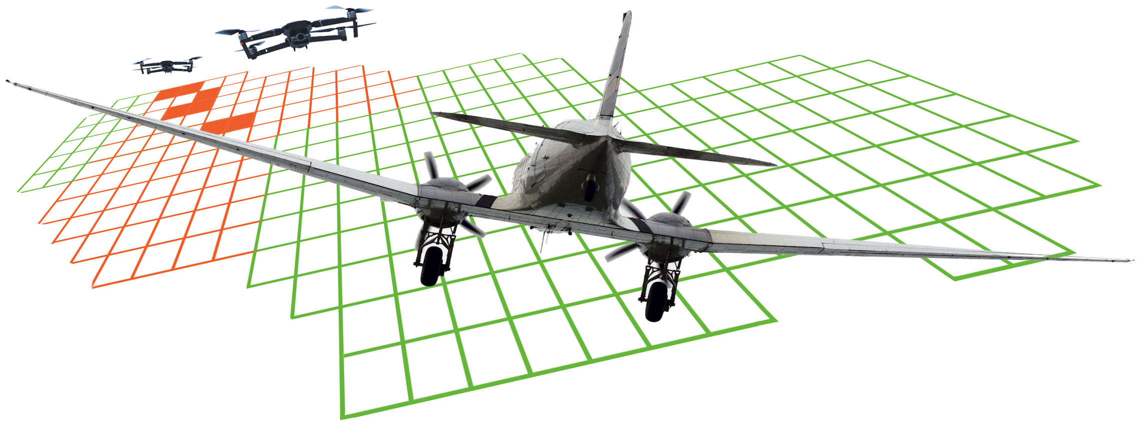


Improving Cockpit Awareness of Unmanned Aircraft Systems Near Airports

A method to display active LAANC/UTM airspace to manned aircraft pilots

—A Working Paper—

Version 1.0 — March 8, 2019

Invitation for Comment

Comments to Michael Baum — michael@secureav.com

ACI AVIATORS CODE INITIATIVE

This is a *working paper* offered for the limited purpose of sharing ideas and eliciting critical input. It will continue to be revised.

About the Aviators Code Initiative

The Aviators Code Innovative (ACI) provides tools advancing aviation safety though its vision of excellence for aviators. With nearly a half century of aviation experience, the Permanent Editorial Board builds upon the ACI's 17-year foundation of creating a family of best practices guidance materials for manned aircraft pilots, flight instructors, aviation maintenance technicians, and more recently, unmanned aircraft pilots.

Other ACI Publications Addressing Unmanned Aircraft Systems:

The UAS Pilots Code

Recommended Practices to Enhance the Quality & Safety of UAS Flight Operations
http://www.secureav.com/UAS-Listings-Page.html

Flight Safety in the Drone Age

Safety Guidance for Manned Aircraft Pilots Operating in the Presence of Drones
http://www.secureav.com/Drone-Listings-Page.html

Improving Cockpit Awareness of Unmanned Aircraft Systems Near Airports

A method to display active LAANC/UTM airspace to manned aircraft pilots
http://www.secureav.com/UAS-Awareness-Listings-Page.html

Summary Contents

1. **Introduction**
2. **Statement of Problem**
3. **Proposed Method for Mitigation**
4. **Concept of Operations**
5. **Advantages: Voluntary, UTM-Aligned, Open**
6. **Additional Future Recommendations**
7. **Conclusion**
8. **Appendices**

Table of Contents

1. Introduction 7

2. Statement of Problem 7

3. Proposed Method for Mitigation 8

4. Concept of Operations 9

Figure 1 - Prototype Active UASFM Segment Display 10

5. Advantages: Voluntary, UTM-Aligned, Open 11

Figure 2 - MOAs vs. UASFM Segments 11

Figure 3 - Notional System Architecture 12

6. Additional Future Recommendations 12

a. Conventional Notification Tools 12

Figure 4 - Prototype EFB Representation of LAANC - Oklahoma City Area 13

Figure 5 - KOKC LAANC UASFM 13

b. Integration of Ground Control Station, sUAS, and Connected Device Position Data 14

