Unmanned Aircraft Systems (UAS) Traffic Management (UTM)

UTM Pilot Program (UPP)

UPP Summary Report

October 2019

Steve Bradford
FAA
Chief Scientist, Architecture &
NextGen Development
UTM RTT Co-Lead

Date 11/15/2019

Parimal Kopardekar
NASA Ames Research Center
NASA Senior Technologist for Air Transportation System, and
Principal Investigator, Unmanned Aerial Systems Traffic Management (UTM)
UTM RTT Co-Lead

Date 11/18/2019

PAGE INTENTIONALLY LEFT BLANK.

Executive Summary

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). The UPP was identified as an important component for identifying the next set of FAA and industry capabilities required to support UTM operations.

The primary goal for the UPP was to enable the development, testing, and demonstration of a set of UTM capabilities. These capabilities support the sharing of information that promotes situational awareness and deconfliction (i.e., cooperative separation) Some of the UTM capabilities successfully demonstrated in the UPP included (a) sharing of operational intent between operators, (b) the ability for a UAS Service Supplier (USS) to generate a UAS Volume Reservation (UVR), and (c) providing access to FAA Enterprise Services to support shared information.

On January 14, 2019, The Honorable Elaine L. Chao, Secretary, U.S. Department of Transportation, announced the FAA's selection of three industry teams to partner with the agency in the UPP (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)

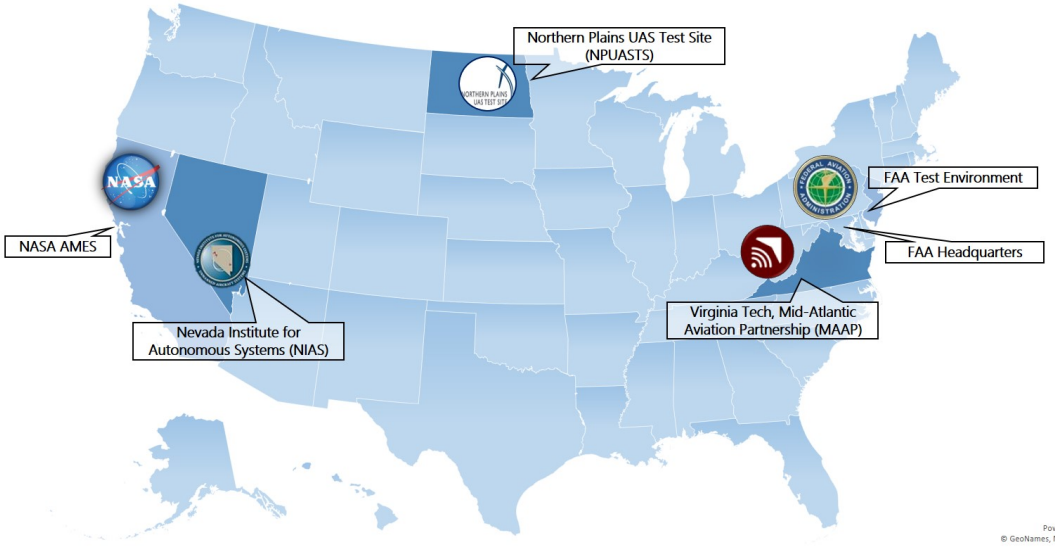

Figure 1: UPP Selected Test Sites

In summer 2019, the FAA, NASA, and their industry partners successfully completed the UPP demonstrations, which consisted of a series of preparation flights and final flight demonstrations, consisting of live UAS flights combined with simulated UTM operations at each test site. The flight activities 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 UPP Demonstration Platform. Through the planning and execution of the UPP activities, each of the three UPP partnerships successfully demonstrated all the requisite capabilities. While the specifics of each use case varied between the partnerships, the key UTM capabilities were exercised with success at each site.

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 was to enable the development, testing, and demonstration of UTM capabilities, and to provide an infrastructure to allow for future testing of new UTM capabilities. The results of the UPP demonstrations will be used to mature UTM to support the continued development of UTM policy, standards, capabilities, and requirements development. The progress achieved with the UPP is critical to public and private sector entities to provide data on the future activities necessary to support successful implementation of the UTM infrastructure and supporting systems.

Version History

Date	Revision	Version #
09/29/19	Initial release.	1.0
10/22/19	Updated per FAA review	1.1
10/28/19	Final release	1.2

Table of Contents

1 Introduction 1

1.1 Purpose 1
1.2 Background 1
1.3 UTM Pilot Program 1

2 Approach 2

3 UPP Execution 2

3.1 UPP Partnerships 3
3.2 Demonstrated Capabilities and Outcomes 7

4 UPP Conclusions 8

5 Conclusion - Path to Implementation 9

5.1 Development Approach 9
5.2 Next Steps 10

Appendix A Use Case Narratives 11

A.1 MAAP 11
A.2 NPUASTS 16
A.3 NIAS 20

Appendix B References 25

Appendix C Acronyms 26

List of Figures

Figure 1: UPP Selected Test Sites i
Figure 2: UPP Selected Test Sites 3
Figure 3: MAAP UPP Team and Functions 4
Figure 4: Kentland Farm and KEAS Lab Aerial Views 4
Figure 5: NPUASTS Team and Functions..... 5
Figure 6: Sectional of NPUASTS UPP Operational Area 6
Figure 7: NIAS UPP Team and Functions..... 6
Figure 8: MAAP Use Case 1 Operational Overview..... 12
Figure 9: MAAP Use Case 2 Operational Overview..... 13
Figure 10: MAAP Use Case 3 Operational Overview..... 15
Figure 11: NPUASTS Use Case 1 Operational Overview..... 17
Figure 12: NPUASTS Use Case 2 Operational Overview..... 18
Figure 13: NPUASTS Use Case 3 Operational Overview..... 19
Figure 14: NIAS Use Case 1 Operational Overview – HUVR..... 20
Figure 15: NIAS Use Case 1 Operational Overview – Searchlight Airpark 21
Figure 16: NIAS Use Case 2 Operational Overview – HUVR..... 22
Figure 17: NIAS Use Case 2 Operational Overview – Searchlight Airpark 22
Figure 18: NIAS Use Case 3 Operational Overview – Downtown Reno, NV 23
Figure 19: NIAS Use Case 3 Operational Overview – Innevation Center 24

List of Tables

Table 1. UPP Capabilities, Use Case Elements, and Related Interactions 7

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 demonstrations. This report documents the approach, execution, and findings from those demonstrations. Throughout the UPP, a set of UTM capabilities was successfully demonstrated, highlighting both FAA and industry UTM capabilities and the technical feasibility for advancement of the UTM operational environment.

