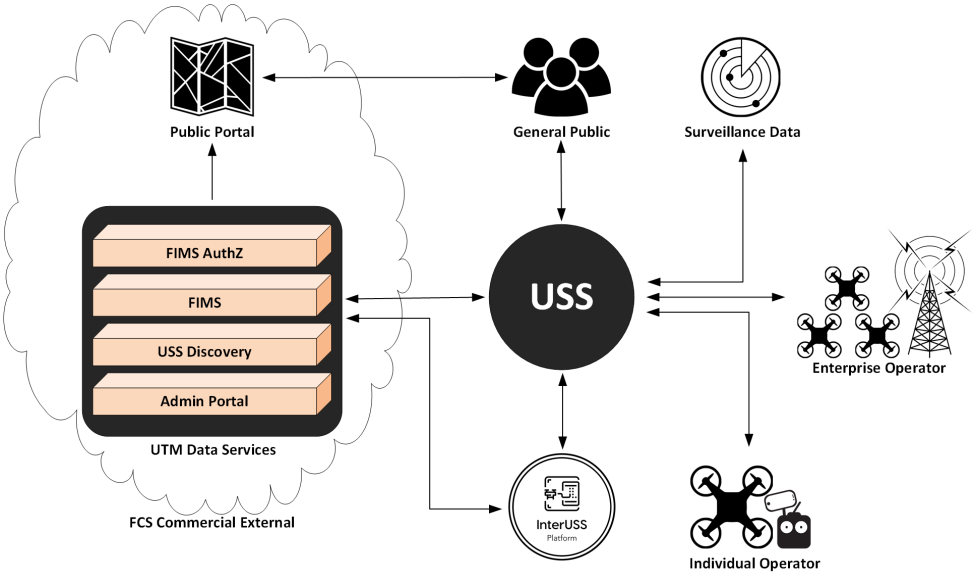


Figure 3: NIEC Laboratory High-Level UPP Phase 1 Architecture

4 Partnerships, Demonstrations Execution, and Outcomes

On January 14, 2019, U.S. Department of Transportation Secretary, The Honorable Elaine L. Chao, announced the FAA's selection of three test sites to partner with the agency in the UPP Phase 1 (shown in Figure 4):

- The Virginia Tech, Mid-Atlantic Aviation Partnership (MAAP)
- The Northern Plains UAS Test Site (NPUASTS)
- The Nevada Institute for Autonomous Systems (NIAS)

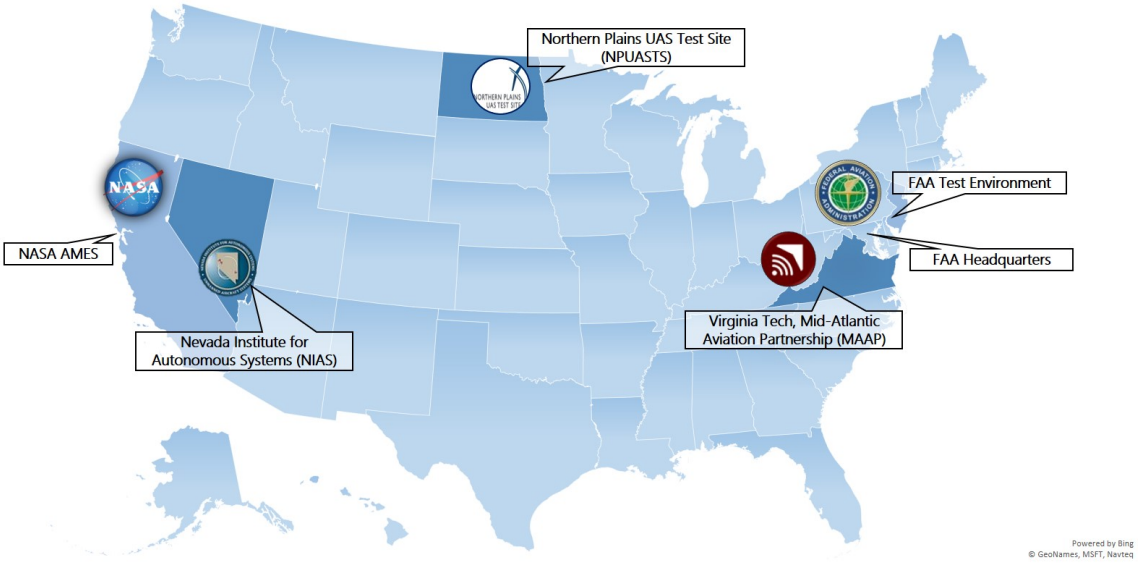


Figure 4: UPP Phase 1 Selected Test Sites

The capabilities demonstrated as part of the UPP Phase 1 are represented in Figure 5. These capabilities demonstrated an expansion of the capabilities currently available through LAANC and the Drone Zone that will eventually enable more complex UAS operations once deployed. Expanded UTM operations and baseline capabilities were supported by the demonstration of enterprise services during the UPP Phase 1 activities. The UPP Phase 1 demonstration participants were able to share information and dynamically adjust operations. As part of the demonstrations, the FAA provided on-demand access to applicable information regarding UTM operations.

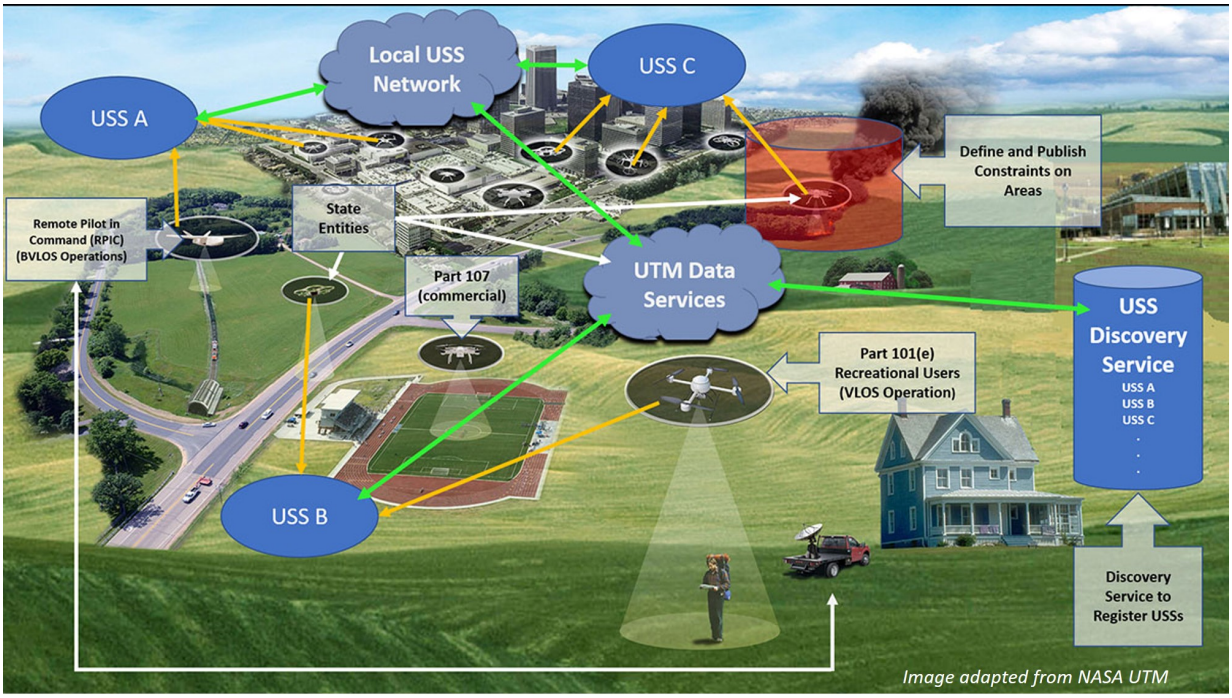


Figure 5: Capabilities to be Demonstrated as Part of the UPP Phase 1

The UPP Phase 1 was designed and executed by the test sites in collaboration with the FAA, NASA, and test site industry partners as a series of flight shakedowns and flight demonstrations, where they executed several live flights combined with simulated UTM operations. The final demonstration and preceding shakedowns were executed while participating vehicles (real and/or simulated) were connected to FIMS via communication with a USS, and with that USS connected to the UDP. The USS implementation employed in the UPP Phase 1 demonstration adhered to the FIMS-USS API documentation and the USS Network documentation.

Execution included the use of current regulations to support Part 101(e) and Part 107 operations. The test sites obtained all necessary approvals, if any were needed, to operate in the NAS, including approval to operate BVLOS or Extended Visual Line of Sight (EVLOS).

4.1 Virginia Tech, Mid-Atlantic Aviation Partnership

MAAP partnered with proven, commercial USSs, UAS operators, and aircraft manufacturers that could achieve the defined VLOS and BVLOS use cases and demonstrated additional operations, including operations over people. MAAP's UPP Phase 1 demonstration built on existing operational systems with a history of successful testing to NASA's Technology Capability Levels (TCLs), FAA-approved LAANC providers, and capabilities that reduced the required development effort by the FAA to support testing.

MAAP's team of industry leaders, including AirMap, AiRXOS, ANRA Technologies, senseFly, and Wing, brought multiple capabilities representing industry efforts to support the UTM initiative. These companies represent four different USSs that have taken different approaches to the development of their individual capabilities. Notably, AirMap and ANRA focus on Area Based Operational Volumes (ABOVs), while AiRXOS and Wing focused on Trajectory Based Operational Volumes (TBOVs). The use of both ABOVs and TBOVs in the demonstrations will provide the FAA with data it can use in designing UTM systems and interfaces that support industry needs while following existing regulations. Figure 6 shows an overview of MAAP's team participating as USSs and UAS Operators. For additional details on each partner's participation, please see Appendix B, Section B.1.

Figure 6: MAAP UPP Team and Functions

4.1.1 Operational Environment and Capabilities

At MAAP, all operations were conducted under 14 CFR Part 107, including those operations that represented Part 101(e) hobbyist flights.

4.1.1.1 Flight Locations

MAAP's activities were performed at Kentland Farm. The Kentland Farm Agricultural Research Center is owned by Virginia Tech and contains the Kentland Experimental Aerial Systems lab. The 1,800-acre Kentland Farm is bordered on the south and west by the New River and covers 2.6 miles corner-to-corner.

The Kentland Farm includes a 70-foot-wide by 300-foot-long asphalt airstrip and two hangar bays with restrooms and a projection screen. The airstrip is located well within the farm's boundaries and were used for takeoffs and landings of fixed wing UASs. UASs capable of vertical takeoff and landing were launched and recovered anywhere within the airspace that was deemed safe and clear of the research center's employees, vehicles, and structures.

On the southeast side and immediately adjacent to the operational area is the Radford Arsenal. The Arsenal's campus covers an area of 4.5 square miles and hosts some 350 buildings (many bunkers) covering approximately 1.3% of the campus. This area is also listed in yellow on a Visual Flight Rules (VFR) sectional aeronautical chart/map, implying it is a populated area. Additionally, there are two military training routes crossing the operational area with one having its airspace floor on the ground surface. Figure 7 shows an aerial view of the flight locations.

Figure 7: Kentland Farm and KEAS Lab Aerial Views

4.1.1.2 System Overview and Architecture

Figure 8 shows the overall UTM architecture used by the MAAP team during the UPP Phase 1 demonstration. The USS and test management teams were able to access displays for each of the USSs. FIMS connected to the USSs and provided information on UVRs to the UTM public portal. This is a minimal example of a potential real-world UTM architecture for USSs cooperating in the same environment and using the InterUSS discovery service.

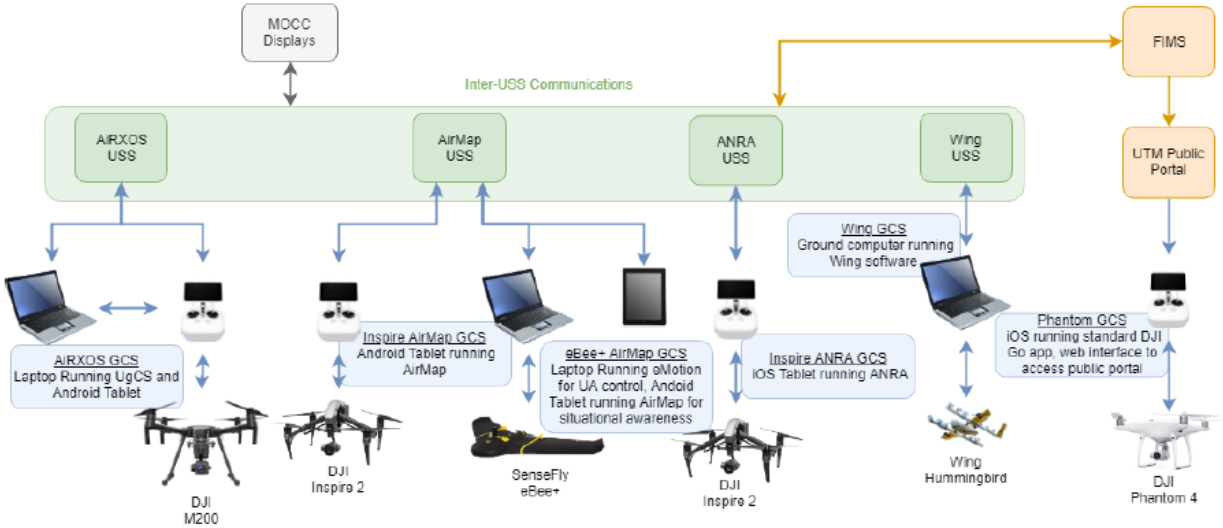


Figure 8: MAAP UTM Demonstration Architecture

The network diagram for MAAP's UTM system is shown in Figure 9. The VT Mobile Operations Command Center (MOCC) was utilized for displays and test administration and was connected to the UTM services via the VT Local Area Network. Flight Location 1 used an Ubiquiti wireless data link to connect via the MOCC network. Flight Locations 2, 3 and 4 all used cellular hotspots to connect to the UTM services. The utilization of a cellular network as a communication method is another example of potential options for UTM in the real-world.

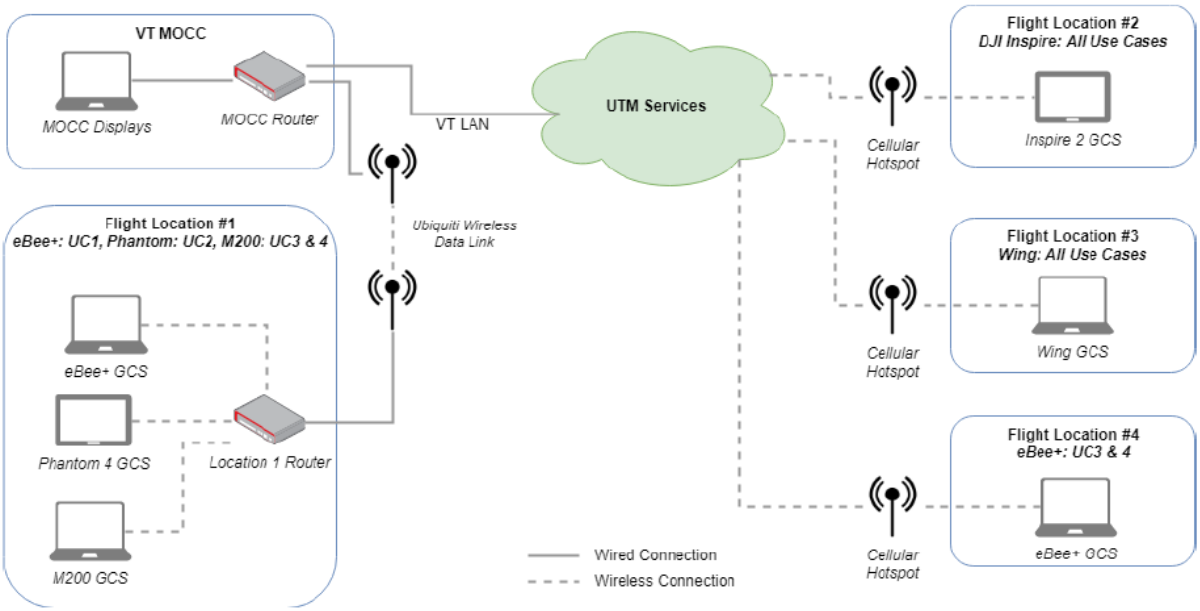


Figure 9: MAAP UTM Demonstration Network Diagram

4.1.1.3 Capabilities

During the planning and execution of the UPP Phase 1 activities, MAAP concentrated on six capabilities that were tested for UTM functionality:

1. UAS Operator to USS Data Exchange – This capability tested specific API commands and confirming responses. The data exchange between USS operators was for the purposes of discovery and situational awareness information to be passed on to UAS operators.
2. USS to USS Communication – This capability tested inter-USS connections through a Local USS Network (LUN).
3. Enterprise Services via API – The data exchange between the FAA and USSs was expected to be bidirectional. USSs coordinated information between their customers and passed information to the FAA. The FAA provided information to USSs regarding authorizations and information transmission confirmations. Additionally, the FAA had the option to query information about past flights from USSs for safety auditing purposes [12].
4. UVR Viewing – This capability tested the creation of UVRs by the designated USSs. ANRA and AiRXOS tested USS-UVR processing.
5. Shared Information
6. UVR Service via API

Each area had partner-specific test objectives and, in some instances, general objectives that applied to all participants in that test area.

4.1.2 Scenarios and Use Cases

MAAP developed three use cases to test the desired UTM interactions [12].

1. VLOS & BVLOS Operations in Uncontrolled Airspace

2. UVR in Uncontrolled Airspace
3. UVR in Controlled Airspace

To ensure the correct interactions, the start and stop times of different planning/operation phases were scripted and listed in the Use Case outline based on the order of events. However, to maintain an operationally relevant demonstration, the actual flights were not scripted. The individual RPICs executed the given mission as required. For safety reasons, there were limits, such as altitude, location, etc., that the RPICs needed to follow. Table 2 below provides a summary of test interactions for MAAP's use cases.

