Federal Aviation Administration

National Aeronautics and Space Administration

Cover Letter

UTM RTT CWG Concept & Use Cases Package #2 Addendum

The Concept and Use Cases Package #2 Addendum: Technical Capability Level (TCL) 3 document represents the collaborative research efforts between the FAA and NASA as joint members of the Unmanned Traffic Management (UTM) Research Transition Team (RTT). Contained in this document are three (3) additional Use Cases focusing on interactions between stakeholders within operating environments considered to be encompassed by Technical Capability Level 3 UTM. Each Use Case contains 1) Overviews of the Use Case, 2) Narratives exploring new or expanded concept elements, 3) Operational Views (OVs), and 4) Roles and Responsibilities of the actors. The contents of this Package #2 Addendum should NOT be considered established policy or construed as regulatory in nature. What is presented is meant to communicate the current, agreed upon understanding between the FAA and NASA on particular features of UTM as exemplified through use cases and concept narratives for the purposes of supporting joint NASA/Industry Demonstrations and the UTM Pilot Program. It is also meant to foster discussion and refinement of the concepts and approaches being pursued by the other RTT working groups.

July 2018

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Federal Aviation
Administration

National Aeronautics and
Space Administration

Unmanned Aircraft System Traffic Management (UTM)

Research Transition Team (RTT)

Concept Working Group

Concept & Use Cases Package #2 Addendum: Technical Capability Level 3

Version 1.0

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1 Use Case: TCL3-5 – High Density UTM Operations in Uncontrolled Airspace

1.1 Assumptions Regarding USS Operating Rules Established by Industry

This Use Case assumes that industry has established a set of operating protocols that they conform to when provisioning services in certain environments. These protocols relate to each Unmanned Aircraft System (UAS) Service Supplier (USS) cooperating with the others to some degree with regard to management of each of their own subscriber base, i.e., Small Unmanned Aircraft System (sUAS) Operators using their services. The tactics detailed in this use case should not be assumed to be the recommended methods for a cooperative management approach. Rather, they are provided to help foster discussion among RTT industry partners on how such environments could be safely managed.

1.2 Overview

The first four TCL 3 Use Cases examined situations involving low density sUAS operations interacting through use of UTM capabilities. This TCL3-5 Use Case examines complexities in UTM during higher density operations in uncontrolled airspace, including potential increased demand on the USSs and the USS Network generated by higher-density operations.

To illustrate high-density complexities, an operational area is envisioned consisting of two distinct and adjacent well-attended events, multiple sUAS Operators, multiple USSs, disparate sUAS operation interests including imagery/videography of the events, operations consisting of a combination of Transit-Based Operation Volumes (TBOVs)[1] and Area-Based Operation Volumes (ABOVs), and maturation of the combination of the multiple sUAS operations in the environment over time. These characteristics are examined in this Use Case in the main narrative: Maturation of Operational State Over Multiple Events Area. Following the main narrative, the impact on Operator and USS planning and operation execution are explored in more detail in §1.3.2: A Closer Look at the Organization of TBOVs as High-Density UTM Environment Matures.

The Use Case operational area is as follows.

A local golf course is having a tournament south of Lodi, CA. Several wineries near the golf course are holding 5k-10k-half-marathon charity races on the same day as the golf tournament. The two events attract large numbers of participants and sUAS observers, including imagery professionals and enthusiasts. Multiple commercial and private/non-commercial sUAS Operators from the nearby community are involved and determine to conduct Beyond Visual Line of Sight (BVLOS) operations to the two events to support broadcasting and spectating interests. The significant number of sUAS operations occurring en route to the two events and over the combined event area create a high-density UTM environment. The various sUAS Operators individually subscribe to one of several USSs providing services in the area and use multiple TBOVs to transit from their take-off location to the area of interest as shown in Figure 1-1. Above the event areas, sUAS Operators generate ABOV segments allowing

[1] Previous Concepts Working Group (CWG) Packages noted TBOVs as “Trajectory-Based Operation Volumes”. The term has been updated to “Transit-Based Operation Volumes.”

dynamic flight within the ABOV to capture the desired video and photographs. While not examined in detail here, it is conceivable as well that one or more Visual Line of Sight (VLOS) sUAS operations by a nearby curious homeowner or associate of a race participant may occur in the same event areas.

As planning progresses Operator TBOVs are separated from one another through cooperative separation planning protocols utilized by the USSs. The ABOVs in the event area overlap leading to multiple Unmanned Aircraft (UA) in a shared airspace where they are no longer strategically separated. The high-density UTM operations in the event areas may result in cooperative separation planning actions by Operators/Remote Pilots in Command (RPICs) and USSs toward refined TBOV/ABOV and strategic/tactical structures. They may be smaller, strategically separated TBOVs combined with overlapping ABOVs where tactical protocols are crucial to meet separation needs. Regardless of the final state of UTM planning for the event areas, it remains the responsibility of each sUAS Operator to use available systems, capabilities or methodologies to maintain safe distances from other aircraft and structures in the shared airspace, and to conduct safe landings.

1.2.1 Summary Table

Table 1-1 - Summary - Use Case TCL3-5

Operation	Operational Description	Environmental Description
Operations of More Sophisticated sUAS, e.g., for Professional Videography; Qty: Numerous	- More capable sUAS with longer duration and/or successive operations for desired coverage; better SAA and safe landing capability - BVLOS or VLOS - Shared airspace - Operation Intent made available - Position reporting	- Class G only, no airport near - Operation over people - Operation over property
Operations of Less Sophisticated sUAS, e.g., for Private/Non-Commercial Videography/ Photography; Qty: Numerous	- Less capable sUAS with shorter duration; lesser SAA and safe landing capability - BVLOS or VLOS - Shared airspace - Operation Intent made available - Position reporting	- Class G only, no airport near - Operation over people - Operation over property

TABLE NOTES:

1. This Use Case does not examine the details of the process of an individual Operator creating Operation Intent. Previous Use Cases have examined this process and may be referred to as needed.
2. In these scenarios, the majority of the planning of operation volumes is assumed to be done by USSs in an automated fashion, using Operation Intent of any operations already shared with the USS Network to efficiently manage the airspace. Some Operators, particularly when not many other operations have been filed, may plan operations that are not conducive to this goal of efficient management. However, as the airspace becomes more operationally-dense with UTM participants, it is expected that Operators who do not need certain airspaces (particularly through unnecessary use of large ABOVs) will adjust through recommendations by their USS.

3. In this Use Case, it is assumed that Operators and USSs generally avoid overlap of TBOVs, in order to reduce the possibility of collision of UA in a volume that limits maneuverability. ABOVs overlap per operational need, although tactical separation from other UA in the shared airspace necessitates more capability and/or coordination between actors.
4. Any airspace cooperative separation management tactics or protocols by USSs or individual Operators depicted or implied in this Use Case are examples only and should not be construed by the reader to be the expected or required methods employed by actors in actual UTM environments.
5. Performance Authorization approval was obtained by these Operators/USSs from the FAA prior to the events of the narrative below. These processes are not discussed in this Use Case. All sUAS BVLOS flight for each Operator occurs within an Authorized Area of Operations.

1.2.2 Equipment

Equipment being utilized for the Operations of More Sophisticated sUAS may be a variety of commercially available sUAS with upgraded sense and avoid capability, V2V capability, upgraded safe landing capability, conspicuity equipment, avionics, sensors, and endurance. They are a selection of fixed-wing small UA and multi-rotors able to carry professional camera equipment. They have both real-time stick control and waypoint-to-waypoint operation capabilities. Flight status and sensor data is transmitted in near-real time by assured commercial data link transmission. These sUAS are under control of RPICs and have capability to act in accordance with pre-programmed contingency procedures in the event of equipment issues. Standard procedures are programmed and can also be modified (or new procedures added) by the RPIC pre-flight and in-flight.

Equipment being utilized for Operations of Less Sophisticated sUAS may likewise be a variety of commercially available sUAS with disparate levels of sense and avoid capability, V2V capability, conspicuity equipment, avionics, sensors, and moderate endurance. They are lightweight UA able to carry lightweight amateur camera equipment. These sUAS are assumed to be under manual control of RPICs in real-time for the duration of each of their operations (they may have limited way-point to way-point capabilities).

1.2.3 Actor Details

1.2.3.1 Operators and RPICs

The roles of RPIC and Operators may be held by separate entities, or both roles may be fulfilled by the same person.

Commercial enterprises conducting UTM operations in an area may have an employee in their local office fulfilling the Operator role while individual licensed RPICs, whether employees or third party, conduct flight operations.

For private/non-commercial videography and photography operations, the roles of the RPIC and Operators are assumed to more often held by the same person.

1.2.3.2 USSs

Commercial and private/non-commercial sUAS Operators use a mix of different USSs that are actively providing services in the area. The active USSs for the area form a Local USS Network (LUN), wherein relevant Operation Intent and other information pertinent to local UTM stakeholders is only exchanged with the LUN, as opposed to the larger USS Network across the nation (or possibly across nations). USSs that operate at a national level may operate local instances of its USS services specific to the region and would connect that local instance of itself to the LUN.

Depending on needs of subscribing Operators, USSs may provide varying levels of services/capabilities. Those with higher capability may more often be supporting commercial operations that have the need, while USSs meeting the minimum set of service capabilities required for the area are used by persons flying for private/non-commercial purposes.

The USSs may coordinate high-density planning adjustments per agreed upon, industry cooperative separation protocols and operating rules to optimize the UTM operation services, efficiently and safely use the airspace over the events, and assist Operators in planning for safety above all.

1.2.3.3 SDSP

Supplementary Data Service Providers (SDSPs) provide data relating to weather, relevant ground-based obstacles, relevant information regarding areas where safe landing may be conducted, relevant airspace constraint information not already provided by Flight Information Management System (FIMS), etc.

1.2.3.4 FAA

In this Use Case, the focus of exploration is on complexities associated with interactions between sUAS, RPICs, Operators, and USSs rather than on alerts to the FAA, specific potential interactions with FIMS, or what may or may not be of potential interest to the FAA in situations similar to the scenarios herein.

The FAA has the ability to access any stored or archived information related to the operations as required.

1.2.4 UTM Interaction

1.2.4.1 UTM Participation

All BVLOS Operators are required to participate in UTM, while VLOS Operators flying in accordance with either Part 101(e) or Part 107 may voluntarily opt to participate in UTM (e.g., sharing operation intent, receiving relevant alerts from their USSs, etc.).

1.2.4.2 Shared Information Across Actors

Table 1-2 – Shared Information - Use Case TCL3-5

Type of Information	Actor Providing Information	Actors with Access to Information	Examined in this Use Case?
Operation Plan Parameters/Inputs	Operator	USS	Yes
Operation Plan[1]	USS	Operator	Yes
Operation Intent, pre-flight (and other shared data)	USS	USS Network	Yes

Type of Information	Actor Providing Information	Actors with Access to Information	Examined in this Use Case?
Operation Data Relevant to UTM Coordination	USS	USS Network	Yes
Operation Data Relevant to Regulator Information Requirements	USS	FAA	No
Intent Modification Parameters/Inputs	Operator/RPIC	USS	No
Modification to Intent (pre-flight or in-flight)	USS	USS Network	No
Externally-originated data (surveillance, NOTAM, Wx, etc.)	USS or SDSP	USS/Operator/RPIC	Yes
Operationally-Derived Environmental Data	RPIC or SDSP	USS	Yes
Relevant sUAS/Flight Data	sUAS	sUAS	Yes
	sUAS	RPIC/Operator	Yes
	RPIC/Operator	USS	Yes
	USS	USS Network	Yes
Operation Status Updates (subset of Operation Intent)	USS	USS Network	Yes
Spectrum Management	USS	USS Network, RPIC and Operator	No
Dynamic Restriction Request[2]	NAS Stakeholders	USS	No
Dynamic Restriction Approval[2]	USS	Operator/USS	No
Dynamic Restriction Distribution[2]	USS	USS Network and FAA	No
	FAA	Public Portal and other NAS Stakeholders	No
Negotiation Request	USS	USS	Yes
Negotiation Response	USS	USS	Yes
UAS Report (UREP)	RPIC/Operator	USS	No
	USS	UREP Service[3]	No
Manned Aircraft Flight Information	Manned Aircraft	sUAS	No
Manned Aircraft Information	USS/SDSP	Operator/RPIC	No
Operation Hand-Off	USS	USS	No

TABLE NOTES:

1. Operation Plans include information that is shared with the USS Network (e.g. Operation Intent), as well as information that may not be shared with other USSs/Operators (e.g. private/proprietary Operator data used during planning). Once planning is complete, the subset of shared information that includes Operation Intent is made available to the USS Network.
2. A recent conceptual update for Dynamic Restrictions shifts the approval and distribution processes from the FAA to authorized USSs. Use Cases 3-5 through 3-7 do not explore this new concept, but the tables have been updated to reflect the change.
3. The USS Network has access to the UREP Service. Once an individual USS writes a UREP to the UREP Service, the information is then available to other USSs.

1.3 Narrative

NOTE: It is understood for this Use Case many of the functions, communications and decision-making occurring in the narrative below may be automated by the USSs and FAA. Explicit callout to automation is minimized to allow focus on the information exchange and flow of operations.

1.3.1 Maturation of UTM Operational State over Multiple Events Area

1.3.1.1 Early State of UTM Operations Around the Event Area

Some sUAS Operators, particularly those involved in supporting professional videography, begin planning flights several days before either event begins or early on the same day as the events. Operators planning well in advance of the beginning of the events initially see few other nearby UTM operations for which intent has been shared during the times of their intended flights. Early-planning Operators may opt to use a combination of ABOVs and TBOVs to fly to, over the areas of, and return from the events or they may opt to utilize a single large ABOV to complete their objectives. As Operation Intent is shared by each Operator with the USS Network through the USS to which they are subscribed, the USSs in the Local USS Network (LUN) become aware of each new planned flight and make the associated intent information available to other USSs and Operators. Depending on circumstance, a USS may recommend changes to a subscribing Operator's intent if they identify a more efficient method of completing their operation or if cooperative separation protocols require such changes. An early state of the UTM environment near the event areas is depicted in Figure 1-1 showing few operations that are planned or active.

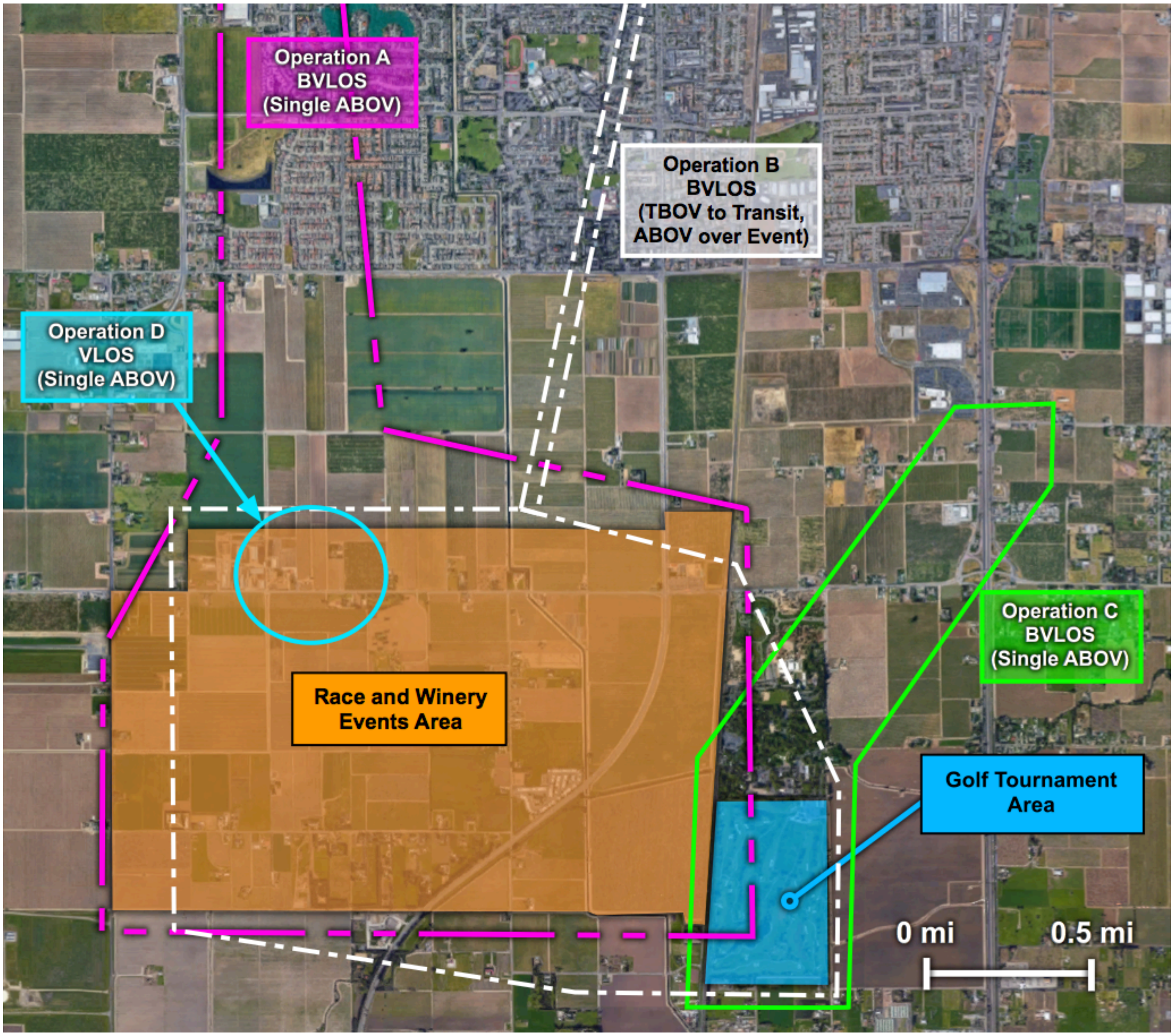


Figure 1-1 – Early State of UTM Operations

As the density of planned or active operations begins to increase in the morning, USSs detect that there is an area of interest with many ABOVs overlapping. With the safety of people and property on the ground below the area paramount, the USSs execute cooperative separation protocols to provide recommendations for their subscribers' Operation Intents in order to organize the airspace and maintain safety. In an operation area such as this Use Case, USSs may provide recommendations for newcomer Operators flying from more distant take-off locations that include the use of TBOVs to transit to/from the event areas (§1.3.2 looks at these transit areas in more detail). Over the event area, most Operators may opt to use an ABOV to allow freedom of movement that is typically desired when taking photos and videos of a live event spread over a large area.

As more TBOVs are created by new Operators for transit to/from the event area, Operators who have previously filed intent with one large ABOV may begin to get notices from their respective USSs indicating that their ABOV is overlapped by one or more TBOVs and that changes are needed according to established cooperative separation protocols. However, this use case does not assume that any special requirements are imposed on UA within an ABOV relating to separation from UA operating in TBOVs. Both sUAS Operators are equally responsible for maintaining separation from one another. A previous note in §1.2.1 indicates that Operators/USSs generally avoid overlap of TBOVs with other TBOVs, whereas TBOVs may more often overlap ABOVs. As more TBOVs overlap an Operator's ABOV, such an Operator may find themselves having to keep track of more and more UA that may be sharing airspace with them, while those in the TBOVs have separated themselves from each other and need only worry about the one UA in the ABOV. While in some areas overlap may be unavoidable, ABOV Operators in the transit areas may opt to adjust to minimize overlap. The Operator may decide to adjust their operation to minimize this issue, conforming to what other newcomer operation intents indicate (TBOVs to transit, ABOV over area of interest).

1.3.1.2 Mature State of UTM Operations around the Event Area

The UTM operational state can change over time either before events begin, throughout the day of the events, or as individual operations close out and new ones occur due to UA flight durations being shorter than the day-long events. As the density of operations grows, strategic deconfliction (e.g., spatial and/or temporal separation of Operation Volumes) according to established cooperative separation protocols may become a prevalent strategy by Operators and USSs when possible. Coupled with USS goals to manage operations safely and efficiently, the state of operations may eventually reach a more organized configuration illustrated in one possible configuration in Figure 1-2.

In this scenario, the operational configuration of the airspace over Lodi eventually reaches a point of maturity wherein operations originating near or within the event area have overlapping ABOVs which form a shared airspace. Those originating from further away may utilize multi-segmented, scheduled volumes to temporally separate UA in TBOVs to transit to and from the overlapping ABOVs over the event area. TBOVs for each operation may be further segmented to allow efficient scheduling of the airspace, facilitating a procession of UA (at any given moment each UA is within its own separated volume) to make their way into the event area. Section §1.3.2 explores this in further detail.