c. Traffic Sensor Integration 14

d. Terrain Risk Data Integration 14

Figure 6 - Terrain-Based LAANC Airspace Separation Risk 14

e. Display of Ad Hoc UTM Corridors 15

f. Human-Readable Waypoints 15

Figure 7 - Gulf of Mexico Grid System Excerpt 15

Figure 8 - Gulf of Mexico Grid Enlargement 15

Figure 9 - Galveston UASFM Segment GlobalID 16

g. UASFM Overlays at Non-LAANC Airports 16

h. ATCT Operational Tool Supplement 16

7. Conclusion 16

8. Appendices 18

Appendix 1. *UASFM Segments: Potential Separation Issues* 18

Figure 10 - Sample UASFM Segments 18

Example 1: Helicopter LPV Final Approach Course Intersecting LAANC Airspace 18
Figure 11 - Hospital Copter Approach 19
Figure 12 - Conflicting UASFM Segments 19
Example 2: Helipad Approach through LAANC Airspace 20
Example 3: Marginal LAANC Airspace Buffer Inside FAF 21
Figure 13 - KPAO GPS Final Approach 21
Figure 14 - Abutting Airport Segments 21
Example 4: Final Approach Path Without LAANC Buffer 22
Figure 15 - KAPA RNAV FAF to Airport 22
Figure 16 - KAPA RNAV (GPS) 17L MDA 22
Figure 17 - KAPA LAANC UASFM Segments 22
Example 5: IFR to Adjacent VFR Airport Transition 24
Figure 18 - Medford to Ashland Transition - Sectional 24
Figure 19 - Medford to Ashland Transition - UASFM 24
Example 6: Dulles Int'l Airport (KIAD) Final Approach Conflict 25
Figure 20 - KIAD RNAV (GPS) Rwy 12 25
Figure 21 - Intersecting UASFM Segment 25
Example 7: South Shore Helicopter Route Abeam JFK Int'l Airport 26
Figure 22 - South Shore Helicopter Route Below KJFK Bravo 26
Figure 23 - UASFM Segments Below KJFK Bravo Airspace 26
Example 8: LAANC Segment Saturation 27
Figure 24 - FAA LAANC Administrative Tool 28
Appendix 2. *Service Protocols and Message Format Overview* 29
Figure 25 - FIS-B Products by Product Class 29
Figure 26 - Prototype FAA Domestic NOTAM for UASFM Segment 30
Figure 27 - Prototype ICAO NOTAM for UASFM Segment 30
Figure 28 - Graphical Overlay Record [Ref. *DO-358*] 32
Figure 29 - Prototype Graphical Overlay Record - Element Analysis 33
Appendix 3. *System Architecture* 36
Figure 30 - Notional System Architecture 36
Appendix 4. *Abbreviations* 38

Appendix 5. *Glossary of Selected Terms* 42
Figure 31 - Selected CAS and DAA Standards and Concepts 43
Appendix 6. *Selected References* 47
Acknowledgements 54
Endnotes 57

**

"Ideally, all NAS airspace users should have access to situational awareness information about UAS flights relevant to them. Disseminating UAS activity to other airspace users ensures safety of flight . . . ."

LAANC CONOPS[1]

1. *Introduction*

There is an emerging aviation safety concern regarding risks to manned flight from the increasing population of small Unmanned Aircraft Systems (sUAS).[2] This paper describes a method to support pilots in manned aircraft by providing them with essential safety information: the potential location of nearby sUAS within certain active[3] Unmanned Traffic Management (UTM)-enabled airspace.[4] Such airspace is designated within UAS Facility Map (UASFM) segments[5] reflecting Low Altitude Authorization and Notification Capability (LAANC)[6]-enabled airspace. UASFM segments specify maximum altitudes authorized for certain sUAS operations without further coordination with the controlling facility. Enhanced awareness of nearby UAS could be crucial to flight safety as manned aircraft pilots are required by regulation to be familiar with all available information[7] to avoid operating an aircraft so close to another aircraft as to create a collision hazard, and to see and avoid other aircraft.[8] The proposed method would serve as a non-exclusive, interim safety mitigation until the widespread deployment of effective sUAS traffic detection and avoidance technologies. The method may also have future applicability to other airspace proximate to airports.