Table 2: MAAP Summary of Use Case Interactions

Type of Information	Providing Information	Accessing Information	Description of Interaction	UC 1	UC 2	UC 3
Operation Intent Parameters	RPIC/Operator	USS	Utilizing the USS's interface, the RPIC/Operator relays the operation intent (volume, UAS info, etc.) to its connected USS.	✓	✓	✓
Operation Intent, Preflight	USS	USS Network	Prior to flight the USS forwards the operation intent to the LUN.	✓	✓	✓
Relevant Flight Data/Messages	RPIC/Operator	USS	Relevant flight data between operator and USS. This includes live position for BVLOS.	✓	✓	✓
USS Messages	USS	Operator	General USS related messages sent to the operator. These include notifications of other UAS operations and notifications of UVRs.	✓	✓	✓

Type of Information	Providing Information	Accessing Information	Description of Interaction	UC 1	UC 2	UC 3
USS Message Acknowledgement	RPIC/Operator	USS	The RPIC acknowledging any messages sent by the USS. An acknowledgement message is sent back to the USS.	✓	✓	✓
UVR Request	Originator	USS with UVR Capabilities	Request for a UVR made to USS by approved individual.		✓	✓
UVR Messages	USS with UVR	USS Network FIMS	Receiving USS forwards UVR on to the LUN and FIMS.		✓	✓
	FIMS	Public UTM Portal	FIMS publishes UVR to a public portal.		✓	✓
UAS Facility Maps	FAA	USS	Pre-test the FAA supplies facility maps to the participating USS. For the UPP, this will be a simulated facility map.			✓
Authorization Request	Operator	USS	Operator (107) requesting authorization to operate in controlled airspace.			✓
Automatic Authorization Message	USS	Operator	Message sent to operator after operator shares an operation intent that is within controlled airspace.			✓

Type of Information	Providing Information	Accessing Information	Description of Interaction	UC 1	UC 2	UC 3
Automatic Authorization Record	USS	FAA	Automatic authorization record is sent from the USS to the FAA via FIMS for Part 107 operations in controlled airspace.			✓
101(e) Notification Request	Operator	USS	Hobbyist UAS operator requesting the USS to notify the airport operator.			✓
101(e) Notification Message	USS	Airport Operations	USS forwarding the 101(e) notification to the airport operator via email.			✓
Operation Data Relevant to Regulator Information Request	USS	FAA	Post-flight, the FAA requests that all USSs provide data for a specified timeframe.		✓	

4.1.2.1 Use Case 1: VLOS & BVLOS Operations in Uncontrolled Airspace

This use case demonstrated the operation planning and operation intent sharing capabilities. It also demonstrated the shared situational awareness provided by USSs. Figure 10 presents an overview of the operational scenario of this use case.

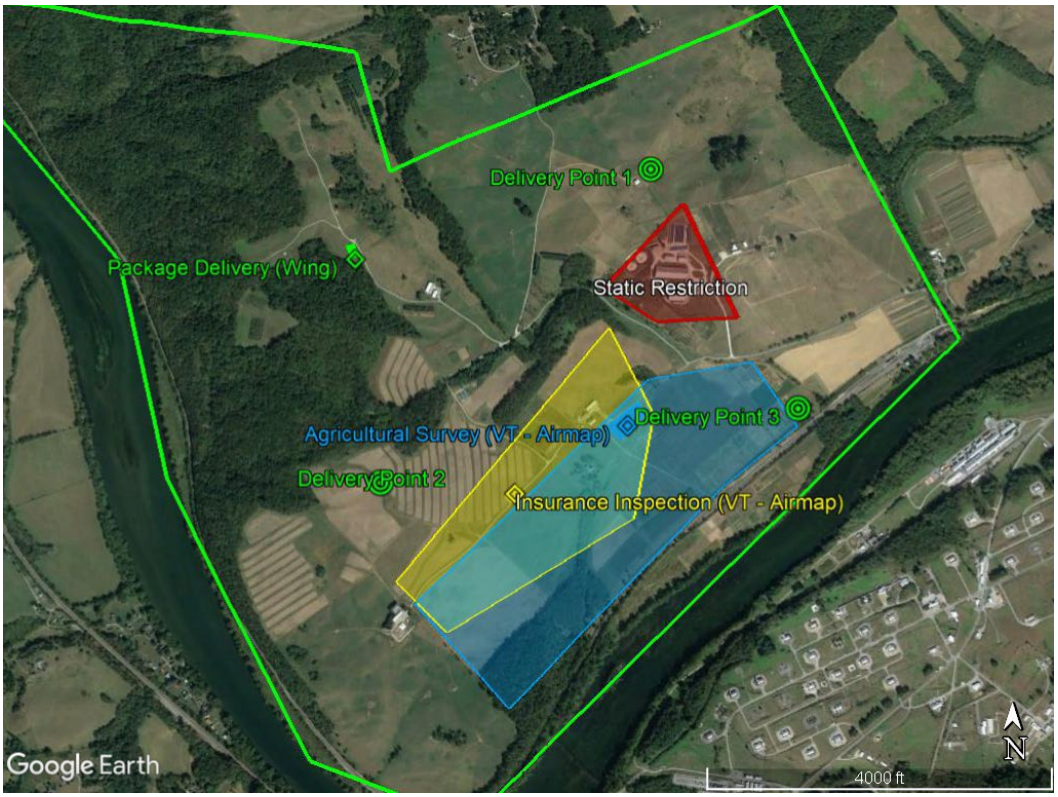


Figure 10: MAAP Use Case 1 Operational Overview

4.1.2.1.1 Scenario Narrative

In the aftermath of a major storm, three operators conduct UAS operations:

1. An insurance company inspects a residence and a few farm structures for damage from hail and high winds.
2. A farmer maps his fields to determine if there is any damage to the crops.
3. A package delivery company delivers needed supplies to the area to support recovery efforts.

All operations are conducted under Part 107 VLOS except for the package delivery operation, which operates under a waiver for BVLOS. All operators are actively seeking to share their operation intent with other UAS operators in the area. The insurance company utilizes the AirMap USS to develop their operational plan and share their operation intent with the LUN. The farmer checks his AirMap USS for flights in the area and notices that the insurance company flight volume overlaps his own but chooses to operate there and remain clear through visual separation. AirMap publishes the operation intent of the two operators to the LUN. The package delivery company has multiple deliveries to make in the area and coordinates around those to conduct multiple BVLOS deliveries of needed goods while publishing the LUN through the Wing USS.

4.1.2.2 Use Case 2: UVR in Uncontrolled Airspace

This use case demonstrated a USS processing a UVR, FIMS processing a UVR (including the display of the UVR to the Public Portal), and the FAA's capability to query participating USSs.

For this use case, the UVR was filed using the ANRA USS by MAAP test personnel. The timing of the UVR was based on the events in the use case outline and was determined by the Test Director for each iteration of the use case. After the test was completed, the Test Director requested that the FAA initiate a historical query. Figure 11 presents an overview of the operational scenario of this use case.

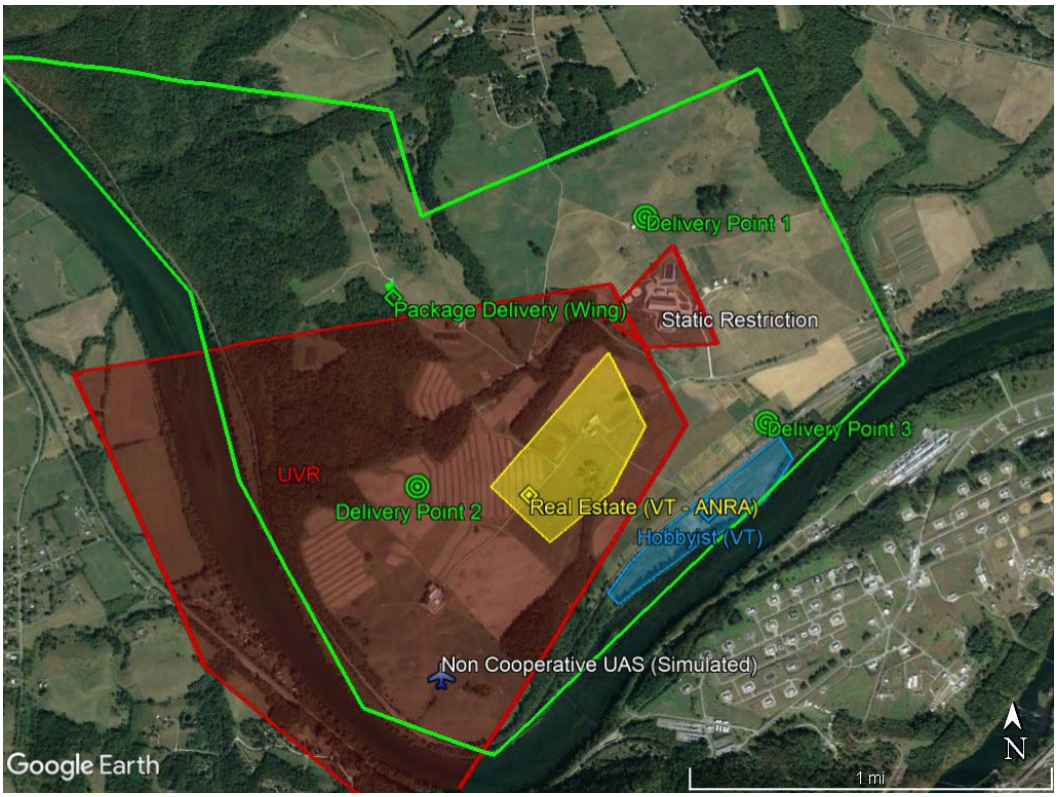


Figure 11: MAAP Use Case 2 Operational Overview

4.1.2.2.1 Use Case Narrative

Wing conducts routine BVLOS package delivery operations to rural areas around the Kentland Farm area using the Wing USS. Wing also shares the operation intent, as appropriate, with the LUN. Meanwhile, a real estate agent wants to obtain aerial imagery of a house and surrounding property. The real estate agent uses the ANRA USS to check for nearby UAS operations and to share their operation intent. It is determined that these two operations do not conflict with each other, and they start their operations accordingly. Nearby, a recreational user wants to fly near the New River to take video of the local trains and his friends kayaking on the river. The recreational user does not use a USS but instead uses the FAA Public Portal to monitor for any UVRs that may occur during his flight and does not actively monitor the operations of other airspace users.

During the UAS flights, a report of a capsized boat on the river with missing persons comes into the local sheriff's office. To expedite the response, a SAR helicopter (simulated) is called in to help facilitate the location of the missing persons and the boat. The SAR helicopter operator files a UVR through the ANRA USS and takes off shortly thereafter from the Blacksburg airport. Wing receives notification of the UVR and determines there is no conflict for some delivery locations while others are within the SAR reservation. The real estate agent receives the same notification

and determines that he must change course and decides to cease operations for the day. The recreational user also receives a notification and checks the FAA Public Portal, determining that no conflict exists and therefore continues operating.

During the SAR mission, the simulated helicopter has a 'near miss' with a small UAS flying near the border of Kentland Farm. The pilot makes a report about the near miss to the FAA upon returning to the Blacksburg airport, and the FAA subsequently queries the UTM system for details. The UTM system provides data from the operators that are using a USS, who are both in compliance, but no data is available for the non-compliant operator.

4.1.2.3 Use Case 3: UVR in Controlled Airspace

This use case demonstrated operation planning and operation intent sharing within controlled airspace. It also demonstrated a USS processing a UVR, FIMS processing a UVR (including the restriction to the Public Portal). Figure 12 presents an overview of the operational scenario of this use case.

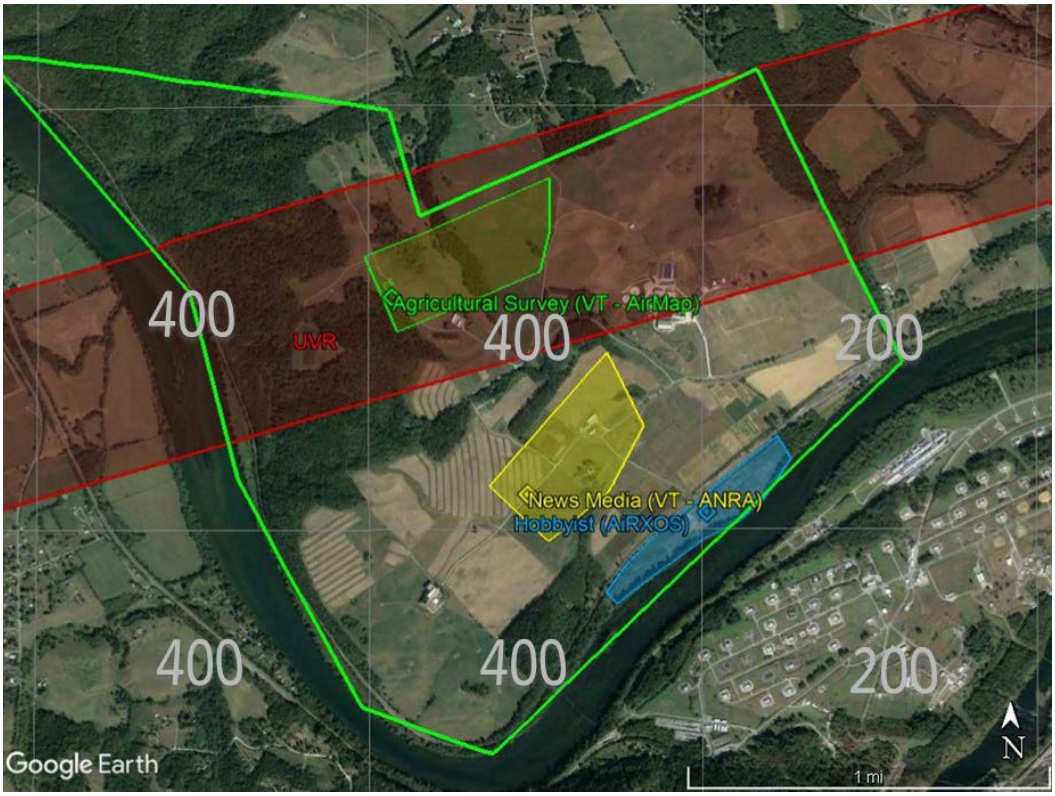


Figure 12: MAAP Use Case 3 Operational Overview

Note: This demonstration was performed in uncontrolled airspace, so the LAANC grid in the narrative was simulated. The USSs processed the flights as normal for uncontrolled airspace and assumed that the individual operators had "approval." The UVR was filed using the AiRXOS USS by test personnel. The timing of the UVR was based on the events in the use case outline and was determined by the Test Director for each iteration of the use case.

4.1.2.3.1 Use Case Narrative

A local farmer is conducting a routine VLOS agricultural survey near the vicinity of a controlled airport that has an approved LAANC grid similar to Roanoke-Blacksburg Regional Airport (ROA). The farmer utilizes the AirMap USS for LAANC approvals and to provide operation intent to the LUN. Meanwhile, a hobbyist wants to fly nearby and uses the AiRXOS USS to create his operation plan and obtain LAANC approval. The hobbyist also makes sure that his flights do not interfere with the planned agricultural operations in the area. Nearby, a local news outlet prepares to do an aerial broadcast for the evening news from the local courthouse which is in the controlled airspace. The news outlet uses the ANRA USS to develop an operation plan, which includes deconfliction with the other UAS operations in the area through the USS.

The hobbyist and survey aircraft launch for their respective missions, and shortly thereafter, a call goes into the local hospital that a critical patient transfer is needed. The local emergency medical services (EMS) helicopter service is located outside of the controlled airspace; however, the hospital is within the controlled airspace. The EMS operator uses the AiRXOS USS to request a UVR for the transit into and departure from the hospital for the patient pickup. The agricultural survey and hobbyist operators both receive notification that a new UVR has been filed in the area. The survey operator checks this notification and determines that there is a conflict, which necessitates a temporary halt of operations in the conflicting area. The hobbyist determines that there is no conflict and continues with their ongoing operation. The news media operator is notified of the upcoming UVR and determines that there is no conflict between their operations volume and the reservation volume. The news media operator proceeds with operations as planned.

4.1.3 Demonstrations Execution

MAAP's UPP Phase 1 activities consisted of three test events:

- Shakedown #1: A simulated test to fully verify all the systems and subsystems required for the flight testing.
- Shakedown #2: Live flights in the UTM environment.
- Final Demonstration: Live flights in the UTM environment.

4.1.3.1 Summary of Shakedown #1 and Simulated Testing

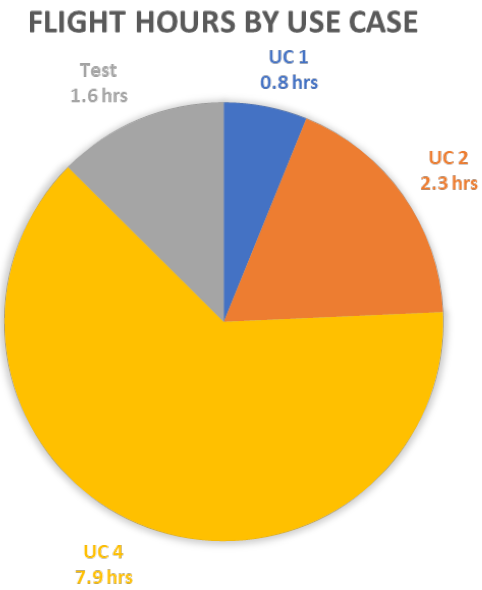
Shakedown #1 was conducted April 22-23, 2019. The Shakedown #1 architecture was very similar to the demonstration architecture shown in Figure 8. Since it was simulated, the major difference was the UAS systems and how they operated, either software in the loop or hardware in the loop. By design, the simulated architecture applied the same USS-to-USS and UAS-to-USS communications as the demonstration architecture.

Overall, Shakedown #1 testing was successful in the primary objective of testing the end-to-end system intended for the UPP Phase 1 demo flights in a simulated environment. During the shakedown, the team conducted two iterations of Use Case 1, two iterations of Use Case 2, and one iteration of Use Case 3. There were issues identified from Shakedown #1, with a few being critical items that needed to be fixed prior to the final demonstration flights.

The issues identified in Shakedown #1 were addressed and validated during three other simulated test events. Retest 1 was performed on May 14, 2019, and Retest 2 was performed on May 20, 2019. Both of these retests involved a modified use case that included Wing, AirMap, and ANRA. This use case was specifically designed to test the fixes to the issues experienced during Shakedown #1. Lastly, the team performed one more simulated test on June 4, 2019 to validate Use Case 4 and fixes for the last remaining open items prior to Shakedown #2.