1.2 Background

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

Incorporation of sUAS operations in the NAS presents a variety of novel challenges, particularly in low-altitude airspace. The FAA and NASA have joint interests in identifying innovative and transformative integration solutions that can effectively respond to these challenges without compromising the 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 UAS operations in airspace where air traffic services are not provided.

UTM is a community-based, cooperative traffic management system where sUAS operators are responsible for the coordination, execution, and management of operations, with governance 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, including flight planning, communications, separation, and weather. The UTM framework will initially provide the capability to exchange information among USSs and the FAA.

1.3 UTM Pilot Program

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 was to enable the development, testing, and demonstration of UTM capabilities, and to provide an infrastructure to allow for future testing of new UTM capabilities. For this phase of the UPP, the focus of the demonstration and evaluation activities was on the following fundamental capabilities of the UTM framework:

1. Operation planning for participating UAS operators
2. Shared situational awareness between UAS operators
3. Automated airspace authorization for 14 CFR Part 107 Operations
4. UAS Volume Reservations (UVRs) and their effect on UAS Operations

These capabilities support the sharing of information that promotes situational awareness and deconfliction (i.e., cooperative separation), and they provide qualified USSs the ability to issue notifications to UAS operators regarding air or ground activities relevant to their safe operation and share it with stakeholders. [1].

As an initial step in completing the UPP demonstrations, the Flight Information Management System (FIMS) prototype, developed by NASA in collaboration with the FAA, was transitioned to the FAA's Next Generation Air Transportation System (NextGen) Integration and Evaluation Capability (NIEC) Laboratory at the William J. Hughes Technical Center (WJHTC) for integration and testing. FIMS provides an interface for data exchange between FAA systems and UTM users, enabling the exchange of airspace constraint data between the FAA and the USS Network. The FAA also uses this interface as an access point for information on active UTM operations. FIMS also provides a means for approved FAA stakeholders to query and receive post-hoc/archived data on UTM operations for the purposes of compliance audits and/or incident or accident investigation. FIMS is managed by the FAA and is a part of the UTM ecosystem

The UPP demonstrations evaluated the effectiveness of the UTM capabilities and supporting infrastructure and identified areas for potential future refinement. The progress achieved with the UPP is critical to public and private sector entities, as it provides data to promote the implementation of the UTM framework and supporting capabilities. [3]

2 Approach

In order to integrate a variety of operations and industry service suppliers, the UPP 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 demonstration events. Additionally, through prior coordination with NASA and the FAA, the industry partners were able to leverage the activities of the RTT to ensure readiness to participate in the UPP exercises.,

The UPP 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.[5].

3 UPP Execution

The UPP activities included a series of preparation flights and final flight demonstrations, consisting of live UAS flights combined with simulated UTM operations. The flight activities 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 UPP Demonstration Platform.

3.1 UPP Partnerships

On January 14, 2019, The Honorable Elaine L. Chao, Secretary, U.S. Department of Transportation, announced the FAA's selection of three industry teams to partner with the agency in the UPP:

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

These test sites, along with key FAA and NASA locations, are shown in Figure 2. The partnerships and their demonstration environments are described briefly in the following subsections.

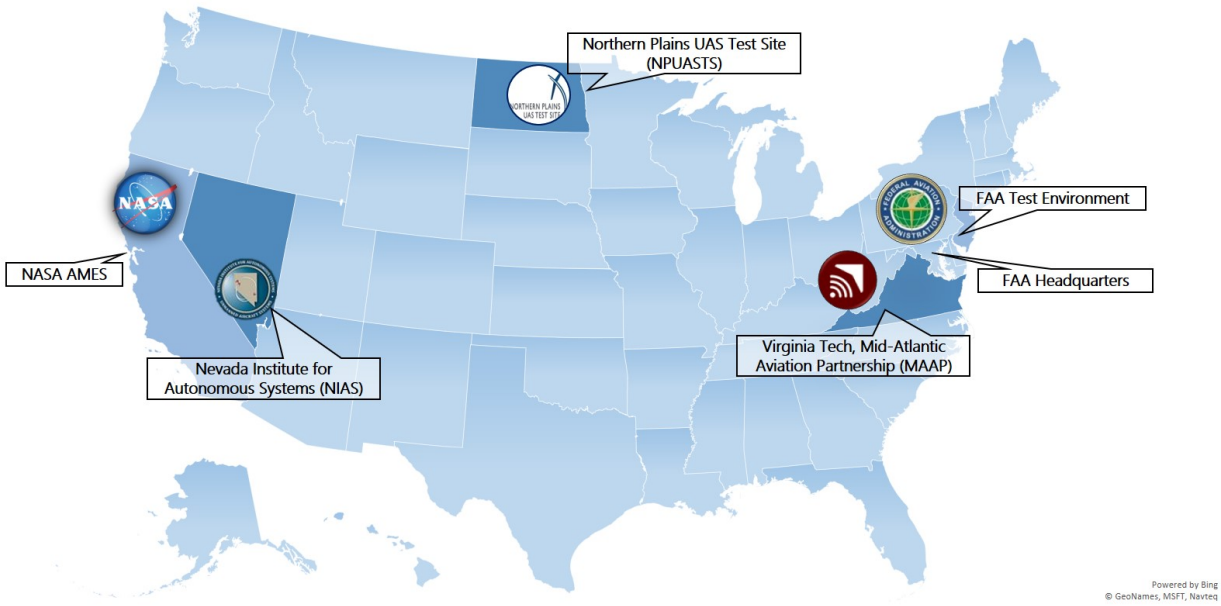

Figure 2: UPP Selected Test Sites

3.1.1 Virginia Tech, Mid-Atlantic Aviation Partnership

MAAP's team included AirMap, AiRXOS, ANRA Technologies, senseFly, and Wing. Figure 3 shows an overview of MAAP's team participating as USSs and UAS Operators.

Figure 3: MAAP UPP Team and Functions

MAAP's activities were performed at the Kentland Farm Agricultural Research Center, which is owned by Virginia Tech and contains the Kentland Experimental Aerial Systems (KEAS) 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. 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 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 4 shows an aerial view of the flight locations.

Figure 4: Kentland Farm and KEAS Lab Aerial Views

3.1.2 Northern Plains Unmanned Aircraft Systems Test Site

The NPUASTS UPP team included AiRXOS, Collins Aerospace, Simulyze, Inc., Echodyne, L3 Harris, uAvionix, and the University of North Dakota (UND).Figure 5 shows an overview of NPUASTS's team participating as USSs, UAS Operators, and Technology Providers.