The intended audience for this proposal includes:

- Experts in civil aviation operations, policy, safety, and technology
- Air Navigation Service Providers (ANSPs) and ANSP policy-making organizations
- Companies specializing in aeronautical information products and services that mitigate loss of separation, and advance aviation safety
- Pilots, flight departments, and aviation associations committed to promoting aviation safety

2. *Statement of Problem*

Small unmanned aircraft systems challenge manned aircraft pilots in terms of see and avoid.[9] Small UAS cannot be detected by manned aircraft systems without supplemental equipment that is not yet generally available or practical.[10] Additionally, most sUAS do not broadcast surveillance/position data such as via ADS-B[11] Out.[12]

Small UAS risks to manned aircraft tend to increase in proportion to their proximity to those aircraft, and are typically greatest at or near airports.[13] NOTAM[14] system limitations may impede effective notification of sUAS operations near airports, particularly in proximity to private airport and heliport facilities.[15] Additionally, LAANC authorized operations are not generally the subject of NOTAMs. Nonetheless, “NAS users are required to review published notification information for relevant UAS activity along their intended routes of flight.”[16]

Moreover, air traffic control tower (ATCT) advisories to manned aircraft pilots concerning nearby sUAS operations are typically issued only at controllers' discretion, if available at all, and may not be precise or accurate.[17]

Furthermore, the FAA order instructing ATC personnel how to designate safe altitudes for UASFM segments may not provide sufficient guidance to facilitate safe separation between sUAS and manned aircraft,[18] and the order's implementation lacks stakeholder input and consistency among similarly situated airports.[19]

Finally, to address hazards associated with sUAS operating near airports, Federal law required model aircraft operators to notify the airport operator and the airport air traffic control tower.[20] The law was subsequently revised to require authorization (paralleling Part 107 obligations).[21] However, even this revision falls short of providing effective notice to those with the greatest and most immediate need—manned aircraft pilots. Nonetheless, the FAA LAANC CONOPS states, "Ideally, *all* NAS airspace users should have access to situational awareness information about UAS flights relevant to them. Disseminating UAS activity to other airspace users ensures safety of flight as UAS present additional safety concerns . . . that vary significantly from manned aircraft."[22]

This proposal seeks to address these challenges in the near-term, and contemplates a migration path to ubiquitous UTM support in the future. It recognizes that a single approach to separating manned and unmanned traffic is less than optimal,[23] and urges engagement of the manned aircraft community, and support for manned aircraft operations.

3. *Proposed Method for Mitigation*

To improve manned aircraft pilot awareness of sUAS in LAANC-enabled environments, this proposal suggests a method for display of nearby active UASFM segments in the cockpit.[24] Relevant UASFM operation data would be transmitted for graphical presentation on cockpit avionics, electronic flight bags (EFB),[25] tablets, and other displays via diverse networks,[26] services and protocols including satcom,[27] Flight Information Services-Broadcast (FIS-B),[28] and cellular networks.[29]

The proposed method is consistent with—and a modest extension of—available services. Using existing infrastructure, data-sharing, and graphical product protocols and standards, this method:

- requires no additional ground or airborne surveillance equipment,
- supports all sUAS using LAANC,
- supports all LAANC-enabled airspace, and is extensible to other airspace,

- requires minimal pilot training,[30]
- is not comparably susceptible to UAS electromagnetic interference, radar, or radio propagation or reception limitations (to the extent its authorization data derives from terrestrial servers facilitating LAANC authorizations rather than radio-communicated sensors),
- displays the authorized altitude of active UASFM segments and is thus unaffected by altimetric errors stemming from barometric equipment or GPS,[31]
- responds to the greatest hazard identified by the LAANC Preliminary Hazard Analysis: granting authorization that should have been rejected,[32]
- requires only small, manageable data transfers,[33]
- exploits the widespread use of electronic flight bags, tablets, and fixed avionics displays in the cockpit,[34]
- could integrate sUAS position data derived from available onboard GPS, ground control stations (GCS), linked cellular, and other devices to enhance confidence in LAANC authorization data, and to help fill gaps where authorization data becomes unavailable,
- could fuse ground-based sensor output to increase data confidence, and display UASFM segments containing non-cooperative aircraft,
- could be implemented quickly throughout the NAS, with non-certified products and services leading implementation,
- provides additional hazard mitigations, including support of certain UAS waiver applications,[35]
- avoids personally identifiable and UAS Service Supplier (USS) proprietary information,[36] and
- could support open data architecture for interoperability.