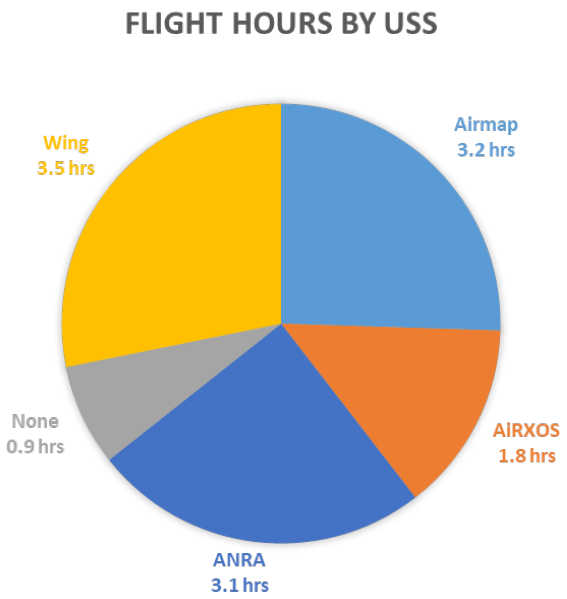
4.1.3.2 Summary of Shakedown #2 and Final Demonstration

Shakedown #2 was conducted June 10-12, 2019, and the UPP Phase 1 Final Demonstration was conducted on June 13, 2019. During this combined test event, the team successfully completed two iterations of Use Case 1, two iterations of Use Case 2, and four iterations of Use Case 4. A total of 106 live flights were performed for a total of 12.5 flight hours. Use Case 3 was omitted from Shakedown #2 and the Final Demonstration, as it was deemed unnecessary since Use Case 4 met all the necessary test points. Figure 13, Figure 14, and Figure 15 show a summary of the flights performed.



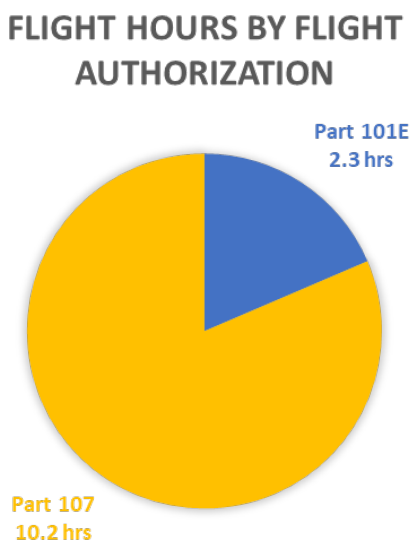
Use Case	Flight #	Flight Time (hr)
UC 1	9	0.8
UC 2	22	2.3
UC 4	56	7.9
Test	19	1.6
Grand Total	106	12.5

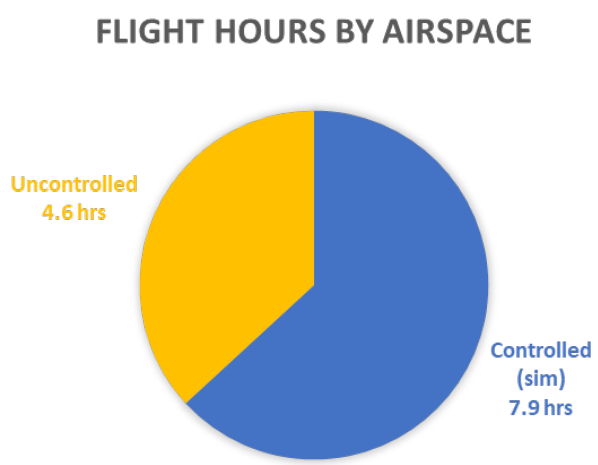
Figure 13: Flight Number and Hours by Use Case (Shakedown #2 and Final Demonstration)



USS	Flight #	Flight Time (hr)
Airmap	20	3.2
AiRXOS	12	1.8
ANRA	16	3.1
None	6	0.9
Wing	52	3.5
Grand Total	106	12.5

Figure 14: Flight Number and Hours by USS (Shakedown #2 and Final Demonstration)





Flight Details	Flight #	Flight Time (hr)
Part 101E*	**13**	**2.3**
Controlled Airspace (sim)**	8	1.5
Uncontrolled Airspace	5	0.8
Part 107	**93**	**10.2**
Controlled Airspace (sim)**	48	6.4
Uncontrolled Airspace	45	3.8
Grand Total	106	12.5

** Flights represented 101E flights, but were actually flown as 107*
*** Controlled airspace was simulated in the Use Case Narrative*

Figure 15: Flight Number and Hours by Flight Authorization and Airspace (Shakedown #2 and Final Demonstration)

4.1.4 Lessons Learned

During all testing, the performance of the overall UTM system was monitored. The following sections consist of lessons learned on the operational viability of UTM as deployed for the MAAP UPP Phase 1 testing, based on user feedback.

4.1.4.1 UTM Performance in Testing Environment

By the end of Shakedown #2 and during the Final Demonstration, the UTM performed well overall in the UPP Phase 1 testing environment. All pilots were notified and were aware of overlapping flight volumes and UVRs. During all testing, there were no instances of a violation where one UAS entered another UAS's airspace. However, much of the success of the UPP Phase 1 testing was due to the testing environment. Based on test planning, most operations were separated to minimize the risk of collisions. In addition, test personnel were monitoring all flights and interactions to ensure safety, and all pilots for the UPP Phase 1 testing were trained and had previous experience operating during large-scale tests. Given these aspects, the UPP Phase 1 testing revealed operational challenges to be overcome for large scale UTM operations.

One of the biggest challenges preventing the operational use of UTM is a "barrier to entry" for normal operators. Inconsistent and limited functionality of the USS pilot interfaces supporting UTM operations has the potential to overload the pilot. At the current level of maturity, the UTM system would be used to support more complex operations, rather than be used in normal everyday situations. Overcoming these challenges will require the UTM system to:

1. USSs to make UTM functionality transparent to the pilot.
2. Better ensure that safety critical information is readily displayed and persistent.

Below is a brief description of the operational viability of the tested UTM system, organized by the capability areas tested during this program. The following sections provide more detailed assessment of the issues seen with UTM during this effort.

4.1.4.1.1 Capability 1: UAS Operator to USS Data Exchange

UAS operator to USS communications was an area in need of large improvement to transition to an operational system. Much of the focus up to this point in UTM development has been on establishing the standards needed for USS to USS communication, but similar standards for UAS operator to USS communication have not been developed. Of specific concern was the pilot interfaces, which experienced many deficiencies in showing the needed information to the pilot. Notifications of critical items, such as overlapping volumes and UVRs, were not consistent or prominent enough. The altitude issues (described in detail in Section 4.1.4.1.9) led to pilot confusion. Pilot interfaces were also prone to failing or crashing during testing.

Another area of concern was lack of operator visibility into the status of the USS. This allowed a UAS operator to conduct a flight without knowing if USS functionality was degraded. If the USS is relied on for airspace deconfliction, this is not acceptable.

4.1.4.1.2 Capability 2: USS to USS Communication

USS to USS Communications have been a major emphasis during previous UTM development and testing and thus is closer to an operational system. The major current issue with USS to USS communication is consistency of operations. Throughout the UPP Phase 1 testing it was evident that there was inconsistent performance. This was most likely due to a limited amount of testing with the complete UTM system. Most testing was done by individual USS providers without interfacing with other USSs.

4.1.4.1.3 Capability 3: USS-UTM Data Services

The communication between the USS and FIMS worked well during the UPP Phase 1 testing. There were initial problems with the historical query where several USSs did not respond to the request as expected, but these problems were resolved by the end of testing. From the limited data points that the MAAP team were monitoring, the enterprise services via API worked well; however, the NIEC Lab would be better suited to evaluate the operational viability of this capability as tested.

4.1.4.1.4 Capability 4: USS UVR Processing

By the end of the UPP Phase 1 testing, the processing of a UVR was working well; however, the user interface for viewing the UVRs requires more development for an operational system. There were three ways the UVR was viewed during the UPP Phase 1:

1. Utilizing the USS applications.
2. Utilizing the FAA public portal.
3. Processed automatically, as part of the Wing mission planning.

The USS applications displayed the UVRs to the operator, but they were inconsistent, and the UVRs usually were not displayed until after the operator had planned the mission. In addition, the format and standard of the UVR information given to the operator needed be investigated further to ensure usability.

The FAA public portal, as deployed for Shakedown #2 and the final demonstration, worked well in showing the upcoming and active UVRs. The major limits to an operational system were the difficulty in determining the boundary of the UVR visually and the lack of notifications. The UVR 3D volume needed to be properly located relative to terrain, and the interface should have been designed with portable electronics in mind.

4.1.4.1.5 Capability 5: Shared Information

During the UPP Phase 1 testing, there was only one use case that had an overlapping ABOV between two operations. For this use case, the operators were allowed to choose to proceed with the flight if safe. For an operational system it was clear that a level of negotiation between the operations was needed. The operator always had an option of continuing to fly (especially if VLOS); however, an automated negotiation could simplify the deconfliction of multiple operations.

4.1.4.1.6 Altitude Standards

A common issue throughout the testing was inconsistent altitude standards. This affected both the back-end and front-end interfaces. While the USS-to-USS altitude standards have been well established, there is still work to be done setting the altitude standards for UAS-to-USS communications and display to the UAS operator.

4.1.4.1.7 Vertical Datum Conventions

All the USSs tested during the UPP Phase 1 used the World Geodetic System 1984[2] (WGS84) vertical datum to define altitude. However, not all UAS software used the WGS84 vertical datum. This became an issue during the UPP Phase 1 testing with the eMotion-to-AirMap communications. eMotion was the ground control software used to control the SenseFly eBee+ and used the Earth Gravitational Model 1996 (EGM96) vertical datum, which was referenced to the EGM96 Geoid. The difference in these two measurements of altitude is called the geoid separation and is the difference between the ellipsoid and geoid at the given location. An example of this is shown in. At the MAAP test site (Kentland Farms), the geoid separation is 107 feet.

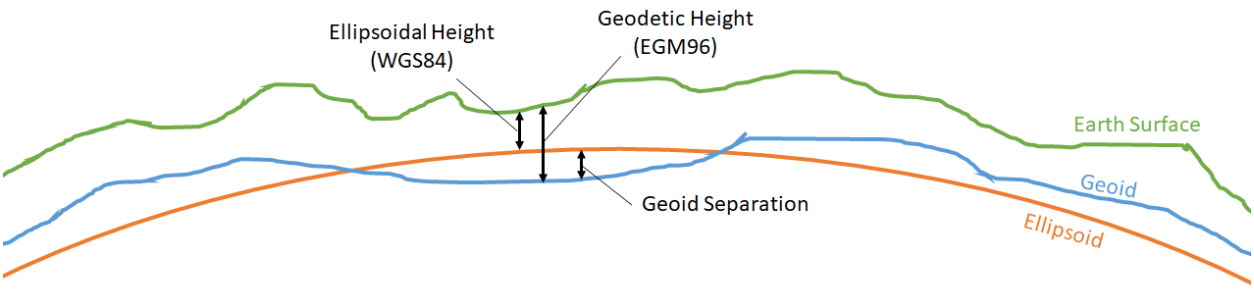


Figure 16: Depiction of the Difference Between Ellipsoidal Height and Geodetic Height

If the difference in vertical datum between the USS and UAS is known and accounted for, this does not inherently cause any issues. However, during the UPP Phase 1 testing, it was not known that eMotion was using a different vertical datum until Shakedown #2. Furthermore, it appeared that when submitting the operation, eMotion sent the ellipsoidal height to AirMap, but telemetry updates were sent using the geodetic height. This resulted in the aircraft going rogue, as it was flying higher than the operation. This issue emphasized the need to make clear in the future what vertical datum is used by the UAS software and what altitude formats are allowable inputs for the USS.

4.1.4.1.8 Altitude Reference Conventions

There are several common altitude references used by UAS systems, as shown in Figure 17. Above mean sea level (MSL) is simply the altitude above the established mean sea level, which varies some based on vertical datum (see Section 4.1.4.1.7). AGL is the altitude above the ground elevation at a given point. AGL will vary throughout a flight, even if the aircraft is maintaining a

[2] WGS84 is the standard reference coordinate system for the Global Positioning System (GPS). It encompasses a reference ellipsoid, a standard coordinate system, altitude data, and a geoid. WGS84 uses the Earth's center mass as the coordinate origin, and geodesists believe the error is less than two centimeters.

constant MSL altitude. AGL is also the standard used by Part 107 to define the maximum operating altitude for UAS. Lastly, above takeoff (ATO) is the altitude as referenced by the takeoff location (or sometimes another location, such as home or ground control station [GCS] location).

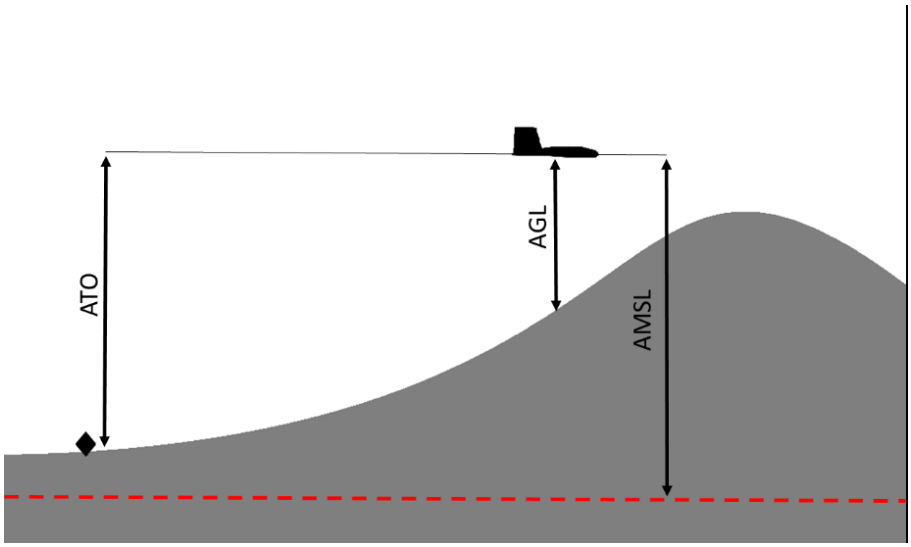


Figure 17: Common UAS Altitude References

During Shakedown #1, there were some incorrect assumptions of altitude references used by UAS software that caused some issues. These were addressed prior to Shakedown #2; however, it highlighted the need to clearly define the altitude reference used by UAS software and expected by the USS.

4.1.4.1.9 Displaying of Altitude to UAS Operator

A consistent issue during the UPP Phase 1 testing was a lack of clarity on the altitude standards used for UAS operator input and notifications sent to the operators. This was an issue experienced both when submitting volumes as well as receiving notifications. For notifications, all the USSs tested gave the notification altitudes in MSL (WGS84). However, many of the systems flown operated in altitude referenced from the ATO altitude. To account for this, the UAS operators were required to keep track of their GCS MSL altitude and make sure they were using the WGS84 vertical datum. Simply pulling the elevation from Google Earth, which was a common practice, would lead to errors because Google Earth used the EGM96 vertical datum. To assist the pilots, the test cards provided for the UPP Phase 1 included the GCS altitude in MSL and an approximate minimum and maximum operational altitude.

This represents another "barrier to entry" for normal Part 107 operations. For the most part, these operations were flown using ATO altitude. Notifications to the UAS operator should have included both the MSL altitude as well as the altitude specified in a reference system the operator chooses (likely ATO altitude). This would minimize the burden of using a USS.

Likewise, a similar confusion could be caused during submission of an operational volume. The method of determining minimum and maximum altitudes varied by USS, with some who used ATO altitude while others used MSL. It should have been very clear what altitude was being submitted and conformed to the standard used by the existing UAS software.

For example, if the pilot was flying ATO altitude, they should have input the operation using ATO altitude. The USS should have then converted the altitude as needed and a buffer added to both the minimum and maximum altitudes. Special consideration would also need to be taken for areas with varied terrain, as the pilot could fly below their takeoff location (negative altitudes in ATO altitude).

4.1.4.2 UVR Processing and Viewing

4.1.4.2.1 Pilot Applications and Notifications

All the pilot applications tested during the UPP Phase 1 were set up to facilitate notification and viewing of UVRs. One exception to this was Wing, which relied on autonomous route planning, described in Section 4.1.4.2.3. Once the initial issues were resolved, most of the pilot applications provided UVR notifications and gave the RPIC the information needed for an informed decision. However, there were several issues noted during testing. Examples of UVR displays in the pilot applications are shown in Figure 18.

- UVR notifications needed to be prominent, and the UVR information should have been displayed to the operator even if they were concentrating on other tasks. The notification of UVRs was handled in several ways, but in some instances the RPIC was focused on the aircraft or other duties and completely missed the notification due to its timing out. The length of time for the notification needed to be long enough to ensure the RPIC would see it. Even if the RPIC missed the notification, the UVR information should have been permanently displayed on the pilot interface; another option would be to require the RPIC to acknowledge the notification before it disappears from the display. Refer to Section 4.1.4.2.1 for a detailed description of general pilot notifications.
- UVR display and information should have been on the GCS interface and been persistent. There were several cases where the UVR information was given to the RPIC, but the information would disappear once the operator returned to flying. This information should have been persistent so the operator could return and review the information as needed. Also, for the eBee+, the UVR information was only displayed on a secondary device, which made it difficult for the operator to compare their current flight plan and location to the UVR.
- While the UVR information needed to be obvious and persistent, it should not have interfered with normal flight operations. One USS instance required the operator to leave the flight interface to click on an email or text and then view the UVR away from the flight interface. Another instance would automatically move the map display to a corner of the UVR, causing a distraction to the RPIC. Ideally, the UVR information would be displayed on the GCS display automatically, and a notification would be displayed in a way that would not interfere with flight operations. The RPIC could then review the UVR information when tasking allowed.
- UVR information needed to be displayed during flight planning as well as flight execution. In most cases, the UVR was not visible to the operator until they submitted an operation to the USS. This resulted in having to re-plan and resubmit until the volume did not overlap the UVR.
- Lastly, as described in more detail in 4.1.4.3, the notification and display of UVR information was inconsistent during testing. This pointed to a need for further testing and

validation. Figure 18 and Figure 19 show screenshots of UVR displays in two different applications.