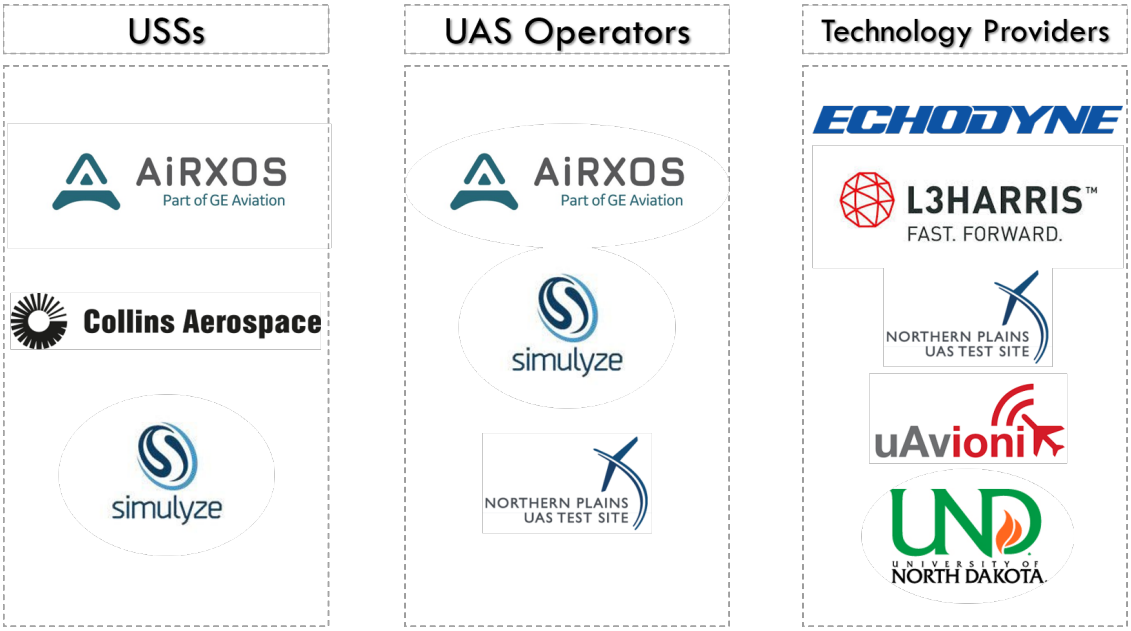

Figure 5: NPUASTS Team and Functions

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. This airspace is shown in Figure 6 , where the red circles indicate the flight locations used during the UPP scenarios.

Figure 6: Sectional of NPUASTS UPP Operational Area

3.1.3 Nevada Institute for Autonomous Systems

The NIAS UPP team was made up of 34 different entities including partners shown in Figure 7, which highlights the members participating as USSs, UAS Operators, and Technology Providers.

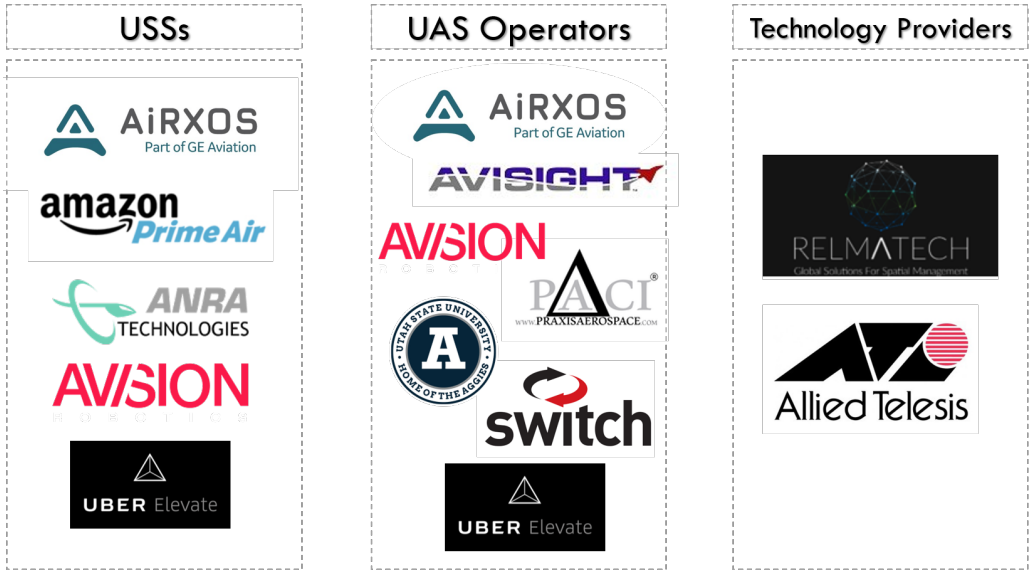

Figure 7: NIAS UPP Team and Functions

UPP flight operations for the NIAS team took place at several locations, including:

- The City of Henderson and Nevada State College's Henderson Unmanned Vehicle Range (HUVR)

- The Searchlight Airport (1L3)
- The City of Reno, in the Class C airspace associated with the Reno International Airport (RNO)
- The Las Vegas Innevation Center, in the Class B airspace associated with the McCarran International Airport (LAS)

3.2 Demonstrated Capabilities and Outcomes

As discussed in Section 1.3, the focus of the UPP was on the demonstration and evaluation of a set of fundamental UTM capabilities:

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**
   This included sharing intent and state information among UAS Operators and between UAS Operators and Remote Pilots in Command (RPICs). The capability demonstrations include the same environmental conditions as Capability #1 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.

To support the evaluation of these capabilities, 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.

Table 1 presents the UPP use cases and maps the use case elements to the UPP capability elements. Each of the UPP partners demonstrated all of the use case elements.

Table 1. UPP Capabilities, Use Case Elements, and Related Interactions

Description		Use Case 1	Use Case 2	Use Case 3
Type of Operation	Part 101(e)		✓	✓
	Part 107	✓	✓	✓
	BVLOS (waivered Part 107)	✓	✓	

Description		Use Case 1	Use Case 2	Use Case 3
Participation	UTM-Participating Operators	✓	✓	✓
	Non-Participating Operators		✓	
Airspace Characteristics	Uncontrolled	✓	✓	
	Controlled			✓
Operation Plan/Intent Development & Sharing		✓	✓	✓
UVR Creation/Dissemination			✓	✓
FIMS query of USS Network for UTM information			✓	

Through the planning and execution of the UPP activities, each of the three UPP partnerships successfully demonstrated all these capabilities. This was evaluated at each of the test sites through a series of flight activities which were governed by the overarching UPP scenarios and use cases. While the specifics of use case execution varied between the partnerships, as detailed in Appendix A, the key UTM capabilities were exercised with success by each of the UPP partner teams.