4. *Concept of Operations*

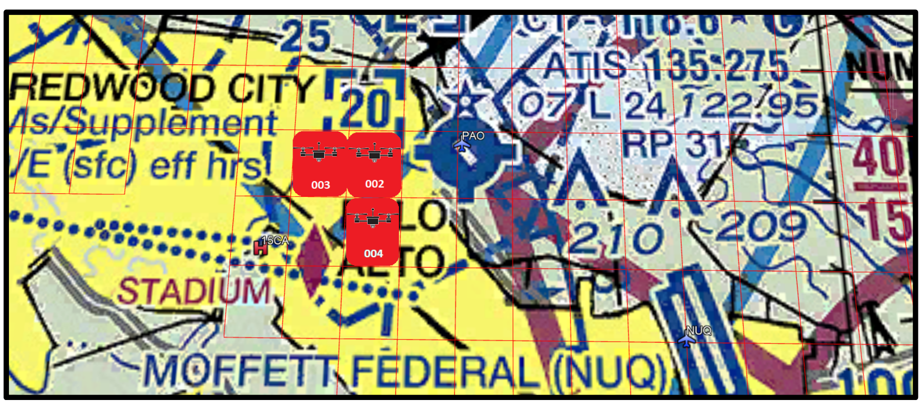
sUAS use LAANC to obtain authorization to fly in designated low altitude airspace near airports. For the proposed method, no beacon or other additional sUAS-on-board equipment would be required.

Data regarding active UASFM segments proximate to a manned aircraft, including location, authorization start and end time, and maximum authorized segment altitude would be queried, discovered, and transmitted[37] via the FAA UAS Data Exchange[38] to properly equipped manned aircraft within a limited airspace volume via diverse public and private communication services and applications (including via satellite, surveillance/flight information broadcast,[39] and cellular).[40] Additionally, for manned aircraft pre-flight planning purposes, such data would be made available to internet-accessible/IP-based applications.[41]

Manned aircraft near[42] active LAANC-enabled airspace could display[43] the relevant UASFM segment(s)[44] as geo-located polygons—each containing the highest UASFM segment altitude authorized for sUAS operation (0-400 ft. AGL in 50 ft. increments; or the altitude approved by ATC, if higher than published value). This aeronautical information is a logical extension[45] of that provided by current FIS-B Text with Graphical Overlay (TWGO) products,[46] such as NOTAM (D) information transmitted to the cockpit.[47]

Figure 1, below, presents an example of how active UASFM segments could be overlaid on a sectional aeronautical chart display. *Red rectangles* denote active UASFM segments, embedded s*UAS graphic icons* identify UASFM segment airspace, and *numerical digits* denote UASFM segment maximum authorized altitude (x100 ft. AGL).[48] The graphical display of such segments could (i) be made semi-transparent to avoid obscuring base-map information; (ii) deprioritized to allow the display of active traffic, specific airspace/restrictions, and hazardous meteorological information,[49] (iii) provide user zoom in/out and pan capability, (iv) present associated text as a pop-up by touching or otherwise querying the graphic, (v) provide change notifications, and (vi) display a distinct color for authorizations requiring further coordination (e.g., for flight at altitudes above standard LAANC maximum altitudes).[50]

Figure 1 - Prototype Active UASFM Segment Display



This proposal could also extend to UASFM segments reserved for future and impending active status by displaying distinct coloration (e.g., orange or yellow vs. red, as is current industry practice for TFRs) for segments approaching saturation,[51] altitude proximate to ownship, other critical LAANC status information,[52] or other UTM-relevant volumes of airspace.[53]

5. *Advantages: Voluntary, UTM-Aligned, Open*

The display of active UASFM segments as described in this proposal would be voluntary and at the full discretion of the pilot-in-command of each aircraft (e.g., a layer containing UASFM segment data could be toggled on/off at will).[54] Thus, consistent with widely held manned and unmanned traffic management (UTM) design expectations, such information would remain unobtrusive to the ATC system, intuitive, and user-friendly all while promoting shared situational awareness.[55]

Consider the safety benefit of displaying UASFM segment data where authorized UAS activity may represent a threat merely a few hundred feet (or closer) to manned aircraft, in contrast to the currently available display of military operations areas (MOAs) that may represent a threat one hundred miles away (see Figure 2).[56]