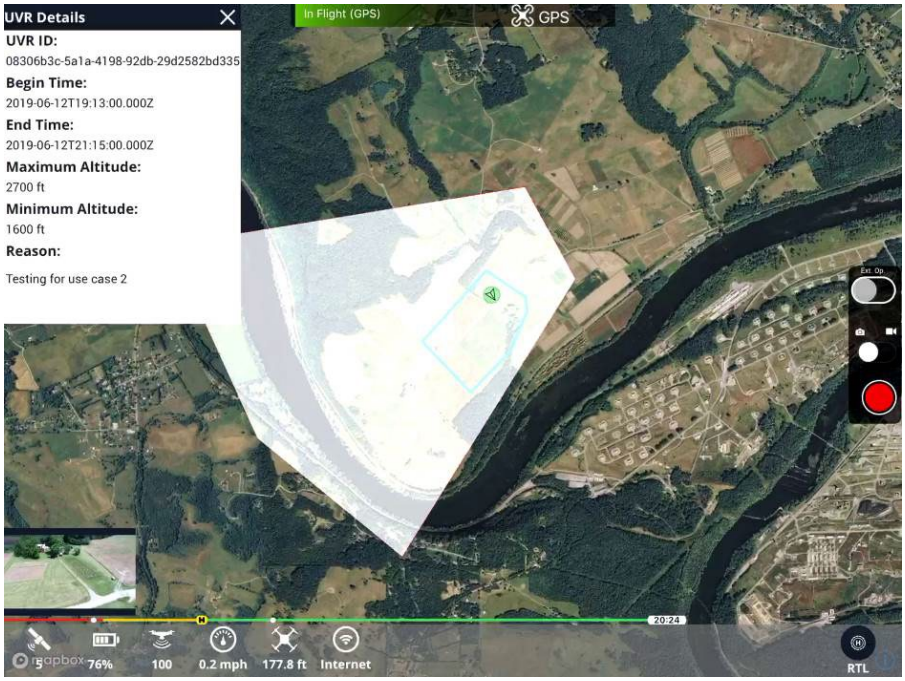


Figure 18: Screenshot of UVR Display with the ANRA USS App

Figure 19: Screenshot of UVR Display with the AirMap USS App

4.1.4.2.2 Public Portal

The public portal was utilized in use case 2 by the "hobbyist" operator to determine if any active or upcoming UVRs would affect their planned flights. During Shakedown #1, it was found that the public portal only showed active UVRs and not upcoming UVRs. After discussion, it was decided that, from a flight planning perspective, visibility into upcoming UVRs was desired. This functionality was implemented into the public portal prior to Shakedown #2. During Shakedown #2, the hobbyist RPIC used the public portal and identified items that would help improve its usefulness:

- The Public Portal functionality should show the min and max altitudes of the UVR (see Figure 20). Including the lower and upper limits of the UVR would improve situational awareness and planning around the area.
- Determining the exact boundary of the UVR proved to be difficult, so the Hobbyist RPIC decided to cease flight operations even though they were not in the UVR boundary. The issue was related to how the map was displayed. The base map was flat and located at 0 feet MSL; however, the UVR was displayed at the MSL altitudes specified by the UVR. This resulted in a parallax that made it hard to determine the actual boundary (shown in Figure 20). Providing a 2D view or modifying how the UVR or base map was displayed would have alleviated the challenge. This problem seemed worse on a mobile screen. When using a laptop, the user could more easily manipulate the view, which helped in determining the correct boundary. In addition, displaying the user's position on the map would also assist in this issue.

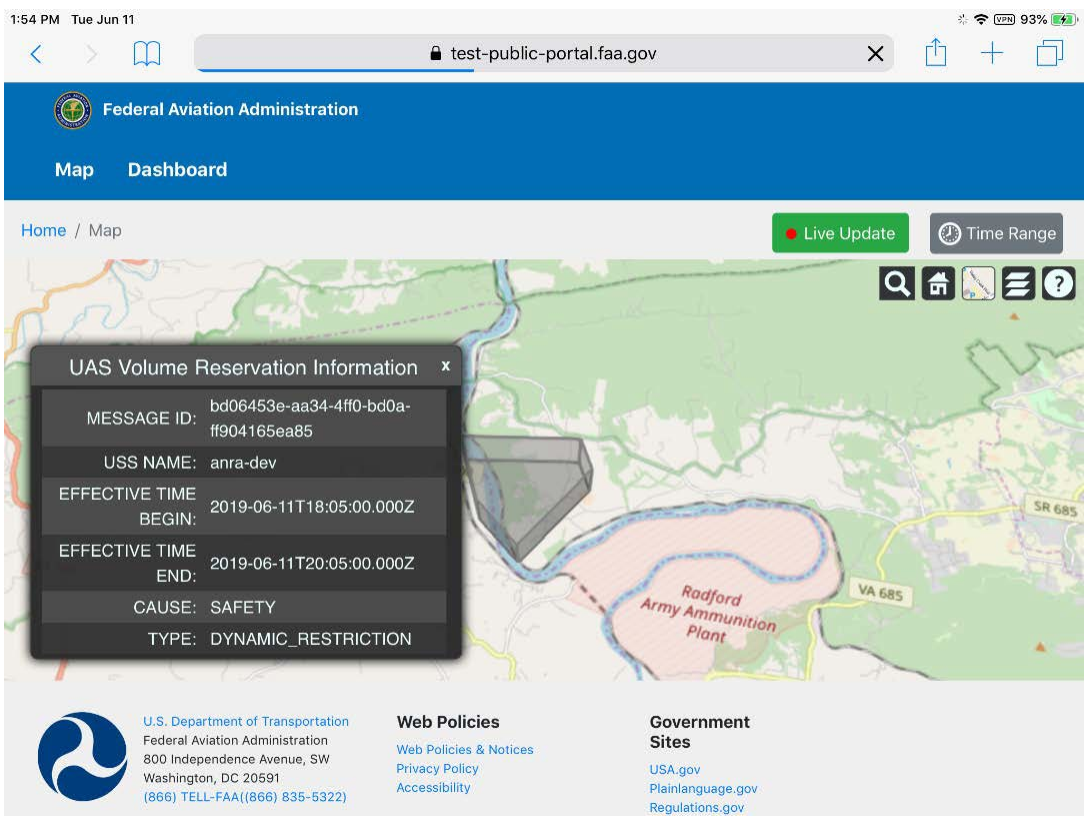


Figure 20: Screenshot of FAA Public Portal on Mobile Device

- During the first run of Use Case 2, the hobbyist RPIC attempted to operate as they would in a real-world scenario and only used one device, both for controlling the aircraft and checking the public portal. To accommodate this, the hobbyist RPIC chose to check for UVRs prior to each flight but did not monitor the public portal during flight. While it didn't happen during the UPP Phase 1 testing, this led to the potential of a UVR being submitted and becoming active before the RPIC noticed it. The addition of some sort of notification to the public portal could help with this issue.

4.1.4.2.3 Autonomous Route Planning

Wing used autonomous route planning for the package delivery flights performed during the UPP Phase 1 testing. Prior to flight, the Wing software would autonomously plan a mission based on a variety of factors, including weather, other operations, UVRs, future wing operations, etc. Once the mission was planned, it was uploaded to the aircraft and could not be changed.

Due to this concept of operations, there was a possibility of accidentally flying in a UVR if the UVR was submitted after the mission was planned and went active before the end of the mission. While the UVR is only intended to be used for notification and situational awareness purposes, flying through the UVR increases the operational risk of the flight and operators would like to avoid flying through a UVR if at all possible.

This could be an issue for an operational system, depending on the time expected between submission and start of a UVR, as well as the maximum endurance of the aircraft using the autonomous route planning. One solution would be to build in the ability to dynamically change the mission profile during flight; however, there are many different scenarios that would need to be addressed, including if the UVR conflicts with all possible return to home routes.

4.1.4.2.4 UVR Meaning and Information

The UVR information given to the UAS operator varied based on the USS being used and should be standardized. In addition, the information given should be in a format that gives the operator the ability to quickly asses if the UVR has an impact to their operation.

- For all USSs tested, the UVR notification included the minimum and maximum altitude of the UVR in MSL (WGS84) standard. While this should be the standard for UVRs and should be provided with the UVR notification, it would also be helpful to display the altitude in the format and datum of which the aircraft is being flown. As described in Section 4.1.4.1.6, many systems operated mostly in above takeoff altitude.
- Also, for all USSs, the start and end time of the UVR was given in UTC time. UTC time should be the standard for UVRs, but this represents another "barrier to entry" for the basic Part 107 operator. The UVR notification should provide the local time in addition to the UTC time.
- Currently, rules have not been made to determine what operations, if any, would be allowed to fly in an active UVR. For the UPP Phase 1 testing, all pilots decided to not fly inside a UVR even though this was not a difficult requirement. For an operational system, it would be helpful for the meaning or level of UVR to be provided to the pilot in the UVR notification.

4.1.4.3 Inconsistent Performance

For the entire UTM system, there was inconsistent performance during testing. For example, the DJI pilot applications had several crashes and exhibited strange behaviors. This included a failure to connect to the sUAS, forcing a complete restart and incorrect battery percentages reported to the operator. Additionally, the USSs had some inconsistent performance and did not always notify other USSs when expected, including when there was a non-conforming or rogue aircraft. This inconsistent performance was indicative of a system that needs further testing and development before being operationally viable.

4.1.4.4 UAS Operator to USS Communication

4.1.4.4.1 Pilot Interfaces

The pilot interfaces represent one of the larger issues with using the tested UTM in an operational environment. Major issues with the pilot interfaces are described below.

- The functionality of the USS applications needed to match the functionality of or be integrated into the standard UAS GCS applications. Especially for DJI flights, the RPICs were required to utilize the standard UAS applications to set up and check important system parameters prior to switching to the USS apps. These important settings could not be viewed in the USS apps, which added to the risk that they may not be set appropriately. In addition, other mission essential settings and checks were not available in the USS applications. This represented a "barrier to entry" for Part 107 operations, as most operators would probably choose to use the UAS application if it had more functionality.
- USS information should be displayed on the GCS to simplify the RPIC's additional workload and to assist the RPIC in making informed decisions. For the eBee+, the USS information was displayed on a secondary display and not overlaid onto the GCS. This increased the pilot workload and made it difficult to accurately assess flight conflicts or UVRs.
- The ANRA and AirMap applications were prone to crashing during the testing, especially when attempting to close volumes or connect to the sUAS.
- Special care should be taken to design the application to prevent pilot task saturation. This was especially true for the eBee+ flights where two screens needed to be monitored. For the UPP Phase 1 testing, each flight team had at least two people while the eBee+ team had three. In an operational environment many pilots would be operating alone.

4.1.4.4.2 USS Status Information

One issue noted was a lack of USS status information provided to the UAS operator. A failure or loss of USS communications was not universally relayed to the operator. The result allowed the UAS operator to conduct the flight mission without knowing that the USS was not providing the needed deconfliction. Pilot interfaces in an operational environment would need to relay important USS status information to the operator to inform their flight decisions. It was also noted that relaying off-nominal issues with neighboring flights could be beneficial. An example would be a loss link event of a neighboring flight. While it was not an immediate conflict, it would give the UAS operator more information to determine the safety of the flight.

4.1.4.4.3 Dynamic Operational Volumes

During Use Case 4, Run 4, the eBee+ RPIC updated the landing profile to account for new winds during flight. The mission profile was updated, but the operational volume remained the same. This resulted in the operation going rogue during landing. This was mostly an issue with autonomous mission-based systems, as they define their operational volume based on the intended flight path. Transitioning these operations to a TBOV instead of an ABOV might be the desired approach. Another option could be to allow the ability to dynamically update an ABOV in flight.

4.1.4.5 Deconfliction of Operations

4.1.4.5.1 Sharing of Operational Information with UAS Operators

For the UPP Phase 1 testing, UAS operators were only notified of other flight operations if they overlapped with the current planned operation. There was some benefit to the notification of nearby, non-overlapping volumes, but it was decided to test according to the TCL4 standard that the USSs had already implemented. It is recommended to further test sharing of operational information with nearby, non-overlapping volumes in future activities.

4.1.4.5.2 Operation Negotiation

Overall, the operational negotiation tested during the UPP Phase 1 was very limited. The only time there was overlapping flight volumes was in Use Case 1. During this use case, there were two overlapping volumes, both filed via the AirMap USS (see Figure 21). The AirMap USS did no negotiation but notified both operators of the overlap.

For Use Case 1, the result of this conflict allowed the eBee+ RPIC to see that the Inspire 2 volume only went up to 250 feet AGL. The eBee+ RPIC could see that during the portion of their flight that overlapped, they would be at 350 feet AGL, and thus made the choice to continue with the flight. The Inspire 2 RPIC saw the overlap but chose to continue with the flight and remain clear of the area of overlap. Figure 21 shows a screenshot of the AirMap app during Use Case 1.

The major issue with respect to the operational negotiation was that the entire interaction was scripted, making it likely that deconfliction would not be as simple as it was in Use Case 1. More work in negotiation will be required for an operational system, much of which will be addressed during TCL4.

Figure 21: Screenshot of eBee+ AirMap Display with Overlapping Flight Volumes

4.1.5 Suggestions for Future Development

According to MAAP, several key areas were determined to be of specific interest for future development:

- Improvement of USS pilot interfaces to reduce or eliminate the "barrier to entry" of Part 107 operations utilizing UTM. This includes improving notifications, expanding functionality, and minimizing the effect to normal operations.
- Investigation and demonstration of more complex UVR concepts, including authorized UAS and varying levels of UVR.
- Investigation and demonstration of various operational deconfliction techniques for overlapping UAS flights, including a level of USS negotiation.
- USS functionality needs to be comprehensive, streamlined, integrated into a single GCS display, and provide safety critical information prominently to the pilot.
- Investigation of UTM performance during off-nominal or failure scenarios (e.g., a USS going offline).
- Ability for operational volumes to be updated during flight to allow for dynamic re-planning of missions.

- More USS health and latency testing. Operators should be notified of degraded USS performance and health.
- More rigorous USS checkout and validation including better software quality assurance and robustness.

4.2 Northern Plains Unmanned Aircraft Systems Test Site

The NPUASTS has been actively engaged with the UTM community through participation in NASA-sponsored UTM workshops, flight demonstrations, conferences, and other interactions. The NPUASTS also works with industry to continue to push the boundaries in FAA approvals and technology development. The environments that the NPUASTS provided for the UPP's flight execution allowed advanced concepts to be explored and executed. Many research efforts in sense-and-avoid, command non-payload communications, cooperative airspace techniques, and UAS operations at airports have provided the NPUASTS with the experience to execute these types of UAS operations to include those in BVLOS environments. These activities and experience obtained through past and current research efforts provides an excellent environment to continue advancing the technologies supporting UTM.

The NPUASTS UPP Phase 1 team included AiRXOS, Collins Aerospace, Simulyze, Inc., Echodyne, L3 Harris, uAvionix, and the University of North Dakota (UND). Figure 22 shows an overview of NPUASTS's team participating as USSs and UAS Operators. For additional details on each partner's participation, please see Appendix B, Section B.2.

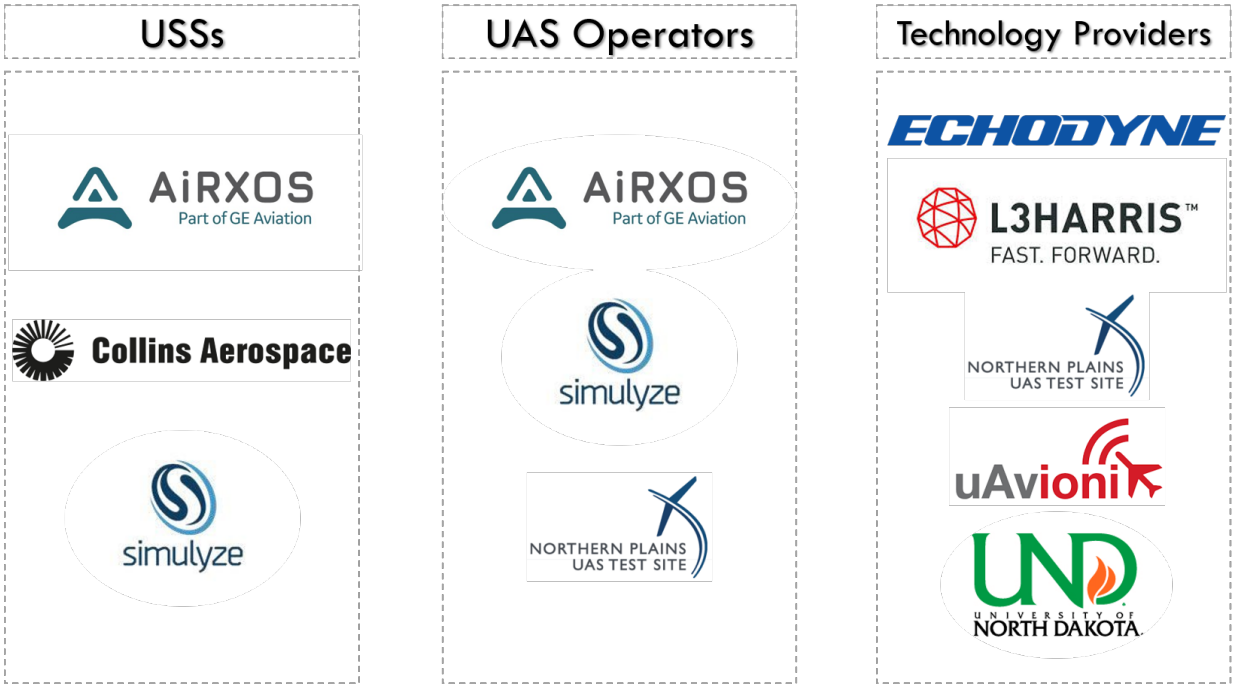


Figure 22: NPUASTS Team and Functions

4.2.1 Operational Environment and Capabilities

4.2.1.1 Flight Locations

Flight tests were performed in the Grand Forks, ND region utilizing the uncontrolled and controlled airspace in and around Grand Forks International Airport (KGFK), which is a Class D airspace. The red circles in Figure 23 indicate the flight locations for the three scenarios. Use Cases 1 and 2 operations were around the Thompson, ND area to include the city park. This location is south of Grand Forks by about eight miles and resides in uncontrolled airspace. Use Case 3 operations were out of the Grand Forks Public Safety Center location on the southwest side of Grand Forks, ND. As seen in Figure 23, this area resides in controlled airspace [14]. Each of the scenario's flight locations are shown later in Figure 25, Figure 26, and Figure 27.

Figure 23: Sectional of NPUASTS UPP Phase 1 Operational Area

4.2.1.2 System Overview and Architecture

Figure 24 depicts the general connections from sensors and systems within the North Dakota UPP Phase 1 architecture. Similar to Figure 8**Error! Reference source not found.**, this is a minimal example of a potential real-world UTM architecture for USSs cooperating in the same environment and using the InterUSS discovery service. There are three groups of functions that support different portions of the architecture. The first group is the USS/FIMS group. There are three USSs connected using InterUSS connection protocols. The USSs and FIMS were connected through a network to share appropriate data from the operations. The second group of functionalities is the supplemental data services suppliers. A combination of sensors ensured proper coverage of cooperative manned aircraft during operations. The third group was the UAS operations. Each

UAS was connected to a UAS ground control station (GCS) through a wireless Command and Control (C2) link. The GCS then sent UAS telemetry data to the UTM client provided by the USS.