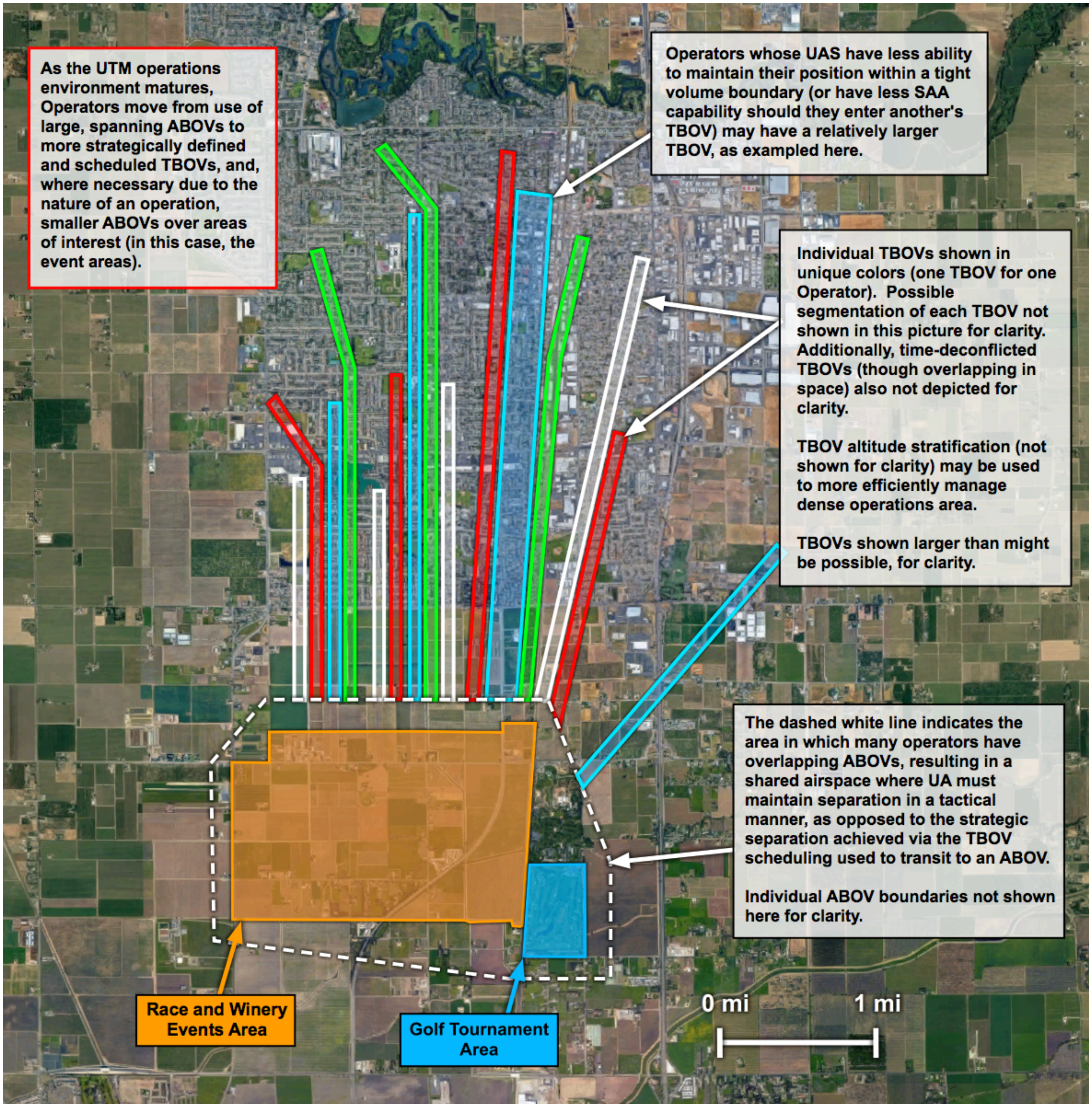


Figure 1-2 – Mature State of UTM Operations

1.3.1.3 Shared Airspace due to Overlapping ABOVs

The use of TBOVs, wherein USSs and Operators avoid 4D overlap by creating and maintaining separation of smaller volumes between disparate operations, imparts an operational benefit to Operators and their sUAS platforms.

Separation between UA is primarily maintained through strategic planning rather than tactical detection or coordination.

The strategic benefit detailed above is severely diminished when UA transition into their individual ABOVs (as shown in the previous figure), since many of the ABOVs overlap due to individual operation needs and are focused on the race and golf event areas. The primary strategic benefit for Operators here is that, due to their shared Operation Intent, they and their USSs are aware of the other UA with which they may be sharing airspace. At this point, separation becomes a tactical endeavor. sUAS Operators are responsible to maintain separation in this shared airspace.

Various methods may be employed by Operators, which may include:

- Highly-capable sense and avoid capabilities, in which the UA autonomously maneuvers to avoid other aircraft it detects around it.
- Cooperative communication capabilities coupled with automated vehicle response.
    - Near-field V2V communications coupled with some standard set of right-of-way rules would allow UA to operate in relatively close proximity to each other.
- Sharing active UA position with the USS Network and indicating little-to-no SAA or cooperative coordination capabilities.
    - Operators of other sUAS with lesser SAA capability would receive this information from their USS which may establish a wider separation margin for these UA.
    - UA with adequate sense and avoid systems could fly closer to these UA and may opt to receive the shared position information from their USS.
- Creation of a smaller ABOV and indicating little-to-no SAA or cooperative coordination capabilities; prior to operation and/or dynamically in-flight during operation as needed.
    - Other Operators with an inability to sense and avoid UA in these smaller ABOVs might change their intent to strategically separate from these volumes in coordination with their USS which participate in cooperative separation protocols.
    - Operators with adequate sense and avoid systems would fly into these smaller volumes without concern and would not change their ABOV to avoid overlap.

1.3.1.4 High Density UTM Environment Notice for NAS Stakeholders

Eventually, the number of planned/active UTM operations over the event area may result in a threshold of operational density or other factors that may be of interest to other National Airspace System (NAS) stakeholders, such as manned aircraft that operate at lower altitudes (e.g., crop-dusters, helicopters). USSs may make notices available to these stakeholders when these, or other events of interest, occur within UTM.

With Operation Intent being shared with the USS Network, individual USSs can determine the total number of operations that may be occurring at a given time in a given area. Such USSs are aware of the Operation Intent of their subscriber base, as well as that of Operators subscribed to other USSs. At some point during the day of the events, when many Operators have filed their intent with the USS Network, a USS detects that the total number of operations has crossed the density threshold for the area. This USS creates a High Density UTM Environment Notice and makes it available to the USS Network and other UTM stakeholders (such as SDSPs). The information in the notice might include some geographic definition of the area of high density, the current maximum number of operations planned or active, and the times during which the high-density state is applicable, etc.

Other USSs, SDSPs, and stakeholders that have access to UTM information are aware of the state. These additional actors may also make this notice available to other UTM participants and/or stakeholders that use their services.

1.3.1.5 Event Wind-Down and Reduction of Operations Density

As the race and golf events hit their peaks and begin to wind down for the day, fewer sUAS Operators have interest in spectating from the air. The number of new Operation Intent submissions steadily decreases, and the UTM operational density for the area returns to a lower state. Operation volumes for future flights resume a less organized state (such as that shown in Figure 1-1 and Figure 1-3).

1.3.2 A Closer Look at the Organization of TBOVs as High-Density UTM Operational State Matures

NOTE: This section provides a closer look at the TBOVs utilized for routes to and from the event area as detailed in the main narrative (§1.3.1).

1.3.2.1 Size of TBOVs as a Function of sUAS Capability

To be considered a TBOV, a volume may be limited to a maximum cross-sectional area. A maximum size for TBOV cross-sections implies a minimum set of capabilities for an Operator and their sUAS system implementation in order to utilize TBOVs for an operation. Taking this implication further, sUAS Operators with more capable unmanned systems may be able to operate within smaller TBOVs than those with less capable systems. Various considerations may affect the sizes of these volumes including, but not limited to, the following.

- Ability of UA to maintain nominal flight path in normal operational and environmental conditions.
- Ability to maintain nominal flight path in increasingly challenging weather conditions, such as higher winds/gusts.
- Ability of the system to react to another UA crossing into the Operator's TBOV (less capable would require a larger buffer).
- Ability of the UA to communicate with other UA in the event it, or other UA, become non-conforming to their Operation Intent.
- Ability of the UA to automatically sense and avoid other UA in the event it, or other UA, become non-conforming to their own Operation Intent.
- Ability to maintain ground speed as planned in increasingly challenging weather conditions such as high winds/gusts.

Less capable sUAS would require a larger margin, resulting in larger cross-sections for the volume (see Figure 1-3).

UA with more advanced communication and coordination capabilities might be able to operate within smaller TBOVs, especially if similarly-capable sUAS Operators were to stack their volumes close to one another. Any deviation of one UA from its volume in such a cluster would result in coordination between it and the UA whose volume boundary it violates.

sUAS with higher capability sense and avoid technologies may be candidates to use the smaller TBOV volumes. Any UA of such capability that deviates from its volume, e.g., due to a gust, would be able to sense any nearby UA to act to avoid it while attempting to re-enter its own volume. It might also be possible for such highly capable UA to occupy the same TBOV as they would be able to maintain tactical separation from each other in this shared airspace.

It is noted that BVLOS sUAS Operators are required to share their position data with the USS to which they are subscribed. Any non-conformance would quickly be detected by the USS. The USS would change the Operation Status to "Non-Conforming" or “Rogue”, depending on the circumstances of the situation, and share the new status, as well as any relevant position information as needed, with the USS Network. Other USSs would alert nearby subscribers of the non-conformance. Operators with less-capable sUAS would be more reliant on information shared via the USS Network when non-conformances occur.

1.3.2.2 Early State of Operation Volume Organization

During the early state of UTM operations (before the day and/or early in the day of the events), Operators planning their flights find few other planned operations that have been shared with the USS Network in the area. There is little need for consideration of a TBOV in relation to other Operator volumes. USSs which provide more automated planning for their subscribers may not necessarily attempt to organize a TBOV in relation to others since the environment is not dense and airspace is widely available in the areas of interest.

Figure 1-3 shows a cross-section of TBOVs during an early state; Operators heading to or from the event area choose whatever altitude and lateral location that is available to suit their needs. There is no particular organization to the arrangement of these volumes at any given moment in the early state.

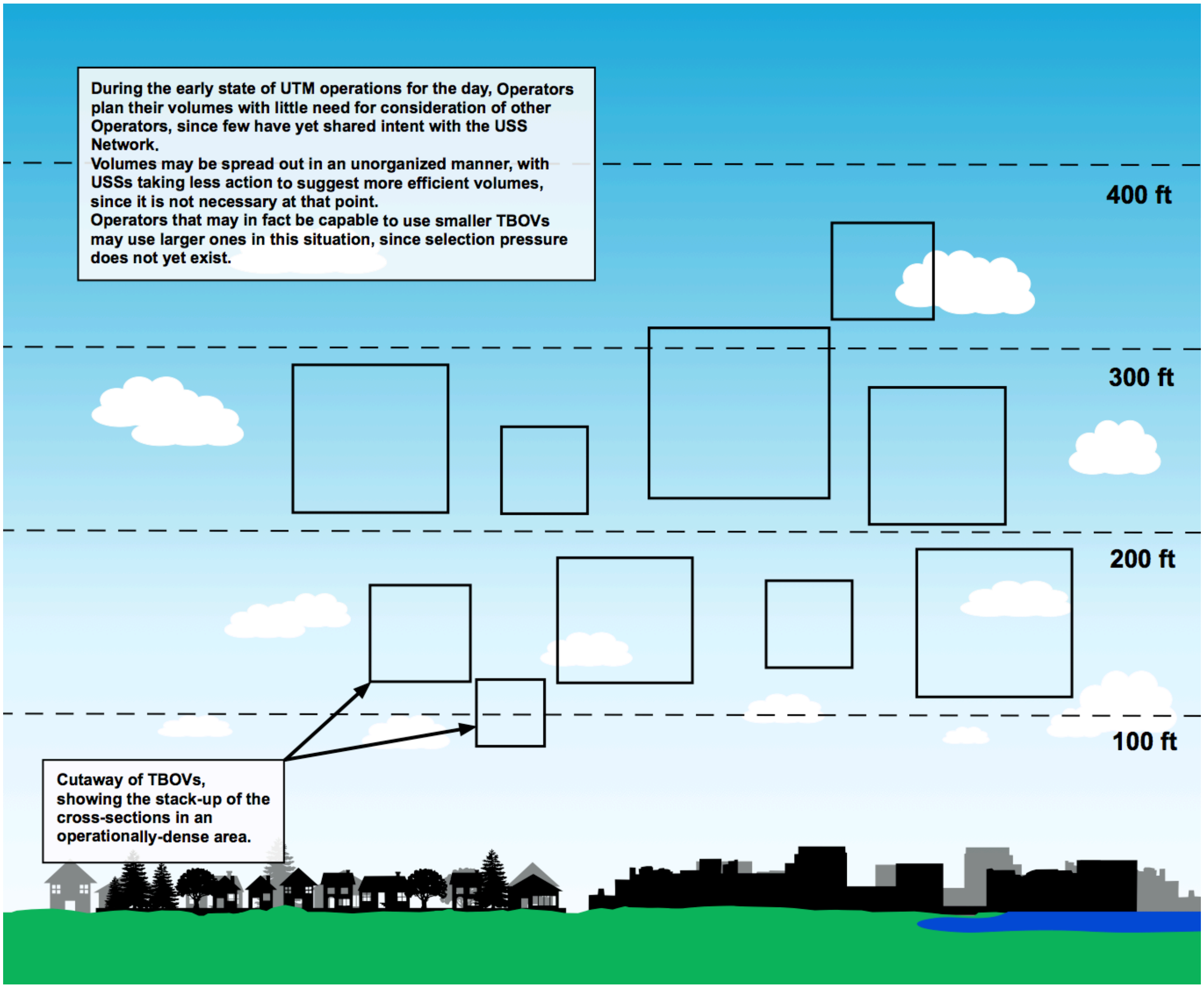


Figure 1-3 – Cross-Section of TBOVs in an Early Operational State for the Area

1.3.2.3 Organization of TBOVs Over Time due to Selection Pressures

As the density of operations increases for the day, so do the number of TBOVs used to transit to and from the event areas. As more and more Operators file intent, USSs may begin to organize traffic moving in the same general direction into groups. This would allow Operators flying in the same direction at a later time after a preceding UA has finished using a volume to use volumes with the same geographical boundaries. These clusters of single direction volumes may be analogous to a "highway." Such volumes could be segmented into smaller arrangements to allow more traffic via scheduling. Use Case TCL3-1 examines segmentation and scheduling in detail. Figure 1-5 shows this segmentation and scheduling approach and how more traffic may be efficiently funneled through repeating blocks of airspace. In this specific scenario, USSs have separated opposite-moving traffic through altitude stratification in which northward traffic lies between 100-200 ft above ground level (AGL) and southward traffic between 200-300 ft AGL.

Additionally, it is possible that less capable UA that require larger TBOVs may gradually be arranged to the outer edges of the grouped traffic. As earlier larger TBOVs become inactive, Operators with more capable sUAS create smaller TBOVs wherein more than one small TBOV may be able to fit within the previous large TBOV. During a busy time, few opportunities may exist in which a larger TBOV may be created in the place where smaller TBOVs have become inactive. Therefore, a dense environment may result in a configuration similar to that shown in Figure 1-4, where smaller TBOVs cluster and larger volumes prevail on the edges of these clusters.