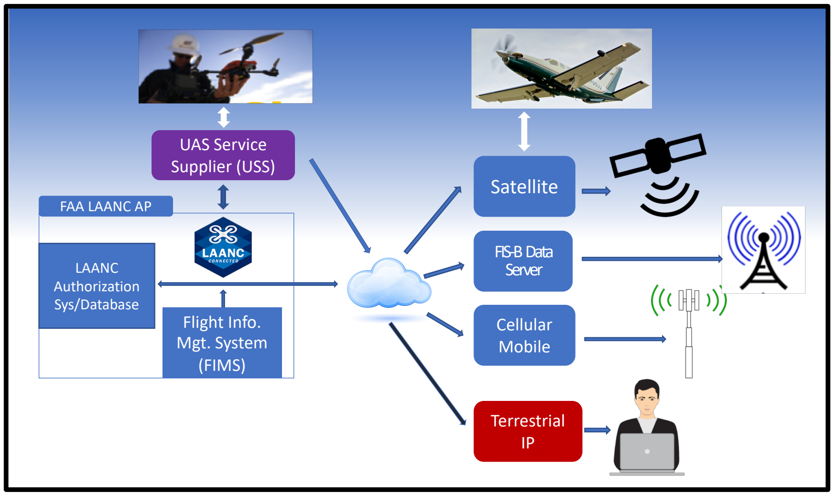
Figure 2 - MOAs vs. UASFM Segments

Military Operations Areas	UASFM Segments
Possibly 100+ *miles* from manned aircraft	Possibly 100s of *feet* from manned aircraft
Outside terminal areas, airways, flyways	In terminal environments
ATC provides minimum vertical separation (500') above or below MOAs	ATC provides no minimum vertical separation from UASFM segments
Presumption of hazard	Assumption of safety

The proposed method constitutes one safety barrier among several different safety mitigations (e.g., airspace separation limits, see and avoid, and deployed collision avoidance systems) that collectively advance airspace safety during sUAS operations.[57] Additionally, as a LAANC gateway connected application,[58] any qualified service provider[59] should be allowed to support the services and products described in this proposal.

Finally, Figure 3 presents an initial high-level, notional representation of the architecture supporting the proposal. Some of the systems and approaches presented are discretionary, evolving and future-looking. Thus, it is offered for discussion only. A description of the schema embodied in Figure 3 is presented in Appendix 3.

Figure 3 - Notional System Architecture



6. *Additional Future Recommendations*

a. Conventional Notification Tools

In concert with implementing this proposal, conventional notification tools[60] could describe/display LAANC-enabled airspace and the services presented in this proposal (in paper and electronic form) within relevant:

(i) airport *Chart Supplement U.S.* (AF/D) listings,[61]

(ii) sectional, terminal area (TAC), and other aeronautical charts,[62]

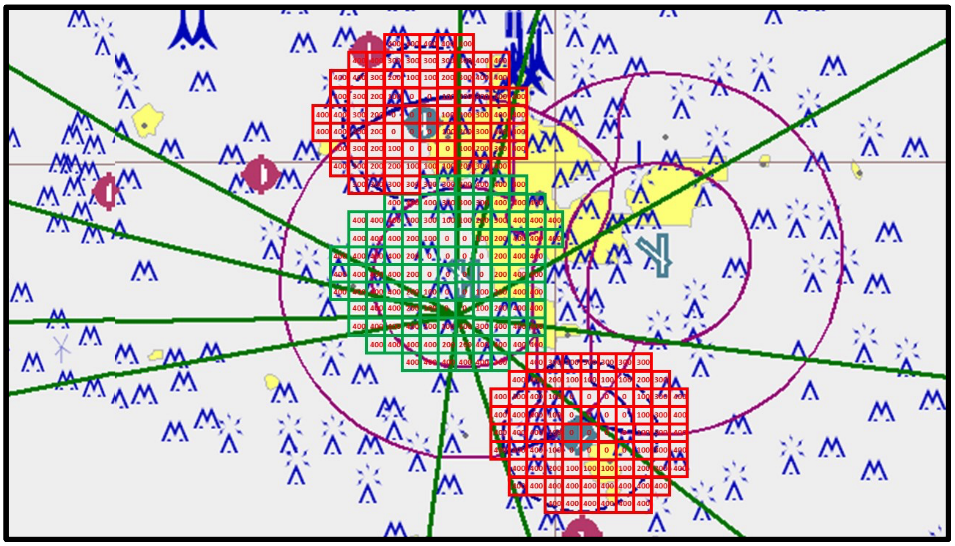
(iii) graphics or notes in approach, standard instrument departure (SID), standard terminal arrival (STAR) charts, and charted visual flight procedures (CVFP),