4 UPP Conclusions

Through the conduct of the UPP, the FAA and industry partners collected significant quantities of data and performance metrics for post-operations analysis. These will be used to refine system and performance requirements for UTM, and these will form the foundation for following UPP activities.

Throughout the preparation and execution of the UPP demonstrations, there were many things that went well, and the overall success of the UPP can be attributed to many factors. The early development and coordination of the UPP partners with both NASA and the FAA through the RTT led to the teams having UAS platforms that were proven and ready for the demonstrations. By participating in early NASA Technology Capability Level (TCL) activities, the UPP partners had demonstrated necessary maturity levels leading up to the UPP. Additionally, collaboration among the team members throughout the process helped to facilitate communication and the sharing of ideas that led to overall UPP success.

While many aspects of the UPP were successful, with any demonstration of this nature there will be areas for potential future enhancements or improvements on the process. The UPP partner teams provided feedback on lessons learned through the development and demonstration activities, and program-level lessons learned were also collected. A summary of these include:

- **Definition of standards** for the shared operational information is critical. Much data was shared between UPP participants, such as altitude reference conventions, vertical datum conventions, and interpretation of UVRs. Defining data standards for this shared information will help in the coordination and execution of future demonstrations and

support UAS operations. Additionally, standardization of the presentation of information to operators and UTM participants will be helpful in supporting deconfliction between operators, better supporting any airspace negotiations and other coordination efforts.

- **Standardization of operational procedures** and regulatory guidance is necessary. The diversity of the partnerships and companies working together proved both challenging and rewarding. Coordination and communication among participants and test conductors, both leading up to and during the demonstration activities, was an area for potential improvement. Defining the regulatory guidance and overall UAS governance supports synchronization of the FAA with the industry, promotes innovation and inspiration, and helps to inform performance-based standards.
- **Incremental development and integration** are important; the UTM framework is both complex and innovative. Development and deployment of this type of innovation is best done in increments, with cyclical testing, demonstration, and revision. Integration of the UAS vision must be modular and scalable to support these increments, while integration of legacy users will require coordination, planning, and prioritization. Participants 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.
- **Security issues** must be addressed. As the UPP moves towards expanded capabilities, data security will be a critical element that must be supported by all participants.

5 Conclusion - Path to Implementation

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

The following sections discuss the plan for capability implementation and the next steps in demonstration of more complex capabilities.

5.1 Development Approach

As described in the UTM ConOps [11] the FAA, in coordination with NASA and industry, is implementing an incremental and modular 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 near 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.

5.2 Next Steps

The next step in the UPP involves taking the results from the UPP demonstrations and feeding them back as appropriate to the stakeholders so that capabilities can be deployed, and standards can be developed. The lessons learned from the UPP demonstrations will be transferred to the industry partners to support future validation activities and promote a more robust series of future evaluation. Phase 2 of the UPP will include the next set of enhancements to the UTM ecosystem, with expected capabilities to support remote identification and tracking of UAS, determining methods of compliance to support FAA rulemaking activities, and supporting UTM message security and data correlation.

Areas for future work include:

- Continued development of fundamental operational concepts and requirements to support ongoing prototyping and future evaluation activities
- Development and refinement of UTM governance including rules and regulations, aviation safety, and UAS standards
- Evaluation and support for infrastructure development and information security standards.

Appendix A Use Case Narratives

This appendix provides details for the use cases created by each test site in the UPP demonstrations.

A.1 MAAP

MAAP developed three use cases to test the desired UTM interactions [7]:

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.

A.1.1 Use Case 1: VLOS & BVLOS Operations in Uncontrolled Airspace

This use case demonstrated the operation planning and operation intent sharing capabilities for both VLOS and BVLOS operations. It also demonstrated the shared situational awareness provided by USSs. Figure 8 presents an overview of the operational scenario of this use case.