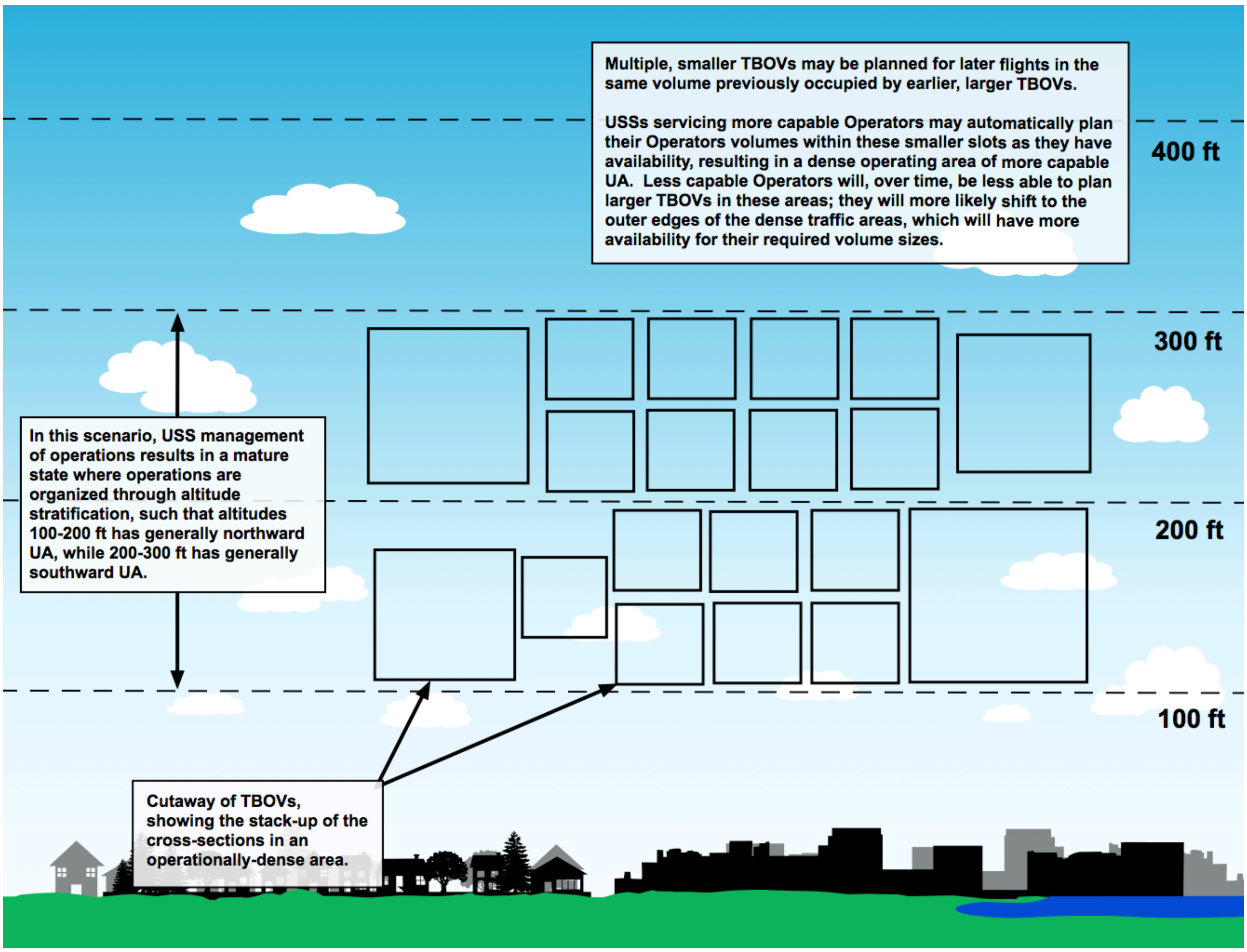


Figure 1-4 – Cross-Section of TBOVs in a Mature Operational State for the Area

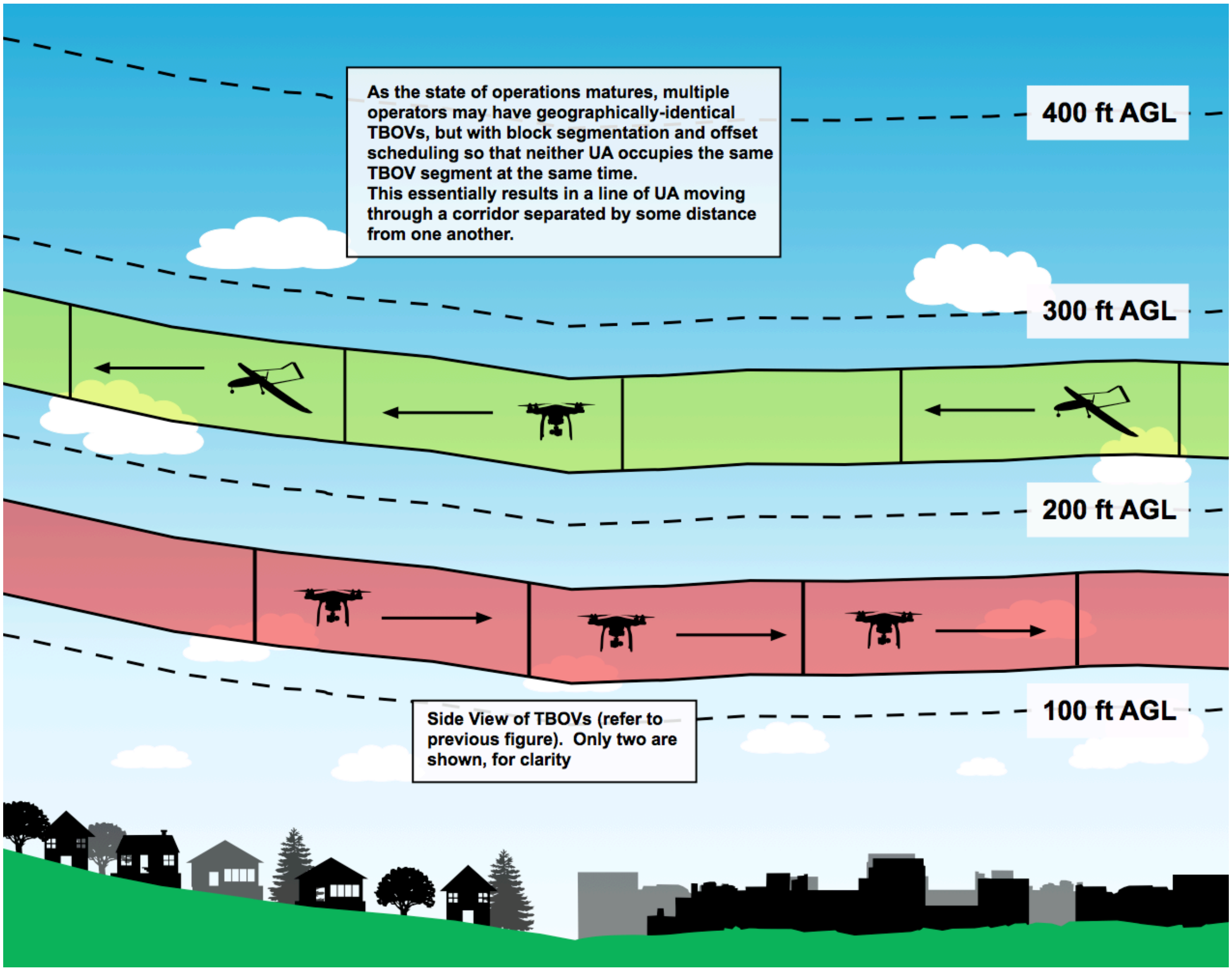
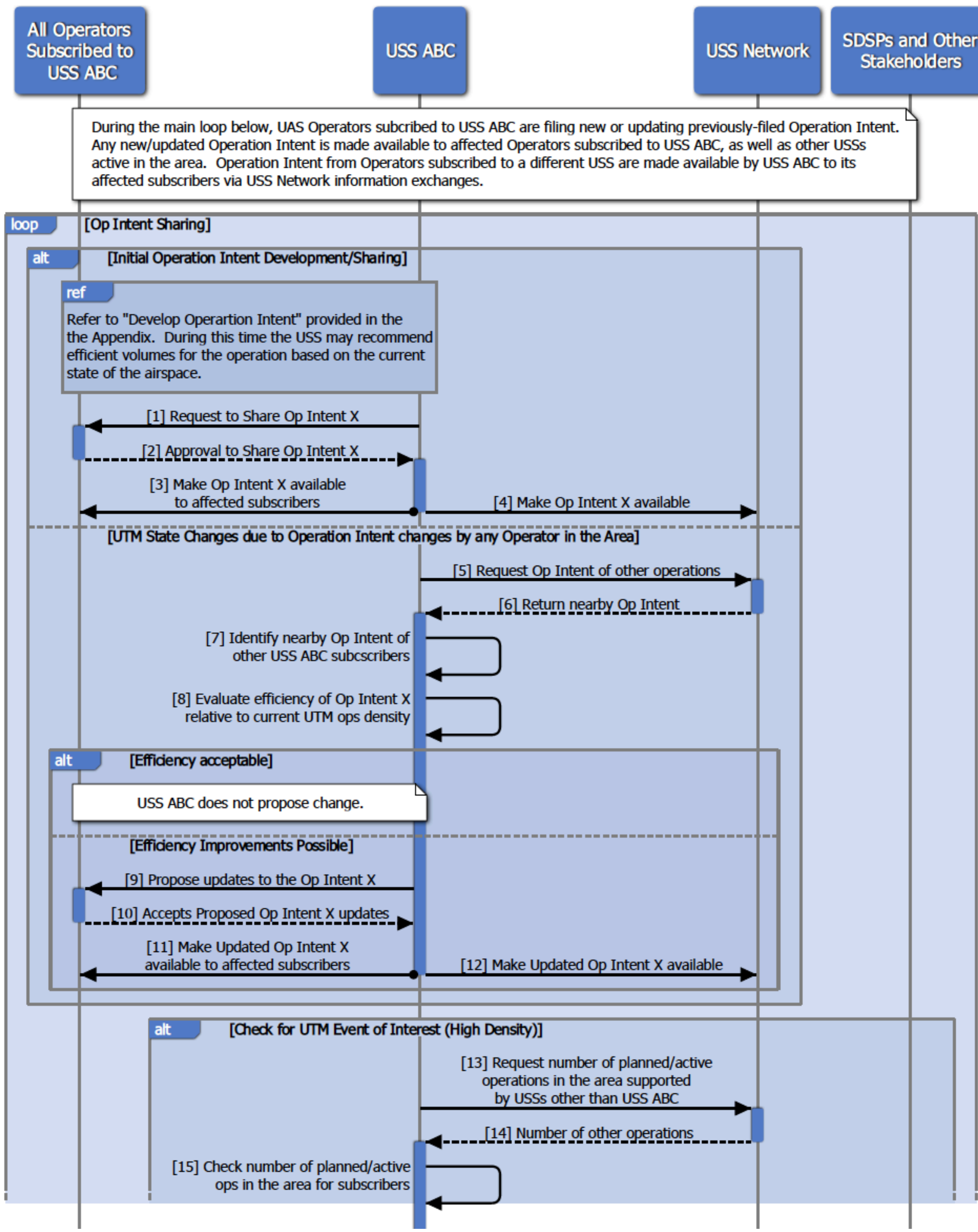


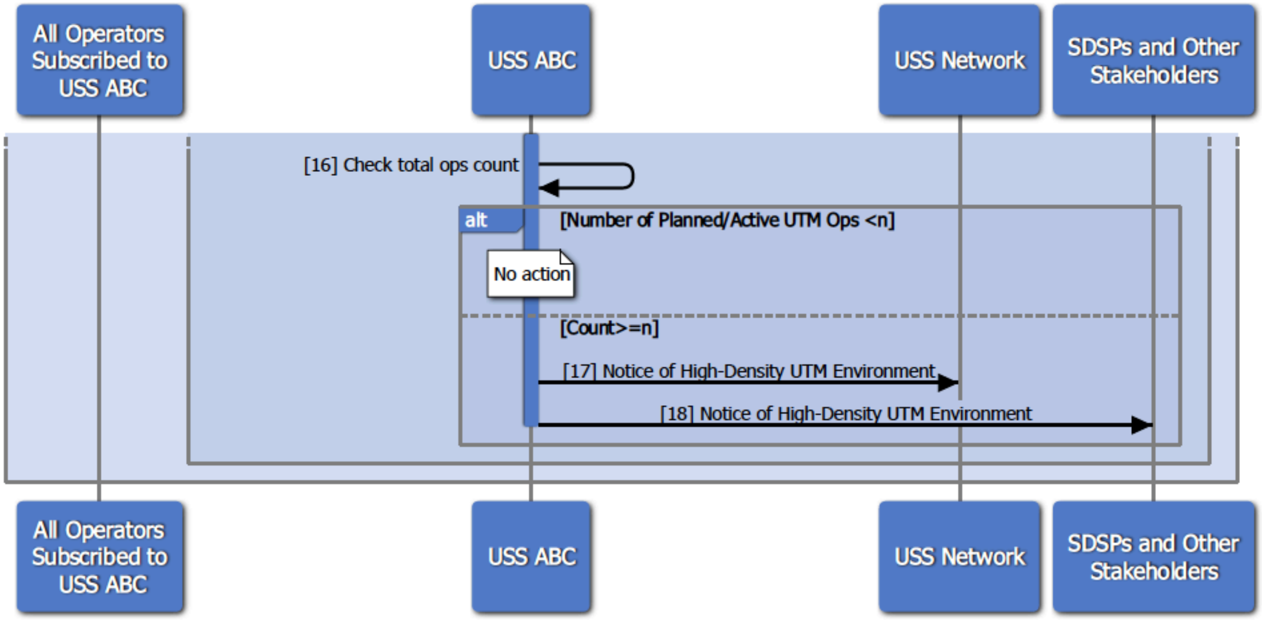
Figure 1-5 – Side Profile of TBOVs in Mature Operational State for the Area

1.4 Operational Views

The following pages provide operational views of the scenario narrative. Referenced diagrams for sub-activities can be found in the Appendix.

The OV below refers to a generic "USS ABC", showing how such a USS in the narrative above would operate through interaction with other USSs (via the USS Network) while managing its own subscribing set of Operators.


All Operators Subscribed to USS ABC
USS ABC
USS Network
SDSPs and Other Stakeholders
During the main loop below, UAS Operators subcribed to USS ABC are filing new or updating previously-filed Operation Intent. Any new/updated Operation Intent is made available to affected Operators subscribed to USS ABC, as well as other USSs active in the area. Operation Intent from Operators subscribed to a different USS are made available by USS ABC to its affected subscribers via USS Network information exchanges.
loop
[Op Intent Sharing]
alt
[Initial Operation Intent Development/Sharing]
ref
Refer to "Develop Operartion Intent" provided in the the Appendix. During this time the USS may recommend efficient volumes for the operation based on the current state of the airspace.
[1] Request to Share Op Intent X
[2] Approval to Share Op Intent X
[3] Make Op Intent X available to affected subscribers
[4] Make Op Intent X available
[UTM State Changes due to Operation Intent changes by any Operator in the Area]
[5] Request Op Intent of other operations
[6] Return nearby Op Intent
[7] Identify nearby Op Intent of other USS ABC subcscribers
[8] Evaluate efficiency of Op Intent X relative to current UTM ops density
alt
[Efficiency acceptable]
USS ABC does not propose change.
[Efficiency Improvements Possible]
[9] Propose updates to the Op Intent X
[10] Accepts Proposed Op Intent X updates
[11] Make Updated Op Intent X available to affected subscribers
[12] Make Updated Op Intent X available
alt
[Check for UTM Event of Interest (High Density)]
[13] Request number of planned/active operations in the area supported by USSs other than USS ABC
[14] Number of other operations
[15] Check number of planned/active ops in the area for subscribers


All Operators Subscribed to USS ABC
USS ABC
USS Network
SDSPs and Other Stakeholders
[16] Check total ops count
alt
[Number of Planned/Active UTM Ops <n]
No action
[Count>=n]
[17] Notice of High-Density UTM Environment
[18] Notice of High-Density UTM Environment
All Operators Subscribed to USS ABC
USS ABC
USS Network
SDSPs and Other Stakeholders

1.5 Roles and Responsibilities

Service/Function		Actors				Explanatory Notes
		X=direct responsibility | S=support role				
		RPIC	Operator	USS	FAA	
Separation	VLOS sUAS from VLOS sUAS	S	X	S		
	VLOS sUAS from BVLOS sUAS	S	X	S		
	BVLOS sUAS from BVLOS sUAS	S	X	S		
	VLOS sUAS from Low-Altitude Manned A/C					Not Explored in Use Case
	BVLOS sUAS from Low-Altitude Manned A/C					Not Explored in Use Case
Hazard/ Terrain Avoidance	Weather Avoidance					Not Explored in Use Case
	Terrain Avoidance					Not Explored in Use Case
	Obstacle Avoidance					Not Explored in Use Case
Status	UTM Operations Status			X		
	Flight Information Archive		X	S		Operator delegates to USS
	Flight Information Status	S	X	S		
Advisories	Weather Information					Not Explored in Use Case
	Hazard Information (Obstacles, terrain, etc.)					Not Explored in Use Case
	Alert Affected Airspace Users of sUAS Hazard			X		High Density UTM Environment Notification
	sUAS-Specific Hazard Information (Power-Lines, No-sUAS Zones, etc.)					Not Explored in Use Case

Table continued…

Service/Function		Actors				Explanatory Notes
		X=direct responsibility | S=support role				
		RPIC	Operator	USS	FAA	
Planning, Intent and Authorization	Priority Status Notification (emergency declaration, public safety, etc.)					Not Explored in Use Case
	Operation Plan Development					Not Explored in Use Case
	Operation Intent Sharing (pre-flight)					Not Explored in Use Case
	Operation Intent Sharing (in-flight)					Not Explored in Use Case
	Dynamic Restriction Request					Not Explored in Use Case
	Operation Intent Negotiation					Not Explored in Use Case
Operations Management	Demand Capacity Management					Not Explored in Use Case
	Airspace Access Management					Not Explored in Use Case
	Airspace Organization			X		
	Control of Flight	X				
	Airspace Allocation & Constraints Definition					Not Explored in Use Case

2 Use Case: TCL3-6 – Last-Mile Rural Deliveries in Uncontrolled Airspace under the Mode C Veil

2.1 Mode C Veil Assumptions for this Use Case

This use case occurs in uncontrolled airspace, but within the limits of the Mode C Veil for airspace surrounding Minneapolis-Saint Paul International Airport (see Figure 2-1 and Figure 2-2). The scenarios in this use case assume that UA that are part of operations conducted under UTM are not required to have transponders when in uncontrolled airspace and under the Mode C Veil. See §2.4 for further discussion regarding this assumption.

2.2 Overview

A Delivery Company operates in a rural area northwest of Northfield, MN is performing last-mile parcel deliveries to customers. The company performs last-mile deliveries to customers in each of these zones using UA launched and recovered from a delivery truck.

The Delivery Company's regional warehouse, located approximately 40 miles from the delivery area, has accommodations for both the delivery Operator (D-Op) and delivery RPICs to operate, including ground control stations (GCSs). Communications links (e.g. satellite-based, LTE, etc.) are used to coordinate with the delivery truck personnel operating in the field. The GCS maintained by the Delivery Company provides the D-Op and RPICs with command and control of UA/parcel payload, real-time video downloads, geolocation data, etc.

The Performance Authorization for the company allows them a 1:2 RPIC to UA ratio; for this Use Case, each RPIC controls up to two UA at a time. It is assumed that only one UA is used per operation. RPICs may hand-off operation control between each other if the need arises.

Multi-rotor copters are utilized for parcel delivery, allowing for relatively high payload weights (the combined UA and payload weight is assumed to not exceed 55 pounds). As part of the payload, ground sensing equipment is installed on each UA allowing for detection of people and animals at/near the intended delivery site. Each UA has the ability to carry two parcels with the option of delivering both parcels to a single location or single parcels to two separate locations.

Operations of other UTM participants are relatively low for the area on the day of deliveries, but there is an agricultural operation that the D-Op plans around for one of the delivery operations (see Figure 2-3).

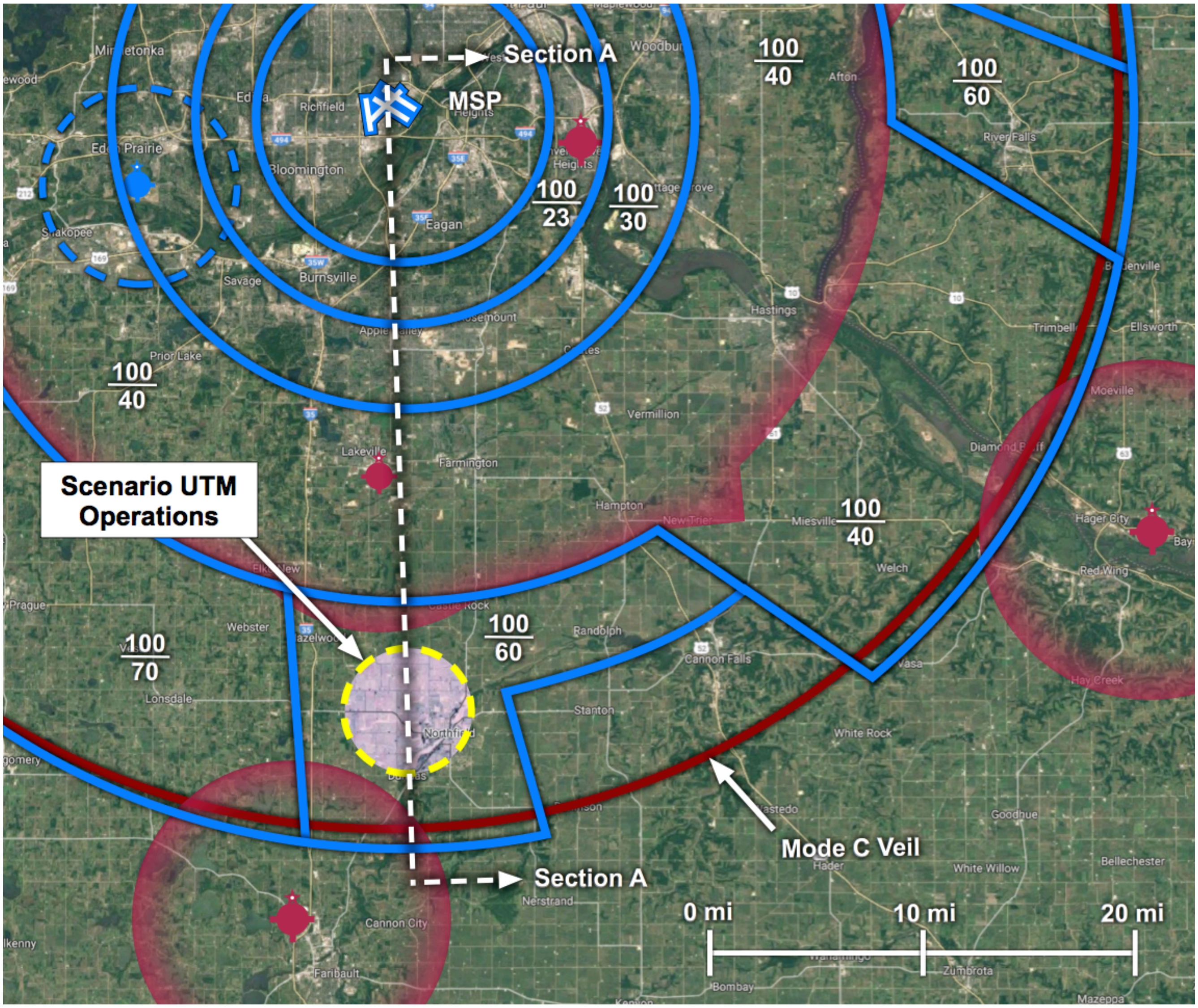


Figure 2-1 - MSP Airspace

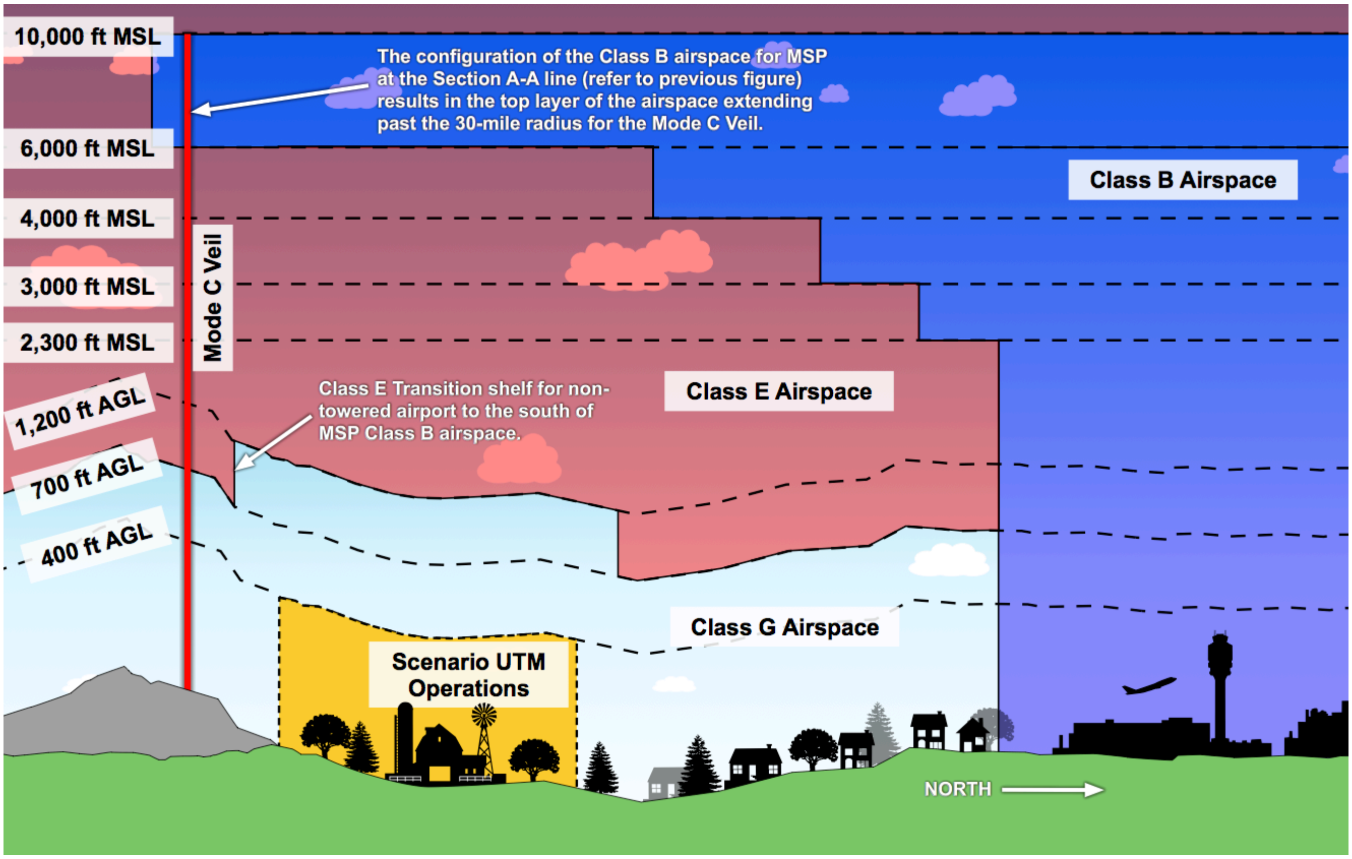


Figure 2-2 - MSP Airspace (Section A-A)

2.2.1 Summary Table

Table 2-1 - Summary - Use Case TCL3-6

Operation	Operational Description	Environmental Description
Delivery Operation 1 Delivery Operation 2 Delivery Operation 3 Delivery Operation 4	BVLOS Parcel Delivery (single/multi) Segmented volumes RPIC:UA ratio of 1:2	Class G, Under Mode C Veil Rural Area Ops Over People (during transit)
Agricultural Operation	BVLOS Pesticide Spraying Segmented Volumes RPIC:UA ratio of 1:1	Class G, Under Mode C Veil Rural Area

TABLE NOTES:

1. The agricultural operation is referred to as needed to examine the processes followed for the delivery operations. The scenarios do not look at all details of this operation.
2. Performance Authorizations were obtained by these Operators from the FAA prior to the events of the narrative below; these processes are not discussed in this Use Case. All sUAS BVLOS flight for each Operator occurs within an Authorized Area of Operations.