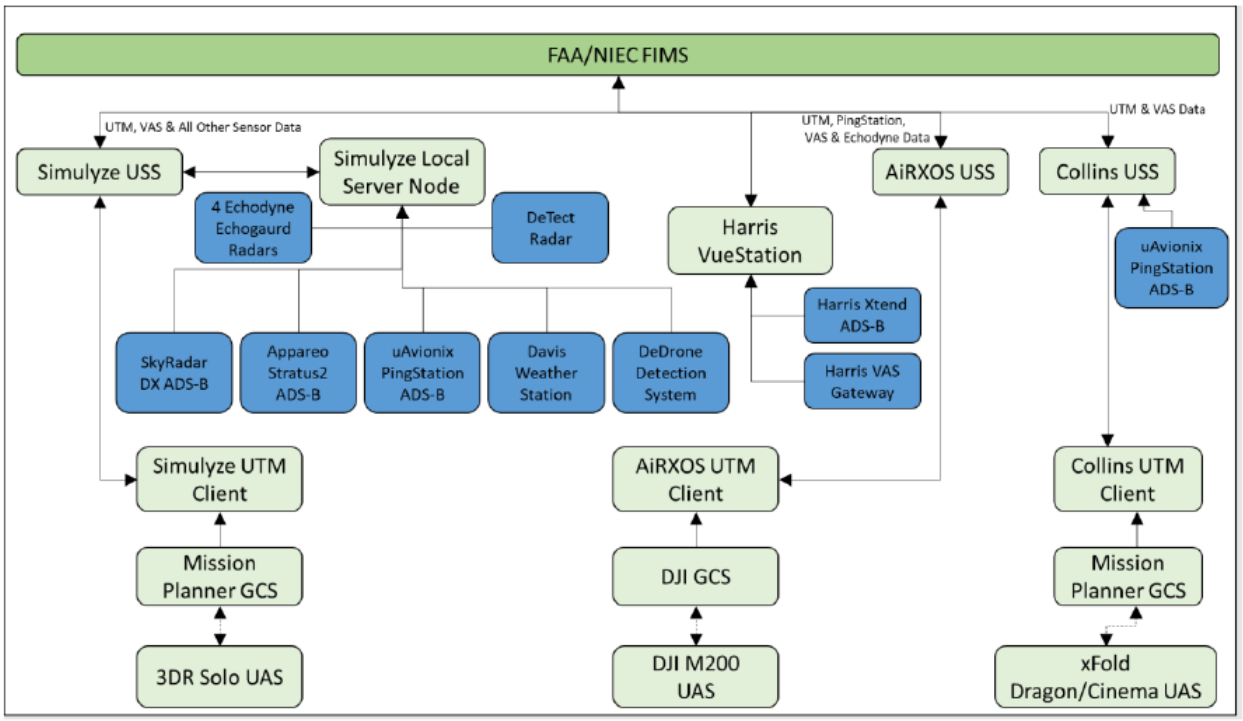


Figure 24: NPUASTS UPP Phase 1 Connection Flow Chart

4.2.1.3 Capabilities

For the execution of the UPP Phase 1, NPUASTS required three capabilities of its partners:

1. USS Development – Each of the three USSs partnering with the NPUASTS were required to have LAANC capabilities and be able to successfully connect to the FAA FIMS. These capabilities were tested through two shakedown periods prior to the final demonstration event. All three USSs participated in NASA TCL3 activities and exercised tests in UVRs, so it was expected that USS development time would be minimal for testing requirements of the UPP, with most time spent on finalizing the LAANC onboarding process and furthering the UVR capabilities in each USS. Efforts were put towards enhancing display and alerting capabilities.
2. UAS-USS Interface – Each USS brought along their own UAS operator, either through a partnering third party operator or internally to the company. Therefore, the UAS-USS interface was already developed and exercised. The USS/UAS operator team provided these functional roles during the shakedown and demonstration events.
3. Human-Computer Interfaces – All USSs developed human interfaces that were utilized in previous NASA UTM TCL activities. These interfaces were continually developed to provide functionality and capabilities to UAS operators and were generally separate displays from the UAS GCS.

4.2.2 Scenarios and Use Cases

NPUASTS developed three use cases to test the desired UTM interactions. These use cases were described in the NPUASTS Demonstration Package [16]. During these operations, there could be non-participating UAS natively operating in the area or purposely introduced to the operations area. These would hopefully be identified by the sensors suite (radars or spectrum sensing equipment), providing data to the UTM system. If they were not, the research team would be diligent at visually acquiring them to remain in a safe operating area.

1. VLOS & BVLOS Operations in Uncontrolled Airspace
2. UVR near VLOS/BVLOS Operations in Uncontrolled Airspace
3. UVR Near VLOS Operations in Controlled Airspace

4.2.2.1 Use Case 1: VLOS & BVLOS Operations in Uncontrolled Airspace

This use case demonstrated the operation planning and operation intent sharing capabilities by servicing USSs to the USS Network. It also demonstrated the shared situational awareness provided by USSs and the flight support provided to meet applicable operator requirements. Figure 25 presents an overview of the operational scenario of this use case.

Figure 25: NPUASTS Use Case 1 Operational Overview

4.2.2.1.1 Scenario Narrative

Two VLOS operators overlap and share airspace via UTM. This occurs at the Thompson park where one operator is monitoring a youth baseball game, and the other is monitoring traffic at the same game. Nearby, a farmer conducts a BVLOS operation to survey farm fields. The baseball game is in between the farmer's launch facility and the farm field, so once the farmer sees nearby operations on UTM, the farmer decides to fly around them. During the game, the operator performing the live streaming returns to its GCS when the battery level is low. The RPIC then installs a new battery and continues flight operations until the mission is complete. Flight over people is not conducted.

4.2.2.2 Use Case 2: UVR Near VLOS/BVLOS Operations in Uncontrolled Airspace

This use case demonstrated the effective use of a UVR on BVLOS, Part 107 and Part 101(e) flight operations. Figure 26 presents an overview of the operational scenario of this use case.

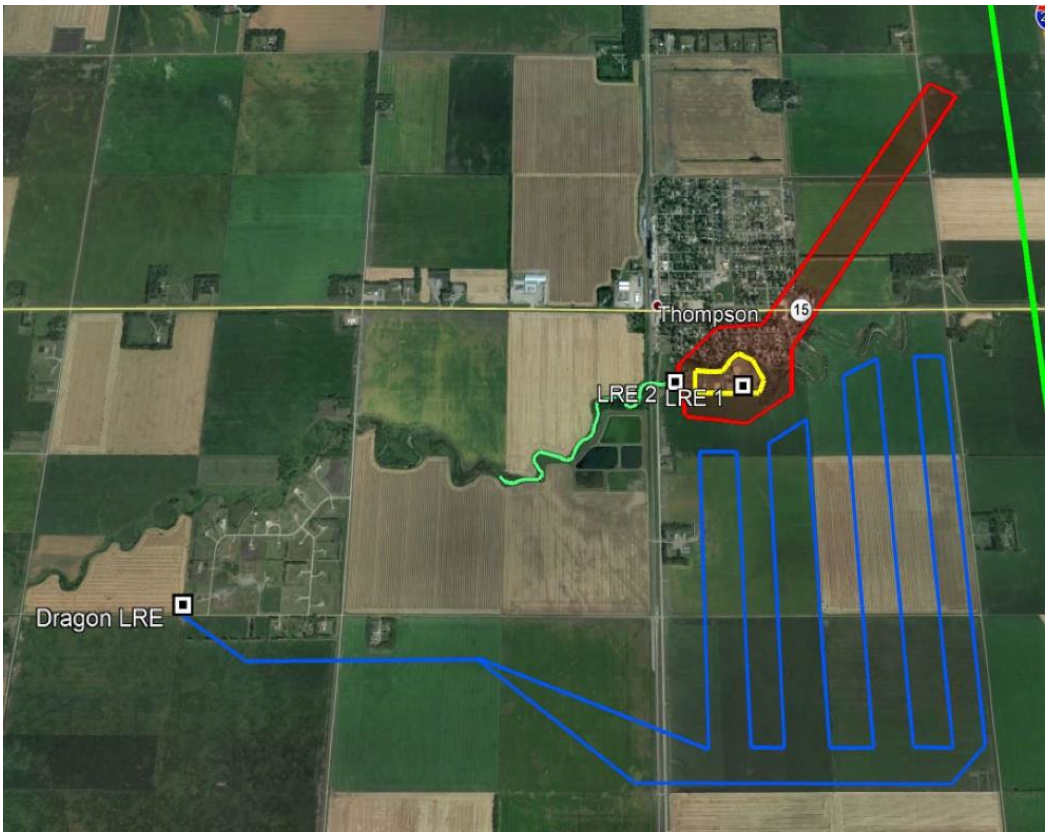


Figure 26: NPUASTS Use Case 2 Operational Overview

4.2.2.2.1 Scenario Narrative

Two VLOS operators conduct flights near but not overlapping each other at a local baseball game. During the game, a player is seriously injured, requiring an EMS helicopter for support. A UVR that overlaps one of the operator's entire operation area is created. The UVR only slightly overlaps the other VLOS operators' operation area. One operator lands the aircraft and the other determines that they can avoid the UVR area or land if UVR traffic is detected. Nearby, a BVLOS operator

conducting agricultural surveys of a field determines the UVR does not affect their operation volume and that original operation intent is in compliance with the UVR.

4.2.2.3 Use Case 3: UVR Near VLOS Operations in Controlled Airspace

This use case demonstrated the ability to have the USSs work with the UAS Facility Maps (UASFM) through LAANC and perform automatic notification of operations to airport authorities, react to UVRs, and volunteer operation intent. Figure 27 presents an overview of the operational scenario of this use case.

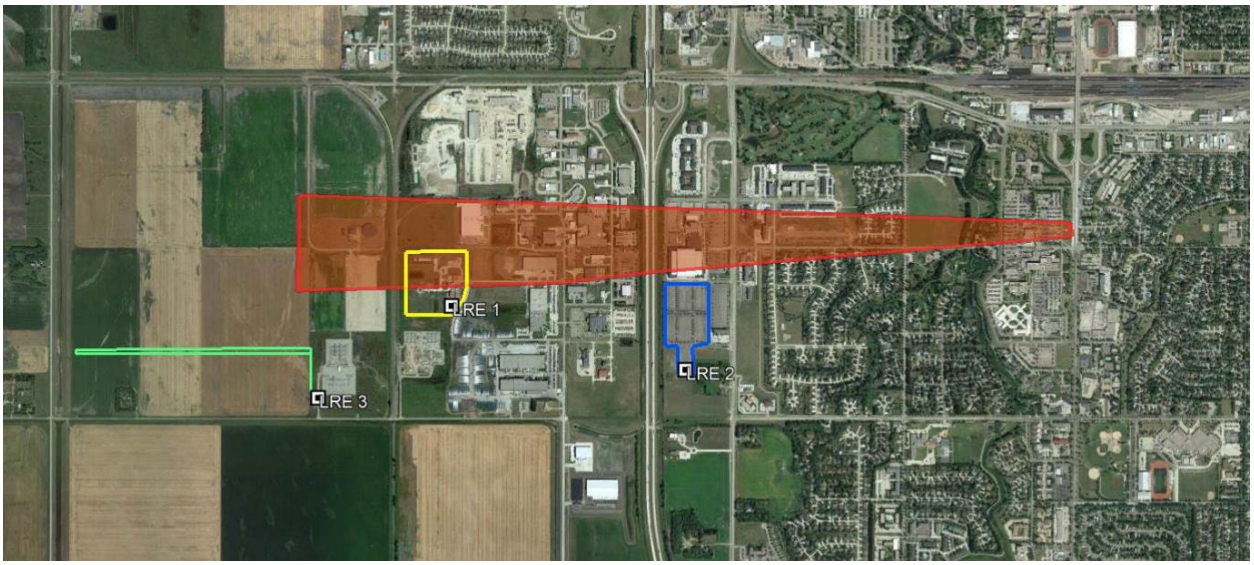


Figure 27: NPUASTS Use Case 3 Operational Overview

4.2.2.3.1 Scenario Narrative

Two Part 107 VLOS operators conduct UTM flights near but not overlapping each other. One Part 107 operator is conducting a geological survey; the other is conducting a powerline inspection mission. Meanwhile, a third operator, a Part 101(e) hobbyist, conducts a flight in the Alerus Center south parking lot to scout out the best tailgating location for the upcoming football season. The Part 101(e) hobbyist is a commercially-rated aviation student at the University of North Dakota working on his flight instructor certificate, so he knows to avoid the other local operations through the use of a LAANC-capable USS. During the flight operations, a UVR notification is sent to USS subscribers for an EMS helicopter after a person is seriously injured at the Grand Forks water treatment plant. The Simulyze operator determines that the UVR affects his mission and decides to land his aircraft before the UVR goes active.

4.2.3 Demonstrations Execution

NPUASTS UPP Phase 1 activities consisted of three test events:

- Shakedown #1: A remote activity focused on connectivity tests between different components of the system.
- Shakedown #2: Live flights in the UTM environment.

- Final Demonstration: Live flights in the UTM environment.

4.2.3.1 Summary of Shakedown #1

Shakedown #1 took place on April 15, 2019 and it focused on connectivity tests between different components of the system. The testing was broken down into two phases. In Phase 1, three connections were tested:

1. UAS-USS Connectivity
2. Sensor-USS Connectivity
3. FIMS-USS Connectivity

During this phase each UAS successfully sent telemetry to their corresponding USS. Initially, the data link for the NPUASTS GCS to Collins Aerospace USS was thought to have had a delay in the data feed. This was addressed and fixed in Phase 2 efforts. Sensor connectivity testing was completed and successful. Additional testing was performed with the Echodyne radars and L3 Harris VAS data feeds. Initial USS checkout with FIMS was completed prior to Shakedown 1 and the third objective was considered successful. Further tests of the FIMS-USS connection were tested in Phase 2. Overall, Phase 1 was successful. A few minor action items were identified from Phase 1 testing and the team addressed those accordingly.

Phase 2 had the following objectives:

1. UAS-USS Connectivity
2. Sensor-USS Connectivity
3. USS-USS Connectivity
4. FIMS-USS Connectivity
5. FIMS Operations Query
6. UVR Submission

The focus of the UAS-USS connectivity testing in Phase 2 was to ensure that the simulated UAS was successfully sending telemetry to the USS in accordance with UTM standards. For the Collins Aerospace USS there was no simulated aircraft. The NPUASTS flight crew transited to the operational location and connected the actual UAS to the USS. All connections were verified as determined by the USS, the NIEC Lab, and the NPUASTS. Sensors were then reverified and it was confirmed that data feeds were still sending data to the appropriate USS.

The USS-USS connectivity test in Phase 2 verified that messages could be sent between USSs in the same grid box as determined by the UTM systems requirements. All connections and messaging were confirmed by the USSs, the NIEC Lab, and the NPUASTS.

As in Phase 1, the focus of the FIMS-USS connectivity testing was to verify that the USSs were successfully able to connect to FIMS and share data. This was verified by submitting a FIMS Operations Query. The query was submitted and validated when the proper information was reported back to FIMS. Verification of the test was successfully confirmed by the NIEC Lab.

The final test of Phase 2 was the UVR submission. The focus of this test was to have a UVR submitted by Simulyze and to validate that the request was disseminated through the UTM system

successfully. All USSs received the UVR and verification was determined by the NIEC Lab and the NPUASTS.

4.2.3.2 Summary of Shakedown #2

The goal of Shakedown #2 was to perform a dry run of the scenarios prior to the Final Demonstration and debug any final issues in the sensor configuration and connectivity, USS connections and communications, and logistical concerns. Each of the three USSs partnering with the NPUASTS were able to successfully connect to the Simulyze Inter-USS Node grid box. All data connections were verified prior to dry run exercises and each use case was executed in sequence.

4.2.3.3 Final Demonstration

Activities for the final demonstration took place during July 8-12, 2019. A formal demonstration event for invited guests was scheduled for Wednesday, July 10, 2019. However, due to inclement weather conditions, a decision was made to run a simulation of Use Case 3 on that date instead. The efforts spent performing simulations proved to be extremely beneficial in the testing of the UTM system. Each team of flight crews and USSs gathered in a room and connected to the UTM system. Use Case 3 test cards were followed to initiate the simulation. The flight crews were able to provide simulated flights into the UTM system and this allowed the team to work on any remaining bugs within the system.

Initially, the goal was to run each scenario a minimum of two times and run two scenarios per day. However, due to weather and schedule modifications, the team was able to conduct operations at a rate of four scenarios per day. This allowed the team to achieve two runs per scenario finishing on Friday, July 12, 2019.

4.2.4 Lessons Learned

During testing, the performance of the overall UTM system was monitored. The following sections consist of lessons learned on the operational feasibility of UTM as deployed for the NPUASTS UPP testing, based on user feedback.

4.2.4.1 Supporting Sensors

Sensors that were deployed during the operations include local ADS-B receivers, four Echodyne Echoguard radars, and a DeDrone detection system with three receivers to triangulate aircraft position. These sensors provided data to the USSs in different ways and each USS was able to properly ingest and display the data from such sensors so that it doesn't confuse the operator. The hardest part of using local sensors display data to the USS was to have the user understand the impacts the information from a sensor could have on the operation if improperly shown to the user.

Just as there are requirements for USS-UAS connectivity to ensure telemetry is feeding the UTM system adequately, the same rigor in USS-Sensor testing needs to be done. The research team was able to run through extensive testing of different sensors feeding data to the USSs, but there remained some ambiguity on the best way to use the data within a UTM system. This discussion topic drives at the heart of USS functionality and being able to offer different services to the

operators. A UTM system does not require supplemental sensors, but the benefits of the additional services are substantial. A USS could offer detect and avoid (DAA) services but would need robust and reliable sensor data to provide such services. This is where the USS and sensor manufacturers work together to provide the best data and service to the operator.

Additionally, sensor data quality is directly related to the sensor location. Depending on how each user deploys the sensor can mean the difference between good and bad data. If the sensor is incorrectly placed, it will provide bad data to the system. The challenge is how the USS controls these types of sensor deployments that are feeding the USS and UTM system.

4.2.5 Suggestions for Future Development

The following are recommendations provided by the NPUASTS based on activities and lessons learned from the UPP Phase 1 efforts:

- It is recommended that USSs can force a re-plan or be able to deny sharing a volume that was previously approved. Currently, USSs have to say 'yes' for another operation that overlaps their previously approve UTM plan. If a UAS operation is uncomfortable with sharing the airspace, this forces them to land and wait until the other operation is done before they can resume with their mission. More robust systems (e.g., aircraft with built-in DAA technologies) could create an environment where they would force other, less robust systems out of the airspace. If the USSs could help the UAS operators with understanding the capabilities of the operators with whom they are sharing the airspace, it may go a long way towards creating a safer shared airspace.
- Unique identifiers for airspace volume requests are important in cases where queries need to be performed on the UTM system. This allows specific volumes to be extracted from a database and identified for analysis if an event were needing further analysis. Through the NASA system, this identifier has been the Globally Unique Flight Identifier (GUFI) number. It is recommended that a different type of identifier is used to allow easier recording and usability for the identification numbers.