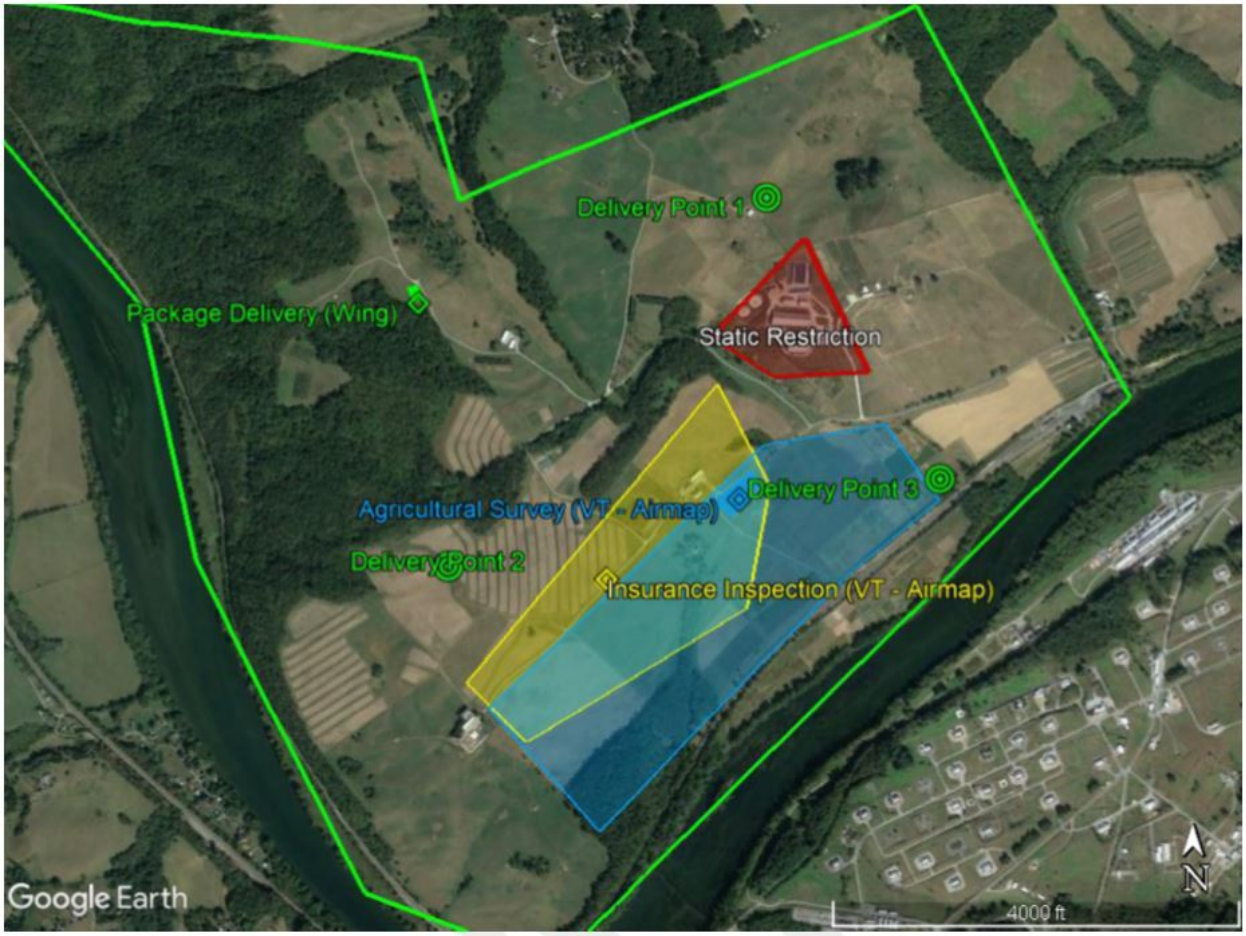

Figure 8: MAAP Use Case 1 Operational Overview

MAAP Use Case 1 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.

A.1.2 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 9 presents an overview of the operational scenario of this use case.

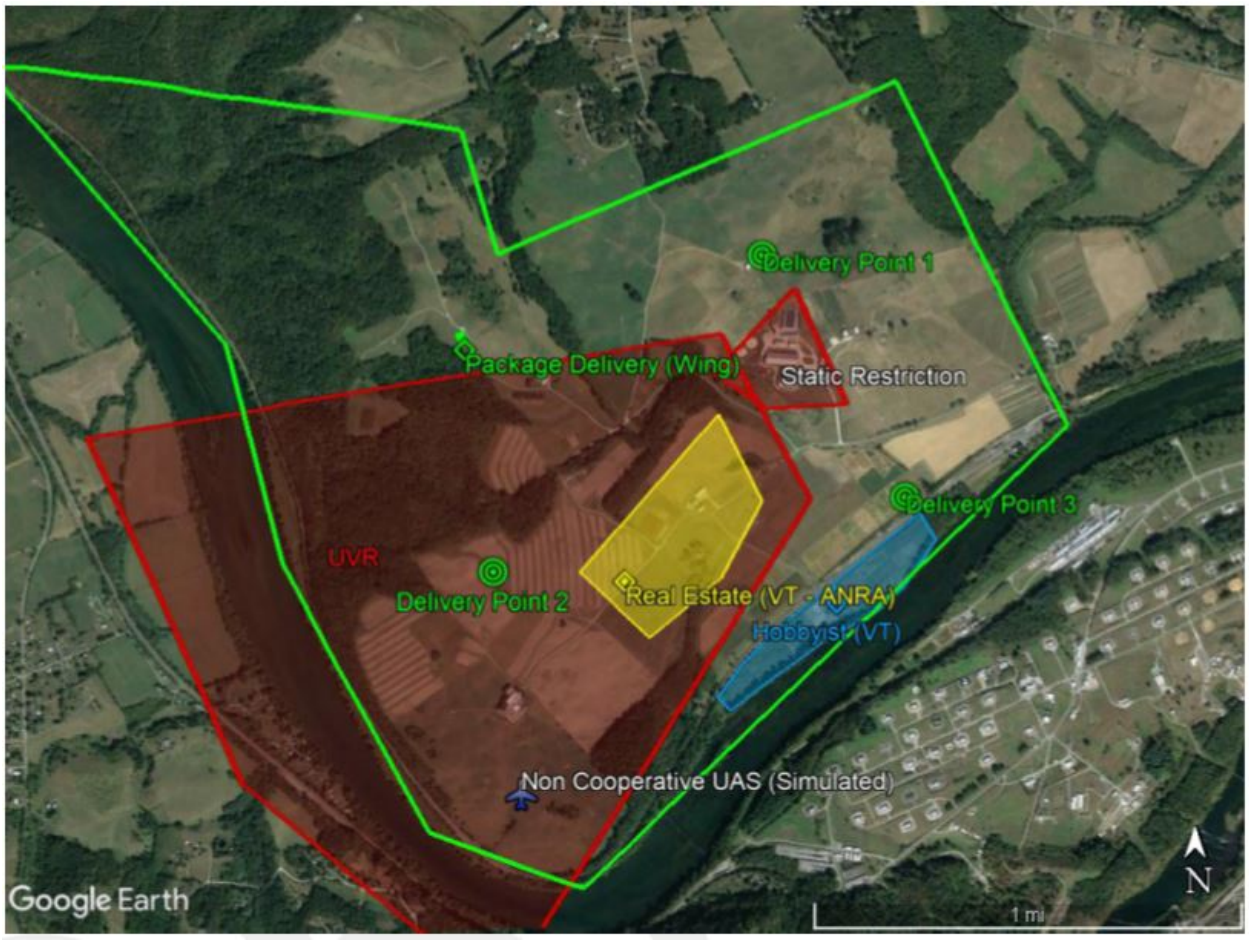

Figure 9: MAAP Use Case 2 Operational Overview

MAAP Use Case 2 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 Search and Rescue (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 sUAS 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.

A.1.3 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 10 presents an overview of the operational scenario of this use case.

Figure 10: 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.

MAAP Use Case 3 Narrative

A local farmer is conducting a routine VLOS agricultural survey near the vicinity of a controlled airport that has an approved LAANC grid like 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.

A.1.4 MAAP Suggestions for Future Development

According to MAAP, several key areas were determined to be of specific interest for future development [7]:

- 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 Ground Control Station (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.

A.2 NPUASTS

NPUASTS developed three use cases to test the desired UTM interactions [8]. 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

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 previously in Figure 6, this area resides in controlled airspace [8].

A.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 11 presents an overview of the operational scenario of this use case.

Figure 11: NPUASTS Use Case 1 Operational Overview

NPUASTS Use Case 1 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.

A.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 12 presents an overview of the operational scenario of this use case.