2.2.2 Equipment

The Delivery Company has a ground control station (GCS) located at the company headquarters, separated from the launch/recovery vehicle (hereafter referred to as the delivery truck). The RPIC(s) control the flight from the remote GCS. Long-range wireless communication (e.g. satellite, LTE, etc.) is used to connect to each UA, as well as the delivery truck. The GCS is connected to the USS to which the D-Op is subscribed.

For launch and recovery functions, the Delivery Company utilizes as ground-based cargo delivery trucks that have been modified to launch and recover up to 4 UA. Each truck has long-range wireless communication for connection to the GCS (e.g. satellite, LTE, etc.). Each truck is capable of launching and recovering UA in an automated fashion such that manual control by the RPIC of the UA when departing from or returning to the delivery truck is not necessary.

The UA are multi-rotor copters with video cameras, as well as advanced on-board sensor packages to detect in-air objects, objects/structures on the ground, persons/animals (infrared). The UA also have V2V capabilities for communication with other aircraft that have cooperative equipment on board, as well as for communication with the delivery truck. Relevant UTM information received by the GCS from USS-D may be automatically relayed to the UA when it is in automated flight, allowing it to act until the RPIC takes direct control.

2.2.3 Actor Details

2.2.3.1 Operators and RPICs

For the parcel delivery operations, an employee at the Delivery Company acts as the Operator, planning the flights and ensuring all equipment and services used meet the requirements commensurate with their Performance Authorization.

The Operator’s Performance Authorization allows for RPICs to control up to two UA at one time. Two employees at the Delivery Company act as the RPICs. Each RPIC has a sUAS pilot certificate appropriate for the operation type being conducted. The RPICs conduct the flights from a remote location at the Delivery Company regional warehouse. Hand-offs of UA may be conducted by the RPICs, so long as each is not in control of more than two UA at any given time. Nominally, RPIC 1 is in control of Delivery Operations 1 and 2, while RPIC 2 is in control of Delivery Operations 3 and 4 (refer to Figure 2-3).

2.2.3.2 USS

The Delivery Company provides its own USS capabilities (referred to as USS-D), providing all services necessary to share information with other applicable UTM stakeholders, receive constraint/other information from the FAA, etc. A different part of the company provides these services, such that there is no overlap in functions between the Operator, RPIC or USS-D.

The USS servicing the agricultural Operator is referred to as USS-A.

2.2.3.3 SDSP

SDSPs provide data relating to weather, relevant ground-based obstacles, relevant airspace constraint information not already provided by FIMS, etc.

2.2.3.4 FAA

The FAA interacts with UTM participants in this use case as follows:

- The FAA has previously provided the Delivery Operator with a Performance Authorization, allowing the Operator to conduct flights within their Authorized Area of Operations. The Operation Volumes shown are all contained within this area.

The FAA has the ability to access any stored or archived information related to the operations as required.

2.2.4 UTM Interaction

2.2.4.1 UTM Participation

All BVLOS Operators are required to participate in UTM, while VLOS Operators flying in accordance with either Part 101(e) or Part 107 may voluntarily opt to participate in UTM (e.g. sharing operation intent, receiving relevant alerts from their USSs, etc.)

2.2.4.2 Shared Information Across Actors

Table 2-2 – Shared Information - Use Case TCL3-6

Type of Information	Actor Providing Information	Actors with Access to Information	Examined in this Use Case?
Operation Plan Parameters/Inputs	Operator	USS	Yes
Operation Plan [1]	USS	Operator	Yes
Operation Intent, pre-flight (and other shared data)	USS	USS Network	Yes
Operation Data Relevant to UTM Coordination	USS	USS Network	No
Operation Data Relevant to Regulator Information Requirements	USS	FAA	No
Intent Modification Parameters/Inputs	Operator/RPIC	USS	No

Type of Information	Actor Providing Information	Actors with Access to Information	Examined in this Use Case?
Modification to Intent (pre-flight or in-flight)	USS	USS Network	No
Externally-originated data (surveillance, NOTAM, Wx, etc.)	USS or SDSP	Operator or RPIC	Yes
Operationally-Derived Environmental Data	RPIC or SDSP	USS	No
Relevant sUAS/Flight Information	sUAS	sUAS	No
	sUAS	RPIC/Operator	Yes
	RPIC/Operator	USS	Yes
	USS	USS Network	Yes
Operation Status Updates (subset of Operation Intent)	USS	USS Network	Yes
Spectrum Management	USS	USS Network, RPIC and Operator	No
Dynamic Restriction Request[2]	NAS Stakeholders	USS	No
Dynamic Restriction Approval[2]	USS	Operator/USS	No
Dynamic Restriction Distribution[2]	USS	USS Network and FAA	No
	FAA	Public Portal and other NAS Stakeholders	No
Negotiation Request	USS	USS	No
Negotiation Response	USS	USS	No
UREP	RPIC/Operator	USS	No
	USS	UREP Service[3]	No
Manned Aircraft Flight Information	Manned Aircraft	sUAS	No
Manned Aircraft Information	USS/SDSP	Operator/RPIC	No
Operation Hand-Off	RPIC	RPIC	Yes

TABLE NOTES:

1. Operation Plans include information that is shared with the USS Network (e.g. Operation Intent), as well as information that may not be shared with other USSs/Operators (e.g. private/proprietary Operator data used during planning). Once planning is complete, the subset of shared information that includes Operation Intent is made available to the USS Network.

2. A recent conceptual update for Dynamic Restrictions shifts the approval and distribution processes from the FAA to authorized USSs. Use Cases 3-5 through 3-7 do not explore this new concept, but the tables have been updated to reflect the change.
3. The USS Network has access to the UREP Service. Once an individual USS writes a UREP to the UREP Service, the information is then available to other USSs.

2.3 Narrative

General Notes for this Narrative

It is understood for this Use Case many of the functions, communications and decision-making occurring in the narrative below may be automated by the USSs and FAA. Explicit callout to automation is minimized to allow focus on the information exchange and flow of operations.

The agricultural operation is referred to as needed to examine the processes followed for the delivery operations. The scenarios do not look at all details of this operation.

This use case assumes that UA may conduct parcel drop-offs in a highly-automated fashion and is based on industry statements regarding expected future performance capabilities of their UA. This use case is not stating that it is expected this is how these operations will be conducted but uses this assumption for the narratives below when exploring moments where direct RPIC observation/control might be needed.

2.3.1 Planning

The Delivery Operator (D-Op) plans 5 parcel deliveries in the area shown in Figure 2-3. Each UA will make a trip from the delivery truck to the delivery address. Due to the size/weight of the parcels, three must be carried separately. Two parcels are light and will be delivered to locations in close proximity to each other. Given this, their delivery will be made during a single launch/recovery event. Four (4) deliveries will be conducted as separate operations at the same time (1 UA per operation), with the two (2) RPICs dividing the UA between them (1:2 RPIC to UA ratio).

Twelve hours prior to starting the delivery process, the D-Op works with the (USS-D) to develop the Operation Intent for the 4 deliveries. Information shared includes the time the operation will begin, location of the launch/recovery platform, approximate location(s) of the launch/recovery and parcel delivery location for each of the flights, UA performance information, pre-programmed contingency procedures, other nearby operations identified through the USS Network, etc. USS-D utilizes a Supplementary Data Service Provider (SDSP) for meteorological data relevant to the operation area, as well as detailed ground obstacle avoidance information.

From the information gathered as noted above, operation volumes for each flight are developed as shown in Figure 2-3 and Figure 2-4. The transit route for Operation 1 is segmented in 4D to maintain strategic separation from an agricultural operation (agri-op). Separation could be maintained by either flying above/below the agri-op volume (separate geographically), or by adjusting the active times for the volumes (geographical overlap could occur).

The position of the delivery truck, which remains in one location for the duration of the 4 deliveries, is selected to provide all 4 UA sufficient endurance buffer such that each can fly to and from the delivery locations under the weighted load of their parcels (should delivery not be possible for some reason). This endurance assessment includes additional flight considerations (e.g. increased winds) and is part of the standard procedures practiced by the Delivery Company.

Once the Operation Intent for each operation has been developed to the satisfaction of the D-Op, USS-D makes the intent available to other USSs via the USS Network. USSs active in the same area confirm receipt of the intent, with no requests to negotiate occurring. With no conflicts identified across the network and Operator planning complete, the Operation Status is in an “Accepted” state, and the Operation Intent (including status changes, modifications to volumes/schedules, etc.) is made available to other USSs operating in the area. USS-A, which is servicing the agri-op, makes relevant information provided by USS-D available to the agri-Operator and agri-RPIC.

With the operation planning completed, the Delivery Company notifies the delivery recipients of the scheduled delivery times and requests that a supplied delivery target be in place for a specific time period so the RPIC (or UA, when in automated flight) can identify the precise delivery location at the address. Per the company’s delivery agreement, the customer makes sure that the delivery target is placed in a location with unobstructed vertical clearance and that the area is clear of people and animals throughout the specified time period.

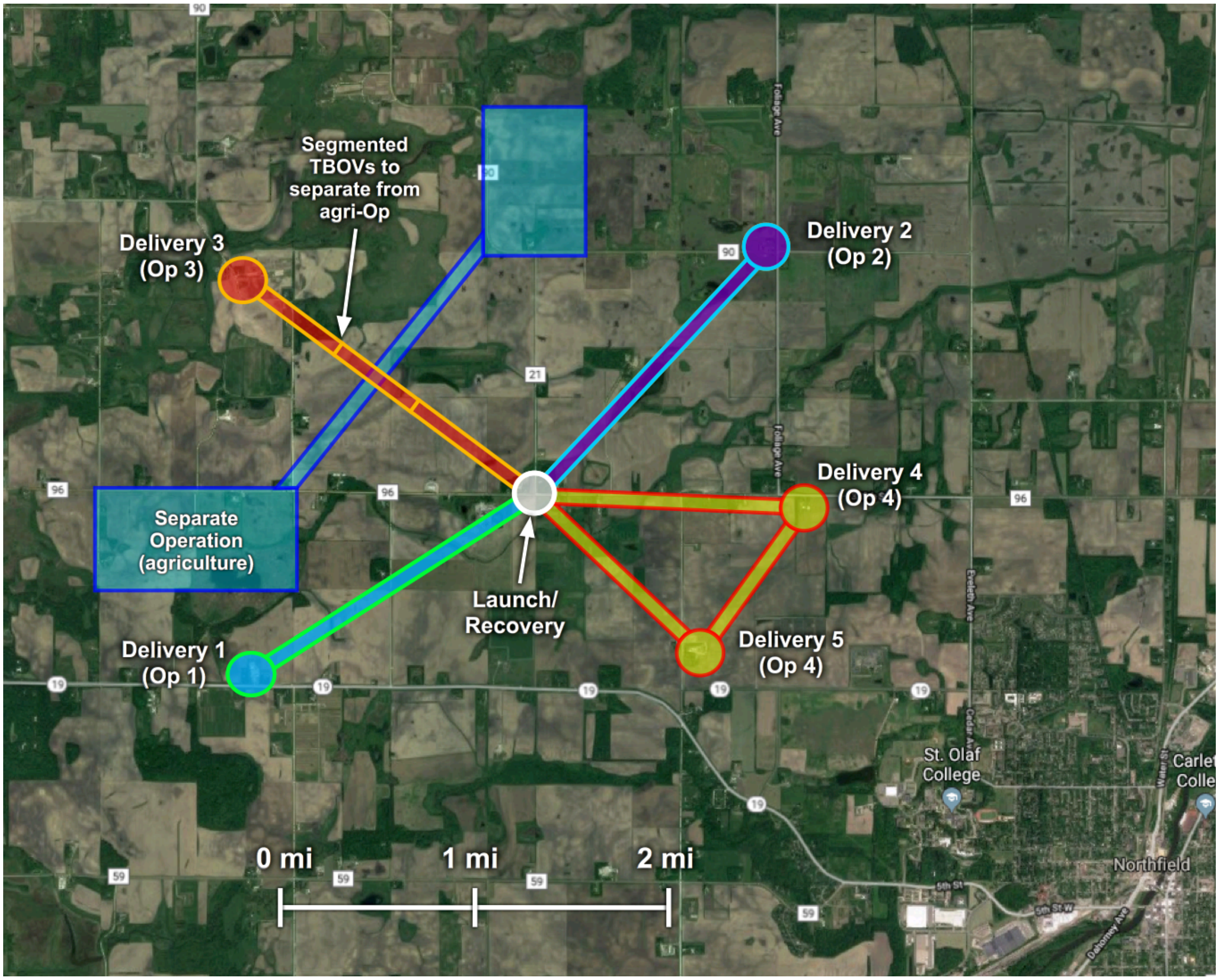


Figure 2-3 - Operation Overview

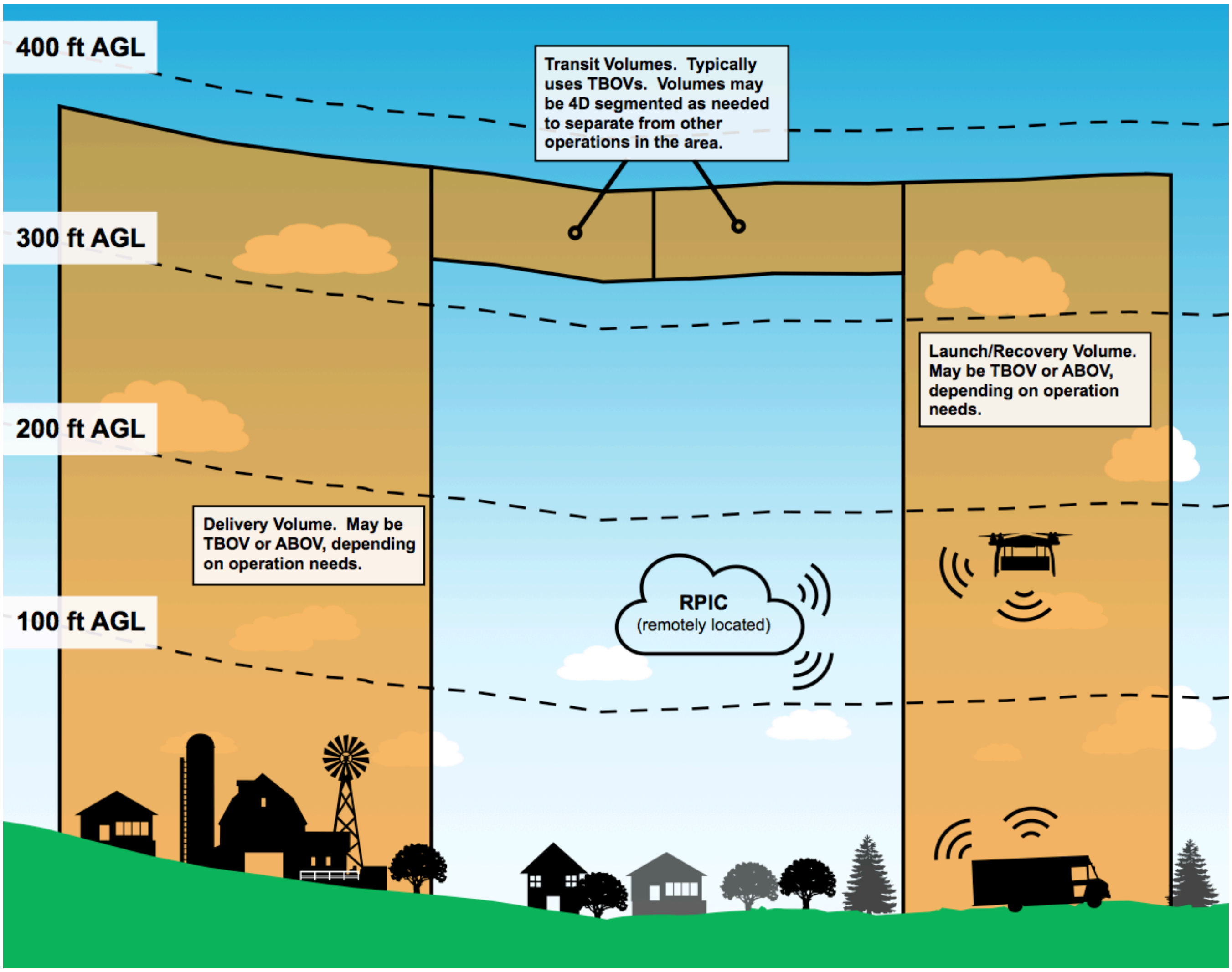


Figure 2-4 - Typical Delivery

2.3.2 Execution

Prior to the start time for the operations, the delivery truck arrives at the take-off location and the truck driver preps each UA with its parcel(s). Once this is done, the drive scans the airspace near the take-off location to make sure it is clear, and informs the RPICs, who are located at the Delivery Company's regional warehouse. While the delivery truck personnel are preparing each UA, the RPICs send pre-programmed routes to each of their respective UA. These routes are aligned with the Operation Intent data previously announced to the USS Network. Once preparations are complete and they know the launch area is clear, both RPICs turn on position reporting to USS-D (the GCSs receives position data from their respective UA and relay it to the USS-D) and notify the USS that they are about to take off. The USS sets the Operation Status for each Operation to "Activated" and makes the update available to the USS Network.

RPIC 1 initiates take-off of the UA for Delivery Operation 1. As the UA ascends through the launch/recovery volume towards its transit volume(s), the RPIC initiates take-off of the UA for Delivery Operation 2. RPIC 2 does the same for Delivery Operations 3 and 4. Position information for each UA is transmitted to the RPICs, whose GCSs relay to the USS-D for conformance monitoring purposes.

Note that the launch/recovery volumes for each delivery operation are equal in geographical bounds of the others and have similar scheduled times, resulting in the potential for 4-D overlap of volumes of separate operations. When this occurs, the UA maintain separation from each other in the shared airspace, which may be accomplished through several methods. A sample of possible methods includes:

- V2V communication coupled with automated responses from on-board systems
- GCS position analysis of the UA and automated commands to the UA
- SAA capabilities resulting in automated maneuvers
- Tracking and/or direct control of UA by the RPICs with real-time coordination between each RPIC
    - Coordination between RPICs conducting operations under the same Operator is assumed to be done through direct GCS to GCS communication, as opposed to coordination/messaging via USSs.

The UA fly in accordance with their preprogrammed routes, relaying information (video, sensor data, messages, etc.) to the RPIC's GCSs. The RPICs monitor their respective UA on each of their GCSs, ready to take manual control or issue additional commands if required.

Operation Volumes for each delivery UA become active or inactive in accordance with their schedules, as defined in the Operation Intent. As each UA enters the delivery Operation Volume, the RPIC monitors the UA while it descends to the touch-down location (a target placed on the ground by the package recipient). The UA sensors identify potential obstructions (structures, trees, etc.) and people/animals near the target. If a safety issue near the landing target is identified, the UA waits at a pre-determined altitude for the issue to be resolved (the decision to wait could be automatic or the RPIC could be in the decision loop), with a time limit placed on the wait period that is determined by the vehicle endurance should it need to return to the delivery truck with the parcel.

RPICs initiate hand-offs of operation control as needed. A situation that could necessitate this could be a delay to landing/release of the parcel for Operation 1, due perhaps to the ground target not having been placed. RPIC 1 monitors for the appearance of the target, while at the same time the UA for Operation 2 approaches its delivery location. RPIC 1, his attention focused on Operation 1, requests that RPIC 2 take over Operation 2 and give him Operation 3, which has already completed delivery and is en route (in automated flight) to the delivery truck for recovery. USS-D receives the Operation Hand-Off alerts from the RPIC's GCSs, and updates the Operation Intent for the respective operations to indicate the current RPIC.