4.3 Nevada Institute for Autonomous Systems (NIAS)

The NIAS UPP Phase 1 team was made up of 34 different entities including partners shown in Figure 28. NIAS's technical experience was comprised of e-commerce/mobility leaders, urban air mobility innovators, established aviation networks and infrastructure companies, forward-thinking "smart" cities/communities, and innovative startups. NIAS provided the City of Reno, the City of Henderson, and Searchlight Airpark as diverse locations in the state of Nevada for realizing commercial UAS operations in varied environments.

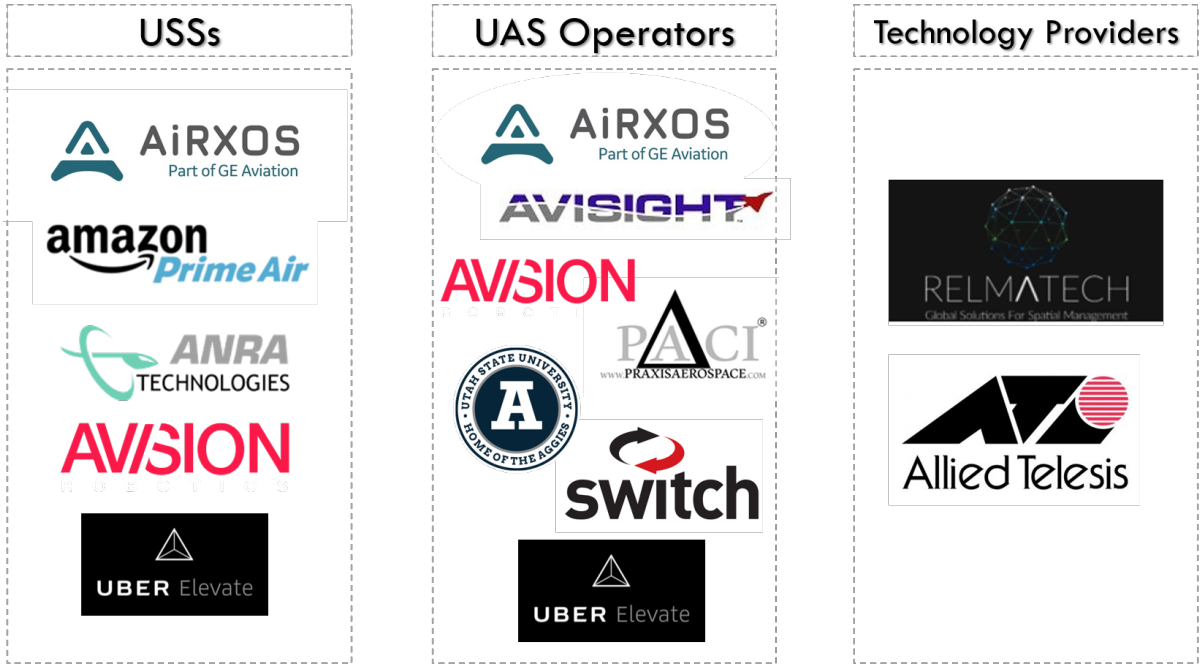


Figure 28: NIAS UPP Team and Functions

The NIAS UPP Phase 1 team performed major roles in prior NASA TCL and FAA projects and worked with industry partners to create a federated and distributed approach to UTM, as well as a highly effective USS-to-USS interoperability model. Fundamental to the NIAS teaming is USS interoperability and collaboration among participating USSs [17]. For additional details on each partner's participation, please see Appendix B, Section B.3.

4.3.1 Operational Environment and Capabilities

4.3.1.1 Flight Locations

The City of Henderson and Nevada State College approved Use Cases 1 (Figure 29) and Use Case 2 (Figure 30) operations at the Henderson Unmanned Vehicle Range (HUVR), and the City of Searchlight approved Use Case 1 (Figure 31) and Use Case 2 operations at Searchlight Airport (Figure 32). Class G airspace was required and fulfilled by both HUVR and Searchlight operations. No environmental or Radio Frequency (RF) spectrum approvals were needed, and no other known approvals are required for this scenario.

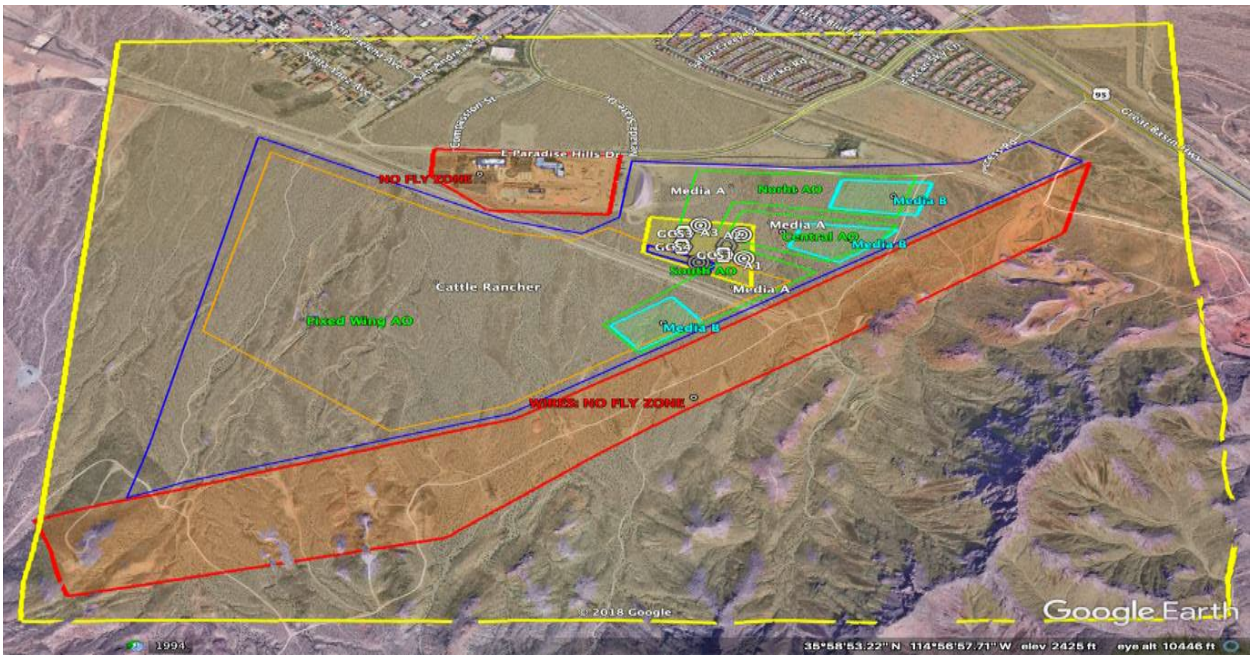


Figure 29: NIAS Use Case 1 Operational Overview – HUVR

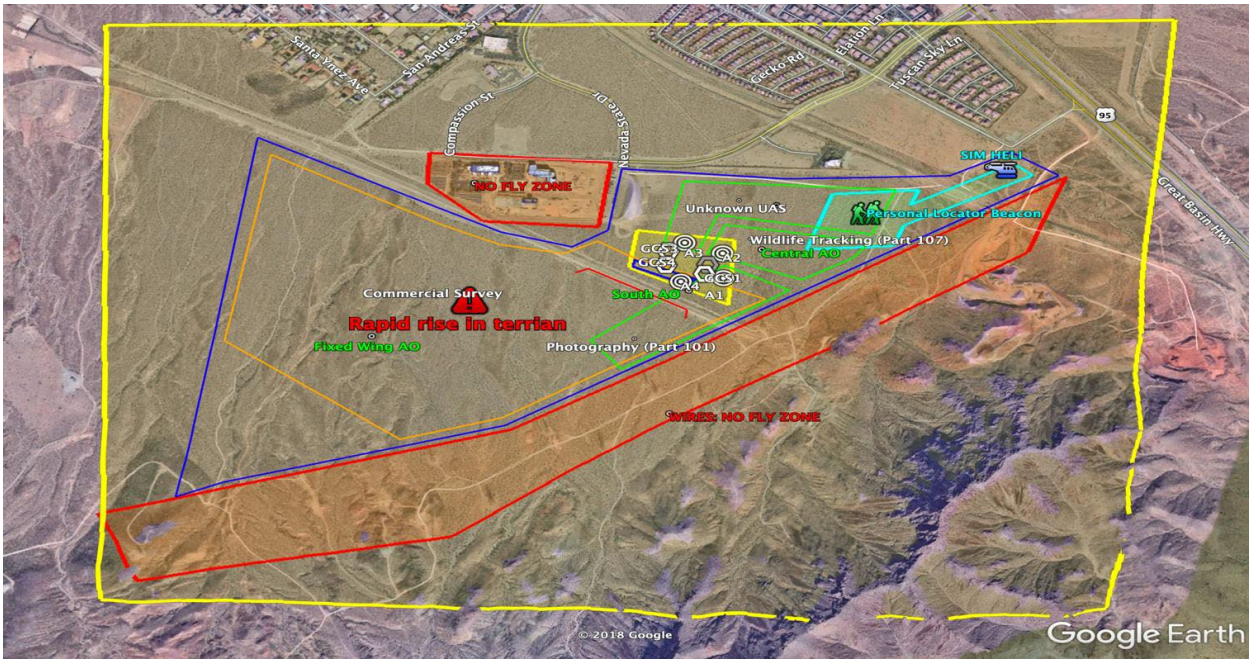


Figure 30: NIAS Use Case 2 Operational Overview – HUVR

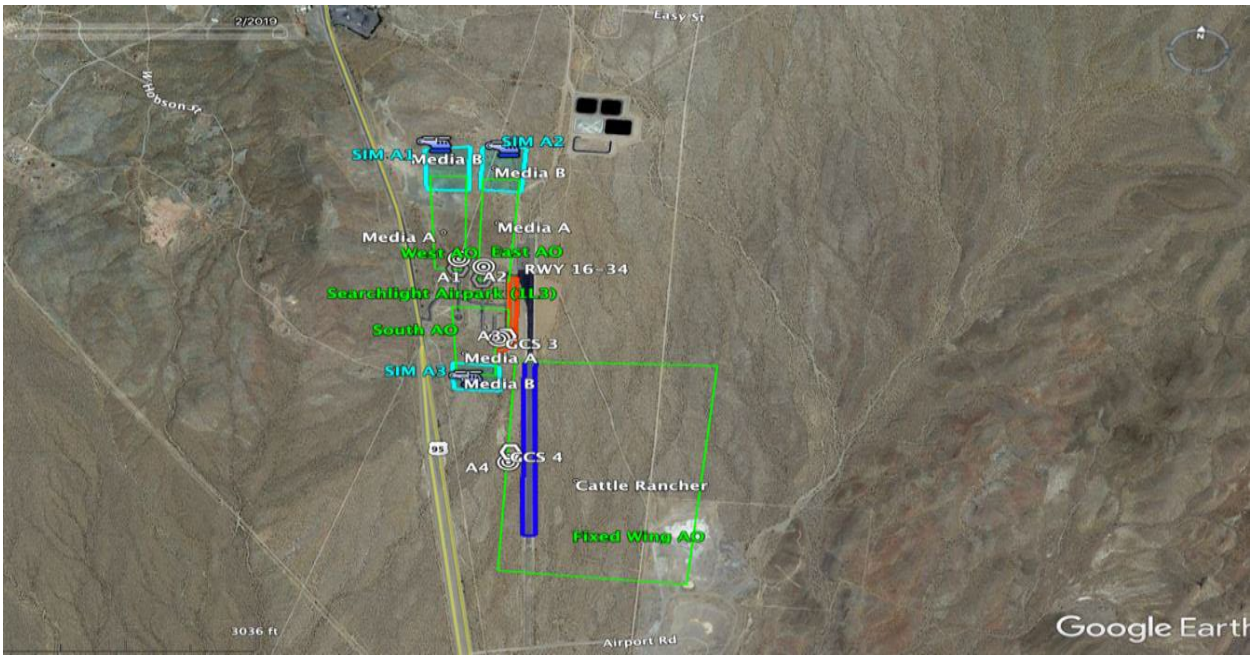


Figure 31: NIAS Use Case 1 Operational Overview – Searchlight Airpark

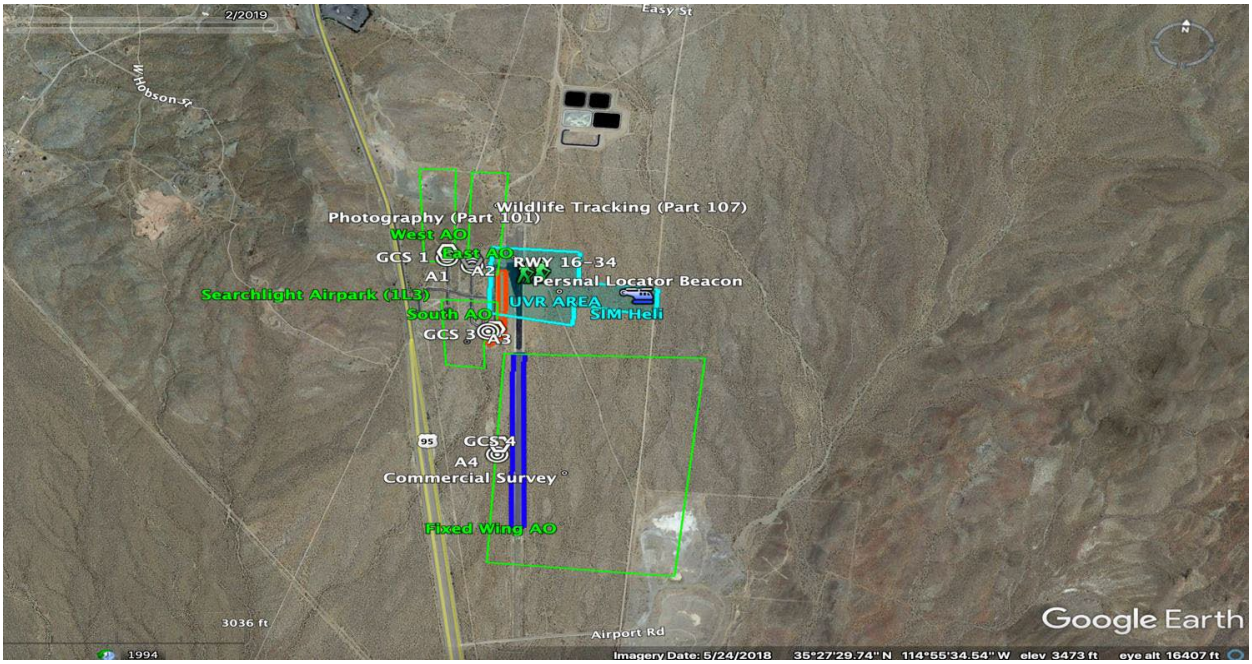


Figure 32: NIAS Use Case 2 Operational Overview – Searchlight Airpark

The Cities of Reno and Las Vegas approved Use Case 3 operations in downtown Reno (Figure 33) and at the Innevation Center (Figure 34). Downtown Reno is Class C airspace with the Reno International Airport (RNO) and the Innevation Center is Class B airspace with McCarran International Airport (LAS). Flight authorizations must be requested via the FAA's approved LAANC, which is effective in Reno and Las Vegas. No environmental or RF spectrum approvals were needed, and no other known approvals were required for this scenario.

Figure 33: NIAS Use Case 3 Operational Overview – Downtown Reno, NV

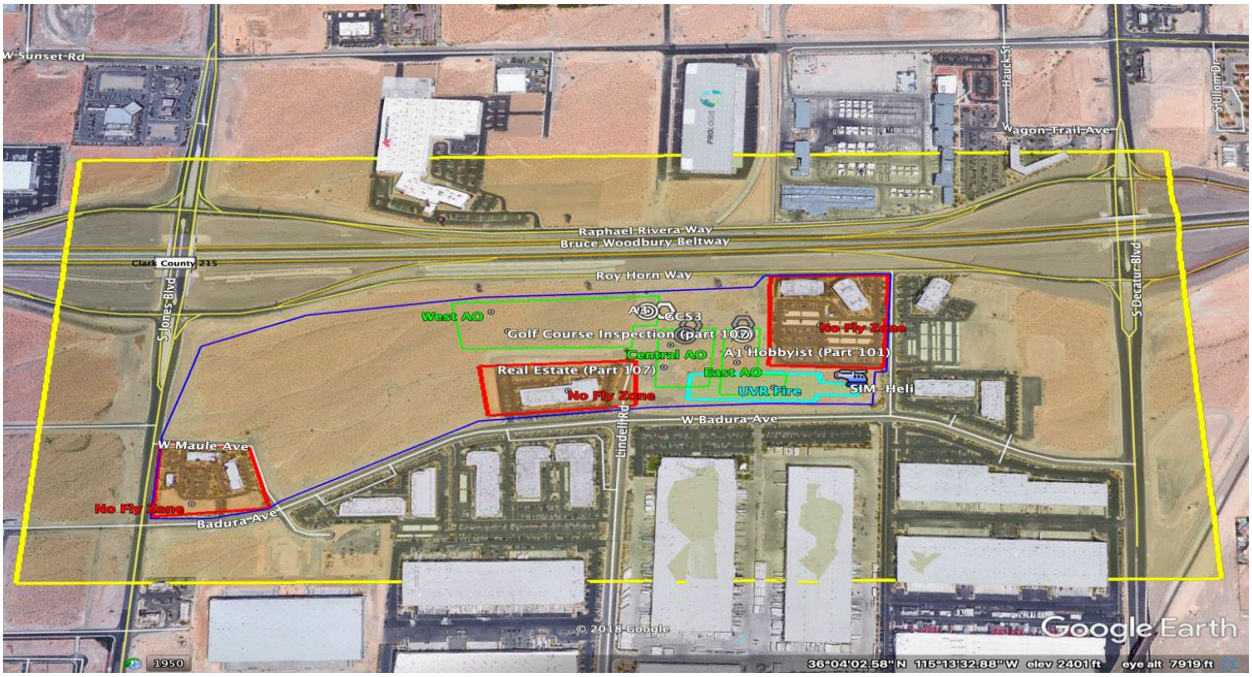


Figure 34: NIAS Use Case 3 Operational Overview – Innevation Center

4.3.1.2 Capabilities

NIAS mapped and integrated the six FAA capabilities into three use case scenarios, as detailed in the NIAS UPP Phase 1 Test Plan [11] and Table 3 below. Additionally, NIAS dynamically supported the FAA by conducting the UPP Phase 1 goals and objectives using live and virtual aircraft in both the Northern and Southern Nevada locations.