(iv) *Advisory Circulars* (ACs) specifically directed to manned aircraft pilots,[63] and

(v) *Aeronautical Information Manual* (AIM) sections.[64]

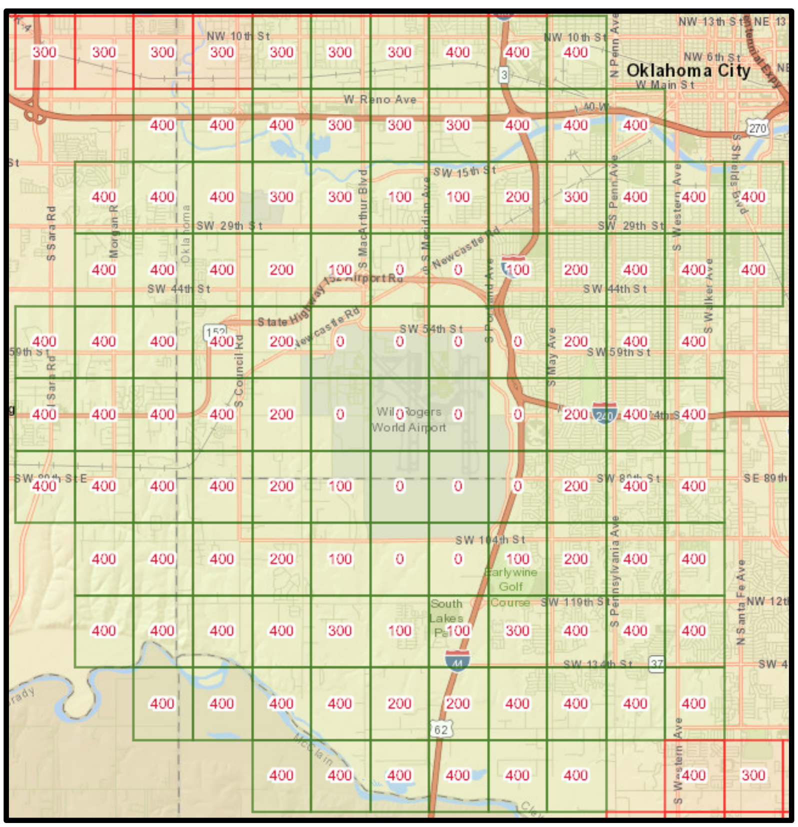
Figure 4 presents a prototype EFB representation of LAANC-enabled airspace in the Oklahoma City terminal area. It seeks to provide a strategic, high-level view of LAANC areas (red and green grid squares provide contrast among adjacent LAANC-enabled facilities). When implemented electronically, it could facilitate "zoom-in" (e.g., the central green UASFM area in Figure 4 enlarged in Figure 5 - KOKC) and other features to enhance situational awareness and usability.

Figure 4 - Prototype EFB Representation of LAANC - Oklahoma City Area



Source: Jeppesen

Figure 5 - KOKC LAANC UASFM



Source: FAA

These proposed new tools should be supported by both government and industry outreach, education, and testing to assist manned pilots to become aware of and learn how to use these tools effectively.

b. Integration of Ground Control Station, sUAS, and Connected Device Position Data

Additional position data from available ground control stations (GCS), sUAS, connected devices (via portals, open API, USSs, or third-party service providers), or via broadcast of device position could be converted to corresponding UASFM segments and then fused with LAANC authorization data for the limited purpose of: (i) supplementing LAANC authorization data to enhance confidence that a sUAS is operating in an active UASFM segment, (ii) substituting for LAANC authorization data where a sUAS pilot/operator failed to obtain authorization, or where such data becomes unavailable, and (iii) conditionally provide strategic, advisory awareness of uncooperative sUAS.[65]

