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UTM Data Working Group Demonstration 1
Final Report

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1 Overview

This document summarizes activities defining and executing the first demonstration of the NASA-FAA Research Transition Team (RTT) Data Exchange and Information Architecture (DEIA) working group (DWG). The demonstration focused on testing the interactions between two key components in the future Unmanned Aircraft Systems (UAS) Traffic Management (UTM) System through a collaborative and distributed simulation of representative scenarios. The summary incorporates written feedback from each of the participants in the demonstration. In addition to reporting the activities, this report also provides some insight into future steps of this working group.

2 Background

The NASA-FAA RTT on UTM has been in force since 2014, however recently the team has formalized its approaches and organization. As part of this formalization, a meeting of FAA, NASA and industry partners with an interest in UTM was hosted by NASA on the 21st of July 2016. The agenda included the following:

- FAA's work to date on UAS integration activities
- The form of the RTT in terms of the working groups
- An initial UTM architecture
- Kickstarting collaboration between all stakeholders

The development and field-testing efforts of NASA to that point had been significant enough to offer a platform for this working group to begin collaborative testing activities. The hope was that these testing activities could serve as a catalyst for other discussions within and between the various UTM working groups. NASA and industry tentatively agreed on a plan to architect and test an initial data exchange system to support UTM by the end of the 2016 calendar year. The result from that decision forward is documented herein.

Additional background on the architecture under test is provided in Appendix A, but the high-level architecture diagram used to guide this effort is provided here for reference (Figure 1). Note that Figure 1 represents an updated, evolved version of the architecture in Appendix A, but is indicative of the same concept. While there are many components of this system, the two central pieces to enabling the UTM System are the Flight Information Management System (FIMS) and the UAS Service Supplier (USS), which are provided by the Air Navigation Service Provider (ANSP) and industry, respectively. This specific demonstration focused on the data exchanges between the FIMS and the USS; all other components and data exchanges were explicitly out of scope. Other exchanges needed to enable an effective demonstration were appropriately emulated and not necessarily documented in detail here. The philosophy with this initial test was to build confidence in and acceptance of the central components, thus enabling further definition of the other components and interfaces of the overall UTM System.

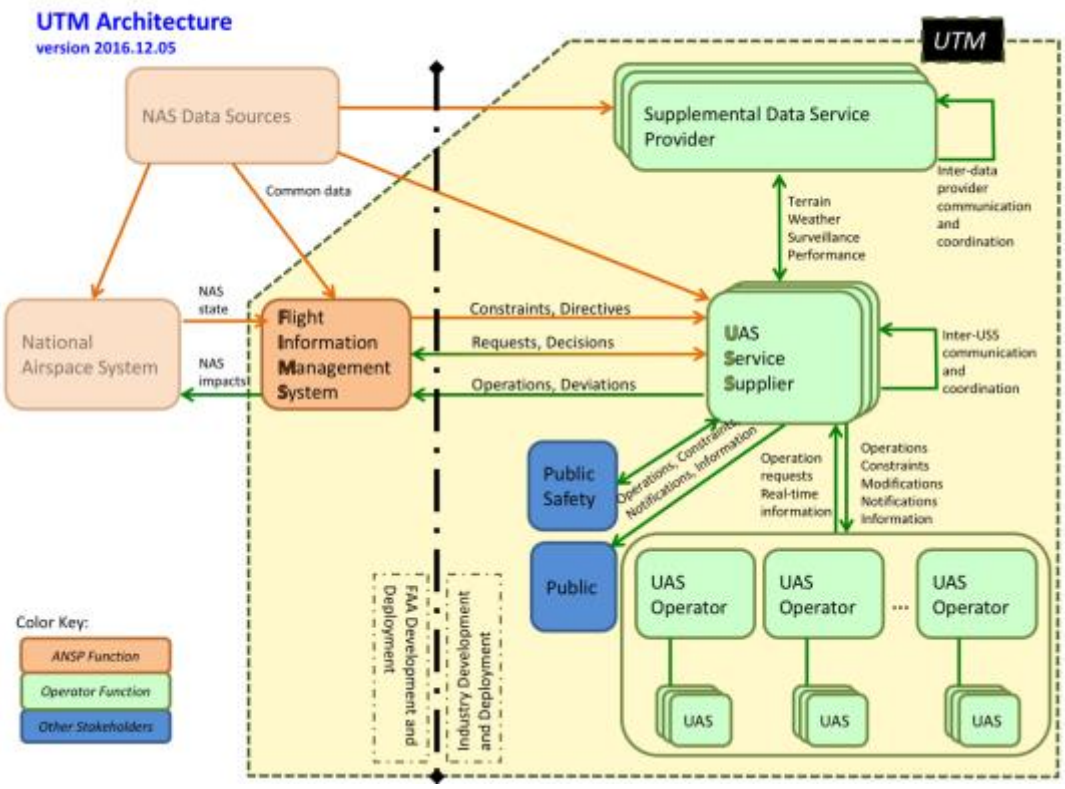

Figure 1: UTM Architecture

Note that all of the NASA-related UTM discussions, implementations, artifacts, and other elements must be viewed as part of a research effort and not a rule-making or regulatory effort. The use cases discussed, the specific technologies tested, and the methods used do not necessarily constitute a view of how a future UTM System will look or operate. Rather, these exercises are used to provide insight into how such a system should or might operate. At the most aggressive, these activities may be seen as a validation of particular options for a future system, not necessarily a roadmap to a future system.

NASA has run several other field tests and simulations leading up to the DWG demonstration described in this document. For further information on those tests and other related documentation, please see https://utm.arc.nasa.gov/documents.shtml.

3 Related Documents

Additional detailed information is provided in four related documents, for convenience included as appendices below. Appendix A is the overall plan initially formulated through discussions with the working group. Appendix B is the detailed implementation of the plan carried out through coordination with the demonstration participants. Appendix C is a technical document describing the interface to the NASA UTM server used by developers participating in the collaborative demonstration. Finally, Appendix D is the technical checkout document NASA used to collaboratively test that the various partner-developed systems implemented the specifications in Appendix C correctly.

4 Demonstration Objectives

For this initial demonstration of the DWG there were four high-level objectives:

- Map existing schema to requirements
- Demonstrate reasonable situational awareness
- Accelerate related efforts
- Develop an initial architecture

Each of these objectives is described in the following subsections.

4.1 Mapping existing schema to requirements

NASA has been developing the concept of UTM since originating it in 2013. As such, there were already field-tested data schemas to support small UAS (sUAS) – UAS less than 55 lbs. – research operations at low altitudes. In parallel, the FAA developed initial data requirements for a potential operational system to support Part 107 (non-hobbyist) and Part 101-E (hobbyist) operations in an automated environment. To accompany this effort, NASA endeavored to map the existing NASA UTM research platform schemas to the FAA-identified data requirements, while identifying any gaps in the requirements that would be needed to enable future automated management of operations and the airspace. This was an initial effort. The goal was not to finalize a schema for future tests and operational purposes, but to obtain a first cut at a reasonable schema that supported basic use cases. This first cut should be sufficient to act as a platform for future improvement and building in coverage of additional use cases.

This mapping and initial schema-definition exercise was the primary objective of the demonstration.

4.2 Demonstrate reasonable situational awareness

One of the major functions of the data schema is to provide the basis for tools to provide appropriate situational awareness to human and automated UTM stakeholders. This demonstration did not prioritize this objective; however, with the implementation as tested, we were able to demonstrate how disparate systems could request, process, and display information, thus creating an initial level of situational awareness.

4.3 Accelerate related efforts

The sUAS industry is progressing rapidly. Research and development efforts need to keep pace in order to ensure safe, efficient, and fair access to the National Airspace System for these sUAS platforms. By building out an initial capability, soliciting feedback on how it performs, and sharing it amongst the stakeholders of this system, the goal is to define and refine the UTM concept.

4.4 Develop initial architecture

In order to perform this demonstration, an initial UTM architecture was required. This architecture, while not intended to be an operational system, can inform how a future operational system should be built. More specifically, through this exercise, it is hoped that lessons learned may help define requirements of the future operational version of UTM.

5 Demonstration Overview

A detailed description of the demonstration is provided in Appendices A and B. This section provides a short summary of the information provided there.

The DWG developed future sUAS scenarios that would necessitate operational information exchanges. These included an sUAS fly-away in a remote area, incursion into a no-fly zone, an all-land scenario, and a capacity-management scenario. Using these scenarios together with an initial set of data elements that the FAA drafted for future automated waivers of Part 107 rules, the DWG looked for gaps in the data-exchange elements that might need to be filled in order to provide appropriate situational awareness for all stakeholders. By leveraging previous work by NASA on the UTM project, a complete data schema was drafted that is hypothesized to cover the situational awareness needs of the identified scenarios.

Using the scenarios, the drafted data schema, and previous UTM architectural efforts by NASA, a collaborative demonstration was planned to test the data exchanges and initial architecture. NASA served as the ANSP within the demonstration by implementing the FIMS. Partners and NASA then each implemented a USS adhering to a collaboratively defined Interface Control Document (ICD) and Application Programming Interface (API).

The execution plan involved having the external partners complete a software checkout to ensure their systems implemented the agreed-upon specification correctly, then meeting virtually as a group to run through several nominal scenarios, then meeting once more to run through the more involved scenarios. Following these steps, NASA collected qualitative feedback in the form of written evaluations from the partners and then produced this document.

The testing was built up in a hierarchical fashion. First, specific Data Exchanges were identified (see Appendix B) based on the previously defined use cases. A single Data Exchange is a collection of data elements representing all of the information sent from one party to another party in a single data message. These Data Exchanges were then organized into sequences of exchanges that described an interaction between various stakeholders. These were called "Tests" for this demonstration. Finally, collections of these Tests were grouped to run together into Experiments wherein every participant had a distinct role within exactly one Test. Thus, individual Data Exchanges were logically sequenced into Tests which were then grouped into Experiments to tell the story of a particular scenario. Each experiment could be run multiple times with varying assignments of roles for each run. These were termed "Configurations" for this demonstration.

6 Execution

There were two dates of execution. On the 4th of November, 2016, the DWG met via a shared video conference and completed two Experiments. On the 14th of November, 2016, the group met again and completed the remaining Experiments. Overall, the execution was smooth. The team was able to adjust the schedule on the fly to accelerate execution, which helped end each day's work early. There was no absenteeism and no significant technical problems. The sessions were recorded and are available from NASA for appropriate use.

7 Results

This was not an overly quantitative demonstration. It could be better described as an acceptance activity or initial validation of the concept. As such, the success criteria as encapsulated in the demonstration objectives can be said to have been met. Each of the objectives are reviewed here in light of the completed demonstration.

7.1 Mapping existing schema to requirements

This was identified as a primary objective and can be evaluated as complete or successful through inspection of the resulting API. Given that the API (and associated data schema)

allowed for completion of the identified experiments to the participants' satisfaction, we can claim there is a reasonable data mapping to meet the requirements as currently understood.

7.2 Demonstrate reasonable situational awareness

The NASA systems were able to see the plans and data as they were submitted. At least two of the UTM partners developed systems that allowed for visualization of other operators' submitted data by querying the FIMS and/or subscribing to data message queues. The data they received were deemed reasonable for those operators to appropriately plan their operations such that they would avoid other conflicting operations. Thus, reasonable situational awareness was possible via this initial architecture.

7.3 Accelerate related efforts

The efforts of the DWG provided topics for discussion within NASA and within the related Concepts Working Group of the RTT. The format of the DWG also allowed for an initial blueprint for the Communication & Navigation and Sense & Avoid working groups. Thus, the efforts of the DWG with this demonstration aided in the acceleration of related efforts.

7.4 Develop an initial architecture.

This was indeed completed to allow for the demonstration to occur. From this initial architecture and the various lessons learned, future iterations of the architecture will be developed.

8 Lessons Learned

After the demonstration was complete, a qualitative report was requested from each of the non-NASA participants discussing their impressions of the activity. In this section, we provide some of this feedback – the five participants will remain anonymous and have been randomly labeled as Participant A through E.

8.1 Overall Impressions

Overall, the feedback was positive. The way in which the concept was presented and demonstrated resonated well with the participants. The "demonstration was successful and beneficial"[A] and the "architecture has proven to be a great starting-point."[B] There was a general belief "that simulation is the most appropriate methodology for these kind of tests and research activities."[C] "The execution of the tests was fairly smooth"[D] with the "demo documentation [being] thorough and help[ing] ... development go smoothly."[E] The process made "users/teams think about certain aspects of flight ... that would otherwise be overlooked."[C] Also, "the group as a whole learned more about this subject than it would have with each team doing these tests individually."[B]

8.2 Architecture Design

Several participants had detailed comments on the overall architecture of the FIMS-USS subsystem within UTM. Those comments are grouped by participant below. The takeaway message from NASA's perspective is that the individual technologies selected for this initial demonstration (based on prior NASA development efforts) were both reasonable, at least for the demonstration, and also potentially applicable for future implementations as an operational system. As noted by several participants–and as known by the NASA UTM project–the technologies were not tested or selected based on a full engineering analysis. Such an analysis is needed in the future and should include elements of cybersecurity, scalability, reliability, and other measurable qualities.

8.2.1 Comments of Participant "B"

"It allows an authority (such as the FAA) to both audit ongoing sUAS flight operations, as well as intervene with specific restrictions when necessary. Especially notable is the fact that it is designed on the concept of 'no human in the loop' of operations—meaning that it can ultimately scale to meet demand. This exercise was limited enough in scope that the working group could demonstrate the basic functionality of the architecture—although there are still plenty of hurdles before we can confirm that this works in all cases.

"The NASA-designed scheme supports provisions for many features that are not yet supported in the implementation. Of course, much of this design will require some degree of refactoring as the implementation evolves and is tested, but the NASA designed architecture suggests how these features could be incorporated into a more comprehensive and scalable implementation.

"The current design relies on a mix of technologies, with HTTPS at the core and higher-level components (i.e. “web sockets”) on top of this. This makes the implementation of a UTM client somewhat clumsy. It would be relatively straight-forward to develop a simpler approach that would streamline this implementation and eliminate the dependency on higher-level constructs.

"No attention was given to concepts such as: (a) detecting/preventing loss of data, (b) the system’s methods and processes for identifying/reacting to delayed data transmissions or vehicles that lose communication. Although these were not an objective of the initial trial, we are confident that these issues can be addressed in future trials."

8.2.2 Comments of Participant "C"

"We are in support of using RESTful APIs and use of STOMP was a good choice. Down the line, we may as a group need to look at the scalability/load testing aspects of the solution when UTM goes past the limited research/experimentation traffic."

8.2.3 Comments of Participant "D"

"[It was] beneficial to test stomp as a data exchange mechanism [but as a] sender [it was] hard to maintain connections. [We] lost messages if not connected until [we] went to full broker [and it] worked better in TCL2. Swagger was great for specifics about APIs [but] no change history to clearly point out changes."

8.2.4 Comments of Participant "E"

"The REST/STOMPoverWS combination is not the most natural to code against. It might be more performant at scale to have positions sent via WS as well. STOMP was actually very easy to work with and is an easy protocol to debug because it is text based."

8.3 Development Process

The planning and execution of the demonstration occurred between July and November 2016. This timeline was extremely tight. The aggressive schedule was driven by many factors, including other UAS/UTM related activities on the calendar, providing input to the other working groups, keeping momentum on the overall effort moving forward, amongst others. The activity was impacted by other parallel UTM project efforts, not the least of which was the TCL 2 Demonstration held at Reno-Stead airport in Nevada in October 2016. That demonstration was the highest priority for the UTM project given the long lead times for performing live, beyond visual line of sight (BVLOS) flights in the National Airspace System in coordination with dozens of partners. Thus, the NASA software development team was splitting time between competing versions of the server side of UTM, with the TCL 2 Demonstration taking priority. Also, it needs

to be noted that the concepts driving this DWG demonstration were being developed in parallel with the software.

All of these issues negatively affected the partners participating in this DWG demonstration. The documentation from NASA that was required for the partners to build their software clients was often incomplete and/or late arriving, necessitating many last-minute adjustments to their code and our collaborative plans. Below are some quotations from the partners related to this impact:

- "The only gripe we have is that the interfaces/API/Parameters were changing [until] the last minute (some not even in line with the documentation) for each of the two tests which required last minute troubleshooting and changes."[C]
- "FIMS was operated in a manual way which made it difficult to develop against when it only worked with operators on the back end."[D]
- "Many API changes right up to the client checkout requiring us to essentially certify twice."[D]
- "Too many API and messaging changes close to the end that required significant effort... Breaking changes so we had to code on the spot."[D]
- "Only very near the test did the FIMS start posting geometries for closures."[D]
- "Without participant access to Confluence, we were always working with old documentation."[D]
- "In the future, it might be better to be more specific about flight paths and UAV speeds to reduce the amount of waiting."[E]
- "Testing should be made simpler as the implementation evolves. Many of the test cases in this trial required manual intervention to inject simulated events. It is preferable to automate these events so that the client tests could be easily regression-tested as well as expanded in scope."[B]
- "Operation areas did not always line up with the defined scenario. Some of the operating areas that were supposed to be in compliance were submitted in no-fly areas. Some of the submitted geometries seemed to have points that were not in order or transposed."[A]

8.4 Summary

Synthesizing the feedback, the following may be a reasonable list of lessons learned to help guide future demonstrations:

- Provide adequate time for planning and implementation of future demonstrations. This includes appropriate planning in conjunction with all of the UAS/UTM activities to ensure availability of resources to appropriately execute.
- Build on the architecture and open up the technology choices to include more future operational requirements.
- Define parameters even more precisely for simulated operations to ensure smooth compatibility.
- Attempt to open up the documentation process to avoid outdated, slow releases of required information.

9 Next Steps

This demonstration helped highlight and test a reasonable architecture for the future UTM System, including definitions of several key data exchanges. However, this demonstration focused on communications between the ANSP and users of the airspace. In architectural terms, the only data exchanges exercised were those between the FIMS and USS. Moving forward, there are several other data exchanges that need to be formalized. Of current highest priority are the exchanges between various USSs (i.e., USS-to-USS communication). Some of the basic questions are as follows:

1. What data are required to be shared amongst USSs?
2. How should those data be shared?
3. How does a USS become vetted?
4. How do other stakeholders "find" or "discover" a USS?

There are many other questions that can be formed. Via the DWG, NASA will define these questions and develop additional collaborative demonstrations to prove and refine the concepts. In addition to USS-to-USS communication, the other high-value technical questions to be addressed include, but are not limited to the following:

1. How is authentication, authorization, and accounting achieved within the UTM System?
2. How do public safety and other public entities interact with UTM?
3. What is the general discovery mechanism needed for the various components in UTM?
4. What levels of quality of service are required for the various components in UTM?
5. What, precisely, is the complete set of roles and responsibilities in UTM?

Each of these questions, as well as others not explicitly listed, need discussion, documentation, and some level of testing. These will be the issues dictating the next steps of the DWG.

10 Conclusion

NASA previously conducted simulations and flight tests as part of the UTM Project, but the effort described here was the first under the banner of the NASA-FAA RTT for UTM. Not only was the demonstration successful, it provided a solid foundation for future demonstrations, helped give some clarity to the overall concept development, offered a chance for more industry partners to have direct input on the concept, and produced lessons-learned that can make future demonstrations even more successful. The DWG is an excellent resource for the RTT and the UTM cause as a whole. Leveraging this resource by actively engaging in demonstrations and producing software artifacts will help push the concept along.

11 Appendix A – DWG Demonstration 1 Plan

The content of this appendix was originally a stand-alone document. The information contained herein represents the initial planning of the demonstration and may be out of sync with the actual execution as described in the main document or the more recently written Appendix B. This appendix is included for completeness, reference, and context.

11.1 Overview

This document describes the plan for a collaborative demonstration between NASA and industry partners as part of the UTM RTT Data Exchange Working Group (UTM-DWG). This demonstration will exercise the initially proposed data exchange models for the UTM System. The focus of the initial models and this demonstration is upon the data exchanged between the operator and the Airspace Navigation Service Provider (ANSP). To demonstrate the data exchange, the initial models will be developed to support specific demonstration scenarios. Those scenarios are described in this document. Given that the scope of this collaborative demonstration is limited to the exchange between operator and ANSP, there may be future work and demonstrations for other aspects of the overall data exchange model in the UTM System.

11.2 Background

On Wednesday, July 20th, 2016 NASA hosted a meeting that included representatives from the FAA and several partners from industry and academia interested in sUAS access to the low-altitude airspace. This meeting represents an element of the overall NASA-FAA Research Transition Team effort related to UTM research. The FAA provided some background on their UAS work to date and their current thoughts on how sUAS may access the airspace in the future. The FAA is seeking input to inform this process and proposed five working groups. The first of these to begin is the UTM-DWG. A self-selected subset of those organizations in attendance met the following week on Wednesday, July 27th, 2016. NASA produced this document as a result of that initial meeting.