Once package release is complete, the UA vacate their delivery areas and make their way to the edge of the delivery volume, enter the return transit volumes as they become active per the schedule as detailed in the Operation Intent[2] and make their way back to the delivery truck. If a UA were ahead of schedule such that the

[2] The transit volumes for the delivery and return trips may be identical in geographical definition (as shown in Figure 2-3), but the times are different, and are thus considered separate volumes entirely. Previous use cases with similar situations may have not made this distinction, but it is how it is approached in the UTM RTT demonstrations.

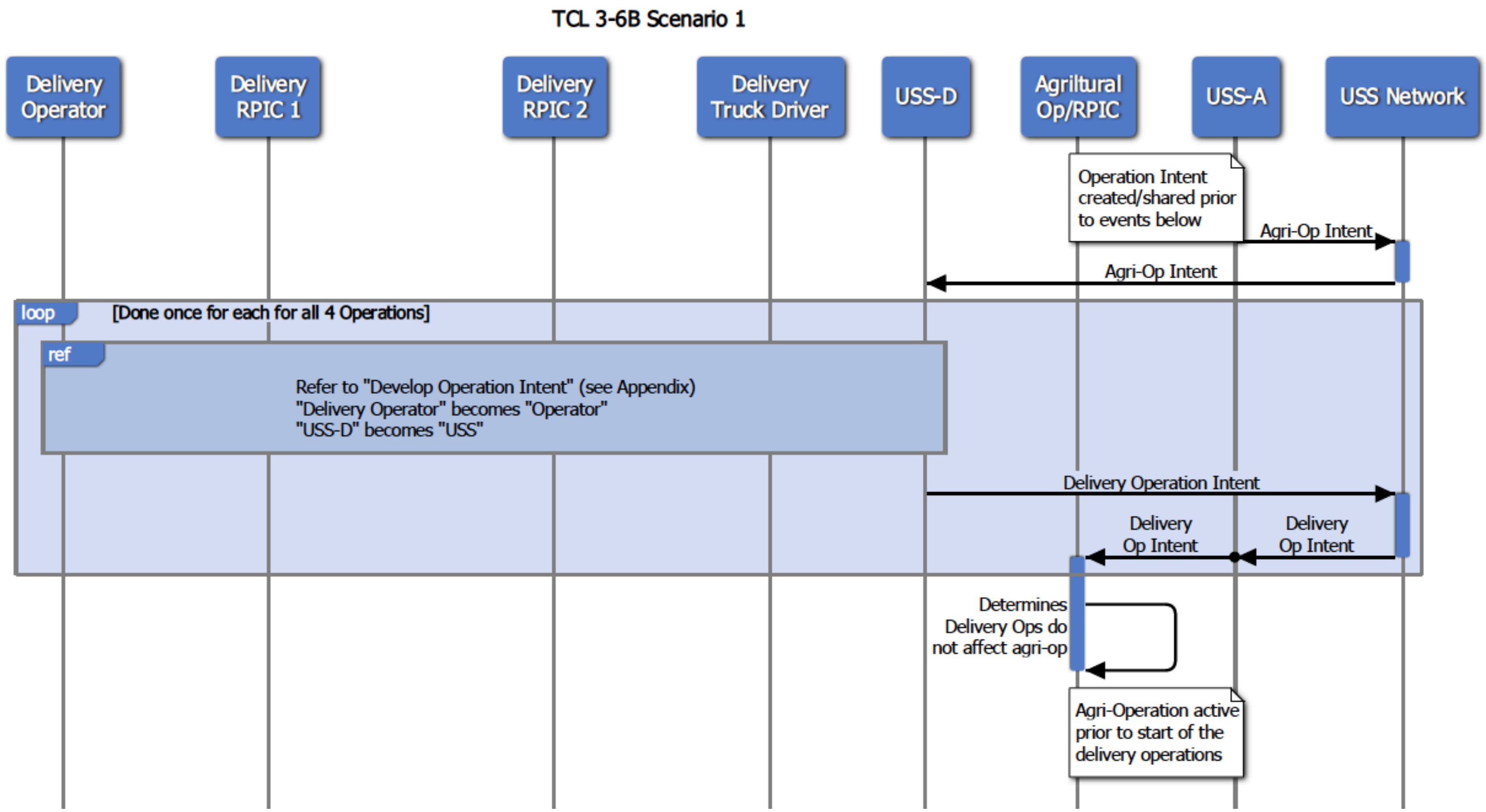
transit volume is not active when it was ready to enter, the RPIC may opt to dynamically change the Operation Volume schedules (any change of which is made available to the USS Network).

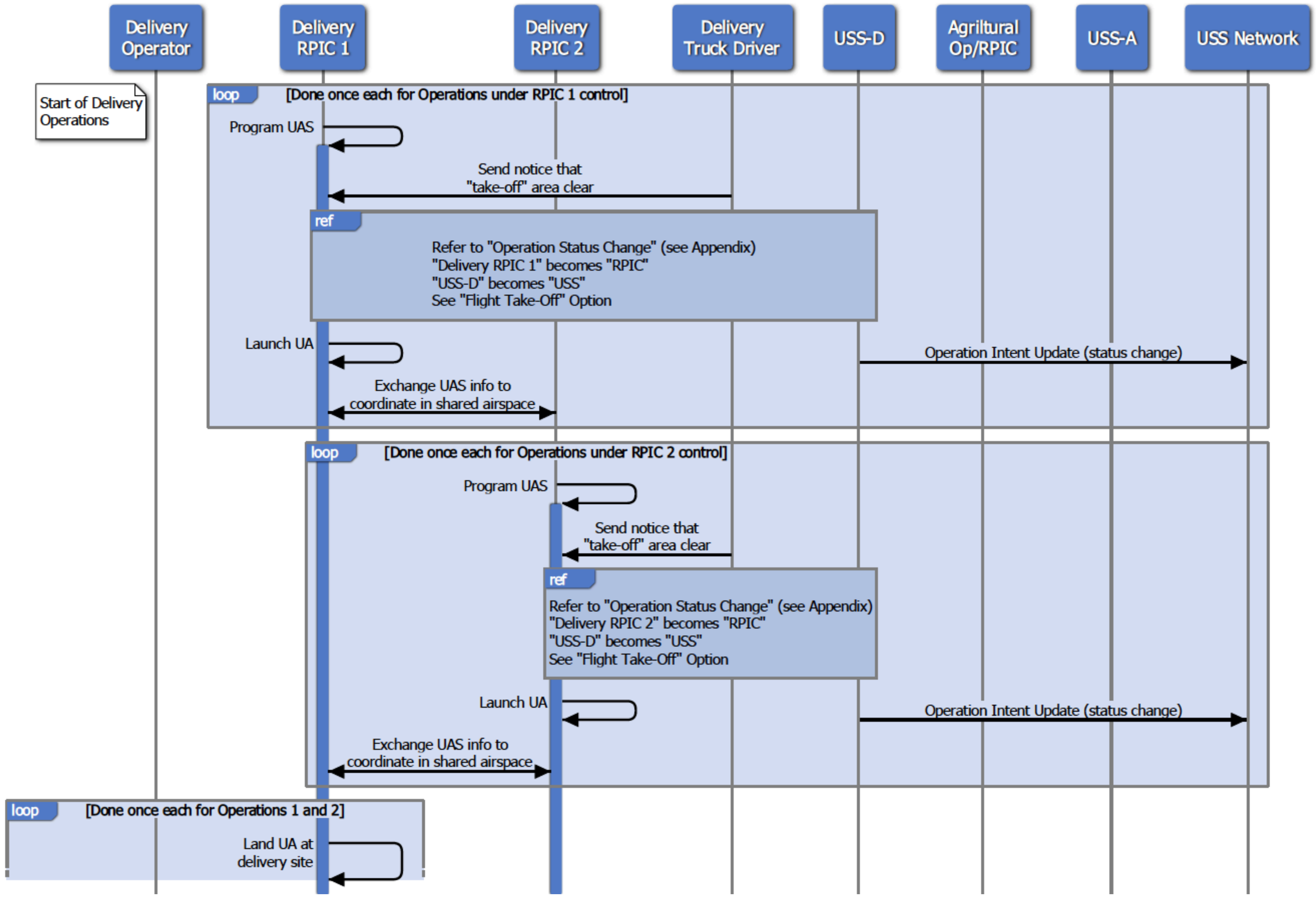
The UA are able to maintain separation from each other in the recovery area should their operational volumes overlap in time (see previous sample list of methods). Each UA loiters some distance from the others while one initiates and completes the recovery sequence with the vehicle below. In this scenario, the delivery truck is equipped with V2V capabilities, allowing direct automated coordination with the UA during the recovery sequence. During the landing sequence, the UA communicates with the delivery truck systems to position itself during descent and trigger the bay door the bay door to open/close as needed.

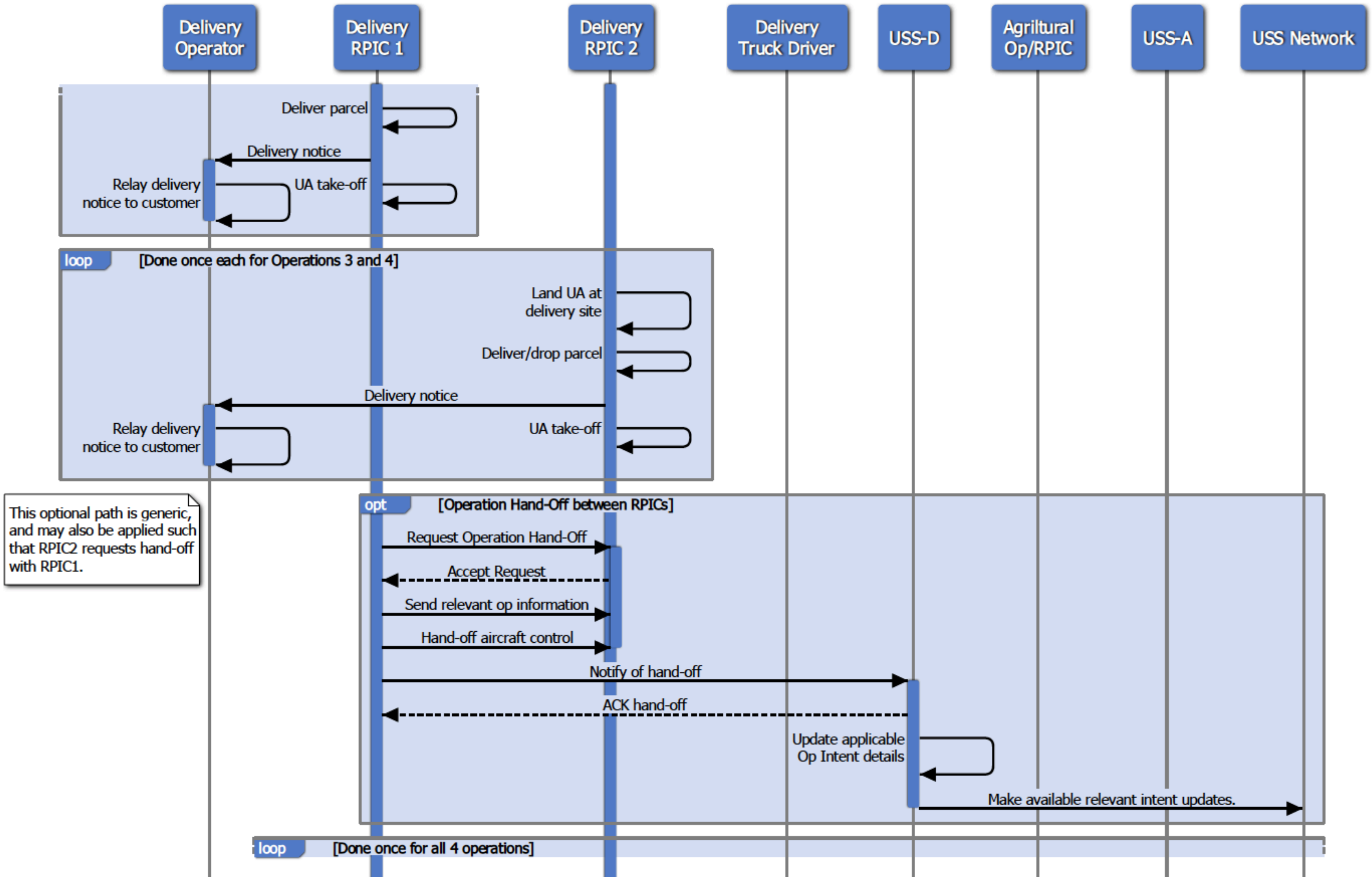
As each UA completes its landing with the delivery truck, the applicable RPIC sends notice to USS-D of the operation completion. The Operation Status becomes “Closed” once there are no remaining volumes scheduled or USS-D manually changes the status (e.g., due to an early landing) and makes the update available to the USS Network.

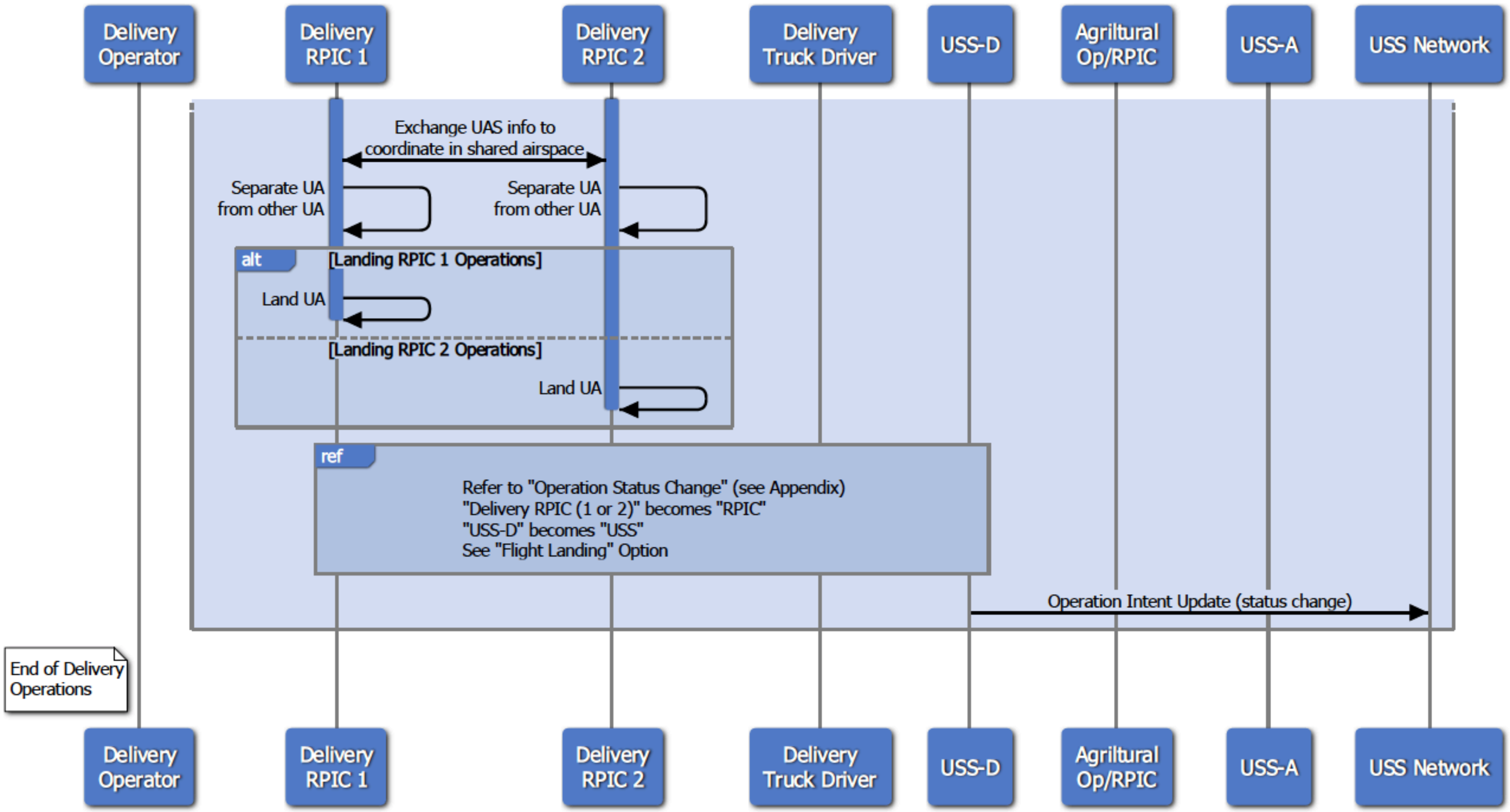
2.3.3 Scenario 1 Operational Views

The following pages provide operational views of the Scenario 1 narrative. Referenced diagrams for sub-activities can be found in the Appendix.




Delivery Operator
Delivery RPIC 1
Delivery RPIC 2
Delivery Truck Driver
USS-D
Agriltural Op/RPIC
USS-A
USS Network
Start of Delivery Operations
loop
[Done once each for Operations under RPIC 1 control]
Program UAS
Send notice that "take-off" area clear
ref
Refer to "Operation Status Change" (see Appendix)
"Delivery RPIC 1" becomes "RPIC"
"USS-D" becomes "USS"
See "Flight Take-Off" Option
Launch UA
Operation Intent Update (status change)
Exchange UAS info to coordinate in shared airspace
loop
[Done once each for Operations under RPIC 2 control]
Program UAS
Send notice that "take-off" area clear
ref
Refer to "Operation Status Change" (see Appendix)
"Delivery RPIC 2" becomes "RPIC"
"USS-D" becomes "USS"
See "Flight Take-Off" Option
Launch UA
Operation Intent Update (status change)
Exchange UAS info to coordinate in shared airspace
loop
[Done once each for Operations 1 and 2]
Land UA at delivery site


Delivery Operator
Delivery RPIC 1
Delivery RPIC 2
Delivery Truck Driver
USS-D
Agriltural Op/RPIC
USS-A
USS Network
Deliver parcel
Delivery notice
Relay delivery notice to customer
UA take-off
loop
[Done once each for Operations 3 and 4]
Land UA at delivery site
Deliver/drop parcel
Delivery notice
Relay delivery notice to customer
UA take-off
This optional path is generic, and may also be applied such that RPIC2 requests hand-off with RPIC1.
opt
[Operation Hand-Off between RPICs]
Request Operation Hand-Off
Accept Request
Send relevant op information
Hand-off aircraft control
Notify of hand-off
ACK hand-off
Update applicable Op Intent details
Make available relevant intent updates.
loop
[Done once for all 4 operations]


Delivery Operator
Delivery RPIC 1
Delivery RPIC 2
Delivery Truck Driver
USS-D
Agriltural Op/RPIC
USS-A
USS Network
Exchange UAS info to coordinate in shared airspace
Separate UA from other UA
Separate UA from other UA
alt
[Landing RPIC 1 Operations]
Land UA
[Landing RPIC 2 Operations]
Land UA
ref
Refer to "Operation Status Change" (see Appendix)
"Delivery RPIC (1 or 2)" becomes "RPIC"
"USS-D" becomes "USS"
See "Flight Landing" Option
Operation Intent Update (status change)
End of Delivery Operations
Delivery Operator
Delivery RPIC 1
Delivery RPIC 2
Delivery Truck Driver
USS-D
Agriltural Op/RPIC
USS-A
USS Network

2.4 Considerations Regarding the Current Regulatory Environment

This use case occurs in uncontrolled airspace, but within the limits of the Mode C Veil for airspace surrounding Minneapolis-Saint Paul International Airport. As previously noted, it is assumed in this use case that UA utilized for UTM operations in this particular airspace are not required to have a transponder.

Table 2-3 – Current Mode C Transponder Requirements within the Veil

Category of Aircraft	Mode C Transponder Required within the Veil					Comments
	Class G	Class E	Class D	Class C	Class B	
Heavier-than-Air Powered Aircraft	Yes	Yes	Yes	Yes	Yes	FAR 91.215/225
Powered Aircraft without an Engine-Driven Electrical System	No	No	No	Yes	Yes	91.215 (b) (3)
VLOS UA	No	No	No	No	No	14 CFR 91.1(f) excludes 107 UA from transponder requirements
BVLOS UA	No[1]	Future Work[2]				Applicable Policies/Regulations under development

1. Assumption for the use case.
2. UTM Operations in controlled airspace will be explored in Future Use Cases.

Table 2-3 above shows the transponder requirements for relevant aircraft types when under the Mode C Veil. This use case's assumption for BVLOS aircraft (uncontrolled airspace under the veil) is based on the following:

- Low altitude (AOB 500' AGL) BVLOS operations under the Mode C Veil in uncontrolled airspace present an operational environment and challenges similar to those addressed in previous use cases for uncontrolled airspace UTM operations.
- For non-towered airports under the Mode C Veil, considerations, assumptions, and principles for UTM operations remain the same as elsewhere in uncontrolled airspace.
  - Operations under Part 107 require the VLOS operator to remain clear of other aircraft.
  - Performance Authorizations granted to BVLOS UTM Operators will include risk mitigation strategies for the specific operation (includes both type of operation and location for the operation).
- Consistent with the UTM principles, BVLOS operations are required to participate in UTM. Manned aircraft may be informed of UA BVLOS operations through participation in UTM (or equivalent publication of information).