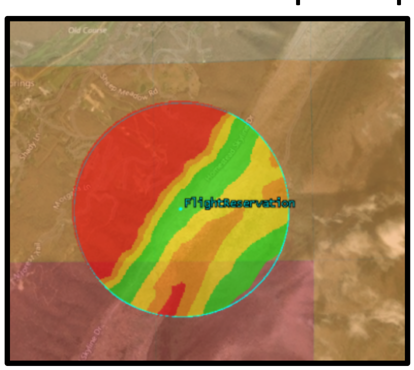
c. Traffic Sensor Integration

As an optional supplement, ground-based and airborne traffic sensors, including radar, electro-optical/infrared, thermal, and/or radio frequency (RF) data could be fused to enhance confidence in the state of LAANC authorizations, or to invoke additional UASFM segments.[66]

d. Terrain Risk Data Integration

Since most sUAS ascertain altitude based upon launch location, terrain variations underlying LAANC-enabled airspace and potential UAS altimetric equipment error may cause sUAS pilots to inadvertently exceed maximum-authorized altitudes. Terrain data could therefore contribute to an overall risk assessment and to an integrated (or separate) cockpit display layer to portray the potential for loss of separation and risk of sUAS collision. Figure 6 presents a graphical view of the risk to separation as a function of terrain variation underlying LAANC-enabled airspace.

Figure 6 - Terrain-Based LAANC Airspace Separation Risk[67]



Source: AGI

e. Display of Ad Hoc UTM Corridors

A further enhancement could provide limited/filtered [delimited] shared UTM planning and intent information, temporally limited to volumetric airspace data of dynamic, ad hoc UTM corridors within the immediate proximity of, and connected to the boundary of LAANC-enabled airspace. Since [planned] UTM corridors do not necessarily rely upon external buffers, a further enhancement could invoke or permit pilot-configurable buffers.[68] Consider that "Strategic Conflict Management (airspace design, airway / altitude separation, flight plan deconfliction) takes place outside the scope of [the core sUAS airborne collision avoidance system standard] sXu."[69]

f. Human-Readable Waypoints

To improve situational awareness and the accuracy and efficiency of communications regarding LAANC operations, certain of the above-mentioned charts could be enhanced to display LAANC grid segments with simple human-readable identification labels. Consider the Gulf of Mexico Grid System (Figure 6)[70] that defines over 300 offshore grid location waypoints located 20 min Lat/Lon apart (vs. UASFM segments of 1 min Lat/Lon), and supports the underlying oil/gas lease grid parcels—and associated helicopter operations, providing a practical "unique naming system [enabling] pilots and controllers to derive the fix position from the name."[71]

Figure 7 - Gulf of Mexico Grid System Excerpt

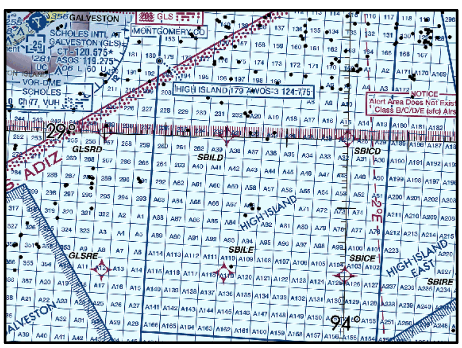
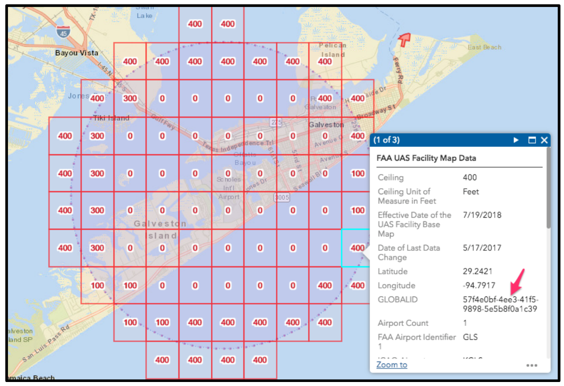


Figure 8 - Gulf of Mexico Grid Enlargement

Unlike the Gulf of Mexico Grid naming convention, UASFM segments do not incorporate a user-friendly identifier. Instead, they provide—off record—a "GlobalID"[72], presented exclusively as a hexadecimal string. For example, the 36-character GlobalID "57f4e0bf-4ee3-41f5-9898-5e5b8f0a1c39" (Figure 9 - see red arrow) corresponds roughly to the position "816" located SSW of the Gulf of Mexico waypoint **CRPCH** (Figure 8 - lower center).