At the July 20th meeting, the group used a diagram supplied by NASA as a basis for discussion of the overall concept and the flow of data in particular. That diagram has evolved into the following:

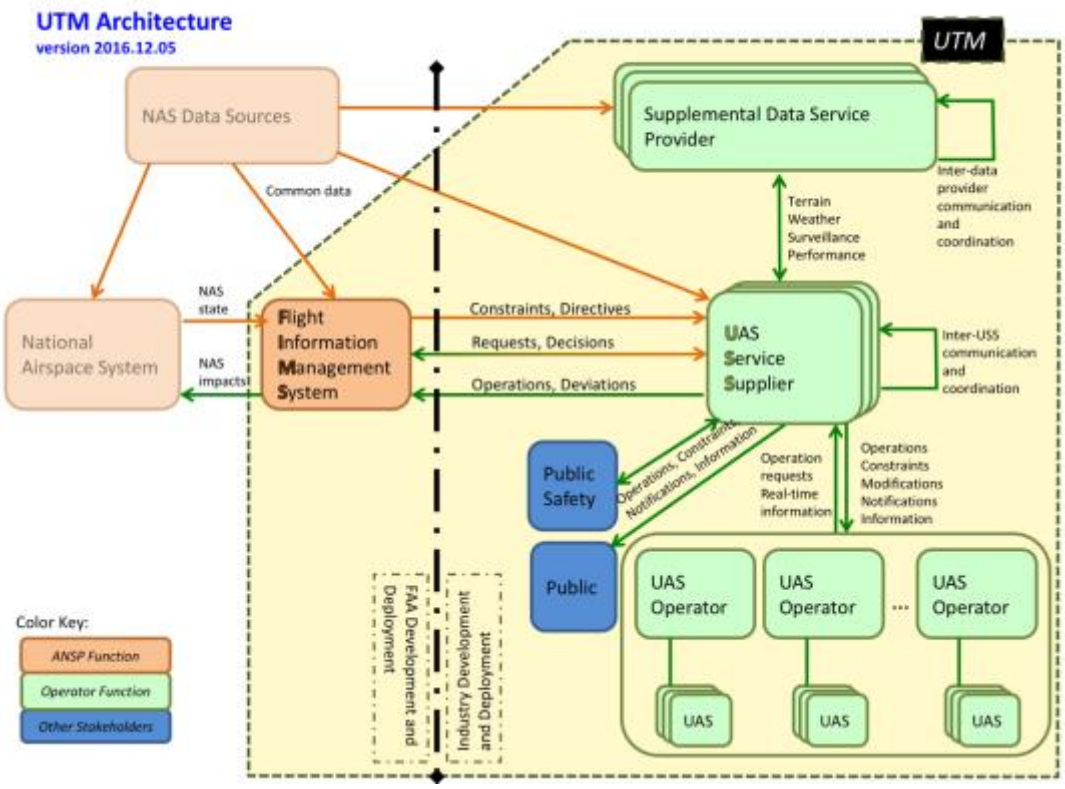

Figure A-1: UTM Architecture

This diagram should not be considered final. Discussions are ongoing and will be informed by this collaborative demonstration.

11.3 Current Scope

The scope of this working group is driven by test scenarios for this collaborative demonstration. Those test scenarios are detailed below. To focus the technical discussion on a manageable and meaningful part of the diagrams above, the connection between the USS and the FIMS will drive the technical work associated with this demonstration. This does not intend to lessen the importance of the other connections in the diagram and eventual UTM System, however, through the process of defining and developing the FIMS-USS connections, the requirements and path forward for the other connections may become clearer.

11.4 Deliverables

This activity will produce, at a minimum, the following deliverables (Table A-1). The customer for these deliverables is UTM Research Transition Team including NASA, FAA, other government participants, and industry partners.

Table A-1: Deliverable DWG Artifacts

Date	Artifact(s)	Description
TBD	Demonstration plan document	A final version of this document.
TBD	Data collected during demonstration	• Log of communications to and from FIMS • Log of communications to and from each Operator

Date	Artifact(s)	Description
		• Any media recorded during demonstration (telecon, videocon, etc.)
TBD	Qualitative statements	Each participant will provide feedback on the working group and demonstration.
TBD	Plan for future UTM DWG	retiring? continuing with additional demos? etc.

11.5 Test Scenarios

11.5.1 Assumptions

The scenarios are detailed in the following subsections. For each scenario, the following assumptions are in place:

- Operations are BVLOS of the UAS controller.
- BVLOS operations require notification of intent.
- The Operator acts as a "full stack" operator (UAS, UAS Operator, USS, Supplemental Data Service Provider all under control of one entity)
- These are not real flights, only simulated.
- Any roles that are believed to be filled by humans will be filled by humans for the demonstration/test.

Note that not all of these assumptions are necessarily part of any future operational environment. These assumptions simply provide a clearer baseline for all participants in the demonstration.

11.5.2 Scenario 1: Operator Incursion

11.5.2.1 Overview

While performing an operation near the boundary of U.S. National Park that is located in a suburban or urban area, an operator inadvertently crosses over that boundary. This incursion into an unauthorized area will trigger a series of data exchanges between the operator and the FIMS, these exchanges may trigger further data exchanges between:

- FIMS and other operators
- The offending operator and other operators
- FIMS and other NAS elements

This scenario will exercise data exchanges that occur for operations flying near and within National Park boundaries.

11.5.2.2 Story A

An operator plans an operation in a populated area. This operation's planned trajectory keeps it clear of all known constraints. The platform being flown has been registered with the ANSP for operation in the airspace and meets all operational and maintenance requirements. The operator has the appropriate licensing and credentials to perform such operations. The operator begins the operation as planned, however during the operation the vehicle deviates from its planned course and enters airspace that is restricted to sUAS operations. This incursion is into a national park area. As soon as the operator is aware of the incursion, it sends a message to the FIMS indicating a deviation in its intended operation. This communication

occurs in parallel with the operator's attempts to correct the incursion. The operator receives directives from the FIMS to correct its current trajectory. Other nearby operators receive directives and messages related to the offending operation. The operator is able to correct the trajectory and return its operation to the originally intended plan. The operator updates the FIMS on its deviation status. Figure A-2 shows an example sequence diagram for this scenario.

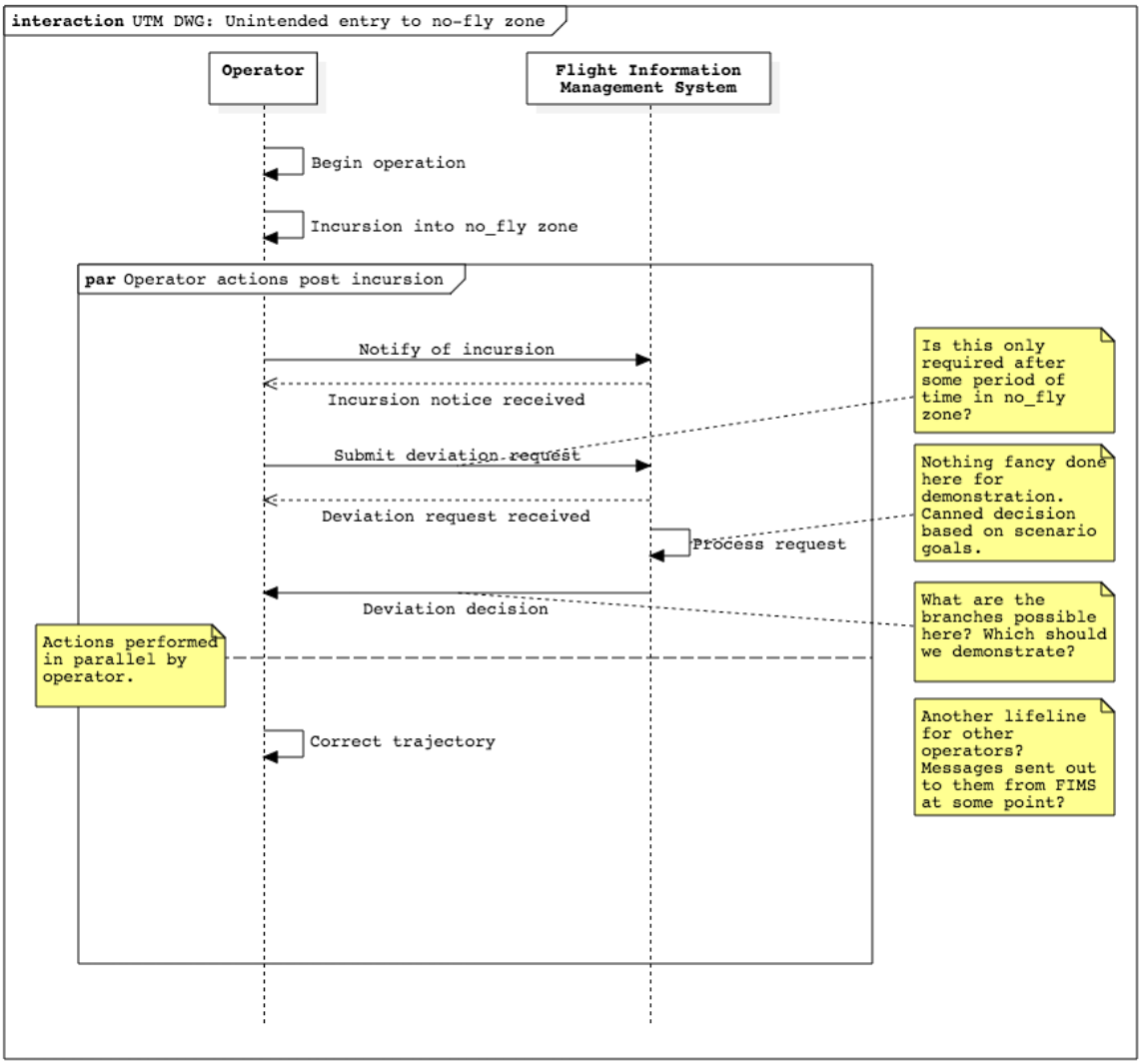

Figure A-2: Incursion into No-Fly Zone

11.5.2.3 Story B

An operator plans an operation in a populated area. This operation's planned trajectory keeps it clear of all known constraints. The platform being flown has been registered with the ANSP for operation in the airspace and meets all operational and maintenance requirements. The operator has the appropriate licensing and credentials to perform such operations. The operator does not have any special role or credentials (e.g. public safety). The operator begins the operation as planned, however during the operation the operator notices an opportunity for a more optimal flight plan that would take the UAS over National Park territory. The operator sends a request to the FIMS for access to the nominally off-limits area for a time-limited, planned incursion. The FIMS receives the request and approves it. The operator adjusts the flight plans accordingly and completes the operation including the segment through the National

Park territory. When trying the same request for a similar operation at a later time, the request is not granted and the operator is obliged to use the original plan for that second operation. Figure A-3 shows an example sequence diagram for this scenario.

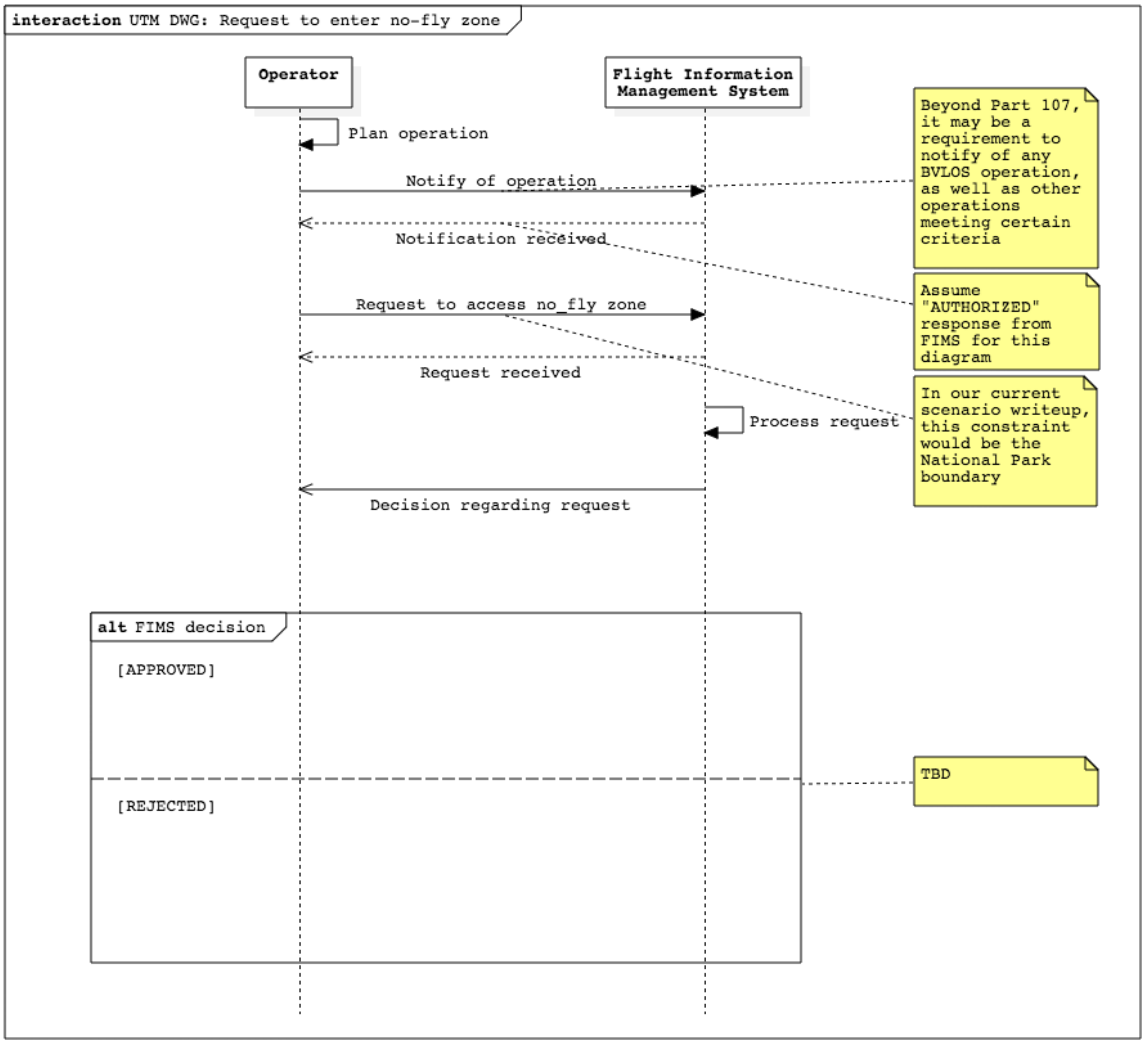

Figure A-3: Request to Enter No-Fly Zone

11.5.2.4 Story C

An operator plans an operation in a populated area. This operation's planned trajectory keeps it clear of all known constraints. The platform being flown has been registered with the ANSP for operation in the airspace and meets all operational and maintenance requirements. The operator has the appropriate licensing and credentials to perform such operations. The operator does not have any special role or credentials (e.g. public safety). The operator begins the operation as planned. During the flight, the vehicle deviates from its planned trajectory, though does not enter any "no-fly" areas. The operator begins to take corrective actions while announcing the deviation to other stakeholders.

11.5.2.5 Discussion

To focus this scenario, two specific National Parks will be used. More precisely, two National Historic Sites will be used. The first is the John Muir National Historic Site in Martinez, CA,

which is in the Bay Area to the east of San Francisco, CA. The second is the William Howard Taft National Historic Site located in Cincinnati, OH. GeoJSON descriptions of these areas are provided here:

https://gist.github.com/alotau/4ff38d01fa6a7dee6132e474c3bf08bf

These data were collected from the US Department of Transportation data website. Specifically, the URL for the National Park data is:

http://www.rita.dot.gov/bts/sites/rita.dot.gov.bts/files/AdditionalAttachmentFiles/parks.zip

The shapefile within that zip file was imported to QGIS. The specific sites were extracted using QGIS and exported as a GeoJSON file.

The focus of this scenario is on the exchange between the operator and the FIMS. As a stretch goal, other exchanges may be investigated. The technical mechanisms for data exchange will not be finalized with this demonstration, however, various options may be discussed and a reasonable method for actually sending and receiving data will be chosen by the working group. This chosen method may inform future demonstrations and working groups.

The working group will decide on the necessary and sufficient data to be exchanged to satisfy this scenario from all involved perspectives (ANSP and operator).

11.5.2.6 Questions

What are the time requirements for these communications? How quickly must operator report? How long can the operation fly in the constraint before some other action by ANSP takes place? Which other operators should be notified? What directives, if any, are they provided? What if there is surveillance active in these areas? Do those systems alert anyone?

11.5.3 Scenario 2: Airspace Constraint Change

11.5.3.1 Overview

Operations are allowed near an airport, but the available areas are dictated on the current runway configuration. An unplanned configuration change triggers data exchange between the FIMS and operators. While the initial data exchange is a push from the FIMS, subsequent data exchanges would be required to keep operations in the appropriate areas.

11.5.3.2 Story

Mineta San Jose International Airport (SJC) has parallel runways 12L-30R/12R-30L and has two major flows: South Flow and North Flow indicating the direction of the departing and arriving traffic. These configurations typically change based on weather (wind) events. Given the altitude of the manned aircraft on approach, the arriving traffic has a protected zone added to keep sUAS from operating in that zone. Thus, on a configuration change, that zone changes as well. When a configuration change happens, there is a ten-minute delay before any arrivals, thus the ANSP allows for a five-minute period for existing operations to clear the newly established protected zone. New sUAS operations may immediately use the other protected zone that was deactivated.

11.5.3.3 Discussion

A pseudo (hand drawn) dataset for the airport configurations was hastily created and placed here:

https://gist.github.com/alotau/cfd4695f79208ac0b980b00259cbac9c

If real-world data for an airport configuration change is easily available for an airport in an urban area, we should substitute those real data.

11.5.3.4 Questions

What does the constraint announcement contain from the FIMS?
How do operators with active operations in the new constraint react safely?
What if they can't land within five minutes?
Should they not have been allowed to operate in that zone in the first place in that case?
What if they can't land within five minutes due to some safety issue?
How does the airport ultimately get notified?
Are the time values proposed reasonable?

11.5.4 Scenario 3: All Land

11.5.4.1 Overview

This scenario exercises the case where the ANSP provides a directive to all operators to clear the airspace (also known as an "all land" scenario). There will be operations that are active that need to land and operations planned for the near future that need to stay grounded.

11.5.4.2 Story

A national security issue is affecting the entire conterminous United States. The ANSP decides it is safest to ground all sUAS operations until further analysis of the situation can be completed. A message from the FIMS provides the directive for all active operations to go to ground within the next five minutes and to cancel any planned operations. Operators submit their deviation plans to comply with the directive and commence grounding operations. Operations that are in an unsafe or unknown state are reported to the FIMS to allow the ANSP to incorporate that information into NAS-wide contingency management.

11.5.4.3 Discussion

This seems like an important functionality to begin hashing out. We need to think about how each type of operation might be affected by such a scenario. This can help make the discussion about the need for reliable communication between FIMS and USS more concrete. The argument should be that each operation should be reachable within some time window to enable these types of contingencies.

11.5.4.4 Questions

1. What does the directive look like?
2. What time parameters make sense? Time to execute, time to notify of diversion plans, time to notify of failure to comply, etc.
3. What do the messages from the operator look like?
4. What happens to priority operations (public safety, military, etc.) in this scenario? Should we mock them out?

11.5.5 Scenario 4: Dense Operations

11.5.5.1 Overview

Despite the vast airspace and current low density of sUAS operations, there are cases in the future where multiple sUAS will seek to access the same volume of airspace. There may be a

need to implement some traffic management directives to maintain safety and efficiency in the system. At the very least, there should be availability of data for operators to make informed decisions about their operations with respect to other known sUAS operations. This scenario aims to explore this issue in terms of the data exchanges necessary to support these operations and the ANSP.

11.5.5.2 Story

The daughter of a B-list actor is getting married. The day of the wedding sparks a plethora of activity at the site of the event. The videographer is planning to use two sUAS to capture aerial shots. Paparazzi drones want to perform a few flybys to capture footage. Some last-minute items are ordered by the caterer for the reception requiring three separate drone deliveries. One of the guests realize that their favorite beverage is not available at the bar and orders some to be delivered directly to him via sUAS. Meanwhile in the park next door to the site, there is a soccer game being recorded by a separate sUAS. In addition, there is a planned surveying activity by the state of the local roads. The local police also routinely patrol with drones at various times during the day along/above the public streets. Each operation announces its plan to operate per requirements since the wedding site is within 2 miles of an active airport.

11.5.5.3 Discussion

This is an artificial, though possible, scenario. The goal is to begin investigating what data need to be exchanged to keep the airspace safe and efficient. We will not focus on the algorithms or rules that the FIMS may use to calculate capacity of the airspace.

An initial area where this might fictionally occur is proposed here (near San Francisco (SFO) and San Carlos airports, has parks, suburban/urban environment):

https://gist.github.com/alotau/f01ad7fdf4571061819c6a7e27b85cc5

11.5.5.4 Questions

1. Are the operation notifications really requests in this scenario?
2. Is there a static procedure/rule that operator should follow in terms of managing the density of operations?
3. Does the FIMS keep track of the density of operations?
4. How does the FIMS notify if a critical density is reached?
5. How do USSs respond?

11.6 Data

To facilitate the scenarios described above, the data to be exchanged need definition. For this process, concepts from the FAA and NASA are used as a starting point to identify gaps and suitability for these scenarios.