2.5 Roles and Responsibilities

Service/Function		Actors				Explanatory Notes
		X=direct responsibility | S=support role				
		RPIC	Operator	USS	FAA	
Separation	VLOS UA from VLOS UA					Not Explored in Use Case
	VLOS UA from BVLOS UA					Not Explored in Use Case
	BVLOS UA from BVLOS UA	S	X	S		
	VLOS UA from Low-Altitude Manned A/C					Not Explored in Use Case
	BVLOS UA from Low-Altitude Manned A/C					Not Explored in Use Case
Hazard/ Terrain Avoidance	Weather Avoidance					Not Explored in Use Case
	Terrain Avoidance					Not Explored in Use Case
	Obstacle Avoidance					Not Explored in Use Case
Status	UTM Operations Status			X		
	Flight Information Archive		X	S		Operator delegates to USS
	Flight Information Status	S	X	S		
Advisories	Weather Information		X	S		
	Hazard Information (Obstacles, terrain, etc.)		X	S		
	Alert Affected Airspace Users of UA Hazard					Not Explored in Use Case
	UA-Specific Hazard Information (Power-Lines, No-UA Zones, etc.)		X	S		

Table continued…

Service/Function		Actors				Explanatory Notes
		X=direct responsibility | S=support role				
		RPIC	Operator	USS	FAA	
Planning, Intent and Authorization	Priority Status Notification (emergency declaration, public safety, etc.)					Not Explored in Use Case
	Operation Plan Development		X	S		
	Operation Intent Sharing (pre-flight)		X	S		
	Operation Intent Sharing (in-flight)	S	X	S		
	Dynamic Restriction Request					Not Explored in Use Case
	Operation Intent Negotiation					Not Explored in Use Case
Operations Management	Demand Capacity Management					Not Explored in Use Case
	Airspace Access Management					Not Explored in Use Case
	Airspace Organization					Not Explored in Use Case
	Control of Flight	X				
	Airspace Allocation & Constraints Definition					Not Explored in Use Case

3 Use Case: TCL3-7 – sUAS Operator In-Flight Loss of Performance Capabilities in Uncontrolled Airspace

3.1 Overview

This TCL3-7 Use Case details a sUAS Operator in-flight loss of performance capabilities in uncontrolled airspace encountered when communications between sUAS Operator and their contracted USS is lost. The narrative in this Use Case consists of two scenarios as follows.

- Scenario 1 – sUAS Operator Able to Adhere to Operator Performance Authorization Requirements
- Scenario 2 – sUAS Operator Unable to Adhere to Operator Performance Authorization Requirements

In both scenarios communication is lost between the sUAS Operator and their contracted USS. The first scenario explores actions taken when communication is lost between the sUAS Operator and their USS and is subsequently established with a second USS, i.e. an alternate or back-up USS. By contrast, in the second scenario the Operator's GCS equipment malfunctions such that communication is lost with their USS and communications cannot be re-established with that USS or a back-up. Both scenarios share the same background and planning stages.

Agricultural Crop Inspections (ACI) is a sUAS Operator conducting an inspection on a remote plot of land with a single UA operating BVLOS in segmented volumes (see Figure 1-1). The ACI UA departs from a GCS Launch Platform several miles from the inspection location, conducting the flight as BVLOS. Two unrelated UA operations are nearby the ACI UA operation and have been strategically deconflicted through geographic, altitude, and/or temporal separation during planning. ACI, the sUAS Operator, assigns a dedicated Project Manager to carry out the Operator functions for the inspection project, and oversee collection of data from the onboard sensors, and the activities of another ACI employee assigned as the RPIC for the operation. The RPIC provides both UA control and monitoring. ACI's Performance Authorization allows for BVLOS operations mandating USS connectivity.

In the first Scenario, the UA is operating in the inspection volume (an ABOV) when communications are lost with USS-A. This scenario examines the actions taken by the Operator/RPIC to re-establish communications with USS-A and then with USS-B. Once communications are confirmed with USS-B (messaging, position-sharing, etc.), the operation continues normally.

In the second Scenario. the UA is initially operating the same as in Scenario 1, and again loses connectivity with USS-A. However, because the loss of connection is due to GCS equipment malfunction, connectivity cannot be re-established with USS-A or established with USS-B. As parts of ACI's Performance Authorization are satisfied by USS services and cannot be provided by the GCS or other on-ground/in-air equipment, options and actions that may be taken by the flight crew are examined.

In both scenarios the UA has the ability to broadcast a V2V distress signal that may be received by other nearby UA with compatible equipment. Also, in both scenarios, in order to focus on the priority considerations in emergency situations such as the ones explored, the planning stage has been omitted for brevity. The scenarios begin with the Operator/RPIC being compliant and having completed developing their Operation Intent.

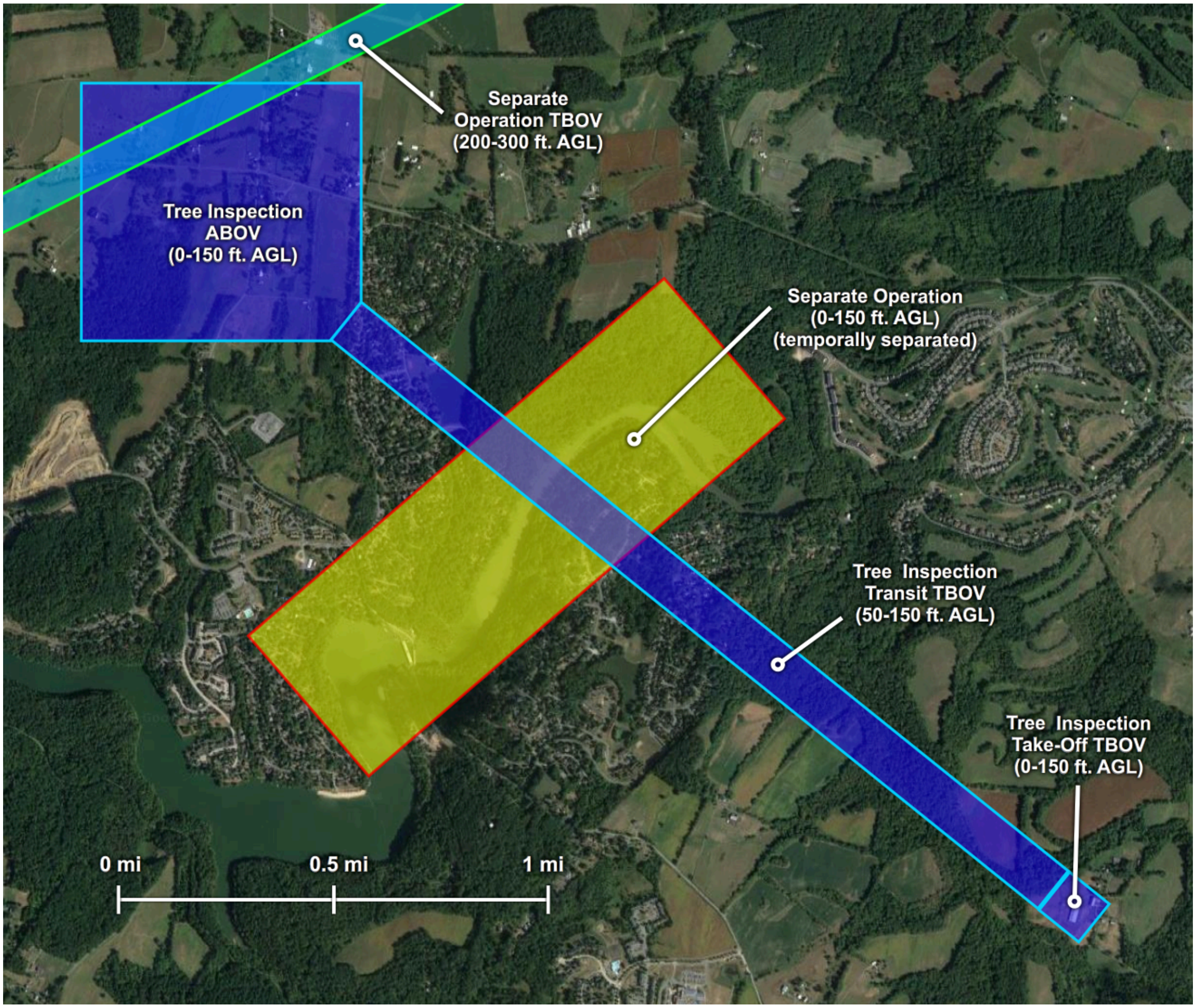


Figure 3-1 – Scenario 1 and 2 Baseline Operation Areas

3.1.1 Summary Table

Table 3-1 – Summary – Use Case TCL 3-7

Scenario	Operation	Operational Description	Operational Description	Event Summary
1	Agricultural inspection over walnut grove	- BVLOS - Other UA operations nearby - Operation Intent made available - Position sharing	- Class G; no airport nearby - Operation populated and unpopulated lands - Operation over suburban property in transit to agricultural area	- sUAS Operator experiences loss of communication with primary USS; loses connectivity with primary USS; establishes connectivity with alternate USS; operation continues
2	Agricultural inspection over walnut grove			- sUAS Operator experiences loss of communication with primary USS; loses connectivity with primary USS; fails to establish connectivity with alternate USS; operation discontinues

TABLE NOTES:

3. This Use Case does not examine all details of the process of an individual Operator creating Operation Intent. Minor details relevant to the primary/backup USS concept being explored are mentioned, however. Previous Use Cases have examined this process and may be referred to as needed.
4. Performance Authorization approval is assumed to have been obtained in advance by these Operators/USSs from the FAA prior to the events of the narrative; these processes are not discussed in this Use Case. All UA BVLOS flight for each Operator occurs within an Authorized Area of Operations.

3.1.2 Equipment

ACI utilizes medium-size long-range quadcopters with multi-spectral imaging sensors. The UA has vehicle-to-vehicle (V2V) capabilities, forward and down-looking video cameras and wireless (e.g., cellular, satellite, etc.) data link for command and control and camera operations. The quadcopter is able to operate for approximately four hours of continuous flight.

In addition to the wireless link to the UA, the GCS is equipped with traditional cellular communications to coordinate with the USS with which the company contracts (in this case, USS-A). ACI also has connection to USS-B, used as a back-up to USS-A to help ensure continuity of mission. The GCS utilized by ACI provides command and control, real-time video and analysis data downloads, and geolocation data to its Operator/RPIC. GCS-to-USS connectivity may be achieved through various methods including LTE internet, wired internet, and others for the sUAS GCS to provide information as needed including aircraft position and health. UA command and control is provided through a dedicated radio link.

3.1.3 Actor Details

3.1.3.1 Operators and RPICs

In both scenarios of this Use Case, the role of Operator is held by management personnel at Agricultural Crop Inspections (ACI) is the sUAS Operator with a Program Manager assigned to directly manage the operation. The role of RPIC is held by an employee of ACI who has obtained appropriate certifications for operating UA in BVLOS flight. In both scenarios, the Operator already has the appropriate Performance Authorizations. Performance Authorizations are obtained by Operators/RPICs and address aircraft/capability requirements to operate in a particular environment (e.g., over people) prior to operations analogous to a manned aircraft pilot license, ratings, and certifications for particular operations.

3.1.3.2 FAA

The FAA ensures compliance with regulations and equitable access for users of the airspace. The FAA has the ability to access live and stored/archived information related to UTM operations as required. Given that the operation for both scenarios occurs in uncontrolled airspace and non-UTM stakeholders are not impacted during the events as described, no FAA interaction occurs.

3.1.3.3 USSs and USS Network

In both scenarios of this use case two USSs, USS-A and USS-B, are used by ACI. USS-A is the primary USS utilized by the Operator; services provided match to those examined in previous use case (operation planning, sharing intent with the USS Network, conformance monitoring, notification relays from FIMS, etc.). USS-B acts as the backup (alternate), and receives relevant information from the Operator/RPIC and/or USS-A until such time as its backup services are required

The USSs receive and provide information to other sUAS operators in the area via the USS Network. The USSs are involved in interchanging information on the Operation Intent as it changes due to the situations examined in the two scenarios.

3.1.3.4 SDSPs

SDSPs provide data relating to weather, relevant ground-based obstacles, relevant airspace constraint information not already provided by FIMS.

3.1.3.5 Stakeholders on Ground

In this Use Case the events of interest take place over a rural area and no emphasis is explored regarding stakeholders on the ground. No communication with stakeholders on the ground is detailed here beyond courtesy communications with local authorities after the scenarios are resolved and closed.

3.1.4 UTM Interaction

3.1.4.1 UTM Participation

All BVLOS Operators are required to participate in UTM, while VLOS Operators flying in accordance with either Part 101(e) or Part 107 may voluntarily opt to participate in UTM (e.g. sharing operation intent, receiving relevant alerts from their USSs, etc.).

This use case does not assume that any special requirements are imposed on UA within an ABOV relating to separation from UA operating in TBOVs; both UA are equally responsible for maintaining separation from one another. A previous note in §3.1.1 indicates that Operators/USSs generally avoid overlap of TBOVs with other TBOVs, whereas TBOVs may more often overlap ABOVs.

3.1.4.2 Shared Information Across Actors

Table 3-2 – Shared Information – Use Case TCL 3-7

Type of Information	Actor Providing Information	Actors with Access to Information	Examined in this Use Case?
Operation Plan Parameters/Inputs	Operator	USS	Yes
Operation Plan [1]	USS	Operator	Yes
Operation Intent, pre-flight (and other shared data)	USS	USS Network	Yes
Operation Data Relevant to UTM Coordination	USS	USS Network	Yes
Operation Data Relevant to Regulator Information Requirements	USS	FAA	No
Intent Modification Parameters/Inputs	Operator/RPIC	USS	Yes
Modification to Intent (pre-flight or in-flight)	USS	USS Network	Yes
Externally-originated data (surveillance, NOTAM, Wx, etc.)	USS or SDSP	Operator or RPIC	Yes
Operationally-Derived Environmental Data	RPIC or SDSP	USS	No
Relevant sUAS/Flight Information	sUAS	sUAS	No
	sUAS	RPIC/Operator	Yes
	RPIC/Operator	USS	Yes
	USS	USS Network	Yes
Operation Status Updates	USS	USS Network	Yes

Type of Information	Actor Providing Information	Actors with Access to Information	Examined in this Use Case?
(subset of Operation Intent)			
Spectrum Management	USS	USS Network, RPIC and Operator	No
Dynamic Restriction Request[2]	NAS Stakeholders	USS	No
Dynamic Restriction Approval[2]	USS	Operator/USS	No
Dynamic Restriction Distribution[2]	USS	USS Network and FAA	No
	FAA	Public Portal and other NAS Stakeholders	No
Negotiation Request	USS	USS	No
Negotiation Response	USS	USS	No
UREP	RPIC/Operator	USS	No
	USS	UREP Service[3]	No
Manned Aircraft Flight Information	Manned Aircraft	sUAS	No
Manned Aircraft Information	USS/SDSP	Operator/RPIC	No
Operation Hand-Off	RPIC	RPIC	Yes

TABLE NOTES:

1. Operation Plans include information that is shared with the USS Network (e.g. Operation Intent), as well as information that may not be shared with other USSs/Operators (e.g. private/proprietary Operator data used during planning). Once planning is complete, the subset of shared information that includes Operation Intent is made available to the USS Network.
2. A recent conceptual update for Dynamic Restrictions shifts the approval and distribution processes from the FAA to authorized USSs. Use Cases 3-5 through 3-7 do not explore this new concept, but the tables have been updated to reflect the change.
3. The USS Network has access to the UREP Service. Once an individual USS writes a UREP to the UREP Service, the information is then available to other USSs.

3.2 Narrative

NOTE: It is understood for this Use Case many of the functions, communications and decision-making occurring in the narrative below may be automated by the USSs and FAA. Explicit callout to automation is minimized to allow focus on the information exchange and flow of operations.

The narrative is discussed below in two scenarios.

3.2.1 Scenario 1: sUAS Operator Able to Adhere to Operator Performance Authorization Requirements

3.2.1.1 Scenario 1 Planning

The ACI Operator plans an operation using the services of USS-A in similar fashion to previous use cases (Operation Volumes, deconfliction from other operations, etc.). Details on this process are not repeated in this use case. The primary difference from previous use cases is that the Operator indicates in the Operation Intent that USS-B is the back-up USS for the operation.

It is possible that USS-B is made aware of their support for this operation in various ways. Possible methods might include, but are not limited to, (1) the Operator completes the planning, USS-A shares the Operation Intent with the USS Network, and the Operator or RPIC directly notifies USS-B of their role in this operation, (2) USS-A notifies USS-B once the Operation Intent is complete and is shared with the network, or (3) the Operator, USS-A and USS-B have an established agreement for the USS backup approach.

Once the Operation Intent is complete, USS-A confirms and shares it with the USS Network. Other nearby operations, as shown in Figure 3-1, are made aware of the new operation. Strategic planning has resulted in geographic and/or temporal separation of the operation from others.

3.2.1.2 Scenario 1 Execution

The ACI sUAS RPIC operates from a GCS located at the company branch near the inspection area. When the GCS and launch/recovery platform are ready for the operation to begin, the RPIC begins sending UA position information, and then notifies USS-A that he is about to take off. USS-A updates the operation status to indicate the operation has been activated and makes the update available to the USS Network.

The Operator/RPIC initiates the flight and transits to the inspection volume. Volumes are considered active/inactive per the scheduled times as defined by the Operation Intent.

Thirty (30)s minutes into the inspection the RPIC receives an alert from the GCS that connection to USS-A has been disrupted. Attempts by the RPIC to reestablish communications by primary and backup systems are unsuccessful, but connection to USS-B is indicated as available on the GCS display.

Similar to the initial planning situation, various methods of an operation hand-off could exist, and for various reasons. Exploration of various possibilities are shown below (these are not exhaustive but are meant to foster discussion on how it may be done).

Exploration 1: RPIC Initiates Connection to USS-B

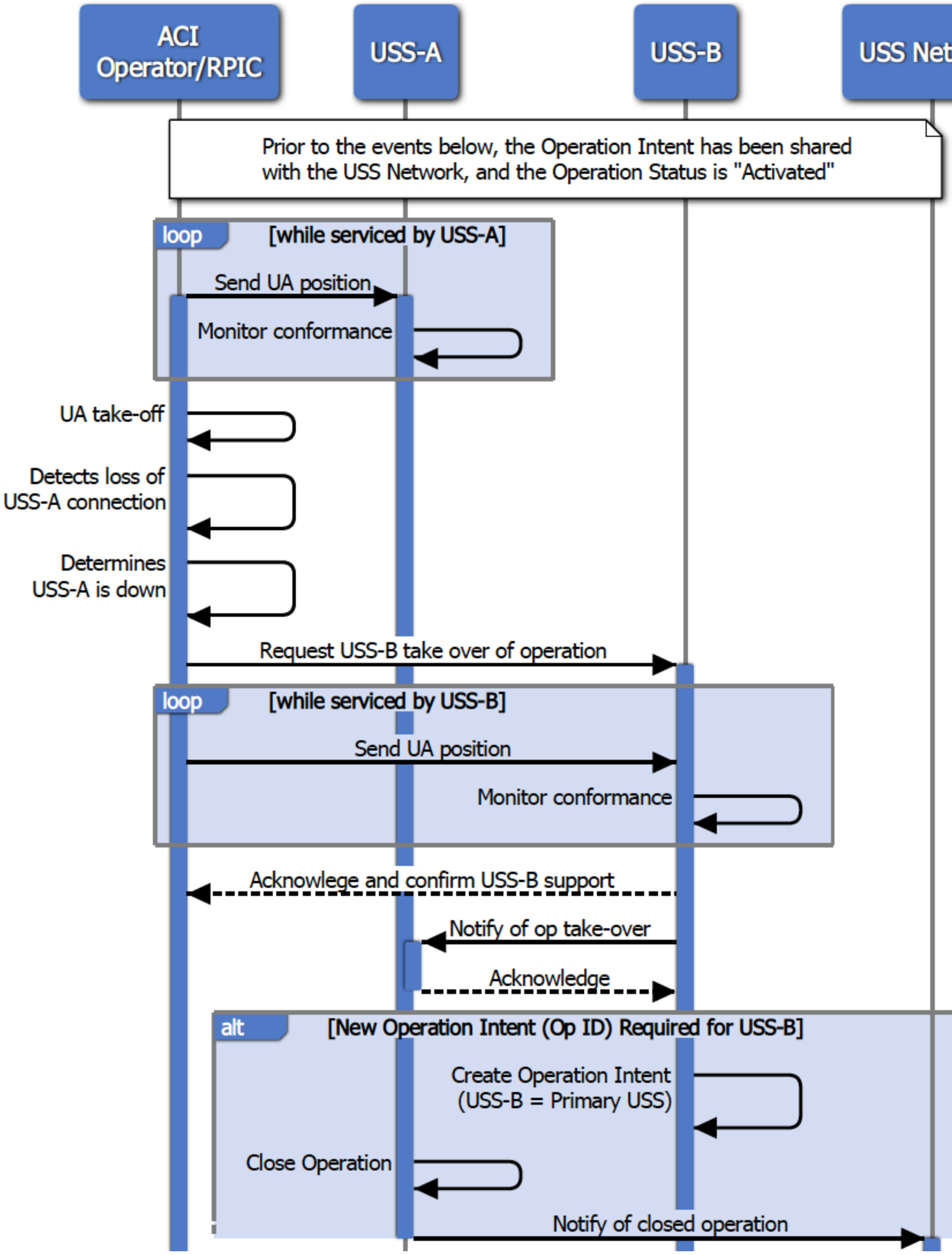
The RPIC concludes that the communications error is due to an issue with USS-A systems and proceeds to establish communications with alternate USS-B, requesting they take over USS services for the operation. Part of this request includes starting to send the UA position information from the GCS so that USS-B can begin conformance monitoring. USS-B sends a notification message to USS-A indicating that they are taking over the operation. USS-

B sends out an updated (or new)[3] set of Operation Intent to the USS Network, which contains an update to the servicing/primary USS (now USS-B).