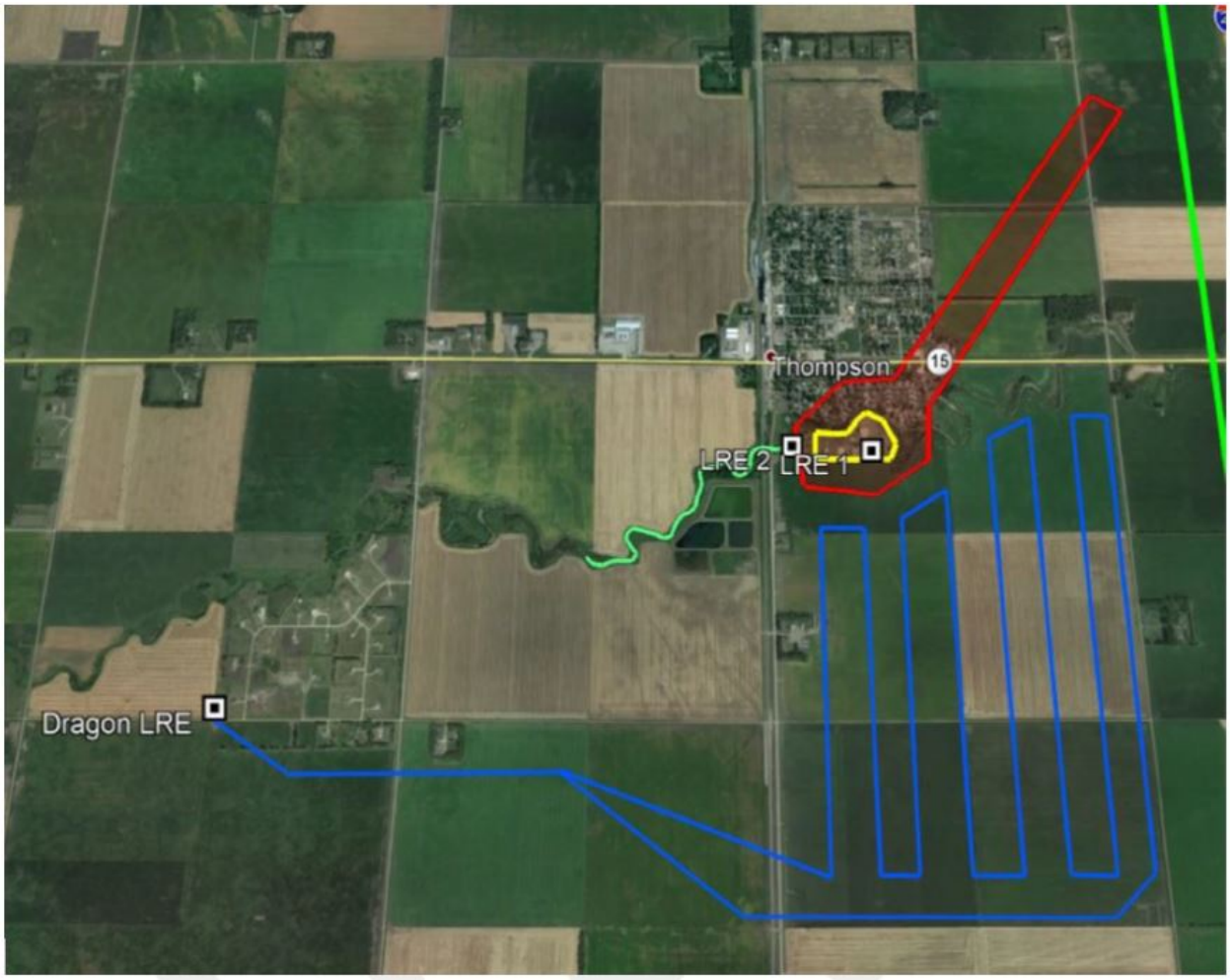

Figure 12: NPUASTS Use Case 2 Operational Overview

NPUASTS Use Case 2 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.

A.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 13 presents an overview of the operational scenario of this use case.

Figure 13: NPUASTS Use Case 3 Operational Overview

NPUASTS Use Case 3 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 using 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.

A.2.4 NPUASTS Suggestions for Future Development

The following are recommendations provided by the NPUASTS based on activities and lessons learned from the UPP efforts [11]:

- 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 approved 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

detect and avoid 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.

A.3 NIAS

NIAS developed three scenarios that reflected its intent to safely conduct operations at multiple locations across Nevada [12].

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

A.3.1 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. Figure 14 presents an overview of the operational scenario of this use case at HUVR and Figure 15 at the Searchlight Airpark.

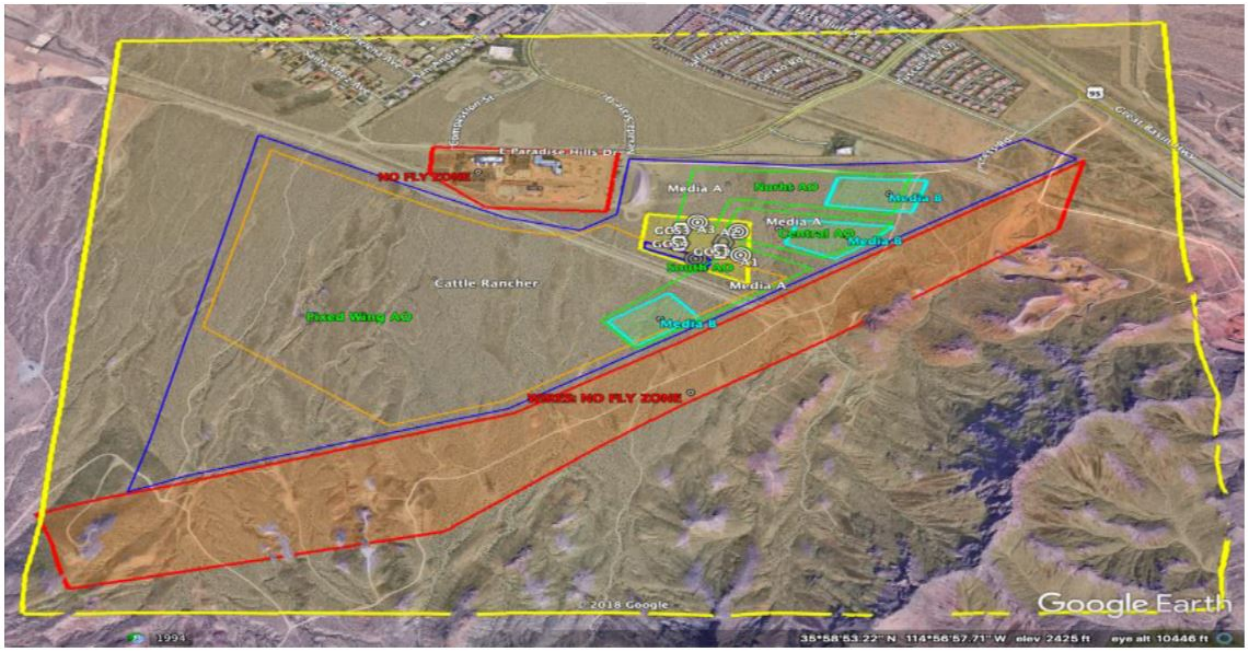

Figure 14: NIAS Use Case 1 Operational Overview – HUVR

Figure 15: NIAS Use Case 1 Operational Overview – Searchlight Airpark

NIAS Use Case 1 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.