11.6.1 Initial Requirements from FAA

The FAA has some initial thoughts on the data to be exchanged between the operator and the FIMS. These are detailed in the Table A-2 below:

Table A-2: Initial FAA Data-Exchange Requirements

UAS Operator (Part 101-E and Part 107)[1] Data Exchanges with FIMS		
Flight Request (Operator -> FIMS)	**Flight Authorization (FIMS -> Operator)**	**Flight Status (Operator -> FIMS)[2]**

• Operator Information
  ○ Operator Name
  ○ Phone Number
• Aircraft Information
  ○ Registration Number (or Serial Number if <250g)
• Operation Information
  ○ Indication whether operation is under Part 101-E, Part 107, or Part 107 waiver; If waiver then:
  ▪ Waiver Certificate Number
  ○ Date of Proposed Operation
  ○ Start Time of Operation
  ○ Duration of Operation
  ○ Geographical Operating Area
  ○ Maximum Operating Altitude
  ▪ Indication if operating within 400ft radius of structure
  ○ Purpose of Operation (voluntary)
• Acceptance of Terms and Conditions
• Flight denial challenge (Part 107 only if flight is initially denied)
	• Indication if flight information is submitted too far in advance of operation
	• Indication that flight information has been received
	• Response to flight operation request:
	  ○ Accepted (Part 101-E) / Authorized (Part 107)
	  ○ Denied
	  ○ ATC notification not required (Part 101-E) / ATC authorization not required (Part 107)
	• Changes in authorization status *prior to* proposed flight (acceptance/authorization -> denial)
	• Changes in authorization status *during* the proposed flight (acceptance/authorization -> termination)
		• Cancellation of flight operation (prior to operation)
		• Change in flight operation end time (if operation ends earlier than originally planned; extension requires new request)
		• Operator acknowledgement that flight operation will no longer be conducted (if initially accepted / authorized, then denied or terminated by ATC)

1 *The data elements identified herein are limited to Part 101-E and Part 107 data exchanges with the Flight Information Management System (FIMS), and are not inclusive of all possible operations that require notification/authorization in lieu of an IFR flight plan.*

2 *The UAS Operator will access relevant NAS information via NAS Data Services to ensure regulatory compliance and safety of flight. NAS Data Services may provide information such as locations of Special Activity Airspace, controlled airspace boundaries, airspace within 5 miles of an airport, airport-specific "no-fly zones" and "fly zones", and other areas designated as "no-fly zones".*

11.6.2 Initial Implementation by NASA

The following are a subset of the elements from NASA's current (as of this writing) implementation of UTM. More details are available in the UTM Client Interface Control Document.

11.6.2.1 Operation

An operation within NASA's research platform consists of vehicle, operator, and intent information for a particular sUAS operation – this information is listed in Table A-3 below. Note that this table is directly from the ICD so some context for the comments and section references may be missing.

Table A-3: Vehicle, Operator and Intent Information

Field name	Data type	Req'd on submission	Allowed on submission	Description
gufi	String, UUID	No.	No.	Each operation has a globally unique flight identifier (GUFI) assigned upon submission. It is a JSON string that conforms to the UUID version 4 specification (see Section 3.1)
submit_time	String, Date	No.	No.	Time the operation submission was received by UTM System.
decision_time	String, Date	No.	No.	A timestamp set by the UTM System any time the state of the operation is updated, for example when the flight goes from PROPOSING to ACCEPTED (see Section 4.1)
aircraft_comments	String	No.	Yes.	Informative text about the aircraft. Not used by the UTM System.
flight_comments	String	No.	Yes.	Informative text about the operation. Not used by the UTM System.
flight_geography_description	String	No.	Yes.	Informative text about the operational geography. Not used by the UTM System.
registration	String, UUID	Yes.	Yes.	The registration ID of the vehicle flying this operation. Note the UTM System assumes a single vehicle per operation

Field name	Data type	Req'd on submission	Allowed on submission	Description
				currently. This registration value is provided to operators upon manual registration of their vehicle with NASA. See Section 4.3.3.
flight_number	String	No.	Yes.	Optional. Currently unused by the UTM System, may be useful to the operator for identification purposes.
unmanned	String, Boolean	Yes.	Yes.	Please include "unmanned":"true" with all submissions.
user_id	String	No.	Yes.	This field is populated based on the provided credentials in the HTTPS header. If submitted by a user, the value will be ignored.
created_by	String	No.	No.	The user that created the operation. It is possible that an operation is created on behalf of an operator by, say, a manager. Nominally, this field will be equal to user_id.
primary_contact_name **primary_contact_phone** **primary_contact_email**	String	Yes.	Yes.	These are required fields. They are not currently checked for validity, but clients should endeavor to provide useful, appropriate information in these fields. Validity will be checked in the future. These values should represent the contact that should be used in case of an issue with the operation before, during, or after that operation.
secondary_contact_name **secondary _contact_phone** **secondary _contact_email**	String	No.	Yes.	These are optional fields. They are not currently checked for validity, but clients should endeavor to provide useful, appropriate

Field name	Data type	Req'd on submission	Allowed on submission	Description
				information in these fields. Validity will be checked in the future. These values should represent the back-up contact that should be used in case of an issue with the operation before, during, or after that operation.
extra_contact_info	String	No.	Yes.	Any additional contact information that may be useful (hours of availability, fax number, communication limitations, etc.).
state	String	No.	No.	The current state of the operation. Not required for submission, will be assigned by the UTM System.
controller_location	Geometry of type POINT	Yes.	Yes.	The planned position of the UAS Controller during the operation. Assumed to be a static location.
gcs_location	Geometry of type POINT	No.	Yes.	If not submitted, the UTM System will assume the GCS is co-located with the UAS Controller. Assumed to be a static location.
faa_rule	String	No.	Yes.	Indication whether this operation is under Part 101-E, Part 107, Part 107 waiver, or a Part TBD. Part TBD is a potential future rule that may cover operations such as those under test by UTM.
waiver_certificate_number	String	No.	Yes.	If a waiver has been obtained for the Part 107 rules, then the operator would have a waiver certificate number. For any operation submissions with faa_rule=PART_107W, this field is required.

Field name	Data type	Req'd on submission	Allowed on submission	Description
operation_volumes	Array of type operation_volume	Yes.	Yes.	The actual geographical information for the operation.

11.6.2.2 Operation Volume

Operation volumes are used to describe where and when an operation is to take place. Multiple operation volumes can be used for a single operation. This promotes more efficient use of the airspace by allowing operators to only claim/announce use of the airspace they really need during a particular time period. Table A-4 describes the information used to describe an operation volume.

Table A-4: Operation Volume Information

Field name	Data type	Req'd on submission	Allowed on submission	Description
ordinal	Integer	Yes.	Yes.	This integer represents the ordering of the operation volume within the set of operation volumes. Need not be consecutive integers.
effective_time_begin	String, Date	Yes.	Yes.	Earliest time the operation will use the operation volume.
effective_time_end	String, Date	Yes.	Yes.	Latest time the operation will done with the operation volume.
actual_time_end	String, Date	No.	No.	Time that the operational volume was freed for use by other operations.
conformance_time_begin	String, Date	No.	No.	Assigned by UTM System. Time buffer before the submitted begin time.
conformance_time_end	String, Date	No.	No.	Assigned by UTM System. Time buffer after the submitted end time.
min_altitude_wgs84_ft	Number, Double	Yes.	Yes.	The minimum altitude for this operation in this operation volume. In WGS84 reference system using feet as units.
max_altitude_wgs84_ft	Number, Double	Yes.	Yes.	The maximum altitude for this operation in this operation volume. In WGS84 reference system using feet as units.

Field name	Data type	Req'd on submission	Allowed on submission	Description
conform_min_altitude_wgs84_ft	Number, Double	No.	No.	The minimum altitude assigned and used by the UTM System to check vertical conformance of an operation. Based on UTM Client-provided min altitude.
conform_max_altitude_wgs84_ft	Number, Double	No.	No.	The maximum altitude assigned and used by the UTM System to check vertical conformance of an operation. Based on UTM Client-provided max altitude.
flight_geography	Geometry	Yes.	Yes.	A description of the operational area. This should be the area within which the operation will remain.
conformance_geography	Geometry	No.	No.	A UTM-generated geography based on the flight geography. See Section 4.4.2 for discussion.

11.6.2.3 Messages

To convey information between the UTM Core and operators within the UTM research platform, message can be exchanged. The schema for messages is presented in Table A-5 below:

Table A-5: Message Information

Field name	Data type	Required from Client upon submission?	Allowed from Client upon submission?	Description
message_id	String, UUID	No	No	Unique identifier
origin	String	No	No	Must take exactly one of three values: • **CLIENT**. Message is from a UTM Client to the UTM System. • **UTM**: Message was automatically generated by the UTM System. • **MANAGER**: Message was generated by a UTM Manager (a human).
user	String	No	No	Populated by the UTM System. The target user for a message from the UTM System.
gufi	String, UUID	Yes	Yes	The assigned GUFI for the operation referenced by the message.

Field name	Data type	Required from Client upon submission?	Allowed from Client upon submission?	Description
category	String	Yes	Yes	The type of message. Must take exactly one of the following values: • **INFORM**: The UTM System sends this message when an operation changes state for any reason. • **INTENT**: A message from a UTM Client or UTM Manager requesting a state change in an operation. • **ALERT**: An alert sent from the UTM System or UTM Manager to UTM Clients. • **RESPONSE**: A response from the UTM System to a UTM Client/Manager that a prior message was received. • **FREE**: A free text message.
free_text	String	No	Yes	Any free text. Not used in an automated way by the UTM System and is optional.
sent_time	String, Date	No	No	Either the time the message was sent by the UTM System or the time it was received by the UTM System.
ack_time	String, Date	No	No	Applied by the UTM System. Further documentation on this element not available.
alert_message	String	No	No	Only included with messages from the ALERT category. Must take one of the following values: • **WEATHER** • **SECURITY** • **OPERATIONS** • **SYSTEM**
alert_severity	String	No	No	Only included with messages from the ALERT category. Can take the following, increasingly important values: • **INFORMATIONAL** • **NOTICE** • **WARNING** • **CRITICAL** • **EMERGENCY**
intent_message	String	Yes	Yes	Only included with messages from the INTENT category. Can take the following values referring to state changes that are requested by a UTM Client or UTM Manager: • **ALL_CLEAR** • **CANCEL** • **CLOSE**

Field name	Data type	Required from Client upon submission?	Allowed from Client upon submission?	Description
inform_message	String	No	No	Only included with messages from the INFORM category. Can take the following values referring to states of an operation: • **ACCEPTED** • **REJECTED** • **ACTIVATED** • **CANCELED** • **CLOSED**
violations	Array	No	No	Included with messages from the INFORM category with inform_message = REJECTED. The array is of pairs of types and constraining_ids. The type refers to a constraint in the system (national parks, airports, etc.) and the constraining_ids are the UUIDs associated with those constraints. This will allow for querying of the system for more information about those particular constraints.
warnings	Array	No	No	An array of type, warning_id, message triplets.

11.6.3 Mapping FAA Initial Requirements to NASA UTM Research Platform Schema

In this section, we present an initial mapping of the FAA's initial thoughts on data exchange with the existing NASA schema (Table A-6).

Table A-6: Initial Data Exchange Mapping

FAA Statement	NASA Data Element	Discussion
Operator Information • Operator Name • Phone Number	Operation: • user_id • primary_contact_name • primary_contact_phone • primary_contact_email • secondary_contact_name • secondary _contact_phone • secondary _contact_email	This is a relatively clean mapping of data elements. The NASA schema appears more (or overly) complete for the FAA's purposes. Note that in the NASA UTM research platform, each user_id is associated with a specific operator. Typically, the operator in the UTM research platform would be an organization. That operator may have several user_id's associated with it. It is the user_id that is submitted with the operation, thus allowing a look up of the associated operator.
Aircraft Information • Registration Number (or Serial Number if <250g)	Operation: • registration	This is a relatively clean mapping. In the UTM research platform, each vehicle is required to be registered. That registration includes a set of performance characteristics that may

FAA Statement	NASA Data Element	Discussion
		be useful in contingency or capacity management activities. A successful registration of a vehicle in the UTM research platform provides a UUID for that registered vehicle, which is the value required in the registration field.
Operation Information • Indication whether operation is under Part 101-E, Part 107, or Part 107 waiver; If waiver then: ○ Waiver Certificate Number	-	Suggesting the addition of a new field to the operational plan. An enumerated string field called "faa_rule" to indicate which FAA rule is being used for this operation that is required upon submission with the following allowed values: • Part 101-E • Part 107 • Part 107 Waiver Add an additional field for Waiver Certificate Number that is only required if "faa_rule" has the value "Part 107 Waiver". This field will be a string with the name "waiver_certificate_number" and its value will be the waiver certificate number that was supplied by the FAA. Currently no other information from the FAA has been received on these values.
Operation Information • Date of Proposed Operation • Start Time of Operation • Duration of Operation • Geographical Operating Area • Maximum Operating Altitude ○ Indication if operating within 400ft radius of structure	Operation: • operation_volumes Operation_volume: • effective_time_begin • effective_time_end • min_altitude_wgs84_ft • max_altitude_wgs84_ft • flight_geography	Each operation in the UTM research platform provides a set of operation_volumes to define where and when it will be operating. This maps cleanly to the data elements requested by the FAA. The only gap is the "indication if operating within 400ft radius of structure." Further details on this data requirement may be needed from the FAA side. An additional field may be required by the UTM research platform to accommodate this data element.
Operation Information • Purpose of Operation (voluntary)	Operation flight_comments	This is a clean mapping of voluntary fields. The only concern is the potential overloading of the flight_comments field if it is used for other purposes in addition to "purpose of operation."
• Acceptance of Terms and Conditions	-	An argument can be made that use of the system implies acceptance of terms and conditions of the system. However, if this must be explicit, a new

FAA Statement	NASA Data Element	Discussion
• Flight denial challenge (Part 107 only if flight is initially denied)		field in the current UTM schema will be required. More information is needed to further define the flight denial challenge. There is no current field in the UTM research platform to support this.

• Indication if flight information is submitted too far in advance of operation
• Indication that flight information has been received
• Response to flight operation request:
  ○ Accepted (Part 101-E) / Authorized (Part 107)
  ○ Denied
  ○ ATC notification not required (Part 101-E) / ATC authorization not required (Part 107)
• Changes in authorization status *prior to* proposed flight (acceptance/authorization -> denial)
• Changes in authorization status *during* the proposed flight (acceptance/authorization -> termination)
	Message
	• INFORM
	• INTENT
		The various messages in the UTM research platform should be adaptable to the initial requirements of the FAA data exchange. Specific instances will need to be mapped out to determine any gaps.

• Cancellation of flight operation (prior to operation) • Change in flight operation end time (if operation ends earlier than originally planned; extension requires new request) • Operator acknowledgement that flight operation will no longer be conducted (if initially accepted / authorized, then denied or terminated by ATC)	Message • INTENT	The goal of INTENT messages in the UTM research platform is to provide the system information from the operator on the state of the operation. This message type should be able to meet the FAA initial requirements. Specific instances will need to be mapped out to determine any gaps.

11.6.4 Data Schema Comments

For the other data fields that do not directly map to those suggested by the FAA, we propose to still include them in the demonstration under the current rules of the UTM research platform. As an example, we would require the inclusion of GCS location information even though there is not a direct mapping to the FAA elements because that is the current implementation of the UTM research platform. In the future, extraneous elements (as determined by this working group and the RTT as a whole) can be eliminated if needed.

11.7 Schedule

Table A-7 describes the schedule for executing the Collaborative Demonstration.

Table A-7: Collaborative Demonstration Schedule

Date	Activity/Milestone/Deliverable	Responsible Party	Description
17 Aug 2016	Complete initial planning with full working group	All	This date will be the final meeting day of the full working group.
19 Aug 2016	UTM DWG Collaborative Demonstration Plan final draft	NASA	The final working draft of this document provided to all members of the working group. May continue to evolve to better represent the planning and implementation of the collaborative demonstration.
~~23 Aug 2016~~	Presentation/Discussion of UTM DWG Demonstration Plan to RTT partners	NASA	A briefing to the larger RTT community on the activities, progress, and plans of the UTM DWG. Essentially a walkthrough of this document with relevant discussion targeted for stakeholders not directly involved in its formulation.
1 Sep 2016	Initial information exchange architecture	All	A description of the system architecture that will support the collaborative demonstration.
7 Sep 2016	Collaborative Demonstration virtual meeting	All	Tag-up to discuss progress. Scenarios should be finalized included the general roles of participants. The final working draft of the data schemas to support the collaborative demonstration should be a product of this meeting.
14 Sep 2016	Finalize roles within the scenarios	All	Each participant will have clearly defined roles for participation within the scenarios. These roles will define, for example, the type of operation(s) that the participant will be responsible for portraying within the scenario. The interaction/timing of the roles/operation will be defined as well. For example, participant A submits operation X at t=3, participant B submits operation Y at t=5, FIMS issues message Q at time=8, etc. Note that some scenarios will not necessarily have precisely

Date	Activity/Milestone/Deliverable	Responsible Party	Description
			defined times in order to more naturally simulate how interactions may occur while other scenarios will necessarily have scripted time triggers in order to capture interactions that might not otherwise be exercised or properly measured/observed.
28 Sep 2016	Initial FIMS instance available to external partners for testing	NASA	Based on the architecture decided on 1 Sep 2016, a reasonable subset will be implemented and available for testing data exchange.
TBD	Partner checkout sheet provided	NASA	To ensure all participants are building to the same specification for the demonstration, NASA will provide a testing specification and checkout process for partner systems.
TBD	Checkout process complete	Partners	All partners need to adequately complete the checkout process by this date to continue participation in the collaborative demonstration.
1 Nov 2016	Collaborative Demo Shakeout	All	Run through the scenarios as a group to shakeout any issues.
15 Nov 2016	Collaborative Demo	All	Execute the UTM DWG Collaborative Demonstration

12 Appendix B – DWG Demonstration 1 Test Details

The content of this appendix was originally a stand-alone document. The information contained herein represents the main guiding documentation for the execution of the demonstration. This document was kept on a NASA-internal website that was frequently updated and occasionally exported for sharing with external partners. This set of test details grew from the original information presented in Appendix A.

12.1 Overview

This document details the testing that will occur as part of the Data Exchange Working Group (DWG) Demonstration 1. An individual test is related to a single operator interacting with the Flight Information Management System (FIMS). Each test maps to a particular scenario as described in the DWG Demonstration 1 Plan. Each step in a test illustrates a single data exchange. Sets of tests may be performed simultaneously in a single experiment. The rest of this document describes some of the testing logistics and then the data exchanges, tests, and experiments.

12.2 Participants

The following organizations are participating in this demonstration (Table B-1). The abbreviations will be used for reference in the test planning.

Table B-1: Participating Organizations

Organization	Abbreviation	Primary Contact	Email	Phone
NASA	NASA	Joseph Rios	joey.rios@nasa.gov	
AirMap	AIRM	-	-	
Amazon	AMZN	-	-	
ANRA Technologies	ANRA	-	-	
Simulyze	SIMU	-	-	
Transtrex	TRTX	-	-	

12.3 Schedule

The Demonstration will take place over several non-consecutive dates. The nominal schedules for those dates are as follows:

12.3.1 4th Nov 2016

Table B-2: 4th Nov 2016 Demonstration

Time (Pacific)	Activity
0900	Telecon setup
0910	Roll call
0915	Practice submissions, debugging
1000	D1X1
1100	D1X2
1200	Conclude

12.3.2 14th Nov 2016

Table B-3: 14th Nov 2016 Demonstration

Time (Pacific)	Activity
0900	Telecon setup
0910	Roll call
0915	Practice submissions, debugging
0945	D1X3
1030	D1X4
1115	D1X5
1200	D1X6
1245	Conclude

12.3.3 17th Nov 2016

Table B-4: 17th Nov 2016 Demonstration

Time (Pacific)	Activity
TBD	TBD

12.4 Location

The testing will be completed remotely. The FIMS role will be filled by NASA Ames Research Center (ARC) by hosting a server reachable by the other participants. The other participants will connect remotely to the FIMS for data exchange. The other participants will not need to connect to each other in any way. Each participant may offer connections to data for monitoring and visualization of the Demonstration.

Throughout the test, there will be an ongoing telecon for communications. In addition, there will be an ongoing video conference for coordination and communication. Only the participants will be on the video conference, but the telecon may be open to nonparticipants. The telecon and the video conference will be recorded.

12.5 Architecture

The architecture for this activity is not to be assumed to be the architecture of any future system. This architecture is mostly based on previous Unmanned Aircraft Systems Traffic Management (UTM) work by NASA.

The FIMS and the Operator will build to a known application programming interface (API). The API will use a RESTful architecture for submitting and requesting data in a synchronous way to and from the FIMS (Figure B-1). This RESTful API will be described in an OpenAPI Specification file. For asynchronous messages, WebSockets will be used. All data exchanges will be over port 443 on the FIMS.