Table 3: NIAS Capability to Performance Objective Mapping

Tasks	Capabilities					
	1	2	3	4	5	6
Operation Plan Development	✓				✓	
Operation Intent Sharing by the Servicing USS to the USS Network		✓			✓	
Operation Intent Parameters/Inputs					✓	
Operation Intent, Pre-flight	✓	✓			✓	
In-Flight Modification to Intent	✓	✓			✓	
Situational Awareness of Other Operations	✓	✓			✓	
Flight Support to Meet Applicable Operator Requirements	✓	✓			✓	
Operation Data Relevant to Regulator Information Requirements	✓	✓		✓	✓	
Relevant Flight Data/Messages	✓	✓		✓	✓	
Operation Intent, In-flight	✓	✓			✓	
UAS Volume Reservation Request	✓	✓	✓		✓	
UAS Volume Reservation Messages	✓	✓	✓	✓	✓	✓
UAS Facility Maps	✓	✓	✓		✓	
Other NAS Constraints Subscription Service (e.g., TFRs)	✓	✓	✓	✓	✓	✓
FIMS Query of USS Network for UTM Information			✓	✓	✓	✓
USS Messages	✓	✓	✓		✓	
USS Message Acknowledgement	✓		✓	✓	✓	
Authorization Request	✓	✓	✓		✓	
Automatic Authorization Message	✓	✓	✓		✓	
Automatic Authorization Record	✓	✓	✓		✓	
101(e) Notification Request	✓	✓	✓		✓	
101(e) Notification Message	✓	✓	✓		✓	

4.3.2 Scenarios and Use Cases

NIAS developed three scenarios that reflected its intent to safely conduct operations at multiple locations across Nevada.

1. Shared Operations Between Operators in Uncontrolled Airspace
2. UVR Near VLOS/BVLOS in Uncontrolled Airspace
3. UVR Near VLOS/BVLOS in Controlled Airspace

Table 4 below provides a summary of use case to capability mapping for NIAS's use cases.

Table 4: NIAS Use Case to Capability Mapping

Description		UC 1	UC 2	UC 3
Type of Operation	Part 101(e)	✓	✓	✓
	Part 107	✓	✓	✓
	BVLOS (waivered Part 107)	✓		
Participation	UTM-Participating Operators	✓	✓	✓
	Non-Participating Operators	✓	✓	
Airspace Characteristics	Uncontrolled	✓	✓	
	Controlled			✓
	Near Airport	✓	✓	✓
Operation Plan/Intent Development & Sharing		✓	✓	✓
UVR Creation/Dissemination			✓	✓
FIMS Query of USS Network for UTM Information			✓	
Capability 1: UAS Operator to USS Communication		✓	✓	✓
Capability 2: USS to USS Communication		✓	✓	✓
Capability 3: Enterprise Services via API			✓	✓
Capability 4: UVR Viewing			✓	✓
Capability 5: Shared Information		✓	✓	✓
Capability 6: UVR Service via API			✓	✓

4.3.2.1 Use Case 1: Shared Operations Between Operators in Uncontrolled Airspace

Use Case 1 demonstrates shared information between operators and takes place in uncontrolled airspace at the HUVR and at the Searchlight Airport, Nevada.

4.3.2.1.1 Scenario Narrative

A group of two to four aircraft with up to three additional simulated aircraft were used to meet the flight operation criteria for Use Case 1. This use case was primarily flown under Part 107 VLOS at Searchlight. The USS approved and shared these operations among other participating operators and USSs. Operations included communication procedures between USS and operators, and each were performed through notifications that represented specific conditions of operational status. USSs initiated approval and authorization for operational tasks and track operations within the planned operational volume for flight support. Situational awareness between operators and UTM allowed for safe traffic management.

4.3.2.2 Use Case 2: UVR Near VLOS/BVLOS in Uncontrolled Airspace

The goal of Use Case 2 was to successfully demonstrate a UVR in uncontrolled airspace. Use Case 2 takes place in the same uncontrolled airspace at HUVR and Searchlight Airpark as Use Case 1.

4.3.2.2.1 Scenario Narrative

NIAS used a group of three to four aircraft with an additional simulated aircraft to meet the flight operation criteria for this use case. The flights are a mix of Part 101(e) and Part 107 VLOS and BVLOS operations. Operation planning and development are performed by the flight teams, and USSs approve and share these operations among other participating operators and USSs. The communication procedures between USSs and operators are performed through notifications that represent specific conditions of operational status. USSs initiate approval and authorization for operational tasks and track operations within the planned operational volume for flight support. An outside entity submits a request to a USS to create a UVR. The UVR facilitates a simulated helicopter that needs reserved airspace over a period of time and specifies the altitude to conduct operations near or overlapping UAS operational volumes. UVR information is also shared with FIMS and the FAA. The FAA shares operational information with public portals. Situational awareness between operators and UTM allows for safe traffic management.

4.3.2.3 Use Case 3: UVR Near VLOS/BVLOS in Controlled Airspace

The primary goal of Use Case 3 is to successfully demonstrate a UVR in controlled airspace. Use Case 3 takes place in controlled airspace around the urban area of the City of Reno.

4.3.2.3.1 Scenario Narrative

A group of three to four aircraft with an additional simulated aircraft are used to meet the flight operation criteria for this use case. The flights include a mix of Part 101(e) and Part 107 VLOS operations. The flight teams perform operation planning, and USSs approve and share these operations among other participating operators and USSs. UASFM data is used to gain automated authorization. The communication procedures between USSs and operators is performed through notifications that represent specific conditions of operational status. USSs initiate approval and authorization for operational tasks and track operations within the planned operational volume for flight support.

An outside entity submits a request to a USS to create a UVR. The UVR facilitates a simulated helicopter that needs reserved airspace over a period of time and specifies the altitude to conduct operations near or overlapping UAS operational volumes. UVR information is also shared with FIMS and the FAA. The FAA shares operational information with public portals. Situational awareness between operators and UTM allows for safe traffic management.

4.3.3 Demonstrations Execution

The NIAS UPP Phase 1 activities consisted of four test events:

- Shakedown #1: A simulated test to check all systems and subsystems required are ready for live flight testing.

- Shakedown #2a & Shakedown #2b: Live flights in the UTM environment on different locations.
- Final Demonstration: Live flights in the UTM environment.

During the activities, the NIAS team was able to accomplish 32 operational test missions cumulating in 76 live flights, five for operational checks and 71 for data collection, and 47 simulated USS flight missions.

4.3.3.1 Summary of Shakedown #1

Shakedown #1 was conducted on April 24, 2019. After this activity, Amazon Prime Air arranged and performed direct testing with AiRXOS, ANRA Uber Elevate, and Avision. Objectives met included FIMS registration, flight plan communication, UVR injection, and deconfliction.

4.3.3.2 Summary of Shakedown #2a

Shakedown #2a was conducted on Monday July 1, 2019 at the Reno location. For this event, three separate airspace volumes were in the controlled airspace of the greater Reno metropolitan area and an altitude range of surface-to-300 feet AGL was authorized by the UASFM. All operators filed flight authorization prior to flight using LAANC. Connectivity checks took place between the USSs and the NIEC Lab before operations commenced; however, once operations were underway, the NIEC Lab was not receiving position reports from the aircraft and needed to verify the versions that all USS were using. After discussions between the NIEC Lab and the USSs, the issue seemed to have been resolved and live flight runs restarted. However, during the morning run Uber experienced a C2 issue, which forced a return to land. Additionally, during the afternoon run, the NIEC Lab was seeing the UVR showing a much higher altitude than it was designated (300 feet AGL). After further investigation, Uber communicated to NIAS that it would only be able to support the UPP Phase 1 demonstrations with a simulated vehicle.

4.3.3.3 Summary of Shakedown #2b

Shakedown #2b was conducted on July 22-26, 2019 and included multiple locations.

4.3.3.3.1 Use Case 1: Las Vegas HUVR Location, July 22

For this event, operations were conducted in uncontrolled airspace. During the setup, and as USSs established connection with each other, a few resolvable issues were found regarding position and elevation reporting. During the test, several issues related to heat and software held up flights and only one flight operation was completed. Due to the flights being attempted late in the day, the environment reached extremely high temperatures which made it unfeasible and unsafe for some aircraft to perform and function properly.

4.3.3.3.2 Use Case 1: Searchlight Location, July 23

For this event, operations were also conducted in uncontrolled airspace. USSs communicated that they had worked out bugs and communication issues from the day before. Avision and Uber performed their flight operations as simulations only for this Use Case iteration. ANRA provided the USS for Praxis live flights. A sequencing of the operations was set to take place so that different

operational flight volumes were submitted with the intent to overlap. All "aircraft" flew their assigned volumes without interfering with each other and kept a safe separation from other "aircraft." A total of three test runs were completed this day and all fliers and USSs successfully submitted the overlapping volumes that demonstrated the objective of sharing UTM information.

4.3.3.3.3 Use Case 2: Las Vegas HUVR Location, July 24

For this event, operations were also conducted in uncontrolled airspace. In this use case, a UVR was submitted to allow a search and rescue helicopter (simulated) to fly within the UVR area and an "unknown UAS" was also present. A sequencing of the operations was set to take place so that different reactions to the UVR could be observed. The "unknown UAS" had a simulated near miss with the helicopter and an investigation (i.e., FIMS Operations Query) was conducted.

After connectivity checks were complete, the USS teams conducted a simulation run. The simulation allowed for correct timing of the UVR placement and subsequent simulated helicopter operations. Live flights were performed without issue and the NIEC Lab confirmed successful reporting on its end. Additionally, two runs of Use Case 1 were successfully completed on this date (Use Case 1 had not been fully executed two days prior due to heat factors).

4.3.3.3.4 Use Case 3: Las Vegas Innevation Location, July 25

For this event, operations were conducted in controlled airspace. In this use case, a UVR was submitted to allow a search and rescue helicopter (simulated) to fly within the UVR area. A sequencing of the operations was set to take place so that different reactions to the UVR could be observed. This day's activities were a rehearsal for the Final Demonstration event. The USSs agreed to walk through several simulated runs to assure proper execution of the test card objectives. The ability for all USSs to receive UVR submission input was verified and all checked in, confirming their systems readiness. There was a sequencing error on the first run attempt and the run was reset to go again. The second run attempt was successful and proper sequencing of UVR authorizations and simulated launches were executed properly. The NIEC Lab confirmed that all operations looked good on their end. Run 2 was attempted three times to make sure all operations went well, and no issues were reported.

4.3.3.3.5 Use Case 2: Searchlight Location, July 26

On this date, operations followed the same script as performed on July 24 at HUVR. On this date, there was only a single live UAS operation and all others were simulated. The designated UVR was reported on the FAA public portal for the first run, but this UVR did not show on the second run until it was resubmitted post-run.

4.3.3.4 Summary of Final Demonstration

The Final Demonstration Event was conducted on July 29-August 1, 2019 and also included multiple locations.

4.3.3.4.1 Use Case 1 and 2: Las Vegas HUVR Location, July 29

On this date, both runs of Use Case 1 were executed without any issues reported. During the first run of Use Case 2, Avision was unable to see the UVR so the UAS flight operator did not know when to avoid and land the operation. This issue was resolved on the next run. The UVR was visible on the FAA public portal.

4.3.3.4.2 Use Case 1 and 2: Searchlight Location, July 30

With Use Case 1, there was some confusion regarding overlapping volumes. Once the volumes were properly configured, two runs progressed without issues. Following this, operations transitioned into Use Case 2, and two operational test runs were executed with no issues reported. The NIEC Lab confirmed that all operations were sufficient on their end and the UVR was displayed on the FAA public portal.

4.3.3.4.3 Use Case 3: Las Vegas Innevation Location, July 31 and August 1

During the operations of July 31, the team was able to verify all USSs' ability to receive UVR submission inputs and confirming all checked airspace platforms' readiness. On this date, no issues were reported during live operations.

On August 1, all USSs agreed to walk through several simulated runs to assure proper execution of the test card objectives. Ability for all USSs to receive UVRs was verified. All live operations were performed without issues. This concluded all the UPP Phase 1 flight operations and the NIEC Lab confirmed that all of their received data was sufficient.

4.3.4 Lessons Learned

The diversity of many partners and companies working together proved both challenging and rewarding due to different work cultures and flight operations procedures. One of the major challenges facing the NIAS team was different operational requirements and procedures. A lack of common standard operating procedures and standardized regulatory guidance regarding UTM operations occasionally created delays in operational timelines.

4.3.5 Suggestions for Future Development

The following recommendation was provided by NIAS based on activities and lessons learned from the UPP Phase 1 efforts:

- As the industry continues to progress and mature, a need for standard operating procedures across all participants are necessary to maintain safe and successful operations.

5 UPP Phase 1 Conclusions

5.1 Overall Lessons Learned

5.1.1 Post-Event Survey Results

At the conclusion of demonstration events, test sites and their partners were asked to fill out surveys to determine what improvements can be made for the UPP Phase 2 demonstrations which are currently in the planning stages as well as other demonstration events that are on the horizon. A representative summary of the survey questions and responses that have been received to date is provided below. Full survey results are being compiled and maintained by NextGen.

Table 5. Post-Event Survey Response Summary

Question	Summary of Responses
Please rank your level of confidence in the level of safety of operations during this event?	Respondents agreed that while the events were safe, there were two potential safety issues that should be explored further. First, due to the highly staged nature of the tests, future demonstrations should explore real-world scenarios where there are multiple Part 107 operations occurring simultaneously using only the UTM ecosystem for deconfliction. Second, it was pointed out that operators and UTM participants may erroneously assume that the UTM ecosystem is a safety mechanism, since plans with overlapping airspaces can be approved through the UTM ecosystem. While this provides information to the participant, it is not sufficient from a safety standpoint.
Based on your observation of this event, are there any areas for improvement that can be applied to the next event?	While several of the responses were quite specific to the test events, the respondent was involved with, there was one common theme among the responses. It was pointed out by multiple respondents that the interfaces need to be reworked for better display of relevant information without overloading the pilot with information. Coordination and communication among participants and test conductors, both leading up to and during the demonstration activities, was also cited by several respondents as an area for potential improvement.
Based on this event, what information (if any) did you not receive but needed to take appropriate action?	Most respondents felt they generally received the necessary information. Specific information that could have been made clearer to some respondents includes: standard use of altitude units, better streaming for remote participants, and the improved interfaces that were discussed in the previous section.

5.2 UPP Phase 1 Advances the UTM Operational Environment

The results of the UPP Phase 1 demonstrations will be used to mature the UTM concepts that will be used as the baseline foundational elements for continued UTM policy, standards, capabilities, and concept development. The progress achieved with the UPP Phase 1 is critical to public and private sector entities to provide data on the future activities to support implementation of the UTM infrastructure and supporting systems.

While an initial infrastructure for the UTM ecosystem has been established via the UPP Phase 1 demonstration activities, enhancement and expansion of the UTM framework will follow a phased approach, gradually allowing increasingly complex UAS operations in the NAS. Regulatory requirements and technological limitations will inform the order in which capabilities are developed, demonstrated, and deployed.

6 Conclusion - Path to Implementation

6.1 Overall Strategy for UTM Ecosystem Expansion

As described in the Integrated UTM Concept Description Paper [2], as the FAA moves towards a more agile approach to capability deployment, there is an opportunity for the FAA to define processes to improve the transition from ideas to deployed capabilities that support operational activities. A high-level process describing the overall flow of activities required to move from idea to deployed capability is illustrated in Figure 35. This process flow can be described as having three stages.

1. Identified Service – In the first stage, basic research activities are done in collaboration with industry to move from identified business needs through the initial research, providing the resulting data to the stakeholders responsible for the subsequent stage in a technology transfer package. This transfer package will include initial concepts, initial high-level requirements, any prototype software used in early testing, and results of initial demonstration events.
2. Concepts and Validation – The second stage of this process consists of testing, analysis, and refinement activities, potentially resulting in a demonstration of capabilities in an FAA test environment performed in collaboration with industry. It is anticipated that future capability development will include stakeholders representing both the previous and subsequent stages as collaborators in this stage. A transfer package, including prototype software, test results, initial safety artifacts, and supporting materials, will be transferred to downstream stakeholders upon completion of this stage. Collaboration with those responsible for Stage 3 is currently underway to define this transfer package.
3. Deployment – The third and final stage of this process consists of the activities required for deployment of UTM capabilities. These activities will include final detailed requirements, full security and safety analyses, and other activities required to support operational deployment.

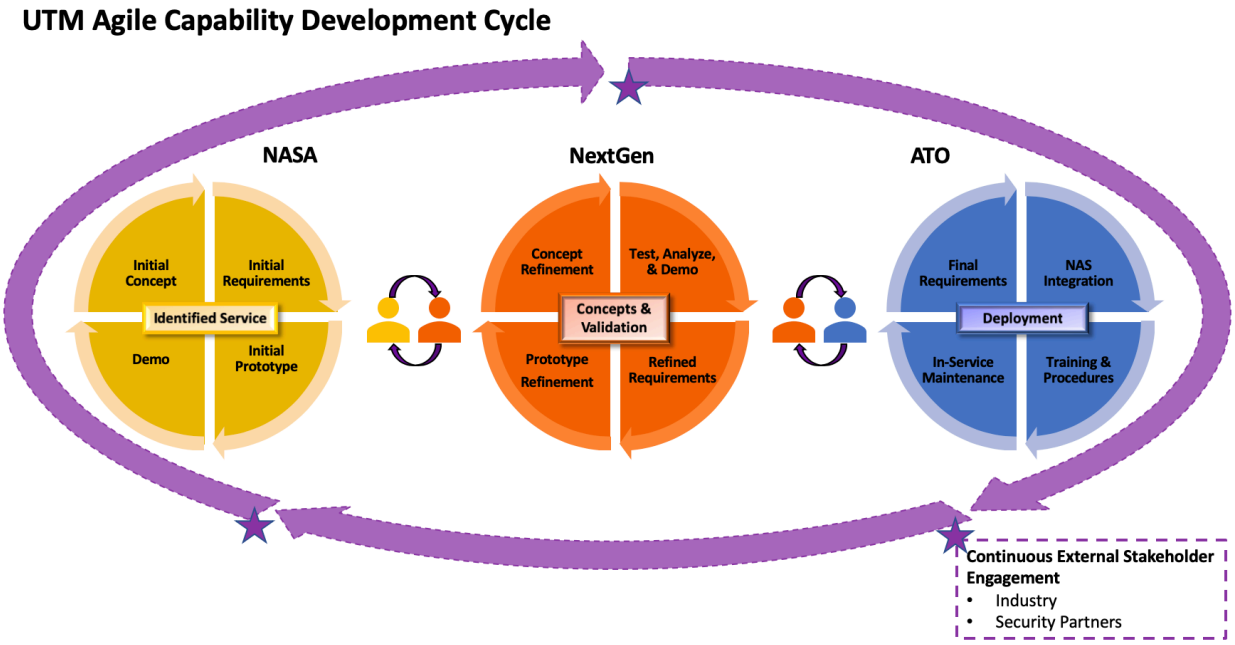


Figure 35: High-Level Process Flow for UTM Capability Deployment

The stages in the process flow will be done collaboratively, with stakeholders who lead each stage involved in other stages to ensure that the required artifacts are created and that they support the downstream stages. While specific organizations are identified below, the process above does not require that these organizations lead the stages outlined above.