A.3.2 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. Figure 16 presents an overview of the operational scenario of this use case at HUVR and Figure 17 at the Searchlight Airpark.

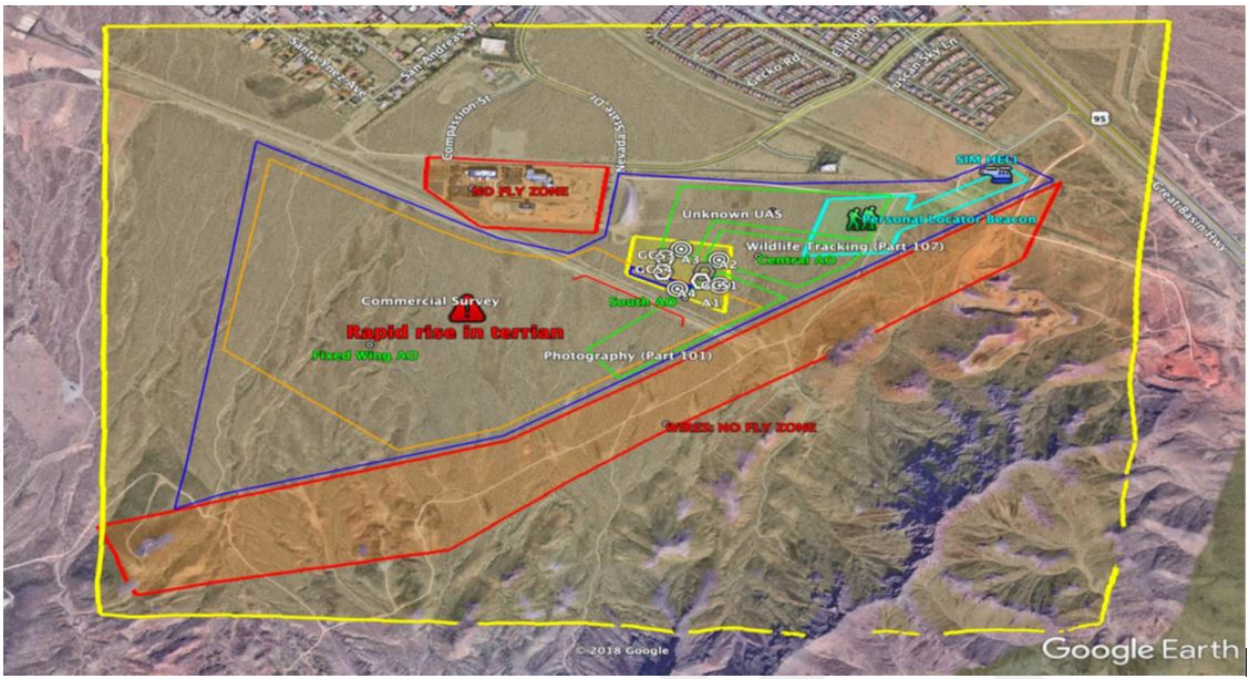

Figure 16: NIAS Use Case 2 Operational Overview – HUVR

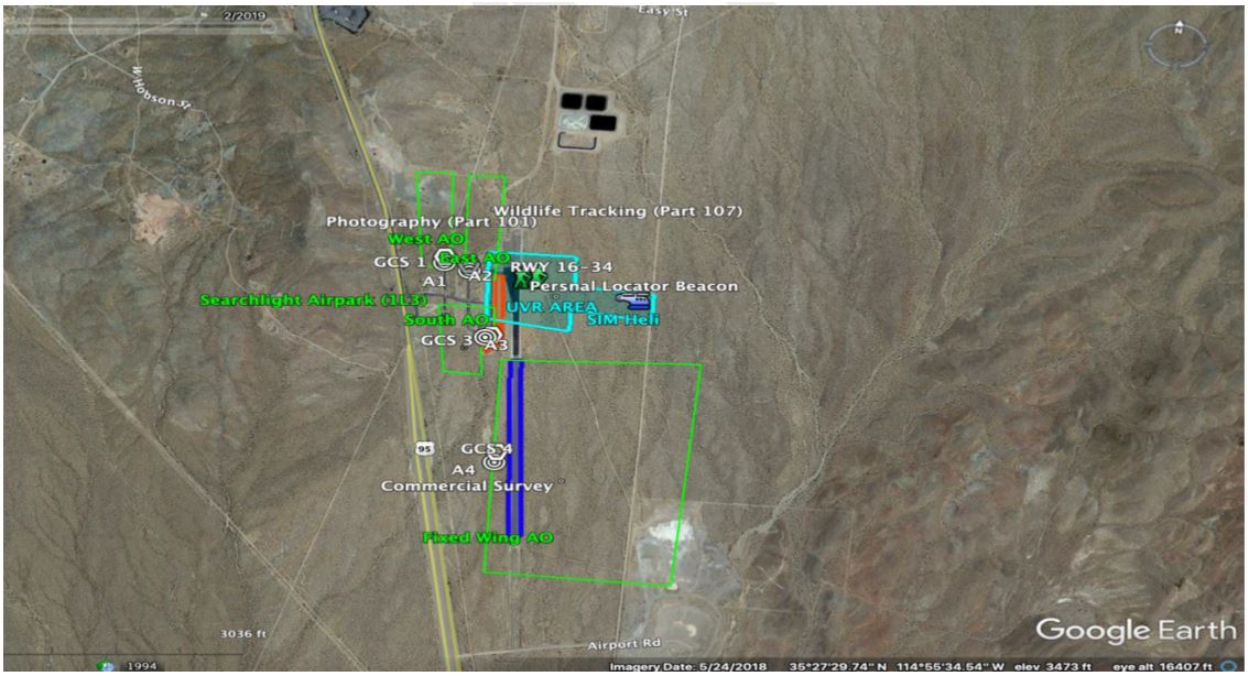

Figure 17: NIAS Use Case 2 Operational Overview – Searchlight Airpark

NIAS Use Case 2 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.

A.3.3 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. Figure 18 presents an overview of the operational scenario of this use case in Downtown Reno and Figure 19 at the Innevation Center.