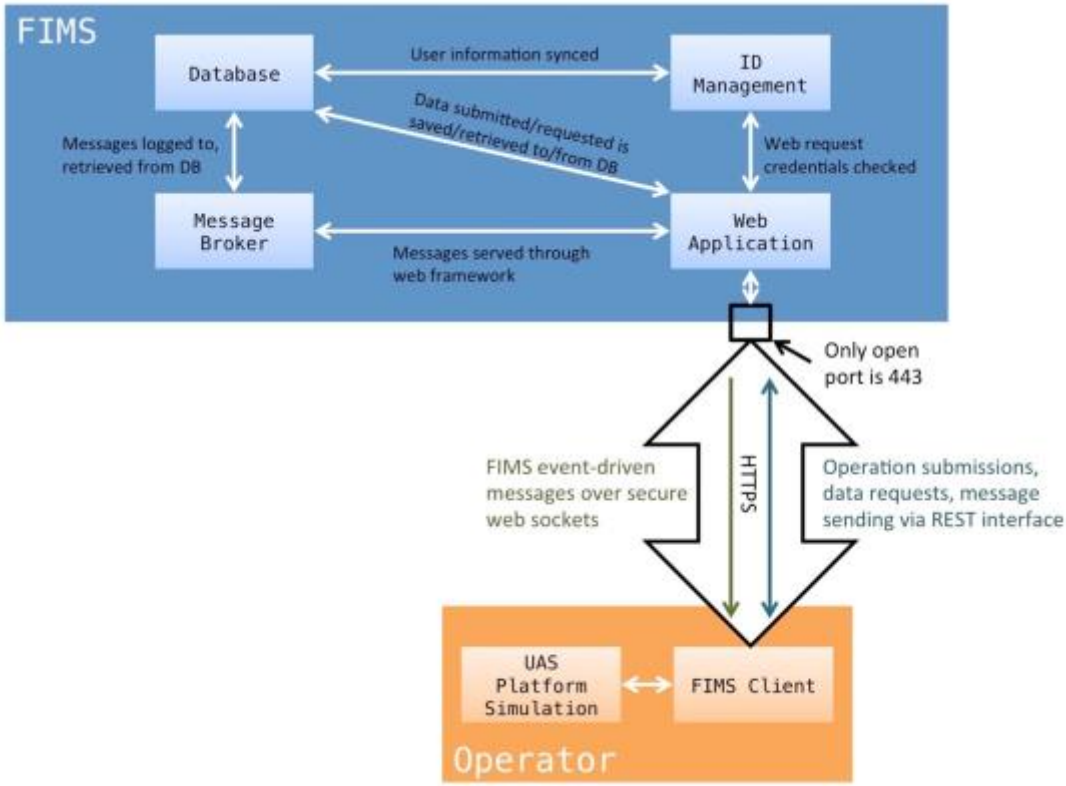

Figure B-1: FIMS RESTful Architecture

12.6 Assumptions

In this section, we capture some of the assumptions of this test.

12.7 Data Exchanges

Table B-5 lists the individual data exchanges that are currently expected between FIMS and operators. This list will likely evolve as testing and discussions continue. For each data exchange, an identifier has been assigned. This identifier will allow for reference within the individual tests to ensure traceability. Most of these are taken from the provided Federal Aviation Administration (FAA) documentation. The rows highlighted in yellow are new data exchanges that may be needed to satisfy the identified scenarios.

Table B-5: Data Exchanges

Data Exchange ID	Statement	Data Direction	RESTful API	STOMP Queue	Application/JSON Model	Notes
D1E1	Flight Request	Operator to FIMS	POST /operations (new operation) PUT /operations/{gufi}	-	Operation	

Data Exchange ID	Statement	Data Direction	RESTful API	STOMP Queue	Application/JSON Model	Notes
			(modify existing operation)			
D1E2	Indication if flight information is submitted too far in advance of operation	FIMS to Operator	-	/user/{operator}/decision	InformMessage	InformMessage • PLAN_SUBMITTED_TOO_EARLY
D1E3	Indication that flight information has been received	FIMS to Operator	HTTP 201 response to POST /operations	-	FIMSApiResponse	FIMSApiResponse • 201 • CREATED • "some string (gufi?)"
D1E4	Response to flight operation request: Accepted (Part 101-E) / Authorized (Part 107)	FIMS to Operator	-	/user/{operator}/decision	InformMessage	InformMessage • ACCEPTED (Part 101-E) • AUTHORIZED (Part 107)
D1E5	Response to flight operation request: Denied	FIMS to Operator	-	/user/{operator}/decision	InformMessage	InformMessage • DENIED
D1E6	Response to flight operation request: ATC notification not required (Part 101-E) / ATC authorization not required (Part 107)	FIMS to Operator	-	/user/{operator}/decision	InformMessage	InformMessage 5. NOTIFICATION_NOT_REQUIRED (Part 101-E) 6. AUTHORIZATION_NOT_REQUIRED (Part 107)
D1E7	Changes in authorization status prior to prior to proposed flight start time, as filed in the operation plan (acceptance/au	FIMS to Operator	-	/user/{operator}/decision	InformMessage	InformMessage 6. DENIED

Data Exchange ID	Statement	Data Direction	RESTful API	STOMP Queue	Application/JSON Model	Notes
	thorization -> denial)					
D1E8	Changes in authorization status during the proposed flight start time, as filed in the operation plan (acceptance/authorization -> termination)	FIMS to Operator	-	/user/{operator}/decision	InformMessage	InformMessage 1 TERMINATED
D1E9	Cancellation of flight operation (prior to proposed operation start time)	Operator to FIMS	POST /messages	-	IntentMessage	IntentMessage 1) CANCEL
D1E10	Change in flight operation end time (if operation ends earlier than originally planned; extension requires new request)	Operator to FIMS	POST /messages	-	IntentMessage	IntentMessage 1) CLOSE
D1E11	Operator acknowledgement that flight operation will no longer be conducted (if initially accepted / authorized, then denied or terminated by ATC)	Operator to FIMS	POST /messages	-	IntentMessage	IntentMessage: D.1 ACK_NO_OPERATION
D1E12	FIMS notifies operators of unplanned deviation.	FIMS to All Operators	-	/topic/emergency	AlertMessage	AlertMessage: E.1 OPERATIONS E.2 WARNING E.3 UNPLANNED_DEVIATION

Data Exchange ID	Statement	Data Direction	RESTful API	STOMP Queue	Application/JSON Model	Notes
						E.4 maybe a free_text or warning element as well?
~~D1E13~~	~~Operator notifies FIMS of unplanned deviation in course.~~	~~Operator to FIMS~~	-	-	-	Can this data exchange be accomplished with D1E15?
D1E14	FIMS notifies operators of airspace constraint change.	FIMS to Operator	-	/topic/constraintChange	AlertMessage	For Scenario 2, this message notifies operators that the no-fly zones around the airport are changing or have changed. This can also take care of a dynamic constraint introduced due to an anomalous operation. AlertMessage: 1 CONSTRAINT_CHANGE
D1E15	Operator notifies FIMS of flight anomaly.	Operator to FIMS	POST /messages	-	AlertMessage	Anomalies may include, but wouldn't be limited to the following alert messages: AlertMessage: 1 UNPLANNED_LANDING 2 UNCONTROLLED_LANDING 3 FLY_AWAY 4 HIJACK 5 OFF_COURSE 6 UNPLANNED_DEVIATION (Currently only sent from FIMS to Operator) 7 Communications failure (between Operator and UAS)?
	Operator notifies FIMS that operation is back in conformance after anomaly.					AlertMessage: BACK_TO_CONFORMANCE
D1E16	FIMS acknowledges receipt of anomaly message.	FIMS to Operator	HTTP 201 response to POST /messages	-	FIMSApiResponse	FIMSApiResponse A Status Code 202 B ACCEPTED C "Received notification of anomaly"

Data Exchange ID	Statement	Data Direction	RESTful API	STOMP Queue	Application/JSON Model	Notes
D1E17	Operator supplies position report(s). Operator supplies a single report or periodic reports, depending on FIMS request (see D1E18 and D1E19).	Operator to FIMS	POST /positions	-	Position	
D1E18	FIMS requests single position report.	FIMS to Operator	-	/user/{operator}/decision	AlertMessage	AlertMessage: 1 OPERATIONS 2 WARNING 3 POSITION_REPORT_REQUEST_SINGLE
D1E19	FIMS requests repeated position reports.	FIMS to Operator	-	/user/{operator}/decision	AlertMessage	AlertMessage: 1. OPERATIONS 2. WARNING 3. POSITION_REPORT_REQUEST_CONTINUOUS
D1E20	FIMS cancels request for position reports.	FIMS to Operator	-	/user/{operator}/decision	AlertMessage	AlertMessage: 1. OPERATIONS 2. WARNING 3. POSITION_REPORT_REQUEST_CANCEL
D1E21	Operator acknowledges that active operation has been cancelled/terminated.	Operator to FIMS	POST /messages	-	IntentMessage	IntentMessage 1. ACK_NO_OPERATION

12.8 Tests

Each table below represents a single test. Each test has a unique designator. That designator is a concatenation of the Demonstration number, scenario number, and test number. In addition, there may be a descriptive title associated with the test. For this demonstration, the

demonstration number is "1" for all tests. So, "D1S2T3" would indicate Demonstration 1, Scenario 2, Test 3.

The tables are grouped by scenario, with a brief description of the scenario preceding the group of test tables.

12.8.1 Scenario and Test Summary

A summary of the scenarios is provided in Table B-6 below:

Table B-6: Scenario Summary

Scenario ID	Scenario Name	Scenario Description
Scenario 0	Nominal Operations	Scenario 0 exercises baseline data exchanges used during nominal operations.
Scenario 1	Operator Incursion	Scenario 1 demonstrates the handling of UAS incursions into unintended or unallocated regions.
Scenario 2	Airspace Constraint Change	Scenario 2 demonstrates the creation and handling of no-fly zones.
Scenario 3	All Land	Scenario 3 demonstrates the issuing of "All Land" alerts to all operations.

A summary of the tests is provided in Table B-7 below:

Table B-7: Test Summary

Scenario ID	Test ID	Test Name	Test Description	Experiment					
Scenario 0	D1S0T1	"NominalNoodle"	Operator notifies FIMS of an operation that gets accepted; operation completes uneventfully.	D1X1	D1X2	D1X3			
	D1S0T2	"CancelledCarrot"	Operator cancels an accepted operation before it begins.	D1X1					
	D1S0T3	"DenialDonut"	FIMS denies a previously accepted operation, effectively cancelling it before it begins.	D1X1					
	D1S0T4	"TerminatedTomato"	FIMS terminates an active operation.		D1X2				
	D1S0T5	"EarlyEwok"	Operator notifies FIMS of an operation too far in advance of the operation.	D1X1					

Scenario ID	Test ID	Test Name	Test Description	Experiment					
	D1S0T6	"CompletedCucumber"	Operator performs a nominal operation that completes earlier than planned.	D1X1	D1X2				
	D1S0T7	"FlyAwayFigs"	Operator notifies FIMS of a fly-away operation.		D1X2	D1X3			
	D1S0T8	"NegatoryNotify"	Operator tries to notify FIMS of operation, but the notification is not required.		D1X2				
	D1S0T9	"PaisleyPositions"	FIMS requests position reports, then cancels request.	D1X1					
	D1S0T10	"WhereOne"	FIMS requests a single position report.		D1X2				
Scenario 1	D1S1T1	"DeviatingDough"	Operator has an unplanned deviation causing the FIMS to terminate that operation.						D1X6
	D1S1T2	"RequestingRhubarb"	Operator requests deviation through a no-fly zone that is denied.						D1X6
	D1S1T3	"ReplanRadish"	Operator requests deviation through a no-fly zone that is accepted.						D1X6
	D1S1T5	"NoHarmNoFoul"	Operator has an unplanned deviation, notifies FIMS and corrects course.						D1X6
	D1S1T6	"FixyFixy"	Operator has an unplanned deviation, requests new plan and is accepted.						D1X6
	D1S1T7	"NoSoupForYou"	Operator has an unplanned deviation, requests new plan and is denied.						D1X6
Scenario 2	D1S2T1	"NoFlyGuy"	FIMS announces a new no-fly zone affecting an active operation.			D1X3		D1X5	

Scenario ID	Test ID	Test Name	Test Description	Experiment					
	D1S2T2	"FlippingFruit"	FIMS announces a new no-fly zone affecting an active operation, operator requests new plan that is denied.					D1X5	
	D1S2T3	"GreatGoose"	FIMS announces a new no-fly zone affecting an active operation, operator requests new plan that is accepted.					D1X5	
Scenario 3	D1S3T1	"LandingLizards"	FIMS issues an 'all land' directive, operator indicates when the operation has landed.				D1X4		
	D1S3T2	"LandingLoons"	FIMS issues an 'all land' directive, operator requests a new plan to land, FIMS accepts.				D1X4		

12.8.2 Scenario 0

The purpose of the tests described in Tables B-8 through B-17 below is to get a baseline of data exchange. These tests are not tied to a particular use case.

Table B-8: NominalNoodle

D1S0T1 **"NominalNoodle": Operator notifies FIMS of an operation that gets accepted; operation completes uneventfully.**				
Step	Action	Actor	Remarks	Data Exchange
1	Operator Flight Request	Operator	Operator requests a beyond visual line-of-sight (BVLOS) operation.	D1E1
2	Flight Request Received	FIMS	FIMS sends message to operator that flight request was received.	D1E3
3	Flight Request Accepted	FIMS	FIMS sends message to operator that flight request was accepted.	D1E4

Table B-9: CancelledCarrot

D1S0T2 **"CancelledCarrot": Operator cancels an accepted operation before it begins.**				
Step	Action	Actor	Remarks	Data Exchange
1	Operator Flight Request	Operator	Operator requests a BVLOS operation.	D1E1
2	Flight Request Received	FIMS	FIMS sends message to operator that flight request was received.	D1E3
3	Flight Request Accepted	FIMS	FIMS sends message to operator that flight request was accepted.	D1E4
4	Flight Cancelled	Operator	Operator sends cancellation message to FIMS.	D1E9

Table B-10: DenialDonut

D1S0T3 **"DenialDonut": FIMS denies a previously accepted operation, effectively cancelling it before it begins.**				
Step	Action	Actor	Remarks	Data Exchange
1	Operator Flight Request	Operator	Operator requests a BVLOS operation.	D1E1
2	Flight Request Received	FIMS	FIMS sends message to operator that flight request was received.	D1E3
3	Flight Request Accepted	FIMS	FIMS sends message to operator that flight request was accepted.	D1E4
4	Flight Request Denied	FIMS	FIMS sends message to operator that the flight request was denied.	D1E7
5	Operator Acknowledgment	Operator	Operator sends message to FIMS indicating that operation will no longer take place.	D1E11

Table B-11: TerminatedTomato

D1S0T4 **"TerminatedTomato": FIMS terminates an active operation.**				
Step	Action	Actor	Remarks	Data Exchange
1	Operator Flight Request	Operator	Operator requests a BVLOS operation.	D1E1
2	Flight Request Received	FIMS	FIMS sends message to operator that flight request was received.	D1E3
3	Flight Request Accepted	FIMS	FIMS sends message to operator that flight request was accepted.	D1E4
4	Flight Request Terminated	FIMS	FIMS sends message to operator that flight request is terminated during operation.	D1E8

D1S0T4 "TerminatedTomato": FIMS terminates an active operation.				
5	Operator Acknowledgment	Operator	Operator sends message indicating that operation is terminated and no longer flying.	D1E10

Table B-12: EarlyEwok

D1S0T5 "EarlyEwok": Operator notifies FIMS of an operation too far in advance of the operation.				
Step	Action	Actor	Remarks	Data Exchange
1	Operator Flight Request	Operator	Operator requests a BVLOS operation.	D1E1
2	Flight Request Received	FIMS	FIMS sends message to operator that flight request was received.	D1E3
3	Flight Request Accepted	FIMS	FIMS sends message to operator that flight request was submitted too far in advance.	D1E2

Table B-13: CompletedCucumber

D1S0T6 "CompletedCucumber": Operator performs a nominal operation that completes earlier than planned.				
Step	Action	Actor	Remarks	Data Exchange
1	Operator Flight Request	Operator	Operator requests a BVLOS operation.	D1E1
2	Flight Request Received	FIMS	FIMS sends message to operator that flight request was received.	D1E3
3	Flight Request Accepted	FIMS	FIMS sends message to operator that flight request was accepted.	D1E4
4	Flight Request Terminated	Operator	Operator sends message indicating that operation completed earlier than planned.	D1E10

Table B-14: FlyAwayFigs

D1S0T7 "FlyAwayFigs": Operator notifies FIMS of a fly-away operation.				
Step	Action	Actor	Remarks	Data Exchange
1	Operator Flight Request	Operator	Operator requests a BVLOS operation.	D1E1
2	Flight Request Received	FIMS	FIMS sends message to operator that flight request was received.	D1E3
3	Flight Request Accepted	FIMS	FIMS sends message to operator that flight request was accepted.	D1E4

D1S0T7 "FlyAwayFigs": Operator notifies FIMS of a fly-away operation.				
4	Operator Reports Fly-Away	Operator	Operator sends message indicating that operation is no longer under positive control.	D1E15
5	Report Received	FIMS	FIMS acknowledges report.	D1E16
6	FIMS Announces No-Fly Zone	FIMS	FIMS implements a no-fly zone that is expected to contain the fly-away vehicle.	D1E14
7	FIMS Announces Unplanned Deviation	FIMS	FIMS sends information to other operations about the unplanned deviation.	D1E12
8	FIMS Requests Position Reports	FIMS	FIMS sends message to operator requesting continuous (1Hz) position reports.	D1E19
9	Operator Supplies Position Reports	Operator	Operator begins supplying position reports at 1Hz.	D1E17
10	Operator Reports Flight Completion/Termination	Operator	Operator sends message indicating when vehicle is known to have landed.	D1E10
11	FIMS Announces Removal of No-Fly Zone	FIMS	When fly-away is clear of airspace, the ad hoc no-fly zone is removed.	D1E14

Table B-15: NegatoryNotify

D1S0T8 "NegatoryNotify": Operator tries to notify FIMS of operation, but the notification is not required.				
Step	Action	Actor	Remarks	Data Exchange
1	Operator Flight Request	Operator	Operator requests a line-of-sight (LOS) operation within Class.	D1E1
2	Flight Request Received	FIMS	FIMS sends message to operator that flight request was received.	D1E3
3	Flight Request Unnecessary	FIMS	FIMS sends message to operator that flight request was not required.	D1E6

Table B-16: PaisleyPositions

D1S0T9 "PaisleyPositions": FIMS requests position reports, then cancels request.				
Step	Action	Actor	Remarks	Data Exchange
1	Operator Flight Request	Operator	Operator requests a LOS operation within Class.	D1E1
2	Flight Request Received	FIMS	FIMS sends message to operator that flight request was received.	D1E3
3	Flight Request Accepted	FIMS	FIMS sends message to operator that flight request was accepted.	D1E4

D1S0T9 "PaisleyPositions": FIMS requests position reports, then cancels request.				
4	FIMS Requests Positions	FIMS	After the start time of the operation, the FIMS requests continuous position reports.	D1E19
5	Operator Submits Positions	Operator	Operator begins to send in position reports at 1Hz.	D1E17
6	FIMS Cancels Request	FIMS	After a couple of minutes of receiving position reports, FIMS cancels position report request.	D1E20

Table B-17: WhereOne

D1S0T10 "WhereOne": FIMS requests a single position report.				
Step	Action	Actor	Remarks	Data Exchange
1	Operator Flight Request	Operator	Operator requests a LOS operation within Class.	D1E1
2	Flight Request Received	FIMS	FIMS sends message to operator that flight request was received.	D1E3
3	Flight Request Accepted	FIMS	FIMS sends message to operator that flight request was accepted.	D1E4
4	FIMS Requests Position	FIMS	After the start time of the operation, the FIMS requests a single position report.	D1E18
5	Operator Submits Positions	Operator	Operator sends a single position report.	D1E17

12.8.3 Scenario 1

The tests described in Tables B-18 through B-23 exercise the ability of the data exchanges to handle cases wherein there is an incursion of an operation into a region that is not typically allocated for use by that operation. To illustrate this scenario, we use National Park boundaries, which have been traditionally off-limits to commercial and hobby drone use.

Table B-18: DeviatingDough

D1S1T1 "DeviatingDough": Operator has an unplanned deviation causing the FIMS to terminate that operation.				
Step	Action	Actor	Remarks	Data Exchange
1	Operator Flight Request	Operator	Operator requests a BVLOS operation skirting a National Park boundary.	D1E1
2	Flight Request Received	FIMS	FIMS sends message to operator that flight request was received.	D1E3
3	Flight Request Accepted	FIMS	FIMS sends message to operator that flight request was accepted.	D1E4
4	Operator Notifies of Deviation	Operator	Operator sends message to FIMS that operation is off course.	D1E15

D1S1T1 "DeviatingDough": Operator has an unplanned deviation causing the FIMS to terminate that operation.				
5	FIMS Acknowledges	FIMS	FIMS indicates that the deviation message was received.	D1E16
6	Flight Request Terminated	FIMS	FIMS cancels the original flight request due to inability to maintain accepted plan.	D1E8
7	FIMS Requests Position Reports	FIMS	FIMS sends message to operator requesting continuous (1Hz) position reports.	D1E19
8	Operator Supplies Position Reports	Operator	Operator begins supplying position reports at 1Hz.	D1E17
9	Flight Request Termination Received	Operator	Operator acknowledges receipt of the the flight termination request.	D1E21
10	Flight Termination Complete	Operator	Operator sends message when flight is successfully terminated.	D1E10

Table B-19: RequestingRhubarb

D1S1T2 "RequestingRhubarb": Operator requests deviation through a no-fly zone that is denied.				
Step	Action	Actor	Remarks	Data Exchange
1	Operator Flight Request	Operator	Operator requests a BVLOS operation skirting a National Park boundary.	D1E1
2	Flight Request Received	FIMS	FIMS sends message to operator that flight request was received.	D1E3
3	Flight Request Accepted	FIMS	FIMS sends message to operator that flight request was accepted.	D1E4
4	Operator Requests Deviation	Operator	Operator sends message to FIMS requesting new plan through nominal no-fly zone (National Park).	D1E1
5	FIMS Acknowledges	FIMS	FIMS indicates that the deviation request message was received.	D1E3
6	Deviation Request Denied	FIMS	FIMS denies the request, leaving the operator to continue with the originally accepted flight plan.	D1E5

Table B-20: ReplanRadish

D1S1T3 "ReplanRadish": Operator requests deviation through a no-fly zone that is accepted.				
Step	Action	Actor	Remarks	Data Exchange
1	Operator Flight Request	Operator	Operator requests a BVLOS operation skirting a National Park boundary.	D1E1
2	Flight Request Received	FIMS	FIMS sends message to operator that flight request was received.	D1E3

D1S1T3 "ReplanRadish": Operator requests deviation through a no-fly zone that is accepted.				
3	Flight Request Accepted	FIMS	FIMS sends message to operator that flight request was accepted.	D1E4
4	Operator Requests Deviation	Operator	Operator sends message to FIMS requesting new plan through nominal no-fly zone (National Park).	D1E1
5	FIMS Acknowledges	FIMS	FIMS indicates that the deviation request message was received.	D1E3
6	Deviation Request Accepted	FIMS	FIMS accepts the requested deviation.	D1E4
7	Flight Request Terminated	Operator	Operator sends message indicating operation completes the new plan early.	D1E10

D1S1T4 REMOVED AS DUPLICATION.