The inspection operation continues to conclusion without further complications.

[3] Implementation of the hand-off from USS-A to USS-B may involve a mechanism of handing over control of the existing operation or closing one operation and opening another simultaneously but is not prescribed in this use case.

3.2.1.2.1 Operational View – Scenario 1 – RPIC Initiates Connection to USS-B



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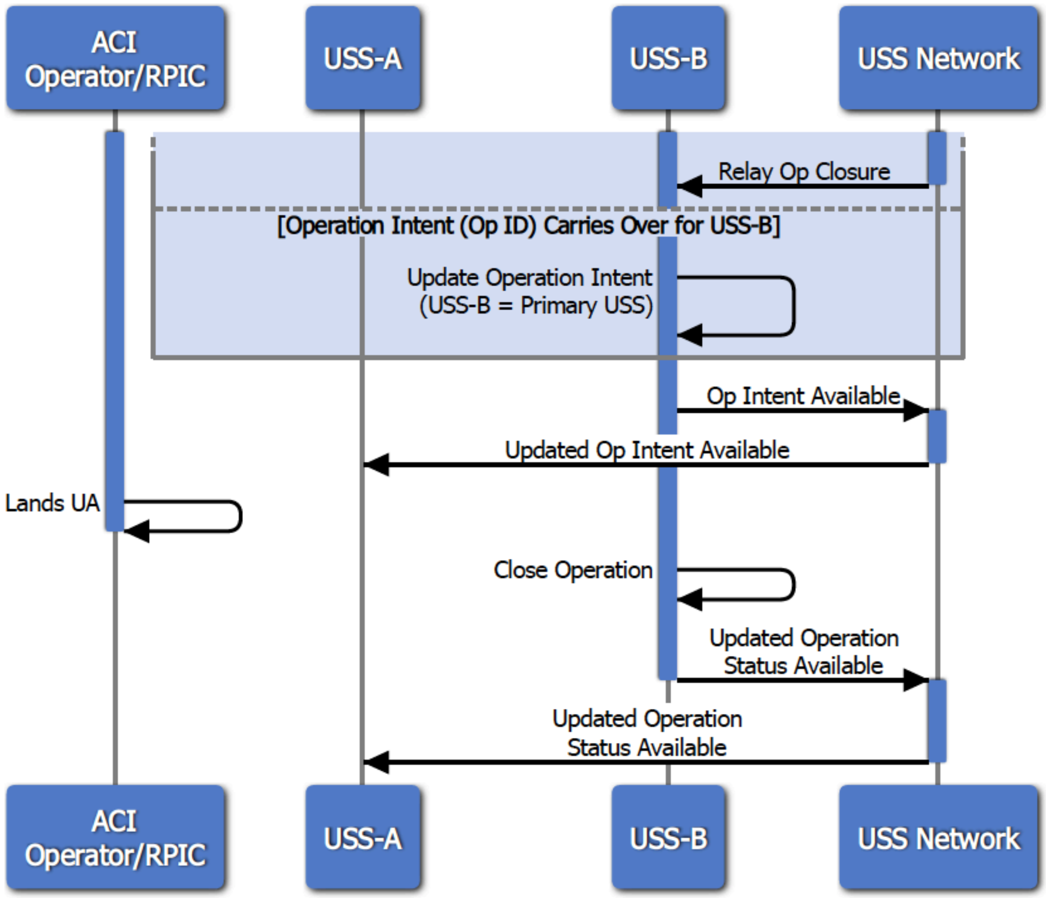


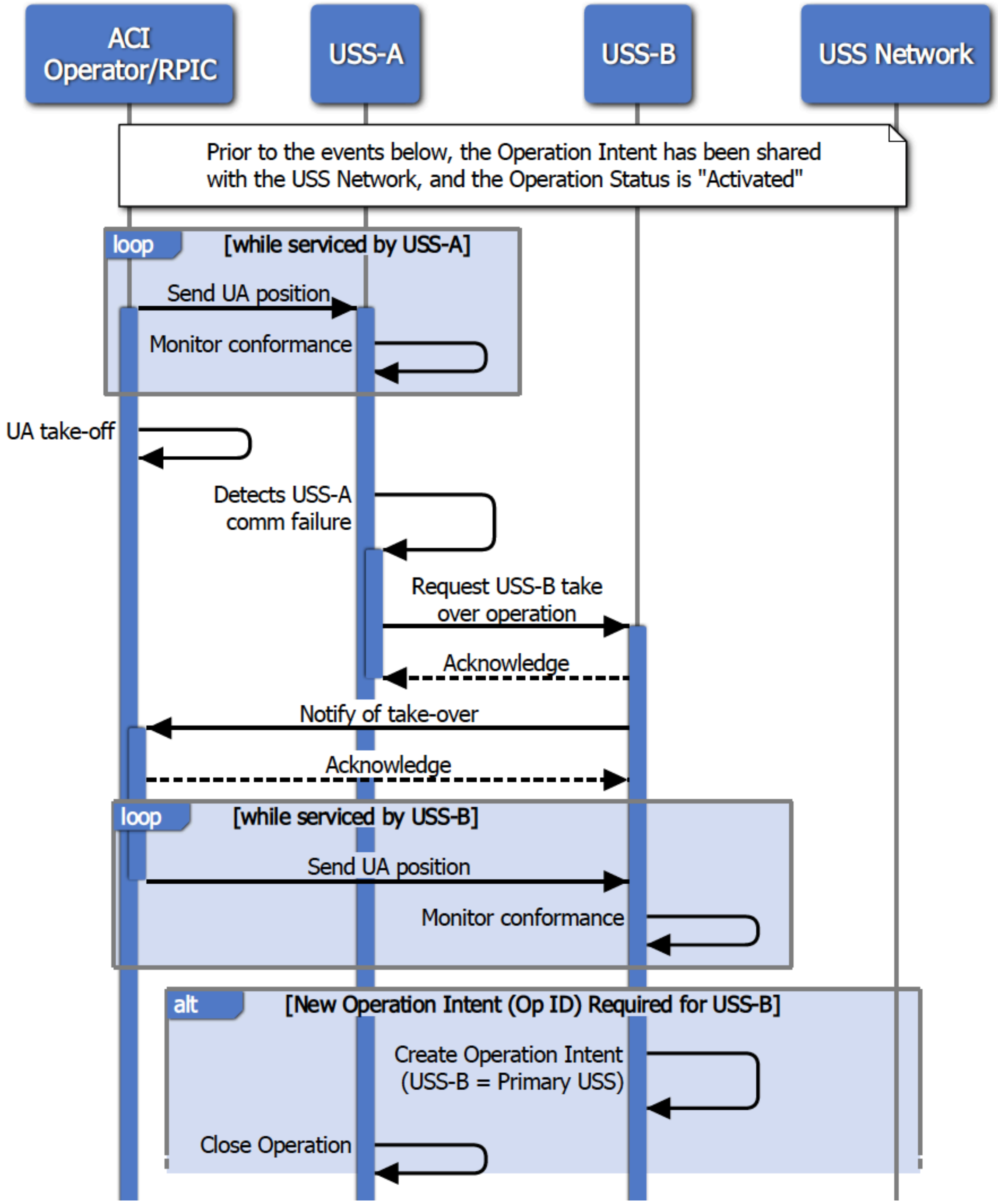
Exploration 2: USS-A Notifies USS-B of Need for Hand-Off[4]

USS-A determines and cannot connect to the GCS due to equipment issues on their own side. USS-B, through agreement with USS-A, provides back-up services as needed for this operation. USS-A contacts USS-B to request they take over servicing the operation. USS-B acknowledges the request, and sends a message to the RPIC GCS indicating they have been requested to take over services for the operation by USS-A. The RPIC confirms the request, and begins sending position information to USS-B. USS-B sends out an updated (or new, see Footnote 3) set of Operation Intent to the USS Network, which contains an update to the servicing/primary USS (now USS-B).

The inspection operation continues to conclusion without further complications.

[4] Explorations 2 and 3 assume that USS-A and USS-B have an established agreement in which USS-B provides redundancy to USS-A in the event of service issues. These explorations are not implying a requirement of USSs or of the USS Network. As previously noted, these explorations are meant to foster discussion, and are not exhaustive regarding possible ways of addressing this situation.

3.2.1.2.2 Operational View – Scenario 1 – USS-A Notifies USS-B of Need for Hand-Off



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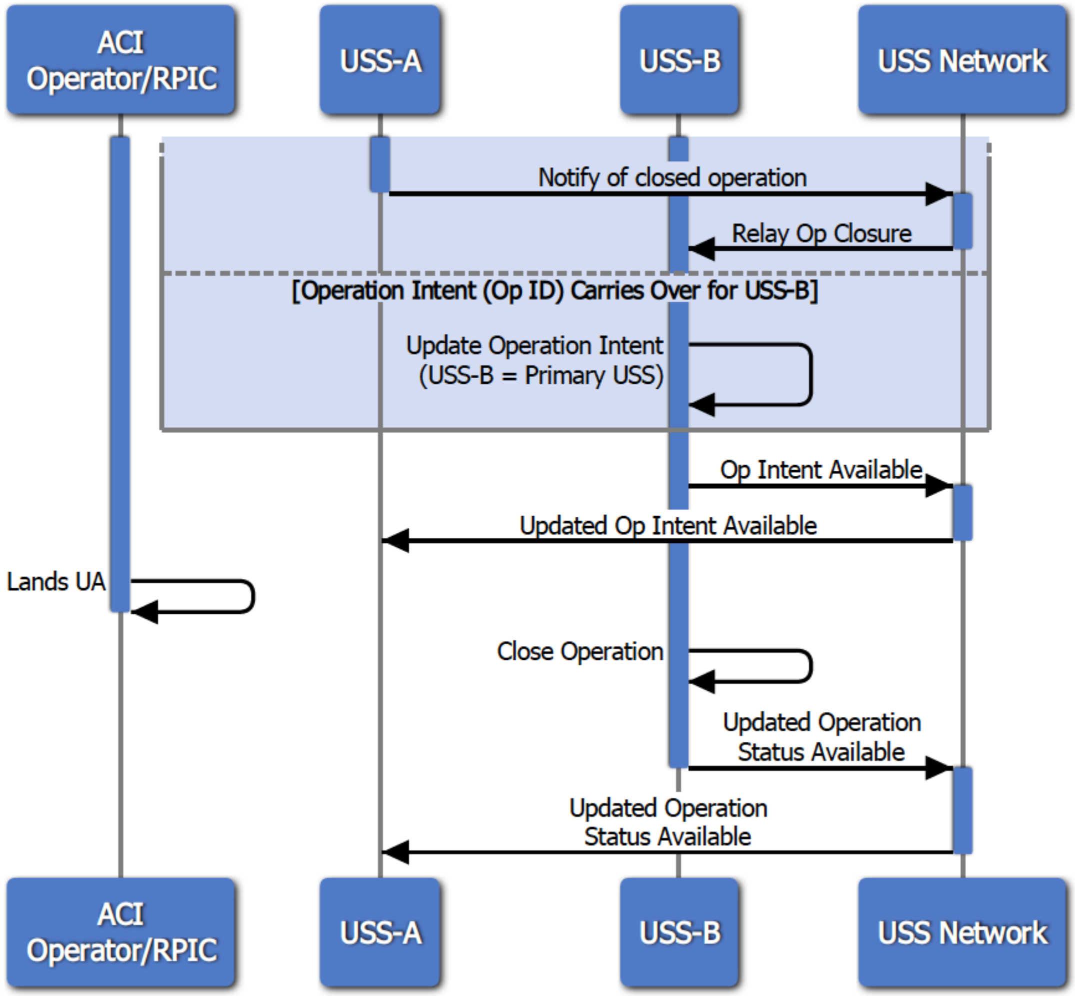


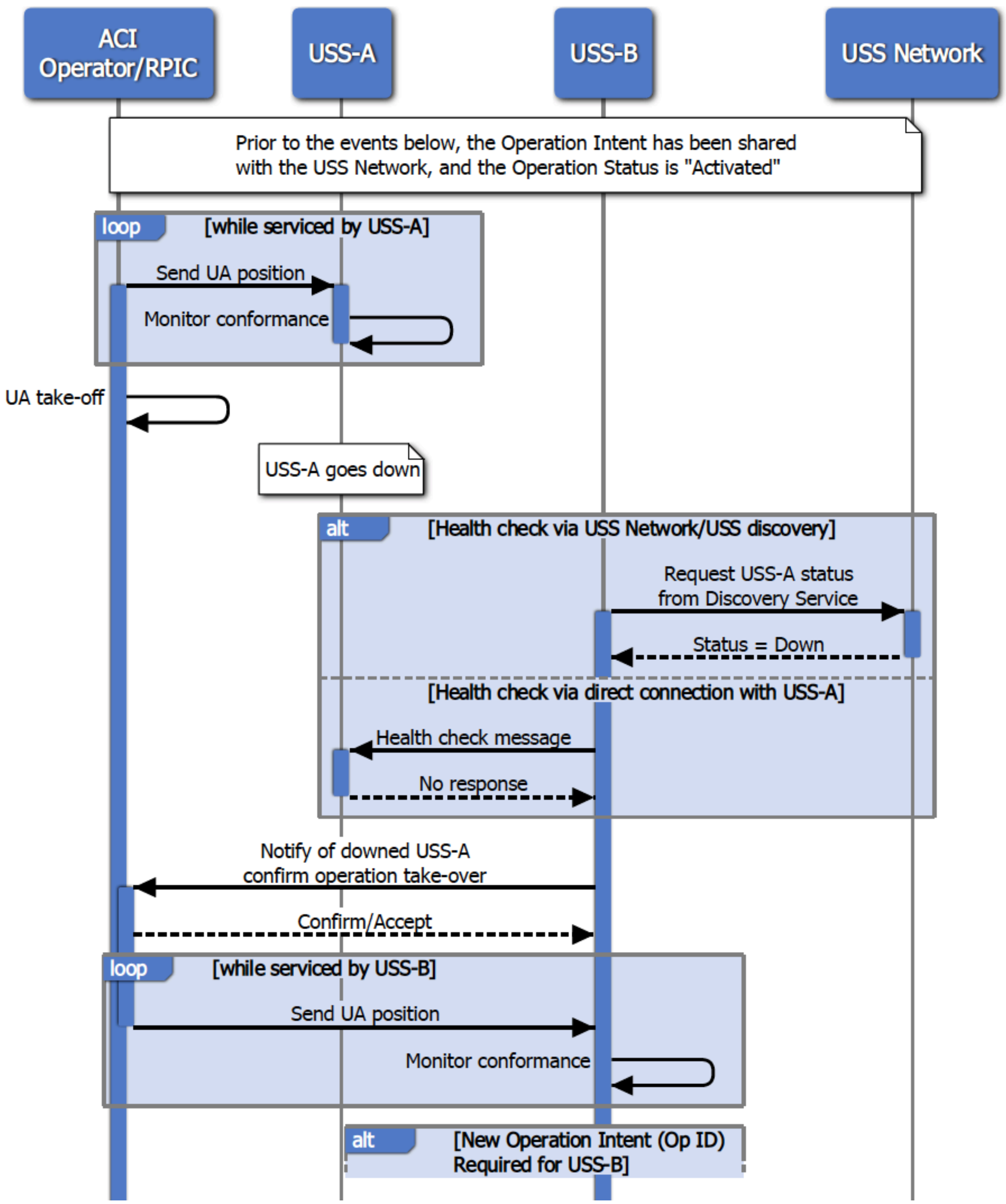
Exploration 3: USS-B Detects the Need for Hand-Off

In this situation, USS-A is assumed to be completely off-line, with no connection to the USS Network. USS-B, as back-up to USS-A, monitors the connection status of USS-A to the network, or maintains a connection to USS-A as a health check, or monitors through some other method. USS-B determines USS-A is no longer connected to the network, and thus cannot continue to service the AIC Operator and RPIC in their responsibilities to share operation information with relevant stakeholders (e.g., nearby operators, FAA, etc.).

USS-B sends a message to the RPIC GCS indicating they have detected an interruption to USS-A services, and that they are requesting to take over services for the operation. The RPIC confirms the request, and begins sending position information to USS-B. USS-B sends out an updated (or new, see Footnote 3) set of Operation Intent to the USS Network, which contains an update to the servicing/primary USS (now USS-B).

The inspection operation continues to conclusion without further complications. If USS-A comes back on-line prior to the scheduled end of the operation, and new Operation Intent was created by USS-B (as opposed to updating the original intent), then USS-A closes the original operation and sends the status update to the USS Network.

3.2.1.2.3 Operational View – Scenario 1 – USS-B Detects the Need for Hand-Off



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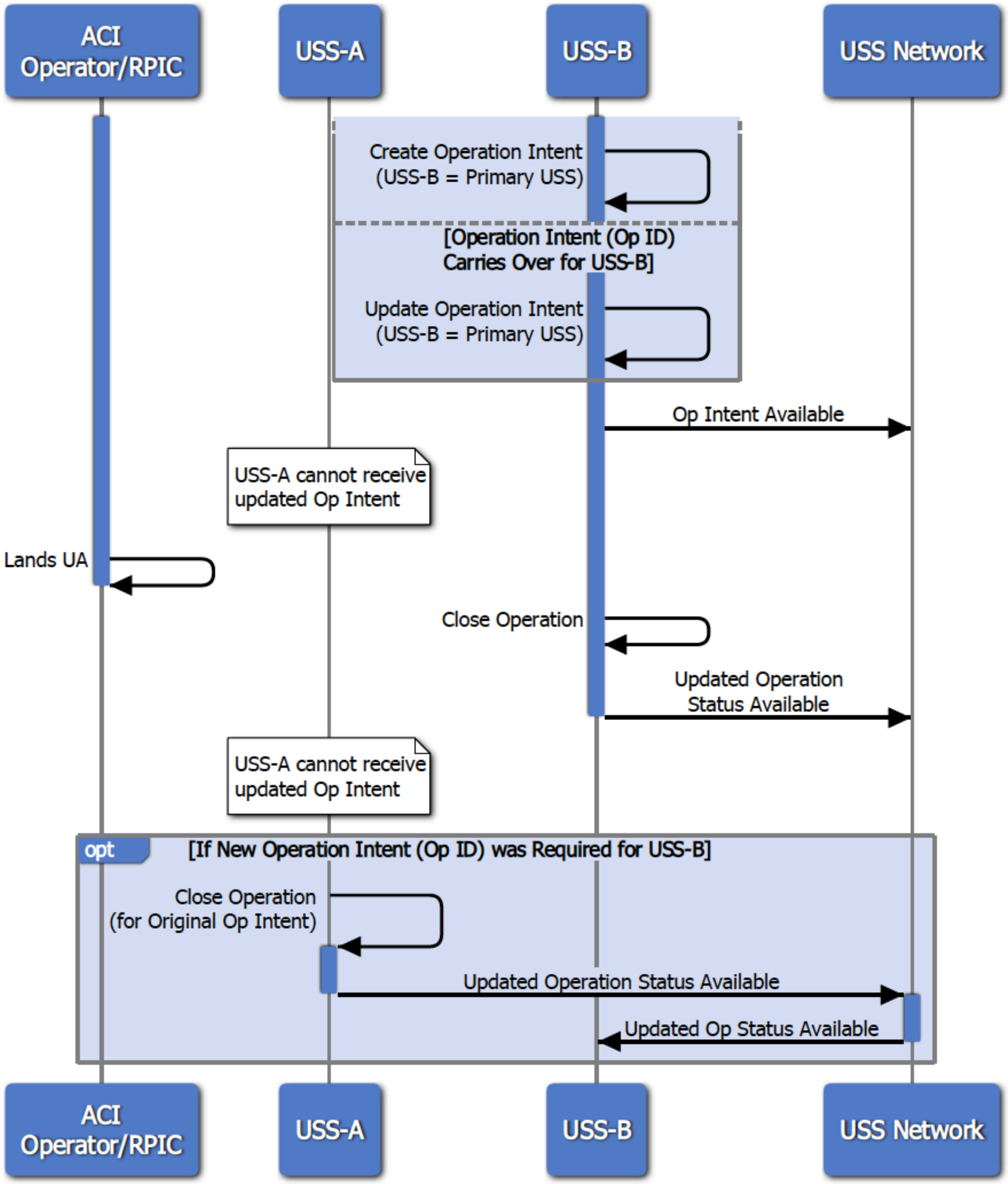


NOTE: Future C2 link capabilities could include a USS being directly connected to a sUAS. In such circumstances, loss of USS-A services to the Operator, including the C2 link, would result in the Operator having to execute lost-link contingency procedures if USS-B does not provide the same service as USS-A. This use case does not address this type of scenario (refer to Use Case TCL3-4 for a lost-link event in uncontrolled airspace).