Figure 18: NIAS Use Case 3 Operational Overview – Downtown Reno, NV

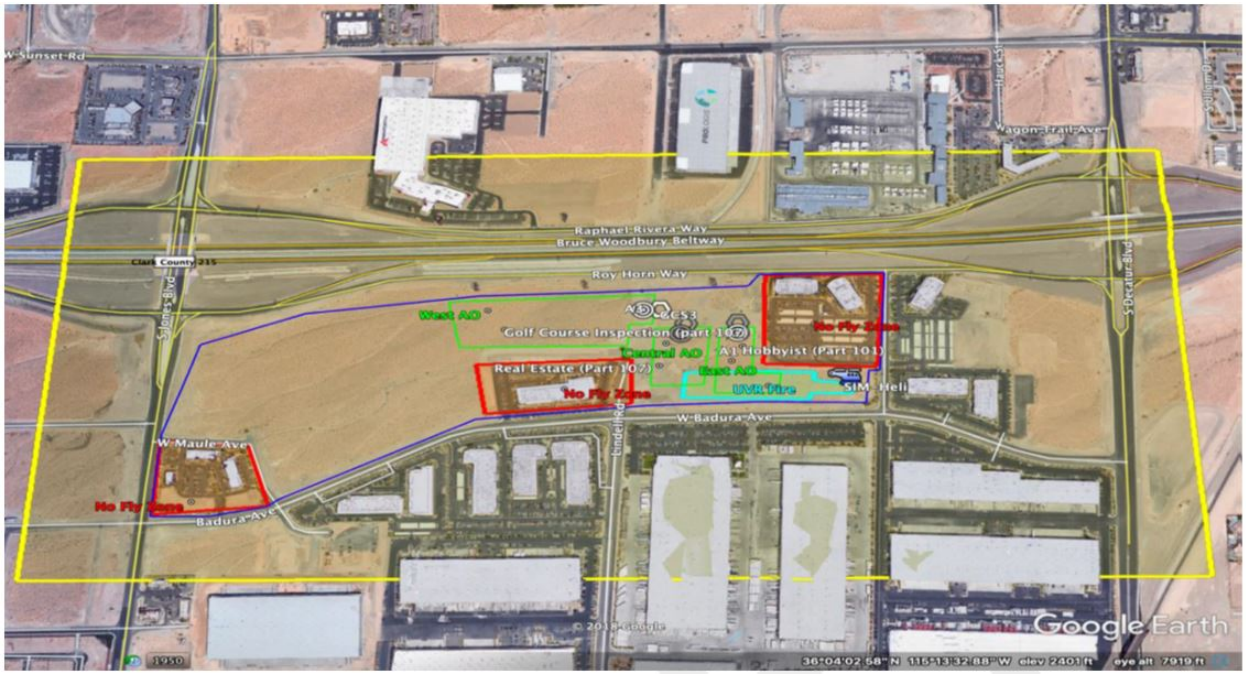

Figure 19: NIAS Use Case 3 Operational Overview – Innevation Center

NIAS Use Case 3 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.

A.3.4 NIAS Suggestions for Future Development

According to the NIAS's final report [9] 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. 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.

Appendix B References

[1] Federal Aviation Administration. (n.d.) Retrieved from https://www.faa.gov/uas/research_development/traffic_management/utm_pilot_program/

[2] UTM Pilot Program (UPP) Data Management Plan, Version 1.2, Federal Aviation Administration, April 2, 2019.

[3] UTM Data Exchange Baseline Infrastructure & Initial Capabilities Implementation Strategy, Version 1.0, Federal Aviation Administration, February 2, 2019.

[4] Integrated UTM Concept Description Paper, Version 1.0, Federal Aviation Administration, April 22, 2019.

[5] Unmanned Aircraft Systems Traffic Management (UTM) Initial Data Exchange Requirements Document, Version 1.0, Federal Aviation Administration, October 1, 2017

[6] UTM Pilot Program Test & Demonstration Plan for Virginia Tech Mid-Atlantic Aviation Partnership, Version 2.0, Virginia Tech-Mid Atlantic Partnership, May 24, 2019.

[7] UTM Pilot Program Final Report for Virginia Tech Mid-Atlantic Aviation Partnership, Version 1.0, Virginia Tech-Mid Atlantic Partnership, August 5, 2019.

[8] Northern Plains Unmanned Aircraft Systems Test Site – Demonstration Package, NP UAS TS, June 11, 2019.

[9] North Dakota Department of Commerce - Northern Plains Unmanned Aircraft Systems Test Site – FAA UTM Pilot Program Final Report, North Dakota Department of Commerce, August 5, 2019.

[10] The Nevada Institute for Autonomous Systems FAA UTM Pilot Program Demonstration Final Report, Nevada Governor's Office of Economic Development, August 16, 2019.

[11] Unmanned Aircraft Systems (UAS) Traffic Management (UTM) Concept of Operations, Version 1.0, Federal Aviation Administration, May 18, 2018.

[12] The Nevada Institute for Autonomous Systems FAA UTM Pilot Program Demonstration – Demonstration Test Plan, Version 1.0, Nevada Governor's Office of Economic Development, March 15, 2019.

Appendix C Acronyms

Acronym	Definition
1L3	Searchlight Airport, Searchlight, NV
ABOV	Area-Based Operational Volume
AGL	Above Ground Level
API	Application Programming Interface
ATM	Air Traffic Management
BVLOS	Behind Visual Line of Sight
EMS	Emergency Medical Services
FAA	Federal Aviation Administration
FIMS	Flight Information Management System
GCS	Ground Control Station
GUFI	Globally Unique Flight Identifier
HUVR	Henderson Unmanned Vehicle Range
KEAS	Kentland Experimental Aerial Systems
KGFK	Grand Forks International Airport
LAANC	Low Altitude Authorization and Notification Capability
LAS	McCarran International Airport, Las Vegas, NV
LUN	Local USS Network
MAAP	Multi-Atlantic Aviation Partnership
NAS	National Airspace System
NASA	National Aeronautics and Space Administration
NextGen	Next Generation Air Transportation System
NIAS	Nevada Institute for Autonomous Systems
NIEC	NextGen Integration and Evaluation Capability
NPUASTS	Northern Plains UAS Test Site
RF	Radio Frequency
RID	Remote Identification
RNO	Reno International Airport, Reno, NV
ROA	Roanoke-Blacksburg Regional Airport, Roanoke, VA
RPIC	Remote Pilot in Command

Acronym	Definition
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
UND	University of North Dakota
UPP	UTM Pilot Program
USS	UAS Service Supplier
UTM	Unmanned Aircraft Systems Traffic Management
UVR	UAS Volume Reservation
VLOS	Visual Line of Sight
WJHTC	William J. Hughes Technical Center