Table B-21: NoHarmNoFoul

D1S1T5 "NoHarmNoFoul": Operator has an unplanned deviation, notifies FIMS, corrects course.				
Step	Action	Actor	Remarks	Data Exchange
1	Operator Flight Request	Operator	Operator requests a BVLOS operation skirting a National Park boundary.	D1E1
2	Flight Request Received	FIMS	FIMS sends message to operator that flight request was received.	D1E3
3	Flight Request Accepted	FIMS	FIMS sends message to operator that flight request was accepted.	D1E4
4	Operator Notifies of Deviation	Operator	Operator sends message to FIMS that operation is off course.	D1E15
5	FIMS Acknowledges	FIMS	FIMS indicates that the deviation message was received.	D1E3
6	Operator Notifies of Correction	Operator	Operator indicates the operation is now back in conformance.	D1E15
7	FIMS Acknowledges	FIMS	FIMS indicates that the correction message was received.	D1E3
8	FIMS Requests Position Report	FIMS	FIMS requests one position report to help verify flight is back on course.	D1E18
9	Operator Supplies Position	Operator	Operator sends in a single position report to the FIMS.	D1E17
10	Flight Termination Complete	Operator	Operator sends message when flight is successfully terminated.	D1E10

Table B-22: FixyFixy

D1S1T6 **"FixyFixy": Operator has an unplanned deviation, requests new plan and is accepted.**				
Step	Action	Actor	Remarks	Data Exchange
1	Operator Flight Request	Operator	Operator requests a BVLOS operation skirting a National Park boundary.	D1E1
2	Flight Request Received	FIMS	FIMS sends message to operator that flight request was received.	D1E3
3	Flight Request Accepted	FIMS	FIMS sends message to operator that flight request was accepted.	D1E4
4	Operator Notifies of Deviation	Operator	Operator sends message to FIMS that operation is off course.	D1E15
5	FIMS Acknowledges	FIMS	FIMS indicates that the deviation message was received.	D1E3
6	Operator Requests Deviation	Operator	Plan modification requested that is compatible with the unplanned deviation.	D1E1
7	FIMS Acknowledges	FIMS	FIMS indicates that the plan request was received.	D1E3
8	FIMS Accepts Deviation	FIMS	FIMS accepts the requested deviation.	D1E4

Table B-23: NoSoupForYou

D1S1T7 **"NoSoupForYou": Operator has an unplanned deviation, requests new plan and is denied.**				
Step	Action	Actor	Remarks	Data Exchange
1	Operator Flight Request	Operator	Operator requests a BVLOS operation skirting a National Park boundary.	D1E1
2	Flight Request Received	FIMS	FIMS sends message to operator that flight request was received.	D1E3
3	Flight Request Accepted	FIMS	FIMS sends message to operator that flight request was accepted.	D1E4
4	Operator Notifies of Deviation	Operator	Operator sends message to FIMS that operation is off course.	D1E15
5	FIMS Acknowledges	FIMS	FIMS indicates that the deviation message was received.	D1E3
6	Operator Requests Deviation	Operator	Plan modification requested that this compatible with the unplanned deviation.	D1E1
7	FIMS Acknowledges	FIMS	FIMS indicates that the plan request was received.	D1E3
8	FIMS Denies Deviation Request	FIMS	FIMS denies the requested deviation.	D1E5

12.8.4 Scenario 2

Tables B-24 through B-26 describe Scenario 2.

Table B-24: NoFlyGuy

D1S2T1 **"NoFlyGuy": FIMS announces a new no-fly zone affecting an active operation.**				
Step	Action	Actor	Remarks	Data Exchange
1	Operator Flight Request	Operator	Operator requests a BVLOS operation near airport in an allowed region.	D1E1
2	Flight Request Received	FIMS	FIMS sends message to operator that flight request was received.	D1E3
3	Flight Request Accepted	FIMS	FIMS sends message to operator that flight request was accepted.	D1E4
4	No-Fly Zone Notification	FIMS	FIMS announces that the airspace configuration is changing: new no-fly zone added which affects the active operation.	D1E14
5	Flight Request Terminated	Operator	Operator sends message indicating operation completes the plan early.	D1E10

Table B-25: FlippingFruit

D1S2T2 **"FlippingFruit": FIMS announces a new no-fly zone affecting an active operation, operator requests new plan that is denied.**				
Step	Action	Actor	Remarks	Data Exchange
1	Operator Flight Request	Operator	Operator requests a BVLOS near airport in an allowed area.	D1E1
2	Flight Request Received	FIMS	FIMS sends message to operator that flight request was received.	D1E3
3	Flight Request Accepted	FIMS	FIMS sends message to operator that flight request was accepted.	D1E4
4	No-Fly Zone Notification	FIMS	FIMS announces airspace configuration is changing with a no-fly zone affecting operation.	D1E14
5	Operator Requests Deviation	Operator	Operator requests new plan to vacate the new no-fly zone.	D1E1
6	Deviation Request Denied	FIMS	FIMS denies the requested deviation.	D1E5
7	Flight Request Terminated	Operator	Operator sends message indicating operation completes the plan early.	D1E10

Table B-26: GreatGoose

D1S2T3 **"GreatGoose": FIMS announces a new no-fly zone affecting an active operation, operator requests new plan that is accepted.**				
Step	Action	Actor	Remarks	Data Exchange
1	Operator Flight Request	Operator	Operator requests a BVLOS near airport in an allowed area.	D1E1
2	Flight Request Received	FIMS	FIMS sends message to operator that flight request was received.	D1E3
3	Flight Request Accepted	FIMS	FIMS sends message to operator that flight request was accepted.	D1E4
4	No-Fly Zone Notification	FIMS	FIMS announces that the airspace configuration is changing with a no-fly zone affecting operation.	D1E14
5	Operator Requests Deviation	Operator	Operator requests new plan to vacate the new no-fly zone.	D1E1
6	Deviation Request Accepted	FIMS	FIMS accepts the requested deviation.	D1E4

12.8.5 Scenario 3

Tables B-27 and B-28 describe Scenario 3.

Table B-27: LandingLizards

D1S3T1 **"LandingLizards": FIMS issues an 'all land' directive, operator indicates when the operation has landed.**				
Step	Action	Actor	Remarks	Data Exchange
1	Operator Flight Request	Operator	Operator requests a BVLOS operation.	D1E1
2	Flight Request Received	FIMS	FIMS sends message to operator that flight request was received.	D1E3
3	Flight Request Accepted	FIMS	FIMS sends message to operator that flight request was accepted.	D1E4
4	Flight Request Terminated	FIMS	FIMS sends message to operator that all operations must land.	D1E8
5	Operator Acknowledgment	Operator	Operator sends message indicating that operation is terminated and no longer flying.	D1E10

Table B-28: LandingLoons

D1S3T2 **"LandingLoons": FIMS issues an 'all land' directive, operator requests a new plan to land, FIMS accepts.**				
Step	Action	Actor	Remarks	Data Exchange
1	Operator Flight Request	Operator	Operator requests a BVLOS operation.	D1E1
2	Flight Request Received	FIMS	FIMS sends message to operator that flight request was received.	D1E3
3	Flight Request Accepted	FIMS	FIMS sends message to operator that flight request was accepted.	D1E4
4	Flight Request Terminated	FIMS	FIMS sends message to operator that all operations must land.	D1E8
5	Operator Requests Deviation	Operator	Operator requests plan that complies with land now directive.	D1E1
6	Flight Request Received	FIMS	FIMS sends message to operator that flight request was received.	D1E3
7	Flight Request Accepted	FIMS	FIMS sends message to operator that flight request was accepted.	D1E4
8	Operator Acknowledgment	Operator	Operator sends message indicating that operation is terminated and no longer flying.	D1E10

12.9 Experiments

Each experiment is comprised of one of more tests. The experiments may be performed multiple times to either verify certain concepts or integrate multiple participants in different roles. The experiments are labeled D1 (for Demonstration 1), followed by 'X' and a number. For each run of an experiment there may be a different configuration. For example, different participants may take different roles, or some starting assumptions may be altered. For each experiment below, we list the planned configurations. A summary of the six experiments is provided in Table B-29 below:

Table B-29: Experiments

Experiment ID	**Title**	**Description**
D1X1	Nominal 1	Run through six non-fly-away tests.
D1X2	Nominal 2	Show nominal operations unaffected by a fly-away operation.
D1X3	Fly-Away Exercise	Show operations affected by a fly-away operation.
D1X4	All Land	Demonstrate notification of an all-land instruction from FIMS.
D1X5	Airport Configuration Change	Demonstrate a change in the airspace relative to no-fly zones.
D1X6	Operator Incursion	Demonstrate interactions between operators and FIMS during incursions to a no-fly zone.

12.9.1 D1X1: Nominal 1

In this experiment, we run the six non-fly-away, nominal scenarios in parallel. The roles for the operators are rotated through the six tests, so there are six configurations (Table B-30). For timing purposes, at T=0, the FIMS is verified to be operational and reachable. The Test Director then announces "All Tests are GO" at which point each participant is free to execute the assigned test for that configuration per the experiment sequence described in Table B-31.

12.9.1.1 Configurations

Table B-30: "Nominal 1" Configurations

Configuration	D1S0T1	D1S0T2	D1S0T3	D1S0T9	D1S0T5	D1S0T6
	NominalNoodle	CancelledCarrot	DenialDonut	PaisleyPositions	EarlyEwok	CompletedCucumber
A	AIRM	TRTX	SIMU	NASA	ANRA	AMZN
B	AMZN	AIRM	TRTX	SIMU	NASA	ANRA
C	ANRA	AMZN	AIRM	TRTX	SIMU	NASA
D	NASA	ANRA	AMZN	AIRM	TRTX	SIMU
E	SIMU	NASA	ANRA	AMZN	AIRM	TRTX
F	TRTX	SIMU	NASA	ANRA	AMZN	AIRM

12.9.1.2 Sequence

Table B-31: "Nominal 1" Sequence

Step	Time (min:sec)	Action	Notes
1	T=0:00	Command Center calls 'mark.'	Potential countdown prior to 'mark.'
2	0:00 to 0:30	Operators submit plans.	Start time between T+30seconds and T+1min. Duration at least 2 minutes.
3	0:30 to 1:00	Operators commence simulated operations.	
4	1:00 to 1:30	FIMS makes position report request per D1S0T9.	
5	1:30 to 2:00	FIMS cancels request per D1S0T9.	
6	2:00	Tests completes.	
7	*	Experiment completes.	

12.9.2 D1X2: Nominal 2

The fly-away test (D1S0T7 "FlyAwayFigs") is exercised here. One operator reports a fly-away while the other five operators are executing nominal scenarios. The assumptions in this experiment include:

1.

- None of the nominal tests are operating near the fly-away.
- None of the nominal tests alter their plans based on the fly-away.

- The no-fly zone implemented based on the fly-away does not intersect any of the nominal operations.

Each participant takes the fly-away role once, allowing for six runs of this experiment (Table B-32). The experiment sequence is described in Table B-33.

12.9.2.1 Configurations

Table B-32: "Nominal 2" Configurations

Configuration	D1S0T7	D1S0T1	D1S0T10	D1S0T6	D1S0T8	D1S0T4
	FlyAwayFigs	NominalNoodle	WhereOne	CompletedCucumber	NegatoryNotify	TerminatedTomato
A	AIRM	TRTX	SIMU	NASA	ANRA	AMZN
B	AMZN	AIRM	TRTX	SIMU	NASA	ANRA
C	ANRA	AMZN	AIRM	TRTX	SIMU	NASA
D	NASA	ANRA	AMZN	AIRM	TRTX	SIMU
E	SIMU	NASA	ANRA	AMZN	AIRM	TRTX
F	TRTX	SIMU	NASA	ANRA	AMZN	AIRM

The fly-away operation will follow this plan:

https://gist.github.com/alotau/9206e45fdc6803a0efa62f20f749a552.

The plans for all the tests in this experiment may file any other appropriate plans for that test such that those plans are well clear of the fly-away plan.

12.9.2.2 Sequence

Table B-33: "Nominal 2" Sequence

Step	Time (min:sec)	Action	Notes
1	T=0:00	Command Center calls 'mark.'	Potential countdown prior to 'mark.'
2	0:00 to 0:30	Operators submit plans.	Start time between T+30seconds and T+1min. Duration at least 3 minutes.
3	0:30 to 1:00	Operators commence simulated operations.	
4	1:00	FIMS sends request for single position report (D1S0T10 - WhereOne).	
5	1:00 to 1:30	Per D1S0T7, operator sends fly-away message to FIMS. FIMS issues no-fly zone announcement.	The fly-away message should be sent by the operator upon their first position report outside their planned area. We could issue a fly-away message earlier than that, assuming the operator would know about loss of command earlier.

Step	Time (min:sec)	Action	Notes
6	> 2:00	Per D1S0T7, operator continues to landing location at constant altitude then lands. Other operations (all unaffected by fly-away) complete their operations,	
7	*	Experiment completes.	

12.9.3 D1X3: Fly-Away Exercise

This experiment allows for D1S0T7 (FlyAwayFigs) to interact with active plans by other operators. This implies the affected operators are clearing the newly created no-fly zone and providing appropriate messages to the FIMS. In the configuration table (Table B-34), those operators tagged as "affected" will have a plan that intersects the fly-away no-fly zone. The others are not affected.

12.9.3.1 Configurations

Table B-34: D1X3 Configurations

Configuration	D1S0T7	D1S2T1 Trajectory	D1S2T1 Volume 1	D1S2T1 Volume 2	D1S0T1 Unaffected 1	D1S0T1 Unaffected 2
	FlyAwayFigs	NoFlyGuy	NoFlyGuy	NoFlyGuy	NominalNoodle	NominalNoodle
A	AIRM	TRTX	SIMU	NASA	ANRA	AMZN
B	AMZN	AIRM	TRTX	SIMU	NASA	ANRA
C	ANRA	AMZN	AIRM	TRTX	SIMU	NASA
D	NASA	ANRA	AMZN	AIRM	TRTX	SIMU
E	SIMU	NASA	ANRA	AMZN	AIRM	TRTX
F	TRTX	SIMU	NASA	ANRA	AMZN	AIRM

Details for each of the plans are provided at

https://gist.github.com/alotau/2409eda1f1c6d80d5da313a0c511c4f5.

These plans are illustrated in Figure B-2 below. The fly-away operation is in orange, the affected operations are in blue, and the unaffected operations are in brown. The fan-shaped FIMS-generated no-fly zone is in red.

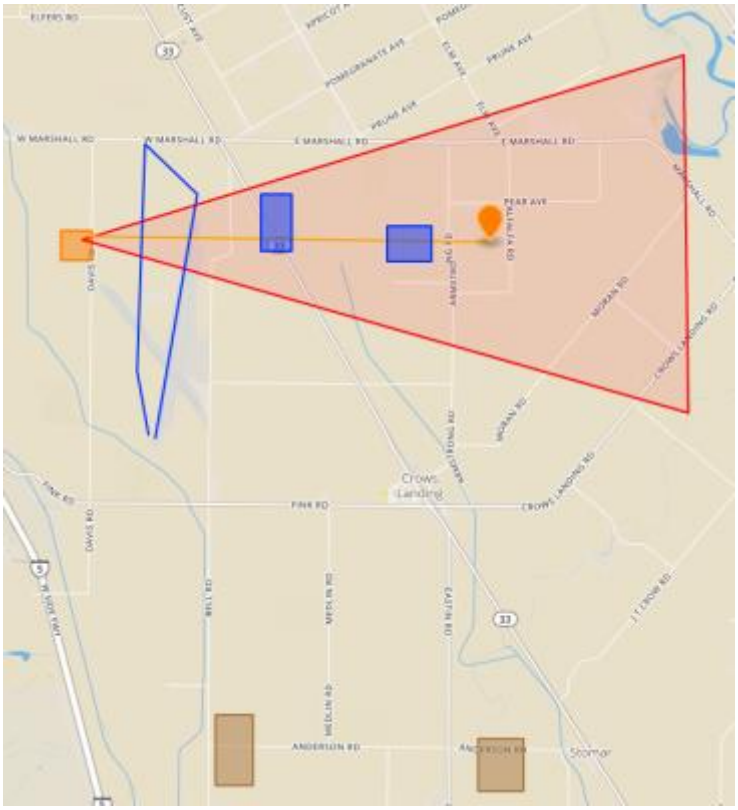

Figure B-2: D1X3 Operation Plans

12.9.3.2 Sequence

The experiment will begin on the mark of the Command Center and will be considered "T=0" for the experiment and then progress as detailed in Table B-35 below:

Table B-35: D1X3 Sequence

Step	Time (min:sec)	Action	Notes
1	T=0:00	Command Center calls 'mark.'	Potential countdown prior to 'mark.'
2	0:00 to 0:30	Operators submit plans.	Start time between T+30seconds and T+1min. Duration at least 10 minutes.
3	0:30 to 1:00	Operators commence simulated operations.	
4	1:00 to 1:30	Per D1S0T7, operator sends fly-away message to FIMS. FIMS issues no-fly zone announcement.	The fly-away message should be sent by the operator upon their first position report outside their planned area. We could issue a fly-away message earlier than that, assuming the operator would know about loss of command earlier.
5	> 1:30	Per D1S0T7, operator continues to landing location at constant altitude then lands.	

Step	Time (min:sec)	Action	Notes
		Affected operations (D1S2T1) safely land ASAP while staying within planned operation area.	
6	*	Experiment completes.	

12.9.4 D1X4: All Land

This experiment exercises Scenario 3 wherein all small unmanned aircraft system (sUAS) operations are ordered to "land now." There are two modes of operation that we are testing in terms of the operator response to this directive. First, the operator just figures out a safe way to land then executes that landing, finally indicating to the FIMS that the operation is complete. Second, the operator may plan a new path to safely terminate, submit that plan to the FIMS for acceptance, then execute (assuming acceptance is granted). Note that there are other information flows that may be equally valid and perhaps better for the concept, but we will only exercise these two options. Other options may include the requirement that such contingency plans are part of the original flight request, or that all operations literally go to ground ASAP from the time receiving the directive, and there could be others.

12.9.4.1 Configurations

Note that in Table B-36 we indicate the test that is run together with a label for the expected initial plan. The initial plans are detailed after the table. For example, in the set of initial plans, one is labeled as "β" so each test in the table that references "β" would use that plan with that test.

Table B-36: D1X4 Configurations

Configuration	α	β	γ	δ
	D1S3T1	D1S3T1	D1S3T1	D1S3T1
	LandingLizards	LandingLizards	LandingLizards	LandingLizards
A	AIRM	SIMU	NASA	AMZN
	D1S3T2	**D1S3T2**	**D1S3T2**	**D1S3T2**
	LandingLoons	LandingLoons	LandingLoons	LandingLoons
B	SIMU	AIRM	TRTX	NASA
	D1S3T1	**D1S3T1**	**D1S3T2**	**D1S3T2**
	LandingLizards	LandingLizards	LandingLoons	LandingLoons
C	ANRA	NASA	AMZN	TRTX
D	AMZN	TRTX	SIMU	ANRA

Details for each of the plans illustrated in Figure B-3 below are provided at

https://gist.github.com/alotau/223fc7bca3d7eb93678868208b6f5484.

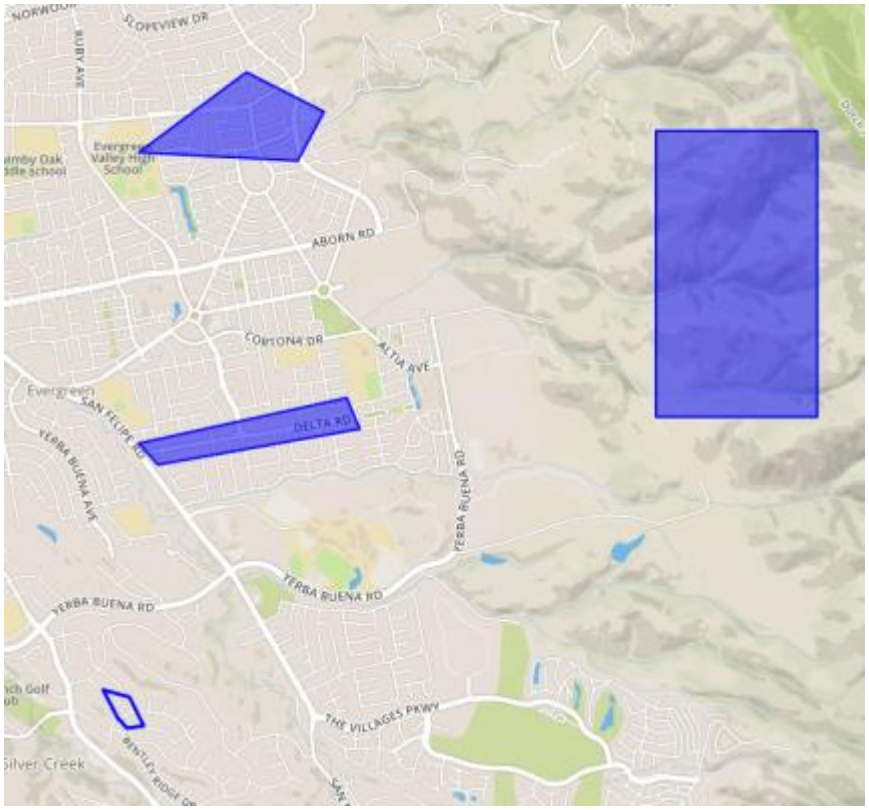

Figure B-3: D1X4 Operation Plans

12.9.4.2 Sequence

The experiment will begin on the mark of the Command Center and will be considered "T=0" for the experiment and then progress as detailed in Table B-37 below:

Table B-37: D1X4 Sequence

Step	Time (min:sec)	Action	Notes
1	T=0:00	Command Center calls 'mark.'	Potential countdown prior to 'mark.'
2	0:00 to 0:30	Operators submit plans.	Start time between T+30seconds and T+1min. Duration at least 10 minutes.
3	0:30 to 1:00	Operators commence simulated operations.	
4	1:00 to 1:30	FIMS issues "all land" directive.	Is there a maximum time associated with the need to land?
5	> 1:30	LandingLoons (D1S3T2) group issues new plan to execute landing. LandingLizards (D1S3T1) land safely within operational plan.	
6	*	Experiment completes.	