The process flow enabling UTM capability deployment can take advantage of recent UTM experience and existing process flows as well as expertise specific to FAA lines of business. As specified in the FAA Extension, Safety, and Security Act of 2016 Pub. L. 114-190 § 2208 (July 15, 2016), the FAA has been collaborating with NASA on the research and development aspects of UTM through the RTT. This research has provided data on prototypes for numerous capabilities, such as shared situational awareness, UVRs, and RID, enabling tests of operations of varying complexity, such as operations over people, and BVLOS. This collaborative proof of concept research is the first step in moving from idea to capability and can serve as a model for how to move future ideas forward.

Recently, as a part of the work directed by the FAA Extension, Safety, and Security Act of 2016 Pub. L. 114-190 § 2208 (July 15, 2016), the UPP Phase 1 described in the previous sections of this report, led by the Advanced Concepts Branch of the FAA's NextGen Technology Development & Prototyping Division, demonstrated the capabilities of the prototype FIMS developed by NASA in collaboration with the FAA. FIMS prototype software and the supporting documentation have been technically transferred to the FAA, and demonstrations of the capabilities were completed in August 2019. The UPP Phase 1 demonstration represents the first time the FAA has completed the technology transfer step, moving a potential UTM capability or capability set from early R&D into an FAA test environment.

Completion of the transition from concept to deployed capability will generally require a transfer of technology from the development team (NextGen for the UPP Phase 1 capabilities) to the team responsible for deployment. A technology transfer package, including prototype software, test results, initial safety artifacts, and supporting materials, will be available for transfer to the deployment team to aid in refinement and deployment of the capabilities tested by the UPP. The requirements for the transfer package will need to be defined collaboratively with stakeholder engagement from both teams throughout the process.

Determination of the order in which capabilities will be researched, developed, and deployed is driven by rulemaking and standards activities, business and operational needs, and technological maturity. Ensuring that automation to support the existing and pending rules is ready for deployment as soon as possible is essential in building the UTM ecosystem. Rulemaking activities are currently underway that will have a direct impact on existing sUAS operational processes. Business needs (e.g., package delivery and urban air mobility), along with the corresponding operational needs (e.g., BVLOS, operations over people, and night operations) will also factor into the order in which capabilities supporting these needs are developed. These drivers will ultimately be limited by technological advancement that supports the underlying capabilities. Without appropriate technology, capability development cannot progress.

6.2 Development Approach

The FAA's UTM development approach is focused on expanding capabilities in the test and demonstration environments. Integration tests are used to validate the interactions between the various services. Test scenarios are derived from use cases, functional allocation, and requirements, and are used to drive the test and evaluation process.

As described in the UTM ConOps [6], the FAA, in coordination with NASA and industry, is implementing an agile development of UTM, starting with low complexity operations and building in modules of 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: (1) the number of people and amount of property on the ground; (2) the number of manned aircraft in close proximity to the UAS operations; and (3) the density of UAS operations. It is anticipated that 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 operations in heavily populated environments and more heavily utilized and regulated airspace. It is expected that 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 (e.g., cybersecurity, resilience, failure modes, redundancy), and efficiency while minimizing environmental impacts and respecting privacy and safety of citizens.

This 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, and 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. UTM must also impose as little disruption to the existing ATM system as possible while maintaining fair and equitable access to airspace.

6.3 Next Steps

The first of two main areas for further work involve taking the results from the UPP Phase 1 demonstrations and feeding them back to the appropriate stakeholders so that capabilities can be deployed, and standards can be developed. For example, the ABOV and TBOV approaches to defining flight plans can provide valuable feedback to the teams responsible for writing system and interface requirements. Another example of how these results can be used is by ensuring that the appropriate standards bodies who are currently working on discovery service standards have access to the results regarding the use of multiple discovery services. Additionally, future demonstration activities (discussed more below) can look to the lessons learned in the UPP Phase 1 demonstrations to build a more robust series of tests.

The second area to expand for future work is in the next phase of the UPP. In the UPP Phase 2 demonstrations, currently anticipated to be complete in late 2020, demonstrations of increasing complexity will build a framework for RID capabilities and address some of the lessons learned (potentially testing with use cases of a less-scripted nature, and/or implementing advanced interfaces) in the UPP Phase 1 demonstrations. Initial planning and scope definition for the UPP Phase 2 demonstrations is currently underway.

Appendix A Aircraft Specifications

This appendix provides detailed specifications for the UASs used by each test site in the UPP Phase 1 demonstrations.

A.1 MAAP Demonstration Aircraft

Table 6: Wing Hummingbird 7000

Type	Hybrid Design
Manufacturer Name	Wing
Wingspan	~ 36 in
Gross Weight	10 lbs

Table 7: DJI Inspire 2

Type	Multi-Rotor
Manufacturer Name	DJI
Gross Weight	9.37 lbs
Max Flight Time	~ 27 mins

Max Speed	58 mph

Table 8: SenseFly eBee Plus

Type	Fixed Wing
Manufacturer Name	SenseFly
Gross Weight	2.4 lbs
Max Flight Time	~ 59 mins
Max Speed	68 mph
Wingspan	43.3”

Table 9: DJI Matrice 200

Type	Multi-Rotor
Manufacturer Name	DJI
Gross Weight	13.5 lbs
Max Flight Time	~ 30 mins

Max Speed	51 mph

Table 10: DJI Phantom 4

Type	Multi-Rotor
Manufacturer Name	DJI
Gross Weight	3.04 lbs
Max Flight Time	~ 28 mins
Max Speed	45 mph

A.2 NPUASTS Demonstration Aircraft

Table 11: xFold Dragon x6 Hybrid

Rotor span	30 in
Height	27.5 in
Max Takeoff Weight	55 lbs
Endurance	90 mins
Line of Sight Range	1 mile
Cruise Speed	13.7 knots (7 m/s)

Table 12: 3DR Solo

Rotor span	10 in
Height	10 in
Max Takeoff Weight	4.4 lbs
Endurance	25 mins
Line of Sight Range	0.75 mi

Cruise Speed	4.9 knots (2.5 m/s)

Table 13: DJI Matrice 200

Rotor span	15in
Height	15 in
Max Takeoff Weight	13.5 lbs
Endurance	27 mins
Line of Sight Range	0.75 mi
Cruise Speed	9.7 knots (5 m/s)

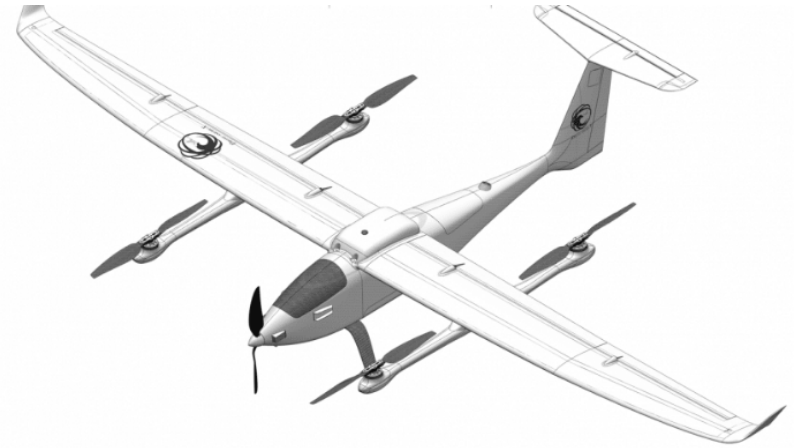
Table 14: xFold Cinema (Back-Up)

Rotor span	20 in
Height	24.5 in

Max Takeoff Weight	35 lbs
Endurance	45 mins
Line of Sight Range	1 mi
Cruise Speed	19 knots (9.7 m/s)

A.2 NIAS Demonstration Aircraft

Table 15: Drone America SAVANT



Wing Span	142 in
Weight	33.8 lbs
Max Takeoff Weight	41 lbs
Max Flight Time	60 min
Max Range	45 mi
Cruise Speed	46 mph

Table 16: Drone America NavX

Rotor Span	31.5 in

Weight	25 lbs
Max Takeoff Weight	25 lbs
Max Flight Time	20 min
Max Range	2 mi
Cruise Speed	15 mph

Table 17: DJI Matrice 600

Rotor Span	44.6 in
Weight	22 lbs
Max Takeoff Weight	34.1 lbs
Max Flight Time	16 min
Max Range	3 mi
Cruise Speed	40 mph

Table 18: Force1 BluJay

Weight	27 lbs
Max Takeoff Weight	28 lbs
Max Flight Time	200 min
Max Range	180 mi
Cruise Speed	45 mph

Appendix B UAS Test Sites Partners Summaries

B.1 Virginia Tech

B.1.1 AirMap

AirMap supports several sUAS enablement and research projects globally, including NASA UTM, SESAR's European Network of U-space Demonstrators, and the United States' UAS Integration Pilot Program. As part of the MAAP UPP Phase 1 team, AirMap provided USS capabilities including flight planning, operational intent sharing, deconfliction as well as situational awareness.

B.1.2 AiRXOS

As part of the MAAP UPP Phase 1 team, AiRXOS provided USS flight planning, deconfliction, situational awareness, and data collection services. AiRXOS conducted Part 101 and Part 107 flight operations. AiRXOS was the lead USS for providing LAANC services through the Air Mobility platform mobile application for all flight operations in the demonstration.

B.1.3 ANRA Technologies

For the UPP Phase 1 at Virginia Tech, ANRA provided USS capabilities such as flight planning, operational intent sharing, deconfliction, situational awareness, and data collection. Additionally, ANRA provided the capability to issue a UVR, which was shared in the public portal via FIMS.

B.1.4 Wing

Wing is an autonomous delivery drone service and in April 2019 became the first drone delivery company to receive an Air operator's certificate from the FAA to allow it to operate as an airline in the United States. As part of the MAAP UPP Phase 1 team, Wing conducted Part 107 flight operations. Additionally, Wing provided USS flight planning, deconfliction, situational awareness, and data collection services.

B.2 NPUASTS

B.2.1 AiRXOS

As part of the Northern Plains UPP Phase 1 team, AiRXOS provided USS flight planning, deconfliction, situational awareness, and data collection services and conducted Part 101 and Part 107 flight operations. AiRXOS was the lead USS for providing LAANC services through the Air Mobility platform mobile application for all flight operations in the demonstration.

B.2.2 Echodyne

For North Dakota's UPP Phase 1 demonstrations, Echodyne provided ground-based detect-and-avoid capabilities through the use of its EchoGuard radar. The sensor provides situational awareness of aircraft in the local airspace, including non-cooperative aircraft. The radar returns position and velocity information in all weather conditions and is easily deployable.

B.2.3 L3 Harris

Leveraging the largest Automatic Dependent Surveillance – Broadcast (ADS-B) network across the United States, L3 Harris was able to provide a real-time, surveillance feed to the NPUASTS and its partners. For the UPP Phase 1 demonstration, L3 Harris provided this surveillance feed, along with augmented ADS-B signals at low altitude through its ADS-B XtendTM unit. This allowed flight operators to see aircraft operating at lower altitudes than traditional aircraft operations, enhancing awareness and safety for UAS operations during the demonstrations.

B.2.4 Collins Aerospace

During the UPP Phase 1 effort, Collins Aerospace did not fly its own aircraft, but was supporting the project as one of the USSs. Collins Aerospace provided the Rockwell Collins WebUAS℠ Operations Management Suite which served to unite a variety of situational awareness capabilities (weather, terrain, real-time traffic), operations monitoring and management, and airspace authorization capabilities in a single united framework. Collins Aerospace also provided an approved LAANC capable system.

B.2.5 Simulyze, Inc.

As part of the North Dakota UPP Phase 1 team, Simulyze provided USS functionalities such as flight planning, deconfliction, situational awareness, and data collection services. It also participated as a UAS operator conducting Part 107 flight operations. Additionally, Simulyze setup the grid domain as part of the InterUSS architecture.

B.2.6 uAvionix

uAvionix worked with the NPUASTS team to test UAS Remote Identification (RID) technologies during the UPP Phase 1 demonstration to test alternative cooperative UAS information techniques.

B.2.7 University of North Dakota (UND)

The University of North Dakota (UND) participated as a technology provider for the NPUASTS. UND provided operational support for the DeDrone UAS Detection Systems and the DeTect surveillance radar.

B.3 NIAS

B.3.1 AiRXOS

As part of the NIAS UPP Phase 1 team, AiRXOS provided USS flight planning, deconfliction, situational awareness, and data collection services and conducting Part 101 and Part 107 VLOS and BVLOS flight operations. Additionally, AiRXOS served as the main USS providing LAANC services through the Air Mobility platform mobile application for all flight operations in the demonstration.

B.3.2 Amazon Prime Air

Amazon Prime Air served as a lead/senior USS between industry partners and other USS developers partnered with NIAS. As a lead USS, Amazon was responsible for overall coordination and for ensuring positive connectivity with FIMS and teammate USSs. Additionally, Amazon provided USS capabilities, including a software solution to collect, organize, validate and submit required data elements in the appropriate format. It also provided a simulated helicopter that would request a UVR to be issued.

B.3.3 ANRA Technologies

For the NIAS UPP Phase 1 team, ANRA provided USS capabilities such as flight planning, operational intent sharing, deconfliction, situational awareness, and data collection. Additionally, ANRA provided simulated Part 107 BVLOS flight operations, and a simulated helicopter that would request a UVR to be issued. Most importantly, it provided the NIAS team with the capability to issue UVRs, which were shared in the public portal via FIMS.

B.3.4 AviSight

As part of the NIAS UPP Phase 1 team, AviSight provided Part 107 VLOS (live and simulated), and Part 101(e) VLOS UAS operations.

B.3.5 Avision Robotics

Avision supported the NIAS UPP Phase 1 team by providing simulated Part 107 VLOS operations and USS capabilities (e.g., flight planning, operational intent sharing, deconfliction, situational awareness, and data collection).

B.3.6 Praxis Aerospace Concepts

During the NIAS UPP Phase 1 activities, Praxis Aerospace Concepts provided Part 107 VLOS UAS operations in multiple use cases.

B.3.7 RelmaTech

An airspace management module manufactured by RelmaTech was placed on the Praxis aircraft for additional situational awareness during the tests. The module is a stand-alone system that can report position, altitude, and heading regardless of the aircraft's functionality or operating condition.

B.3.8 Switch

Switch has an extended history of UAS operations, and it is experienced using LAANC to access the controlled airspace. As part of the NIAS UPP Phase 1 activities, Switch participated in multiple use cases by providing Part 101(e) and 107 VLOS UAS operations.

B.3.9 Telesis

Throughout the NIAS UPP Phase 1 demonstration activities, Telesis provided communication support and connectivity infrastructure for participating partners.

B.3.10 Uber Elevate

Uber Elevate also served as a lead/senior USS for the NIAS UPP Phase 1 team. In this role, and in collaboration with Amazon Prime Air, Uber Elevate was responsible for overall coordination and for ensuring positive system connectivity, as well as the daily monitoring and management of activities. In addition to USS capabilities and leadership, Uber Elevate served as Part 101(e) VLOS (live) and Part 107 VLOS (live and simulated) UAS operator. It also provided simulated BVLOS and non-cooperative operations.

B.3.11 Utah State University (USU)

During the NIAS UPP Phase 1 activities, USU supported NIAS by providing Part 107 VLOS UAS operations in multiple use cases.

Appendix C References

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Appendix D Acronyms

Acronym	Definition
ABOV	Area-Based Operation Volume
ADS-B	Automatic Dependent Surveillance–Broadcast
AGL	Above Ground Level
API	Application Programming Interface
ATM	Air Traffic Management
ATO	Above Take-Off
AWS	Amazon Web Services
BVLOS	Behind Visual Line of Sight
CFR	Code of Federal Regulations
DAA	Detect and Avoid
DJI	Dà-Jiāng Innovations
EMS	Emergency Medical Services
EVLOS	Extended Visual Line of Sight
FAA	Federal Aviation Administration
FIMS	Flight Information Management System
GCS	Ground Control Station
GPS	Global Positioning System
GUFI	Global Unique Flight Indicator
HUVR	Henderson Unmanned Vehicle Range
KEAS	Knots Equivalent Airspeed
KGFK	Grand Forks International Airport
LAANC	Low Altitude Authorization and Notification Capability
LUN	Local USS Network
MAAP	Multi-Atlantic Aviation Partnership
MOCC	Mobile Operations Command Center
MSL	Mean Sea Level
NAS	National Airspace System
NASA	National Aeronautics and Space Administration
NextGen	Next Generation Air Transportation System

Acronym	Definition
NIAS	Nevada Institute for Autonomous Systems
NIEC	NextGen Integration and Evaluation Capability
NPUASTS	Northern Plains UAS Test Site
PIC	Pilot in Command
RF	Radio Frequency
RID	Remote Identification
RNO	Reno International Airport
ROA	Roanoke-Blacksburg Regional Airport
RPIC	Remote Pilot in Command
RTT	Research Transition Team
SAR	Search and Rescue
sUAS	Small Unmanned Aircraft Systems
TBOV	Trajectory Based Operational Volume
TCL	Technology Capability Level
UAS	Unmanned Aircraft Systems
UASFM	UAS Facility Maps
UDP	UPP Demo Platform
UND	University of North Dakota
UPP	UTM Pilot Program
USS	UAS Service Supplier
USU	Utah State University
UTC	Coordinated Universal Time
UTM	Unmanned Aircraft Systems Traffic Management
UVR	UAS Volume Reserve
VAS	Value Added Service
VFR	Visual Flight Rules
VLOS	Visual Line of Sight
VM	Virtual Machines
VT	Virginia Tech
WJHTC	William J. Hughes Technical Center