3.2.2 Scenario 2: sUAS Operator Unable to Adhere to Operator Performance Authorization Requirements

3.2.2.1 Scenario 2 Planning

For this scenario, the planning is conducted exactly as in Scenario 1 (see §3.2.1.1).

3.2.2.2 Scenario 2 Execution

Thirty (30)s minutes into the inspection the RPIC receives an alert from the GCS that connection to USS-A has been disrupted. Attempts by the RPIC to reestablish communications by primary and backup systems are unsuccessful, as are attempts to connect to USS-B. The RPIC concludes that the communications error is due to an issue with his GCS.

The ACI RPIC knows that the ACI Operator satisfies parts of the requirements for the Performance Authorization through utilization of USS services, including keeping informed of airspace constraint status, provision of Operation Status and Intent updates, and receipt of status updates for other UA operations in close proximity. Without these capabilities, the ACI sUAS Operator is unable meet the conditions of their Performance Authorization and must cease the inspection operation as soon as practicable.

USS-A updates the inspection operation to Rogue status and notifies the USS Network when communications with the ACI RPIC have failed, not reestablished between the ACI RPIC and USS-A, and alternate USS-B communications with the sUAS Operator/RPIC have not been established within the time frame in accordance with the mutually agreed protocol.

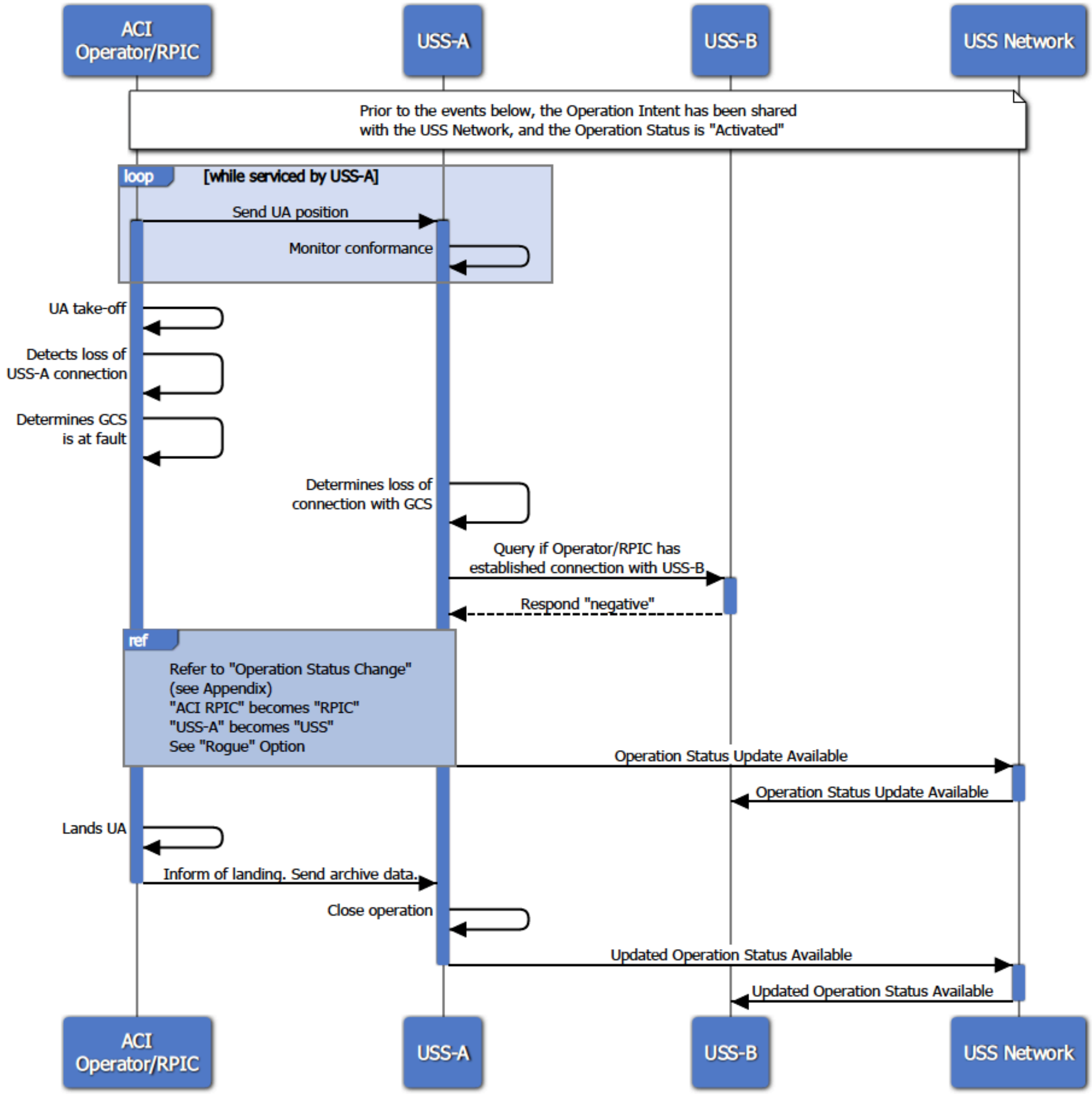
The transit volume back to the launch/recovery location will not be active again for another 30 minutes, and the RPIC cannot determine if there are new operations that may be active in the same geographic location as the transit volume, due to the loss of connection with USSs that can provide the information. Since the ABOV the UA is currently in extends to the ground, the RPIC opts to land at an alternate location within that volume, and manually retrieve the UA later. With the direct command and control link between the RPIC and the UA functioning properly, the RPIC conducts a safe BVLOS landing of the UA.

When communications are later reestablished with USS-A, the ACI Operator provides notification of the safe BVLOS landing and requests that the inspection operation be placed in a closed status, which USS-A implements[5].

All data from the operation is stored for sharing with the USS upon return to the company office. The owner of the orchard is contacted, and arrangements made for recovery of the quadcopter.

[5] For the purposes of this use case, the operation remains in an active state until positive confirmation can be obtained by the primary or alternate USS from the Operator/RPIC that the UA has landed, the revised operation has ended, and it is safe to close the operation volume. A topic for discussion his whether there may be situations, such as a significant passage of time after planned operation closure without the Operator re-establishing contact with the USS, in which the USS closes the operation without Operator input.

3.2.2.3 Operational View – Scenario 2



3.3 Roles and Responsibilities

Table 3-3 – Roles and Responsibilities – Use Case TCL 3-7

Service/Function		Actors				Explanatory Notes
		X=direct responsibility | S=support role				
		RPIC	Operator	USS	FAA	
Separation	VLOS sUAS from VLOS sUAS					Not Explored in Use Case
	VLOS sUAS from BVLOS sUAS					Not Explored in Use Case
	BVLOS sUAS from BVLOS sUAS	S	X			
	VLOS sUAS from Low-Altitude Manned A/C					Not Explored in Use Case
	BVLOS sUAS from Low-Altitude Manned A/C					Not Explored in Use Case
Hazard/ Terrain Avoidance	Weather Avoidance					Not Explored in Use Case
	Terrain Avoidance					Not Explored in Use Case
	Obstacle Avoidance					Not Explored in Use Case
Status	UTM Operations Status			X		
	Flight Information Archive		X	S		Operator delegates to USS
	Flight Information Status	S	X	S		
Advisories	Weather Information					Not Explored in Use Case
	Hazard Information (Obstacles, terrain, etc.)					Not Explored in Use Case
	Alert Affected Airspace Users of sUAS Hazard					Not Explored in Use Case
	sUAS-Specific Hazard Information (Power-Lines, No- sUAS Zones, etc.)					Not Explored in Use Case

Table continued…

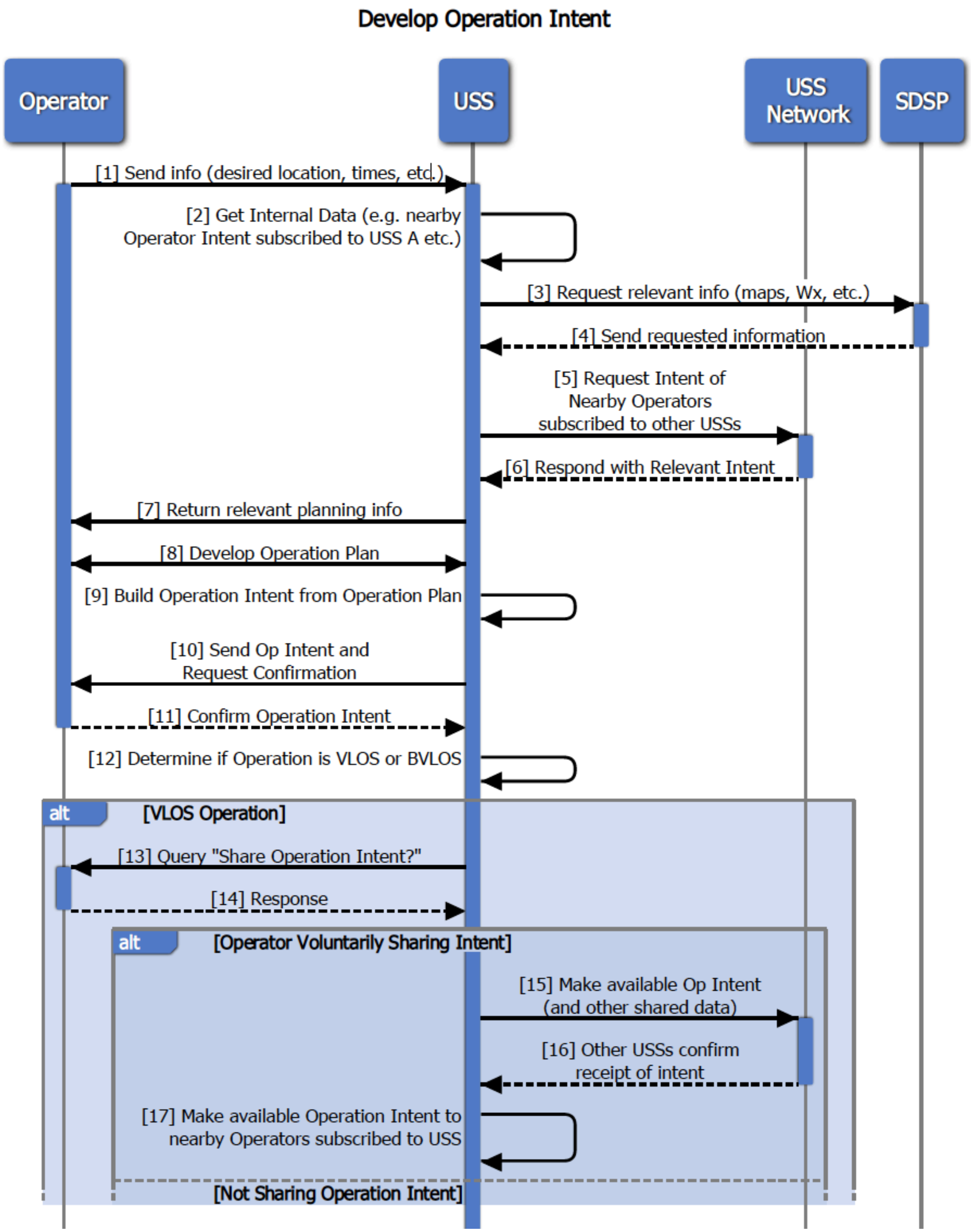
Service/Function		Actors				Explanatory Notes
		X=direct responsibility | S=support role				
		RPIC	Operator	USS	FAA	
Planning, Intent and Authorization	Priority Status Notification (emergency declaration, public safety, etc.)					Not Explored in Use Case
	Operation Plan Development		X	S		
	Operation Intent Sharing (pre-flight)		X	S		
	Operation Intent Sharing (in-flight)		X	S		
	Dynamic Restriction Request					Not Explored in Use Case
	Operation Intent Negotiation					Not Explored in Use Case
Operations Management	Demand Capacity Management					Not Explored in Use Case
	Airspace Access Management					Not Explored in Use Case
	Airspace Organization					Not Explored in Use Case
	Control of Flight	X				
	Airspace Allocation & Constraints Definition					Not Explored in Use Case

Acronyms

Term	Definition
AGL	Above Ground Level
ABOV	Area-Based Operation Volume
BVLOS	Beyond Visual Line of Sight
C2 Link	Command and Communications Link
CFR	Code of Federal Regulations
CWG	Concepts Working Group
DR	Dynamic Restriction
FAA	Federal Aviation Administration
FIMS	Flight Information Management System
NAS	National Airspace System
NASA	National Aeronautics and Space Administration
OOP	Operations Over People
OV	Operational View
PIC	Pilot in Command
sUAS	Small Unmanned Aircraft System
RPIC	Remote Pilot in Command
RTT	Research Transition Team
SDSP	Supplementary Data Service Provider
TBOV	Transit-Based Operation Volume
TCL	Technical Capability Level
UA	Unmanned Aircraft
UAS	Unmanned Aircraft System
UREP	UAS Report
USS	UAS Service Supplier
UTM	Unmanned Traffic Management
VLOS	Visual Line of Sight

Appendix A

The following pages of this section contains two diagrams for OV-6c sub-activities: 1.) Develop Operation Intent, and 2.) Operation Status Change



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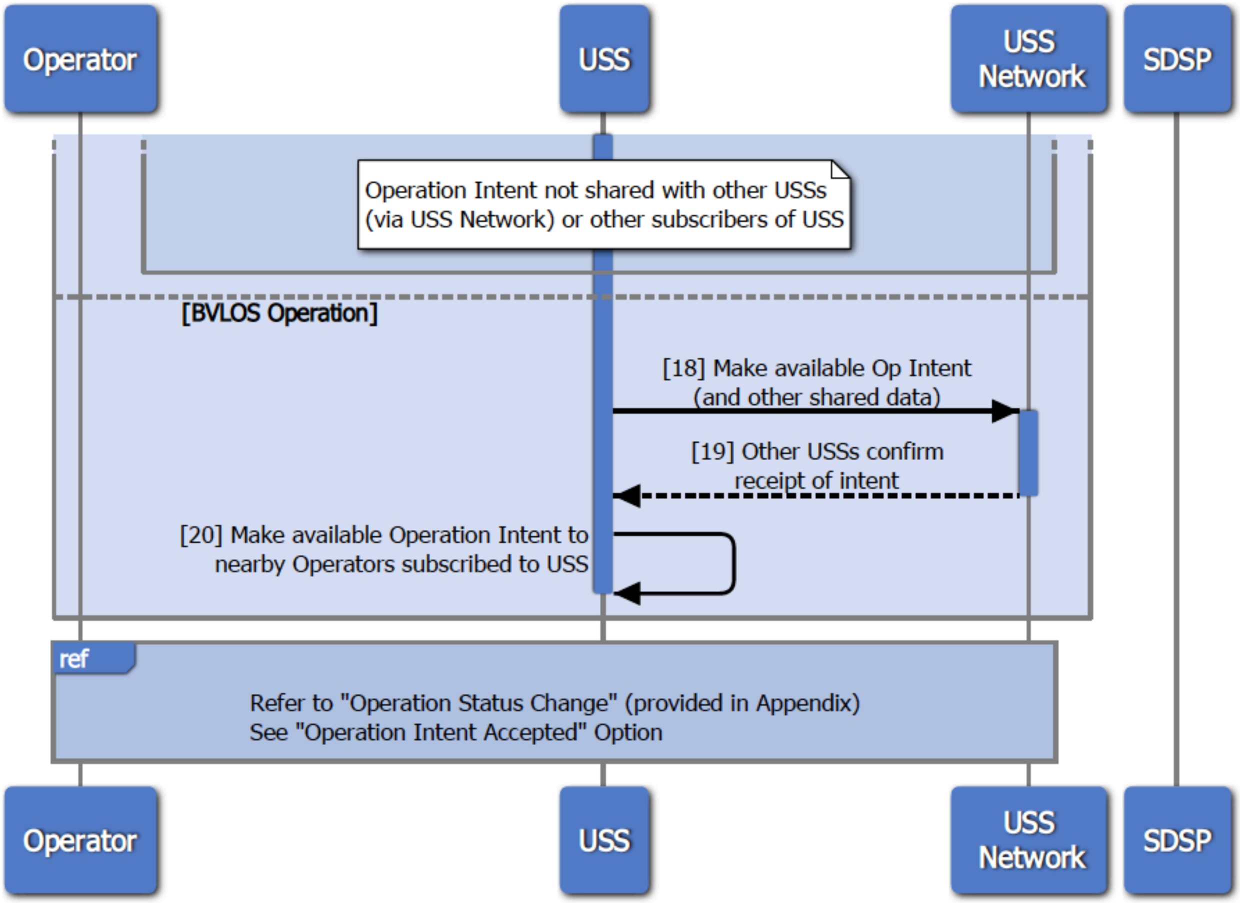

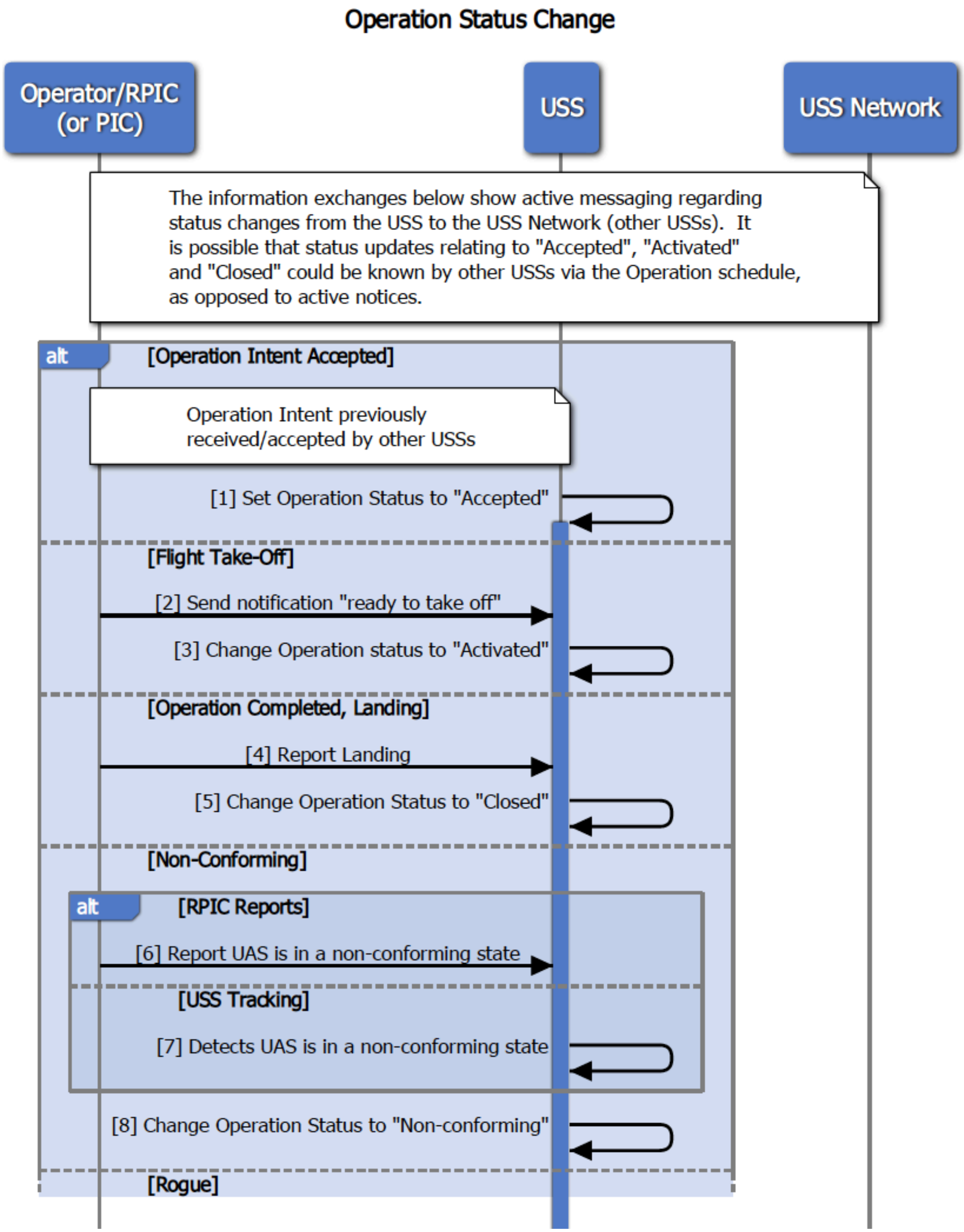

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