12.9.5 D1X5: Airport Configuration Change

This experiment exercises Scenario 2 wherein an airport changes its configuration, which affects nearby sUAS operations by removing a no-fly zone and adding a different no-fly zone. This scenario and experiment is undertaken with the understanding that some of the underlying National Airspace System (NAS) data that would be required to implement such a scenario may not be easily available. Specifically, the dissemination of airport configurations are not necessarily part of the current NAS.

San Jose International airport (SJC) is known to have two major configurations, a south flow configuration and a north flow configuration. The north flow is the nominal configuration. However due to weather/wind or coordination with other airports (SFO and OAK) in the Bay-area metroplex, there may be a need to switch to a south flow. Often this is planned, but the lead time to complete the configuration may be relatively short. To bound this experiment, we choose the artificial value of 10 minutes to allow all sUAS to clear the approach side of the airport when the configuration change is being implemented. More specifically, from the time that the configuration change is announced via the FIMS to Operators, all operations must cease operations in the new no-fly zone, while operations may commence in the newly freed no-fly zone from the other side of the airport.

The airspaces to be used in this experiment are detailed here:

https://gist.github.com/alotau/bfb98a6d372b0c21bacfc881f88581b7.

These are illustrated in Figure B-4 below:

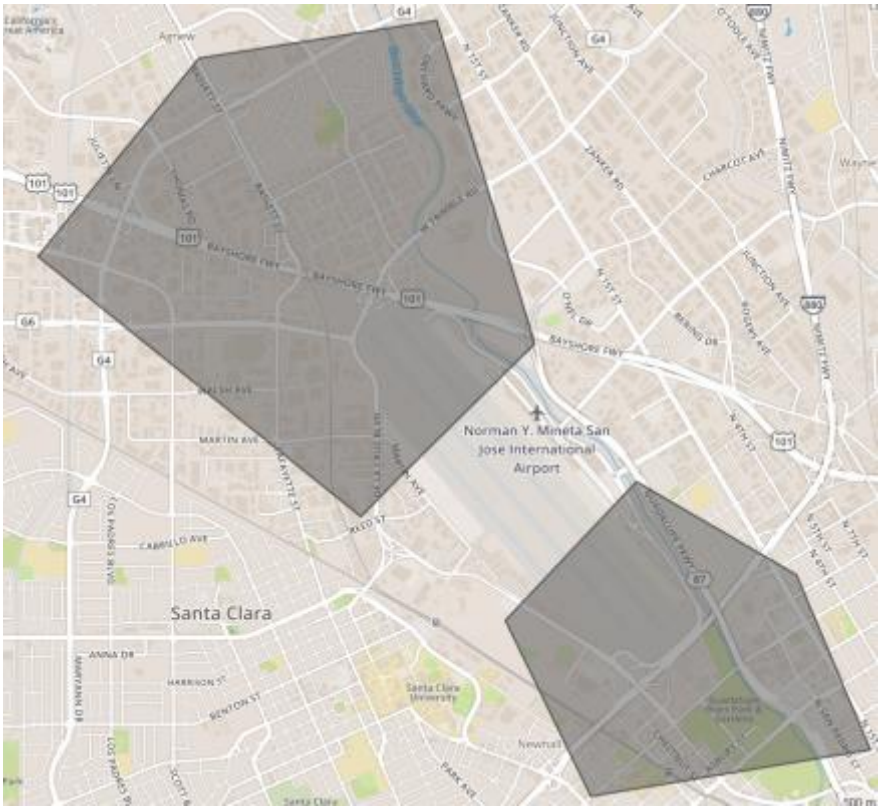

Figure B-4: D1X5 Operation Plans

12.9.5.1 Configurations

The configurations for this experiment are listed in Table B-38 below:

Table B-38: D1X5 Configurations

Configuration	D1S2T1	D1S2T1	D1S2T2	D1S2T2	D1S2T3	D1S2T3
	NoFlyGuy	NoFlyGuy	FlippingFruit	FlippingFruit	GreatGoose	GreatGoose
A	AIRM	TRTX	SIMU	NASA	ANRA	AMZN
B	ANRA	AMZN	AIRM	TRTX	SIMU	NASA
C	SIMU	NASA	ANRA	AMZN	AIRM	TRTX

12.9.5.2 Sequence

The experiment will begin on the mark of the Command Center and will be considered "T=0" for the experiment and then progress as detailed in the Table B-39 below:

Table B-39: D1X5 Sequence

Step	Time (min:sec)	Action	Notes
1	T=0:00	Command Center calls 'mark.'	Potential countdown prior to 'mark.'

Step	Time (min:sec)	Action	Notes
2	0:00 to 0:30	Operators submit plans.	Start time between T+30seconds and T+1min. Duration at least 10 minutes.
3	0:30 to 1:00	Operators commence simulated operations.	
4	1:00 to 1:30	FIMS issues constraint change.	Is there a maximum time associated with the need to land?
5	> 1:00	FlippingFruit (D1S2T2) and GreatGoose (D1S2T3) groups request new plans and receive appropriate responses from FIMS. All participants complete their plans.	
6	*	Experiment completes.	

12.9.6 D1X6: Operator Incursion

This experiment exercises Scenario 1, wherein an operation unintentionally enters a no-fly zone. In this scenario, the no-fly zone is a National Park area that is nominally off-limits to sUAS operations. Two National Historic Sites will be used in this experiment: John Muir National Historic Site and the William Howard Taft National Historic Site. The boundaries of these sites are provided as a GitHub gist.

12.9.6.1 Configurations

The configurations for this experiment are listed in Table B-40 below:

Table B-40: D1X6 Configurations

Configuration	Muir	Muir	Muir	Taft	Taft	Taft
	D1S1T1	D1S1T2	D1S1T3	D1S1T5	D1S1T6	D1S1T7
	DeviatingDough	RequestingRhubarb	ReplanRadish	NoHarmNoFoul	FixyFixy	NoSoupForYou
A	AIRM	TRTX	SIMU	NASA	ANRA	AMZN
B	AMZN	AIRM	TRTX	SIMU	NASA	ANRA
C	ANRA	AMZN	AIRM	TRTX	SIMU	NASA

12.9.6.2 Sequence

The experiment will begin on the mark of the Command Center and will be considered "T=0" for the experiment and then progress as detailed in Table B-41 below:

Table B-41: D1X6 Sequence

Step	Time (min:sec)	Action	Notes
1	T=0:00	Command Center calls 'mark.'	Potential countdown prior to 'mark.'
2	0:00 to 0:30	Operators submit plans.	D1S1T1 & D1S1T5: Start time between T+30seconds and T+1min.

Step	Time (min:sec)	Action	Notes
			D1S1T2 & D1S1T6: Start time between T+3min and T+4min. D1S1T3 & D1S1T7: Start time between T+6min and T+7min. All durations between 2 and 4 minutes. All departures and initial plans very near the respective national park boundary.
3	0:30 to 1:00	D1S1T1 & D1S1T5: Operations commence.	
4	1:30 to 1:50	Step 4 (Operator Notifies of Deviation) of test is executed. FIMS sends cancel/termination message to D1S1T1. Per D1S1T5, operator sends message indicating flight correction. FIMS requests positions from operator per D1S1T1 & D1S1T5 (continuous and single, respectively). Per D1S1T1, operator acknowledges receipt of the the termination request.	
5	2:30	D1S1T1 & D1S1T5: Operations complete.	
6	3:00 to 4:00	D1S1T2 & D1S1T6: Operations commence.	
7	5:00	D1S1T2 & D1S1T6: Operations make their respective requests to FIMS. FIMS sends appropriate responses.	
8	5:30	D1S1T2 & D1S1T6: Operations complete.	
9	6:00 to 7:00	D1S1T3 & D1S1T7: Operations commence.	
10	7:00 to 9:00	D1S1T3 & D1S1T7: Complete test steps.	Need to complete with more detail for these last two operations.
11	*	Experiment completes.	

12.10 Data Exchange Test Coverage

In this section, the individual data exchanges are mapped to the tests and experiments in which they are invoked. This will establish a minimal coverage of the data exchanges under test. As this document has been evolving, it may be that each test or experiment that would cover a data exchange is not listed, however since the goal of Table B-42 below is to establish minimum coverage of the data elements, these potential omissions are acceptable.

Table B-42: Data Exchange Test Coverage

Data Exchange	Tests	Experiments	Notes
D1E1	ALL	ALL	
D1E2	D1S0T5	D1X1	
D1E3	ALL (except for D1S0T5, D1S0T8)	ALL	
D1E4	ALL	ALL	
D1E5	D1S2T2, D1S1T7, D1S2T2	D1X5	
D1E6	D1S0T8	D1X2	
D1E7	D1S0T3	D1X1	
D1E8	D1S0T4, D1S1T1, D1S3T1, D1S3T2	D1X4	
D1E9	D1S0T2	D1X1	
D1E10	D1S0T4, D1S0T6, D1S0T7, D1S1T1, D1S1T3, D1S1T5, D1S2T1, D1S2T2, D1S3T1, D1S3T2	D1X1, D1X2, D1X3, D1X5	
D1E11	D1S0T3	D1X1	
D1E12	D1S0T7	D1X2, D1X3	
D1E13	N/A	N/A	This data exchange was deleted.
D1E14	D1S0T7, D1S2T1, D1S2T2, D1S2T3	D1X3, D1X5	
D1E15	D1S0T7, D1S1T1, D1S1T5, D1S1T6, D1S1T7	D1X2, D1X3	
D1E16	D1S0T7, D1S1T1	D1X2, D1X3, D1X6	
D1E17	D1S0T7, D1S0T9, D1S0T10, D1S1T1, D1S1T5	D1X2, D1X3, D1X6	
D1E18	D1S0T10, D1S1T5	D1X6	
D1E19	D1S0T7, D1S0T9, D1S1T1	D1X1, D1X2, D1X3	
D1E20	D1S0T9	D1X1	
D1E21	D1S1T1	D1X6	

13 Appendix C – DWG Demonstration 1 End Points

The content of this appendix was originally a stand-alone document. The information contained herein provided some technical details for partners to aid in development. It is mainly included for completeness of documentation.

Table C-1 below describes the endpoints used with Demonstration 1:

Table C-1: Demonstration 1 Endpoints

Action	Actor	Detail	ID	end point	Comments	Model definition
Synchronous (HTTP POST) Request	Operator	Submit ops plan with volume	D1E1	/operation		
Synchronous Response	FIMS	Received HTTP 200	D1E3		Please detail the HTTP response. ?	
Synchronous (HTTP POST) Request	Operator	Submit ops plan too far in advance		/operation	How far is too far?	
Synchronous Response	FIMS	Bad Request Received HTTP 400	D1E2	/operation		
Synchronous (HTTP POST) Request	Operator	Submit ops LOS plan		/operation		
Synchronous Response	FIMS	Received HTTP 200	D1E6	/operation	flight request was not required	
Synchronous (HTTP GET)	Operator	Get operational vols		/operation		
Synchronous (HTTP PUT)	Operator	Plan modification	D1E1	/operation		
Response	FIMS	Request received HTTP 200	D1E3		Please detail the HTTP response. HTTP 200?	
Sync Request (HTTP POST)	Operator	Intent to Cancel	D1E9	/messages		
Response	FIMS	Received HTTP 200	D1E3		Please detail the HTTP response. HTTP 200?	

Action	Actor	Detail	ID	end point	Comments	Model definition
Sync Request (HTTP POST)	Operator	Intent to Close	D1E10, D1E11	/messages	D1E10 when operator initiates INTENT to close D1E11 when operator initiates INTENT to close because FIMS terminated the plan	
Response	FIMS	Received HTTP 200	D1E3		Please detail the HTTP response. HTTP 200?	
Sync Request	Operator	Alert - FlyAways, Incursion	D1E15	/messages		
Response	FIMS	Received HTTP 200	D1E16		How are the ACKs for Anomalies different from regular ACKs (D1E3) I don't know that they are different. I think they are the same. HTTP 200's.	
Sync Request	Operator	Alert - Back to conformance	D1E15	/messages		
Response	FIMS	Received HTTP 200	D1E16		Please detail the HTTP response. HTTP 200?	
ASYNC (STOMP Queue)	FIMS	Notification INFORM	D1E4, D1E5, D1E7, D1E8	/user/{operator}/decision	Accepted/Denied/Terminated Does Terminated mean Land Now? Does Operator then perform D1E9? When a deviation is denied, then include original plan	
ASYNC (STOMP Topic)	FIMS	Notification ALERT	D1E14	/topic/constraintChange	Notify AIRSPACE constraint change	
ASYNC (STOMP Topic)	FIMS	Notification ALERT	D1E12	/topic/emergency	Notify other operations of UNPLANNED Deviation	
ASYNC (STOMP Topic)	FIMS	Position subscription	?	/topic/positions	An echo of the position reports received by FIMS	
ASYNC (STOMP Topic)	FIMS	Operation announcements	ALL	/topic/operations	Notify all subscribers of approved/accepted operations	

13.1 Private endpoint to trigger async events from FIMS (for managerial use only)

Table C-2 lists additional private endpoints:

Table C-2: Private Endpoints

Action	Actor	Detail	ID	end point	Comments	Model definition
Synchronous (HTTP POST)	Manager	Acts as a trigger for async messaging from FIMS	D1E5, D1E7, D1E8	/asyncTriggerForUser	FIMS will notify user1 asynchronously	Will include the username and event ID to be sent
Synchronous (HTTP POST)	Manager	Acts as a trigger for async messaging from FIMS	D1E12, D1E14	/asyncTriggerForBroadcast	FIMS will broadcast an event (to a topic)	The event ID to be broadcasted

14 Appendix D – DWG Demonstration 1 FIMS-USS Client Checkout

The content of this appendix was originally a stand-alone document. The information contained herein was the basis for checking the functionality of the various USS systems that were developed by the various participants. As the test was dynamic in planning, as was this checkout document. This represents the final state of the checkout procedures and is provided for completeness and future reference.

14.1 Introduction

This document summarizes the steps and requirements for the checkout of a FIMS Client for the November Demonstration. They may be used with any client.

14.1.1 Scope

These tests are software focused. The idea is to make sure the Client Software has correctly implemented all of the features that meet the requirements of the demonstration. The tests will make sure the Client is successfully able to do the following:

1. Post to all the endpoints (/operations, /messages, /positions)
2. Post each of the intent message types required by the DWG Demonstration 1
3. Receive all of the synchronous message types
4. Receive at least one asynchronous message from each of the stomp queues (/user/{operator}/decision, /topic/constraintChange, /topic/emergency)

14.2 Testing Artifacts

For each test, there will be one or more Test Artifacts that will be generated. Each artifact is a file. All files with a '.txt' extension will have only ASCII text with the requested results/data. All files with a '.json' extension will have only ASCII text representing the JSON (JavaScript Object Notation, ref: https://en.wikipedia.org/wiki/JSON) object requested. Other file types may include pdf, jpeg, etc. as appropriate for the test. File names for all test artifacts shall follow this pattern:

```
FIMS-{providedTag}-{yourOrganizationName}-{artifactName}-{dateOfTest}-
v{versionNumber}.{extension}
```

Field definitions are described below in Table D-1:

Table D-1: Field Definitions

Field	Definition
providedTag	A descriptive string provided by this document. Unique to each phase of testing.
yourOrganizationName	A descriptive string unique to your organization's name. Only alphanumeric characters (no special chars or spaces allowed). Must be the same for all artifacts.
artifactName	Provided by this document. Unique to each test.
dateOfTest/dateOfCompletion	The date the test was performed in the format: `YYYYMMDD`
versionNumber	An integer, the first submission of the artifact to NASA should be '1' with each subsequent submission (as requested by NASA) increasing by 1.
extension	The file type. For example, `.txt` for general text documents or `.json` for JSON files.

Instructions regarding submission of the artifacts are provided in the subsections below.

14.3 Integration Testing

The operator must complete these tests all in one sitting. They must be done along with a FIMS representative. They can be done in person, or via telecommunications.

14.3.1 Test 0: Integration Sync

14.3.1.1 Test Purpose

Ensure proper clock settings to minimize timing issues between the UTM Client machine under test and the remote UTM System server.

14.3.1.2 Test Procedure

Synchronize the clock on each subsystem within your system. These should include your GCS station, the machine your UTM Client runs upon, and potentially your UAS vehicle.

If possible on each system, run a Network Time Protocol (NTP) client and record the output as an artifact (1). The time server that should be targeted is `time.nist.gov`. On a Mac or Linux machine, the command and output might be something like:

```
> sudo ntpdate -u time.nist.gov

10 Feb 07:56:45 ntpdate[73223]: adjust time server 129.6.15.28 offset
0.029740 sec
```

14.3.1.3 Test Artifacts

```
1. FIMS-IntegrationTest-{yourOrganizationName}-SyncClock-{dateOfTest}-
v{versionNumber}.txt
```

14.3.1.4 Test Verification

Inspect artifact for any anomalies.

14.3.2 Test 1: Nominal Operation (D1S0T1)

14.3.2.1 Test Purpose

To test that a nominal operation can be submitted to FIMS.

14.3.2.2 Test Procedure

Submit and record a nominal operation to the FIMS operation endpoint /operations. Record the synchronous response message verifying the operation was created. Record the asynchronous acceptance message from FIMS at /user/{operator}/decision.

Data Exchanges: **D1E1, D1E3, D1E4**

14.3.2.3 Test Artifacts

```
1. FIMS-IntegrationTest-{yourOrganizationName}-NomOpOperation-{dateOfTest}-
v{versionNumber}.json
2. FIMS-IntegrationTest-{yourOrganizationName}-NomOpSyncResponse-
{dateOfTest}-v{versionNumber}.json
```

```
3. FIMS-IntegrationTest-{yourOrganizationName}-NomOpASyncAcceptance-
{dateOfTest}-v{versionNumber}.json
```

14.3.2.4 Test Verification

FIMS representative will inspect artifacts for correctness of json content.

14.3.3 Test 2: Simple Cancel (D1S0T2)

14.3.3.1 Test Purpose

To test that a cancel intent message can be submitted to FIMS.

14.3.3.2 Test Procedure

Submit an operation to the FIMS operation endpoint /operations and receive the asynchronous acceptance message from FIMS at /user/{operator}/decision. Submit and record an INTENT CANCEL message to the FIMS message endpoint at /messages.

Data Exchanges: D1E1, D1E3, D1E4, **D1E9**

14.3.3.3 Test Artifacts

```
1. FIMS-IntegrationTest-{yourOrganizationName}-SimpleCancelIntentCancel-
{dateOfTest}-v{versionNumber}.json
```

14.3.3.4 Test Verification

FIMS representative will inspect artifacts for correctness of json content.

14.3.4 Test 3: Denial Received and Acknowledged (D1S0T3)

14.3.4.1 Test Purpose

To test that a denial can be received from FIMS and acknowledged.

14.3.4.2 Test Procedure

Submit an operation to the FIMS operation endpoint /operations and receive the asynchronous acceptance message from FIMS at /user/{operator}/decision. Receive and record the asynchronous DENIED message from FIMS at /user/{operation}/decision. Submit and record an INTENT ACK_NO_OPERATION message to the FIMS message endpoint at /messages acknowledging that no flight operation will be conducted.

Data Exchanges: D1E1, D1E3, D1E4, **D1E7, D1E11**

14.3.4.3 Test Artifacts

```
1. FIMS-IntegrationTest-{yourOrganizationName}-DenialInformDenied-
{dateOfTest}-v{versionNumber}.json
2. FIMS-IntegrationTest-{yourOrganizationName}-DenialIntentAckNoOp-
{dateOfTest}-v{versionNumber}.json
```

14.3.4.4 Test Verification

FIMS representative will inspect artifacts for correctness of json content.

14.3.5 Test 4: Terminated Operation (D1S0T4)

14.3.5.1 Test Purpose

To test that an operation can be terminated by FIMS.

14.3.5.2 Test Procedure

Submit an operation to the FIMS operation endpoint /operations and receive the asynchronous acceptance message from FIMS at /user/{operator}/decision. Receive and record the asynchronous TERMINATED message from FIMS at /user/{operation}/decsion. Submit and record an INTENT CLOSE message to FIMS at /messages endpoint.

Data Exchanges: D1E1, D1E3, D1E4, **D1E8, D1E10**

14.3.5.3 Test Artifacts

```
1. FIMS-IntegrationTest-{yourOrganizationName}-TerminatedInformTerminated-
{dateOfTest}-v{versionNumber}.json

2. FIMS-IntegrationTest-{yourOrganizationName}-TerminatedOpIntentClose-
{dateOfTest}-v{versionNumber}.json
```

14.3.5.4 Test Verification

FIMS representative will inspect artifacts for correctness of json content.

14.3.6 Test 5: Plan Submitted Too Early (D1S0T5)

14.3.6.1 Test Purpose

To test that a request can be submitted too early and the correct message is received.

14.3.6.2 Test Procedure

Create an operation with begin time that is more than 24 hours after the current time. Submit the operation to the FIMS operation endpoint /operations. Receive and record the asynchronous INFORM from FIMS at /user/{operator}/decision indicating PLAN_SUBMITTED_TOO_EARLY

Data Exchanges: D1E1, D1E3, **D1E2**

14.3.6.3 Test Artifacts

```
1. FIMS-IntegrationTest-{yourOrganizationName}-SubmittedInformEarly-
{dateOfTest}-v{versionNumber}.json
```

14.3.6.4 Test Verification

FIMS representative will inspect artifacts for correctness of json content.

14.3.7 Test 6: Fly Away (D1S0T7)

14.3.7.1 Test Purpose

To test that a user can report fly away and receive correct messages from FIMS

14.3.7.2 Test Procedure

Submit an operation to the FIMS operation endpoint /operations and receive the asynchronous acceptance message from FIMS at /user/{operator}/decision. Send and record an ALERT message with FLY_AWAY alert text to FIMS at /messages. Receive and record synchronous message from FIMS reporting notification of anomaly received. Receive asynchronous ALERT message reporting no fly zone from FIMS at /topic/constraintChange. Receive and record asynchronous ALERT message reporting the UNPLANNED_DEVIATION from FIMS at /topic/emergency. Receive and record asynchronous ALERT message requesting continuous positions from FIMS at /user/{operator}/decision. Submit and record position to FIMS at /positions. Send INTENT CLOSE message to FIMS at /messages. Receive and record asynchronous ALERT message indicating removal of no-fly zone from FIMS at /topic/constraintChange.

Data Exchanges: D1E1, D1E3, D1E4, **D1E15, D1E16, D1E14, D1E12, D1E19, D1E17**, D1E10, **D1E14**

14.3.7.3 Test Artifacts

```
1. FIMS-IntegrationTest-{yourOrganizationName}-FlyAwayAlertFlyAway-
{dateOfTest}-v{versionNumber}.json
2. FIMS-IntegrationTest-{yourOrganizationName}-FlyAwaySyncAnomalyReceived-
{dateOfTest}-v{versionNumber}.json
3. FIMS-IntegrationTest-{yourOrganizationName}-FlyAwayAsyncAlertNoFly-
{dateOfTest}-v{versionNumber}.json
4. FIMS-IntegrationTest-{yourOrganizationName}-FlyAwayAsyncAlertUnplanDev-
{dateOfTest}-v{versionNumber}.json
5. FIMS-IntegrationTest-{yourOrganizationName}-FlyAwayAsyncAlertContPos-
{dateOfTest}-v{versionNumber}.json
6. FIMS-IntegrationTest-{yourOrganizationName}-FlyAwayOpPosition-
{dateOfTest}-v{versionNumber}.json
7. FIMS-IntegrationTest-{yourOrganizationName}-FlyAwayAsyncAlertNoFlyCleared-
{dateOfTest}-v{versionNumber}.json
```

14.3.7.4 Test Verification

FIMS representative will inspect artifacts for correctness of json content.

14.3.8 Test 7: Authorization Not Required (D1S0T8)

14.3.8.1 Test Purpose

To test that a message can be received that Authorization is not required

14.3.8.2 Test Procedure

Create an operation where all operation volumes contain beyond_visual_line_of_sight=false. Submit the operation to the FIMS operation endpoint /operations. Record and receive the asynchronous Authorization Not Required from FIMS at /user/{operator}/decision.
Data Exchanges: D1E1, D1E3, **D1E6**

```
1. FIMS-IntegrationTest-{yourOrganizationName}-AuthNotRequiredAsync-
{dateOfTest}-v{versionNumber}.json
```

14.3.8.3 Test Verification

FIMS representative will inspect artifacts for correctness of json content.

14.3.9 Test 8: Positions requested and sent (D1S0T9)

14.3.9.1 Test Purpose

To test that continuous positions can be requested and sent.

14.3.9.2 Test Procedure

Submit an operation to the FIMS operation endpoint /operations and receive the asynchronous acceptance message from FIMS at /user/{operator}/decision. Receive asynchronous message from FIMS at /user/{operator}/decision requesting continuous position reports. Begin sending positions to /positions endpoint. Receive and record asynchronous message from FIMS at /user/{operator}/decision cancelling position request, and discontinue sending positions.

Data Exchanges: D1E1, D1E3, D1E4, D1E19, D1E17, **D1E20**

```
1. FIMS-IntegrationTest-{yourOrganizationName}-ContinuousPositionRequest-
{dateOfTest}-v{versionNumber}.json
```

14.3.9.3 Test Verification

FIMS representative will inspect artifacts for correctness of json content.

14.3.10 Test 9: Single Position requested and sent (D1S0T10)

14.3.10.1 Test Purpose

To test that a single position can be requested and sent.

14.3.10.2 Test Procedure

Submit an operation to the FIMS operation endpoint /operations and receive the asynchronous acceptance message from FIMS at /user/{operator}/decision. Receive and record asynchronous message from FIMS at /user/{operator}/decision requesting single position reports. Send a single position to /positions endpoint.

Data Exchanges: D1E1, D1E3, D1E4, **D1E18**, D1E17

```
1. FIMS-IntegrationTest-{yourOrganizationName}-SinglePositionRequest-
{dateOfTest}-v{versionNumber}.json
```

14.3.10.3 Test Verification

FIMS representative will inspect artifacts for correctness of json content.

15 Appendix E – DWG Demonstration 1 FIMS-USS Interface

The content of this appendix is a technical document best viewed with appropriate tools, but is human readable on its own. This is the specification to which both the FIMS and the various USS implementations adhered to for the demonstration. Note that the data definitions were based on the various discussions and documentation referenced elsewhere in this document.

```
---
swagger: "2.0"
info:
  description: "This API describes the RESTful interface from a UAS Service
Supplier (USS) to the Flight Information Management System (FIMS) within UTM.
There is an additional API for asynchronous communications that is described in
the Subscription Points section."
  version: "v2"
  title: "UTM Research Platform, FIMS-USS Interface"
  contact:
    name: NASA Ames Research Center, Aviation Systems Division
    url: https://utm.arc.nasa.gov/
    email: joseph.rios@nasa.gov
  license:
    name: NASA Open Source Agreement
    url: https://ti.arc.nasa.gov/opensource/nosa/
  termsOfService: |
    A. No Warranty: THE SUBJECT SOFTWARE IS PROVIDED "AS IS" WITHOUT ANY WARRANTY
OF ANY KIND, EITHER EXPRESSED, IMPLIED, OR STATUTORY, INCLUDING, BUT NOT LIMITED
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IMPLIED WARRANTIES OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE, OR
FREEDOM FROM INFRINGEMENT, ANY WARRANTY THAT THE SUBJECT SOFTWARE WILL BE ERROR
FREE, OR ANY WARRANTY THAT DOCUMENTATION, IF PROVIDED, WILL CONFORM TO THE
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LIABILITIES REGARDING THIRD-PARTY SOFTWARE, IF PRESENT IN THE ORIGINAL SOFTWARE,
AND DISTRIBUTES IT "AS IS."
    B. Waiver and Indemnity: RECIPIENT AGREES TO WAIVE ANY AND ALL CLAIMS AGAINST
THE UNITED STATES GOVERNMENT, ITS CONTRACTORS AND SUBCONTRACTORS, AS WELL AS ANY
PRIOR RECIPIENT. IF RECIPIENT''S USE OF THE SUBJECT SOFTWARE RESULTS IN ANY
LIABILITIES, DEMANDS, DAMAGES, EXPENSES OR LOSSES ARISING FROM SUCH USE,
INCLUDING ANY DAMAGES FROM PRODUCTS BASED ON, OR RESULTING FROM, RECIPIENT''S USE
OF THE SUBJECT SOFTWARE, RECIPIENT SHALL INDEMNIFY AND HOLD HARMLESS THE UNITED
STATES GOVERNMENT, ITS CONTRACTORS AND SUBCONTRACTORS, AS WELL AS ANY PRIOR
RECIPIENT, TO THE EXTENT PERMITTED BY LAW. RECIPIENT''S SOLE REMEDY FOR ANY SUCH
MATTER SHALL BE THE IMMEDIATE, UNILATERAL TERMINATION OF THIS AGREEMENT.
host: "tmiserver.arc.nasa.gov"
basePath: "/fims"
schemes:
```

```
- https
tags: # Have to add 'A' 'B' etc since ordering isn't respected in SwaggerUI.
- name: A. FIMS Endpoints
  description: The primary RESTful endpoints for operators accessing FIMS
  externalDocs:
    url: "https://tmiserver.arc.nasa.gov/fims/api/"
    description: NASA FIMS server generated from this API specification.
- name: B. Subscription Points
  description: Non-REST endpoints for asynchronous communications with FIMS
- name: C. Data Types
  description: Psuedo endpoints used for the documentation of the data schema
- name: D. Version
  description: Get version
responses:
  WRONG_PROTOCOL:
    description: A RESTful call was made to this endpoint but this is not a REST
endpoint. Do not use this endpoint for REST calls.
  # BadRequest:
  #   description: "Bad request. Typically validation error. Fix your request and
retry."
  #   schema:
  #     $ref: "#/definitions/FIMSApiResponse"
  # AuthenticationError:
  #   description: "Authentication Error"
  #   schema:
  #     $ref: "#/definitions/FIMSApiResponse"
  # AuthorizationError:
  #   description: "Authorization Error"
  #   schema:
  #     $ref: "#/definitions/FIMSApiResponse"
  # ResourceNotFound:
  #   description: "Resource not found"
  #   schema:
  #     $ref: "#/definitions/FIMSApiResponse"

paths:
  /operations:
    post:
      tags:
        - A. FIMS Endpoints
      summary: Submit an operation to FIMS
      security:
         - userBasic: [ ]
      operationId: postOperation
      description: Allows for submission of an operation plan to FIMS.
      consumes:
        - application/json
      produces:
        - application/json
```

```
      parameters:
        - in: body
          name: operation
          description: Operational plan to add
          required: true
          schema:
            $ref: "#/definitions/Operation"
      responses:
        201:
          description: Operation Plan request received.
          schema:
            $ref: "#/definitions/FIMSApiResponse"
        400:
          description: "Bad request. Typically validation error. Fix your request
and retry."
          schema:
            $ref: "#/definitions/FIMSApiResponse"
        403:
          description: "Invalid ID supplied.  Fix authorization and retry."
          schema:
            $ref: "#/definitions/FIMSApiResponse"
#    get:
#      tags:
#        - FIMS Endpoints
#      summary: Return operation(s) from FIMS
#      description: Gets the operations from FIMS.
#      operationId: getOperations
#      produces:
#        - application/json
#      responses:
#        200:
#          description: "Operations retrieved successfully."
#          schema:
#            type: array
#            items:
#             $ref: "#/definitions/Operation"
#        403:
#          description: "Unauthorized user."
#          schema:
#            $ref: "#/definitions/FIMSApiResponse"
#        404:
#          description: "Operations not found."
#          schema:
#            $ref: "#/definitions/FIMSApiResponse"

  /operations/{gufi}:
#    get:
#      tags:
#        - FIMS Endpoints
```

```
#     summary: Return an operation from FIMS
#      description: Get a specific operation from FIMS by gufi
#     operationId: getOperationByGufi
#      produces:
#       - application/json
#     parameters:
#     - in: path
#       name: gufi
#       description: "GUFI of the operation"
#       required: true
#        type: string
#        format: uuid
#      responses:
#       200:
#         description: "Operation retrieved."
#          schema:
#           $ref: "#/definitions/Operation"
#       403:
#         description: "Unauthorized user."
#          schema:
#           $ref: "#/definitions/FIMSApiResponse"
#        404:
#          description: "Operations not found."
#         schema:
#           $ref: "#/definitions/FIMSApiResponse"
    put:
      tags:
        - A. FIMS Endpoints
      summary: Modify an operation
      security:
        - userBasic: [ ]
      description: Allows for modifying of an operation plan in FIMS.
      operationId: updateOperation
      consumes:
        - application/json
      produces:
        - application/json
      parameters:
      - in: path
        name: gufi
        description: "GUFI of the operation to update"
        required: true
        type: string
        format: uuid
      - in: body
        name: operation
        description: Operation updates
        required: true
        schema:
```

```
          $ref: "#/definitions/Operation"
      responses:
        200:
          description: "Operation updated."
          schema:
            $ref: "#/definitions/FIMSApiResponse"
        400:
          description: "Bad request. Typically validation error. Fix your request
and retry."
          schema:
            $ref: "#/definitions/FIMSApiResponse"
        403:
          description: "Unauthorized user."
          schema:
            $ref: "#/definitions/FIMSApiResponse"
        404:
          description: "Operations not found."
          schema:
            $ref: "#/definitions/FIMSApiResponse"
  /positions:
    post:
      tags:
        - A. FIMS Endpoints
      summary: Submit position report
      security:
         - userBasic: [ ]
      description: Allows for submission of position data related to a particular
operation.
      operationId: postPosition
      responses:
        201:
          description: "Position posted successfully."
          schema:
            $ref: "#/definitions/FIMSApiResponse"
        400:
          description: "Invalid message. Please fix and retry."
          schema:
            $ref: "#/definitions/FIMSApiResponse"
      parameters:
      - in: body
        name: position
        description: Position to submit
        required: true
        schema:
          $ref: "#/definitions/Position"
#    get:
#      tags:
#        - FIMS Endpoints
#     summary: Return position(s) from FIMS
```

```
#      description: Get positions
#     operationId: getPositions
#      produces:
#        - application/json
#      responses:
#        200:
#          description: "Positions retrieved successfully."
#          schema:
#            type: array
#            items:
#              $ref: "#/definitions/Position"
#        403:
#          description: "Unauthorized user."
#          schema:
#            $ref: "#/definitions/FIMSApiResponse"
#        404:
#          description: "Requested positions not found."
#          schema:
#            $ref: "#/definitions/FIMSApiResponse"

  /messages:
    post:
      tags:
        - A. FIMS Endpoints
      summary: Submit a message to FIMS
      security:
        - userBasic: [ ]
      description: Allows posting of a message to FIMS. Typically an intent
message related to a particular operation.
      operationId: postMessage
      consumes:
        - application/json
      produces:
        - application/json
      responses:
        201:
          description: "Message received successfully."
          schema:
            $ref: "#/definitions/FIMSApiResponse"
        400:
          description: "Invalid message. Please fix and retry."
          schema:
            $ref: "#/definitions/FIMSApiResponse"
        403:
          description: "Unauthorized user."
          schema:
            $ref: "#/definitions/FIMSApiResponse"
      parameters:
      - name: message
```

```
        in: body
        description: Message object being sent
        required: true
        schema:
          $ref: "#/definitions/Message"
#    get:
#     tags:
#       - FIMS Endpoints
#     summary: Return message(s) from FIMS
#     description: Get all the messages
#     operationId: getMessages
#      produces:
#        - application/json
#      responses:
#        200:
#          description: "Messages retrieved successfully."
#         schema:
#            type: array
#           items:
#              $ref: "#/definitions/Message"
#        403:
#          description: "Unauthorized user."
#          schema:
#           $ref: "#/definitions/FIMSApiResponse"
#        404:
#          description: "Messages not found."
#          schema:
#            $ref: "#/definitions/FIMSApiResponse"

  /user/{operator}/decision:
    get:
      tags:
        - B. Subscription Points
      summary: Subscription point for receiving decisions from FIMS
      description: |
        Each operator has a designated queue for decisions. This queue will
provide InformMessage data related to the specified operator's operations.  For
example, after an operator POSTs an operation to the /operations RESTful
endpoint, that operator will receive the appropriate InformMessage (ACCEPTED,
DENIED, etc.) via this queue.
        See the schema information describing InformMessages included within this
document to understand the data that will be received via this queue.
        Note that if you are viewing this in a SwaggerUI, the "try it out"
feature will not work since this is not a RESTful endpoint.
      responses:
        410:
          $ref: "#/responses/WRONG_PROTOCOL"
      produces:
        - application/json
```

```
      parameters:
      - in: path
        name: operator
        description: "the user id"
        required: true
        type: string

  /topic/positions:
    get:
      tags:
        - B. Subscription Points
      summary: Subscription point for receiving position reports
      description: |
        Stakeholders should subscribe to this topic to receive position reports
provided to the FIMS by various operators. This is essentially an echo of the
Postion data POSTed to the /positions endpoint.
        See the schema information describing Postions included within this
document to understand the data that will be received via this queue.
        Note that if you are viewing this in a SwaggerUI, the "try it out"
feature will not work since this is not a RESTful endpoint.
      responses:
        410:
          $ref: "#/responses/WRONG_PROTOCOL"
      produces:
        - application/json
  /topic/operations:
    get:
      tags:
        - B. Subscription Points
      summary: Subscription point for receiving announcements about operations
      description: |
        Stakeholders should subscribe to this topic to receive announcements
about operations that have been accepted/authorized. Information about denied
operations will not be provided here.
        See the schema information describing Operations included within this
document to understand the data that will be received via this queue.
        Note that if you are viewing this in a SwaggerUI, the "try it out"
feature will not work since this is not a RESTful endpoint.
      responses:
        410:
          $ref: "#/responses/WRONG_PROTOCOL"
      produces:
        - application/json
  /topic/constraintChange:
      get:
        tags:
          - B. Subscription Points
        summary: Subscription point for airspace constraint changes
        description: |
```

```
          Stakeholders should subscribe to this topic to get alert messages
regarding airspace constraint changes.
          Note that if you are viewing this in a SwaggerUI, the "try it out"
feature will not work since this is not a RESTful endpoint.
        operationId: topicConstraintChangeUsingGET
        produces:
          - application/json
        responses:
          410:
            $ref: "#/responses/WRONG_PROTOCOL"

  /topic/emergency:
      get:
        tags:
          - B. Subscription Points
        summary: Subscription point for emergency alerts
        description: |
          Stakeholders should subscribe to this topic to get alert messages
regarding emergencies.
          Note that if you are viewing this in a SwaggerUI, the "try it out"
feature will not work since this is not a RESTful endpoint.
        operationId: topicEmergencyUsingGET
        produces:
          - application/json
        responses:
          410:
            $ref: "#/responses/WRONG_PROTOCOL"

  /schema/Operation:
    get:
      tags:
        - C. Data Types
      summary: Operation schema
      description: |
        Illustrates an operation in JSON. This endpoint is not intended for use.
        Note that if you are viewing this in a SwaggerUI, the "try it out"
feature will not work since this is not a RESTful endpoint.
      produces:
        - application/json
      responses:
        200:
          description: OK
          schema:
            $ref: "#/definitions/Operation"
        410:
          $ref: "#/responses/WRONG_PROTOCOL"
  /schema/Point:
    get:
      tags:
```

```
       - C. Data Types
      summary: Point schema
      description: |
        Illustrates an Point in JSON. This endpoint is not intended for use.
        Note that if you are viewing this in a SwaggerUI, the "try it out"
feature will not work since this is not a RESTful endpoint.
      produces:
        - application/json
      responses:
        200:
          description: OK
          schema:
            $ref: "#/definitions/Point"
        410:
          $ref: "#/responses/WRONG_PROTOCOL"

  /schema/LineString:
    get:
      tags:
        - C. Data Types
      summary: LineString schema
      description: |
        Illustrates an LineString in JSON. This endpoint is not intended for use.
        Note that if you are viewing this in a SwaggerUI, the "try it out"
feature will not work since this is not a RESTful endpoint.
      produces:
        - application/json
      responses:
        200:
          description: OK
          schema:
            $ref: "#/definitions/LineString"
        410:
          $ref: "#/responses/WRONG_PROTOCOL"
  /schema/Polygon:
    get:
      tags:
        - C. Data Types
      summary: Polygon schema
      description: |
        Illustrates an Polygon in JSON. This endpoint is not intended for use.
        Note that if you are viewing this in a SwaggerUI, the "try it out"
feature will not work since this is not a RESTful endpoint.
      produces:
        - application/json
      responses:
        200:
          description: OK
          schema:
```

```
            $ref: "#/definitions/Polygon"
        410:
          $ref: "#/responses/WRONG_PROTOCOL"
  /schema/InformMessage:
    get:
      tags:
        - C. Data Types
      summary: Inform Message schema
      description: |
        Illustrates the FIMS Inform Message. This is FIMS' reply to an Intent.
This endpoint is not intended for use.
        Note that if you are viewing this in a SwaggerUI, the "try it out"
feature will not work since this is not a RESTful endpoint.
      operationId: informMsgUsingGET
      produces:
        - application/json
      responses:
        200:
          description: OK
          schema:
            $ref: "#/definitions/InformMessage"
        410:
          $ref: "#/responses/WRONG_PROTOCOL"
  /schema/IntentMessage:
    get:
      tags:
        - C. Data Types
      summary: Intent Message schema
      description: |
        Illustrates the FIMS Intent Message. Your Intent generates a FIMS Inform.
This endpoint is not intended for use.
        Note that if you are viewing this in a SwaggerUI, the "try it out"
feature will not work since this is not a RESTful endpoint.
      operationId: intentMsgUsingGET
      produces:
        - application/json
      responses:
        200:
          description: OK
          schema:
            $ref: "#/definitions/IntentMessage"
        410:
          $ref: "#/responses/WRONG_PROTOCOL"
  /schema/AlertMessage:
    get:
      tags:
        - C. Data Types
      summary: Alert Message schema
      description: |
```

```
        Illustrates the FIMS Alert Message. FIMS may send out Alert Messages from
time to time. This endpoint is not intended for use.
        Note that if you are viewing this in a SwaggerUI, the "try it out"
feature will not work since this is not a RESTful endpoint
      operationId: alertMsgUsingGET
      produces:
        - application/json
      responses:
        200:
          description: OK
          schema:
            $ref: "#/definitions/AlertMessage"
        410:
          $ref: "#/responses/WRONG_PROTOCOL"
  /schema/ConstraintMessage:
    get:
      tags:
        - C. Data Types
      summary: Constraint Message schema
      description: |
        Illustrates the FIMS Constraint Message. FIMS will send out a Constraint
Message when a new constraint is put in place. This endpoint is not intended for
use.
        Note that if you are viewing this in a SwaggerUI, the "try it out"
feature will not work since this is not a RESTful endpoint
      operationId: constraintMsgUsingGET
      produces:
        - application/json
      responses:
        200:
          description: OK
          schema:
            $ref: "#/definitions/ConstraintMessage"
        410:
          $ref: "#/responses/WRONG_PROTOCOL"
#  /version:
#    get:
#      tags:
#        - D. Version
#      summary: Get version
#      produces:
#        - text/plain

securityDefinitions:
   userApiKey:
      type: apiKey
      in: header
      name: userApiKey
   mgrApiKey:
```

```
      type: apiKey
      in: header
      name: mgrApiKey
   userBasic:
    type: basic
   mgrBasic:
    type: basic
definitions:
  FIMSApiResponse:
    type: "object"
    properties:
      code:
        type: "integer"
        format: "int32"
      type:
        type: "string"
      message:
        type: "string"
    example:
      code: 201
      type: CREATED
      message: Operation Plan request received.
  Operation:
    type: object
    required:
    - registration
    - primary_contact_name
    - primary_contact_phone
    - controller_location
    - operation_volumes
    properties:
      gufi:
        description: >

            * *Ignored on initial submission, assigned by server*
            * *Always returned from server*
            Each operation has a GUFI assigned upon submission. It is a JSON
string that conforms to the UUID version 4 specification. Should not be submitted
with a new plan, but is required for modification (PUT).
        type: string
        format: uuid
      submit_time:
        description: "Time the operation submission was received by UTM System."
        type: string
        format: date-time
      decision_time:
        description: "A timestamp set by the UTM System any time the state of the
operation is updated, for example when the flight goes from PROPOSING to ACCEPTED
(see Section 4.1)"
```

```
        type: string
        format: date-time
      aircraft_comments:
        description: "Informative text about the aircraft. Not used by the UTM
System.  Only for human stakeholders."
        type: string
      flight_comments:
        description: "Informative text about the operation.  Not used by the UTM
System.  Only for human stakeholders."
        type: string
      flight_geography_description:
        description: "Informative text about the operational geography.  Not used
by the UTM System.  Only for human stakeholders."
        type: string
      registration:
        description: "The registration ID of the vehicle flying this operation.
Note the UTM System assumes a single vehicle per operation currently.  This
registration value is provided to operators upon manual registration of their
vehicle with NASA."
        type: string
        format: uuid
      flight_number:
        description: "Optional.  Currently unused by the UTM System, may be
useful to the operator for identification purposes."
        type: string
      user_id:
        description: "This field is populated based on the provided credentials
in the HTTPS header."
        type: string
      created_by:
        description: "The user that created the operation. It is possible that an
operation is created on behalf of an operator by, say, a manager. Nominally, this
field will be equal to user_id."
        type: string
      primary_contact_name:
        description: "These are required fields.  They are not currently checked
for validity, but clients should endeavor to provide useful, appropriate
information in these fields.  Validity will be checked in the future.  These
values should represent the contact that should be used in case of an issue with
the operation before, during, or after that operation."
        type: string
      primary_contact_phone:
        type: string
      primary_contact_email:
        type: string
      extra_contact_info:
        description: "Any additional contact information that may be useful
(hours of availability, fax number, communication limitations, etc.)."
        type: string
```

```
      state:
        description: "The current state of the operation.  Not required for
submission, will be assigned by the UTM System."
        type: string
      controller_location:
        # description: "The planned position of the UAS Controller during the
operation. Assumed to be a static location."
        $ref: "#/definitions/Point"
      gcs_location:
        # description: "If not submitted, the UTM System will assume the GCS is
co-located with the UAS Controller.  Assumed to be a static location."
        $ref: "#/definitions/Point"
      faa_rule:
        description: "Indication whether this operation is under Part 101-E, Part
107, Part 107 waiver, or a Part TBD.  Part TBD is a potential future rule that
may cover operations such as those under test by UTM."
        type: string
        enum:
        - PART_107
        - PART_107W
        - PART_101E
        - PART_TBD
      waiver_certificate_number:
        description: "If a waiver has been obtained for the Part 107 rules, then
the operator would have a waiver certificate number. For any operation
submissions with faa_rule=PART_107W, this field is required."
        type: string

      operation_volumes:
        description: "Editable. The actual geographical information for the
operation."
        type: array
        items:
          $ref: "#/definitions/OperationVolume"
    example:
      gufi: "00000000-0000-4444-8888-000000000000"
      submit_time: "2016-10-04T09:15:40.727Z"
      decision_time: "2016-10-04T09:15:40.727Z"
      aircraft_comments: "Comments about the aircraft"
      flight_comments: "Comments about the flight"
      flight_geography_description: "A description of the geography"
      registration: "00000000-0000-4444-8888-000000000000"
      flight_number: "Flight number"
      user_id: "fimsUser"
      created_by: "fimsUser"
      primary_contact_name: "Jane Pilot"
      primary_contact_phone: "XXX-XXX-XXXX"
      primary_contact_email: "pilotjane@janepilot.com"
      extra_contact_info: "Fax: XXX-XXX-XXXX"
```

```
      state: A
      controller_location:
        type: Point
        coordinates: [-122.048589,37.414869]
      gcs_location:
        type: Point
        coordinates: [-122.048589,37.414869]
      operation_volumes:
      - ordinal: 1
        near_structure: false
        effective_time_begin: "2017-10-04T09:15:40.727Z"
        effective_time_end: "2017-10-04T09:25:40.727Z"
        actual_time_end: "2017-10-04T09:25:40.727Z"
        conformance_time_begin: "2017-10-04T09:14:40.727Z"
        conformance_time_end: "2017-10-04T09:26:40.727Z"
        min_altitude_wgs84_ft: 0.0
        max_altitude_wgs84_ft: 300.0
        conform_min_altitude_wgs84_ft: 0.0
        conform_max_altitude_wgs84_ft: 400.0
        flight_geography:
          type: Polygon
          coordinates: [
            [
              [-122.062176579,37.40968041145],
              [-122.05187056889,37.41786527236],
              [-122.03732647634,37.41786440108],
              [-122.062176579,37.40968041145],
            ]
          ]
        conformance_geography:
          type: Polygon
          coordinates: [
            [
              [-122.06382530000002,37.40906970000],
              [-122.05094253233000,37.41930062770],
              [-122.03276206976000,37.41929920176],
              [-122.06382530000002,37.40906970000]
            ]
          ]
        beyond_visual_line_of_sight: false
    OperationVolume:
      type: object
      required:
      - ordinal
      - effective_time_begin
      - effective_time_end
      - min_altitude_wgs84_ft
      - max_altitude_wgs84_ft
      - flight_geography
```

```
    - beyond_visual_line_of_sight
    properties:
      ordinal:
        description: "This integer represents the ordering of the operation
volume within the set of operation volumes. Need not be consecutive integers."
        type: integer
      near_structure:
        description: "Is this operation volume within 400' of a structure?"
        type: boolean
        default: false
      effective_time_begin:
        description: "Earliest time the operation will use the operation volume."
        type: string
        format: date-time
      effective_time_end:
        description: "Latest time the operation will done with the operation
volume."
        type: string
        format: date-time
      actual_time_end:
        description: "Time that the operational volume was freed for use by other
operations."
        type: string
        format: date-time
      conformance_time_begin:
        description: "Assigned by UTM System.  Time buffer before the submitted
begin time."
        type: string
        format: date-time
      conformance_time_end:
        description: "Assigned by UTM System.  Time buffer after the submitted
end time."
        type: string
        format: date-time
      min_altitude_wgs84_ft:
        description: "The minimum altitude for this operation in this operation
volume. In WGS84 reference system using feet as units."
        type: number
        format: double
      max_altitude_wgs84_ft:
        description: "The maximum altitude for this operation in this operation
volume. In WGS84 reference system using feet as units."
        type: number
        format: double
      conform_min_altitude_wgs84_ft:
        description: "The minimum altitude assigned and used by the UTM System to
check vertical conformance of an operation. Based on UTM Client-provided min
altitude."
        type: number
```

```
        format: double
      conform_max_altitude_wgs84_ft:
        description: "The maximum altitude assigned and used by the UTM System to
check vertical conformance of an operation. Based on UTM Client-provided max
altitude."
        type: number
        format: double
      flight_geography:
        # description: "A description of the operational area.  This should be
the area within which the operation will remain."
        $ref: "#/definitions/Geometry"
      conformance_geography:
        # description: "A UTM-generated geography based on the flight geography.
See Section 4.4.2 for discussion."
        $ref: "#/definitions/Geometry"
      beyond_visual_line_of_sight:
        description: "Describes whether the operation volume is beyond the visual
line of sight of the operator."
        type: boolean
  Position:
    type: object
    required:
    - altitude_gps_wgs84_ft
    - altitude_num_gps_satellites
    - gufi
    - hdop_gps
    - location
    - time_measured
    - time_sent
    - track_ground_speed_kn
    - track_true_north_deg
    - vdop_gps
    properties:
      air_speed_source:
        type: string
        description: Required if air_speed_track_kn is submitted. No requirements
          yet on the values here, but suggestions include ESTIMATED or MEASURED.
      air_speed_track_kn:
        type: number
        format: double
        description: Air speed in relation to the direction of travel of the
aircraft.
          Value may be negative.
      altitude_gps_wgs84_ft:
        type: number
        format: double
        description: The altitude as measured via a GPS device on the aircraft.
Units
          in feet using the WGS84 reference system.
```

```
      altitude_num_gps_satellites:
        type: integer
        format: int32
        description: Number of satellites used in calculating the
altitude_gps_wgs84_ft.
      enroute_positions_id:
        type: string
        format: uuid
        description: Each position will be assigned a UUIDv4 by the FIMS
      gufi:
        type: string
        format: uuid
        description: Each operation has an GUFI assigned upon submission.
Required upon
          POSTing a new position. It is a JSON string, but conforms to the UUID
version
          4 specification
      hdop_gps:
        type: number
        format: double
        description: The horizontal dilution of precision as provided by the
onboard
          GPS.
      location:
        # description: "A description of the 2D location.  A Point geojson
fragment."
        "$ref": "#/definitions/Point"
      time_measured:
        type: string
        format: date-time
        description: The time the position was measured. Likely the time provided
with
          the GPS position reading.
      time_received:
        type: string
        format: date-time
        description: Not required for submission, assigned by the UTM System. The
time
          the position was received by the UTM System.
      time_sent:
        type: string
        format: date-time
        description: The time the position was sent.
      track_ground_speed_kn:
        type: number
        format: double
        description: Ground speed int the direction of travel. Value must be >=
0.0.
          In knots.
```

```
      track_magnetic_north_deg:
        type: number
        format: double
        description: The direction of travel relative to magnetic north in
degrees.
          Value must be >= 0.0 and < 360.0.
      track_true_north_deg:
        type: number
        format: double
        description: The direction of travel relative to true north in degrees.
Value
          must be >= 0.0 and < 360.0.
      user_id:
        type: string
        description: Not required for submission. This field is populated based
on the
          provided credentials in the HTTPS header.
      vdop_gps:
        type: number
        format: double
        description: The vertical dilution of precision as provided by the
onboard
          GPS.
    example:
      altitude_gps_wgs84_ft: 1111.111
      altitude_num_gps_satellites: 22
      air_speed_source: "MEASURED"
      gufi: "00000000-0000-4444-8888-000000000000"
      hdop_gps: 77.7
      time_measured: "2016-10-04T09:15:40.727Z"
      time_sent: "2016-10-04T09:15:40.727Z"
      time_received: "2016-10-04T09:15:42.727Z"
      track_ground_speed_kn: 33.33
      track_true_north_deg: 235.027287562664
      track_magnetic_north_deg: 237.123456789123
      vdop_gps: 88.8
      location:
        type: "Point"
        coordinates:
        - -122.05635935068132
        - 37.41436490284069
  Geometry:
    required:
      - type
    type: object
    discriminator: type
    description: "A geometry object in two dimensional space."
    properties:
      type:
```

```
        type: string
  Point:
    required:
      - coordinates
    allOf:
    - $ref: "#/definitions/Geometry"
    - type: object
      properties:
        coordinates:
          type: array
          description: Pair of longitude-latitude values. If a third element is
provided for altitude, it is silently ignored.
          items:
            type: number
            format: double
    example:
      type: Point
      # Moffet Federal Airfield
      # http://bl.ocks.org/d/3410a0f498572d74972719c39382ceff
      coordinates: [-122.048589,37.414869]
  LineString:
    required:
    - coordinates
    allOf:
    - $ref: "#/definitions/Geometry"
    - type: object
      properties:
        coordinates:
          type: array
          items:
            type: array
            items:
              type: number
              format: double
    example:
      type: LineString
      coordinates: [
        # http://bl.ocks.org/d/655a22e1d3c1a85f4304a2133409d76d
        # 1st point NASA Ames Research Center
        # 2nd point 1mi bearing 45˚
        # 3rd point 1mi bearing 90˚
        [-122.06382530000002,37.4090697],
        [-122.05094253233,37.4193006277],
        [-122.03276206976,37.41929920176]
      ]
  Polygon:
    required:
    - coordinates
    allOf:
```

```
    - $ref: "#/definitions/Geometry"
    - type: object
      properties:
        coordinates:
          type: array
          items:
            type: array
            items:
              type: array
              items:
                type: number
                format: double
    example:
      type: Polygon
      coordinates: [
        # http://bl.ocks.org/d/7e0bffe48ff38444b29bbb2e7ec10032
        # outer ring
        # this is a triangle starting at NASA Ames Research Center
        # 2nd point 1mi bearing 45˚
        # 3rd point 1mi bearing 90˚
        # 4th point is same as 1st to close the polygon
        [
          [-122.06382530000002,37.40906970000],
          [-122.05094253233000,37.41930062770],
          [-122.03276206976000,37.41929920176],
          [-122.06382530000002,37.40906970000]
        ],
        # inner ring
        # 1st point is .1mi bearing 65˚ from 1st of outer ring
        # 2nd point .8mi bearing 45˚
        # 3rd point .8mi bearing 90˚
        # 4th point is same as 1st to close the polygon
        [
          [-122.062176579,37.40968041145],
          [-122.05187056889,37.41786527236],
          [-122.03732647634,37.41786440108],
          [-122.062176579,37.40968041145],
        ]
      ]
  Message:
    type: object
    discriminator: category
    required:
    - gufi
    - category
    properties:
      message_id:
        description: A UUID assigned to this message by the FIMS
        type: string
```

```
        format: uuid
      origin:
        type: string
        enum:
        - FIMS
        - CLIENT
        - MANAGER
        description: The user or process that generated this message
      user:
        description: "Populated by the UTM System.  The target user for a message
from the UTM System."
        type: string
      gufi:
        description: "The assigned GUFI for the operation referenced by the
message."
        type: string
        format: uuid
      category:
        type: string
        enum:
        - AlertMessage
        - IntentMessage
        - InformMessage
        - ConstraintMessage
      free_text:
        description: Any remarks or messaging that does not fit any other fields
        type: string
      sent_time:
        description: "Either the time the message was sent by the UTM System or
the time it was received by the UTM System."
        type: string
        format: date-time
      ack_time:
        description: A timestamp stored in the DB upon acknowledgment from the
message receiver
        type: string
        format: date-time
    example:
      gufi: "00000000-0000-4444-8888-000000000000"
      category: "IntentMessage"
      origin: "CLIENT"
      free_text: "An intent message from a client (for example)"
      sent_time: "2016-10-04T09:15:42.727Z"
      intent_message: "CLOSE"
  AlertMessage:
    required:
    - alert_message
    - alert_severity
    - alert_text
```

```
    allOf:
    - $ref: "#/definitions/Message"
    - type: object
      properties:
        alert_message:
          type: string
          enum:
          - WEATHER
          - SECURITY
          - OPERATIONS
          - SYSTEM
          - GENERAL
        alert_severity:
          type: string
          enum:
          - INFORMATIONAL
          - NOTICE
          - WARNING
          - CRITICAL
          - EMERGENCY
        alert_text:
          type: string
          enum:
          - UNPLANNED_LANDING
          - UNCONTROLLED_LANDING
          - FLY_AWAY
          - HIJACK
          - CONSTRAINT_CHANGE
          - UNPLANNED_DEVIATION
          - ROGUE
          - OTHER_SEE_FREE_TEXT
          - POSITION_REPORT_REQUEST_SINGLE
          - POSITION_REPORT_REQUEST_CONTINUOUS
          - POSITION_REPORT_REQUEST_CANCEL
          - OFF_COURSE
          - BACK_TO_CONFORMANCE
        warnings:
          type: array
          items:
            $ref: "#/definitions/Warning"
    example:
      gufi: "00000000-0000-4444-8888-000000000000"
      category: "AlertMessage"
      origin: "FIMS"
      sent_time: "2016-10-04T09:15:42.727Z"
      alert_message: "OPERATIONS"
      alert_severity: "WARNING"
      alert_text: "ROGUE"
      free_text: "
```

```
        reason=RogueNearby,
        reasonDetail=nearby operation 86250f05-d89c-40cf-b932-aa8d10a426a2 in
state U is lateral distance 711.45 feet and vertical danger zone envelope 600
feet;
        This alert message valid for the next 30 seconds (far lateral/far
altitude),
        vehicleType=FixedWing
        vehicleModelName=Silent Falcon,
        longLat=-119.87933795058 39.69702548394,
        alt_gps_wgs84_ft=5187.3645438621,
        track_ground_speed_kn=0.77703200548507,
        track_magnetic_north_deg=null"
  IntentMessage:
    required:
    - intent_message
    allOf:
    - $ref: "#/definitions/Message"
    - type: object
      properties:
        intent_message:
          type: string
          enum:
          - ACK_NO_OPERATION
          - CANCEL
          - CLOSE
    example:
      gufi: "00000000-0000-4444-8888-000000000000"
      category: "IntentMessage"
      origin: "CLIENT"
      sent_time: "2016-10-04T09:15:42.727Z"
      intent_message: "CANCEL"
  InformMessage:
    allOf:
    - $ref: "#/definitions/Message"
    - type: object
      properties:
        inform_message:
          type: string
          enum:
          - PLAN_SUBMITTED_TOO_EARLY
          - ACCEPTED
          - AUTHORIZED
          - DENIED
          - NOTIFICATION_NOT_REQUIRED
          - AUTHORIZATION_NOT_REQUIRED
          - TERMINATED
        violations:
          description: "Included with messages from the INFORM category with
inform_message = DENIED."
```

```
          type: array
          items:
            $ref: "#/definitions/Violation"
        warnings:
          type: array
          items:
            $ref: "#/definitions/Warning"
    example:
      gufi: "00000000-0000-4444-8888-000000000000"
      category: "InformMessage"
      origin: "FIMS"
      free_text: "Plan DENIED. See violations field of this message for
constraining violation(s) and the violating volume(s)."
      sent_time: "2016-10-04T09:15:42.727Z"
      inform_message: "DENIED"
      violations: '[

{"type":"Operations","violating_volume":1,"constraining_volume":1,"constraining_i
d":"90710543-6b18-44c9-a1a6-a3ecd60d14"}
        ]'
  ConstraintMessage:
    allOf:
    - $ref: "#/definitions/Message"
    - type: object
      properties:
        constraint_geography:
          # description: "A description of the geography of the constraint."
          $ref: "#/definitions/Geometry"
        begin_time:
          description: "The time that the constraint begins. Null or no value
implies infinity begin time."
          type: string
          format: date-time
        end_time:
          description: "The time that the constraint ends. Null or no value
implies infinity end time."
          type: string
          format: date-time
    example:
      gufi: "*"
      category: "ConstraintMessage"
      origin: "FIMS"
      free_text: "Constraint added."
      sent_time: "2016-11-29T01:16:41.727Z"
      constraint_geography:
        type: Polygon
        coordinates: [
          [
            [-122.062176579,37.40968041145],
```

```
            [-122.05187056889,37.41786527236],
            [-122.03732647634,37.41786440108],
            [-122.062176579,37.40968041145],
          ]
        ]
      begin_time: "2016-11-29T01:16:41.727Z"
      end_time: "2016-11-30T01:16:41.727Z"
  Violation:
    type: object
    properties:
      type:
        type: string
      constraining_id:
        type: string
        format: uuid
      constraining_volume:
        type: integer
      violating_volume:
        type: integer
  Warning:
    type: object
    properties:
      warning_id:
        type: string
#externalDocs:
#  description: >
#      ### _Find out more about Swagger_
#  url: "http://swagger.io"
x-azure-api-id: "sh-1469571953760"
```