Figure 9 - Galveston UASFM Segment GlobalID



Elements of other recognized grid systems may be incorporated into an effective implementation of the proposal.[73]

g. UASFM Overlays at Non-LAANC Airports

Service providers could deploy UASFM-like grid overlays at non-LAANC enabled airports to display available non-LAANC data—including a subset of that described in this Section 6.

h. ATCT Operational Tool Supplement

Another enhancement could potentially supplement ATCT automation tool[74] augmentation to provide air traffic controllers with improved operational capability—the graphical display of LAANC authorizations to improve situational awareness and managerial action regarding sUAS traffic advisories to manned aircraft pilots.[75] Additionally, where an ATCT approves sUAS flights as a result of *further coordination* (that is, outside of the LAANC automation platform), or at altitudes other than those approved in the UAS Facility Maps, such approvals could be displayed per Figure 1.

7. *Conclusion*

Making LAANC data readily available to manned aircraft pilots is an important step in the integration of sUAS into the NAS. The goal of the proposed method is to enhance manned pilot situational awareness regarding nearby sUAS activity in the airport vicinity. The proposal offers a practical, near-term method for manned pilots to access active UASFM segment data both in flight and during pre-flight planning to advance flight safety of the NAS. The methodology is based on using diverse broadcast mediums to deliver UASFM notices and graphical data to the cockpit of manned aircraft flying in the vicinity of airports. The other end of the data transfer focuses on delivering the LAANC authorization information and sUAS activity maps to users of online flight planning platforms in order to improve and streamline the process of route planning and flight safety. The method proposes using UASFM data and available NOTAM formats. Future recommendations (see Section 6) include: (i) improvements to conventional notification tools, (ii) integration of position data from ground control stations, UAS connected devices, and ground- and airborne-sensors, (iii) terrain risk mitigation data fusion, (iv) display of UTM corridors connecting airports, (v) use of human-readable UASFM segments, (vi) non-LAANC grid overlays, and (vii) ATCT operational tool support.

**

8. *Appendices*

Appendix 1. *UASFM Segments: Potential Separation Issues*

The following examples highlight potential traffic conflicts between manned aircraft and sUAS in or near LAANC-enabled airspace. Each example presents actual operational risks at a given locale that may benefit from the hazard mitigations provided by this proposal. These examples reflect a systemic problem, of national consequence, and illustrate the need to engage the manned aircraft pilot rather than to rely exclusively on the sUAS pilot, ad hoc airport/airspace-specific solutions, and UTM to assure safe separation.

Figure 10 - Sample UASFM Segments

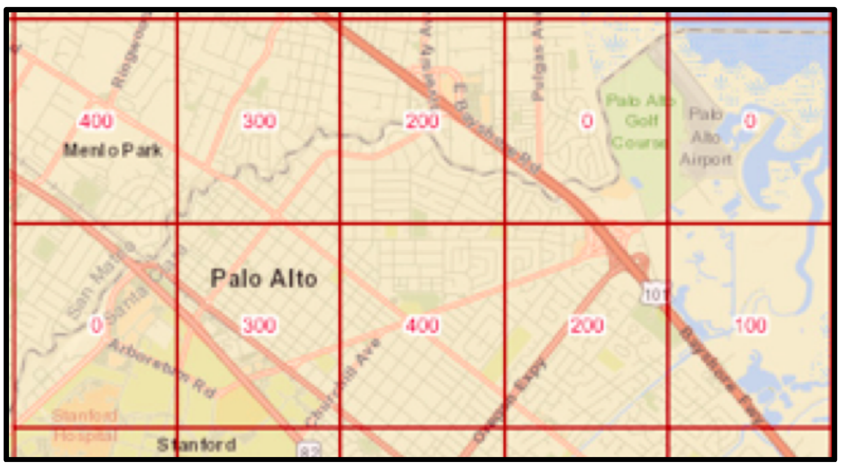
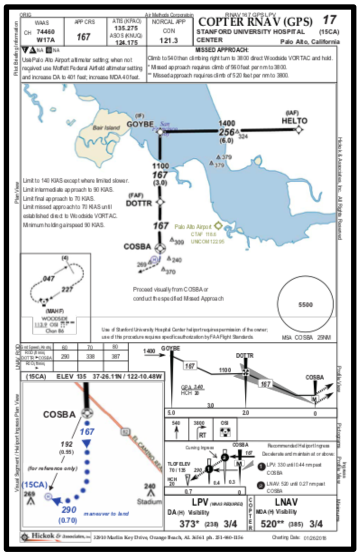


Figure 10 presents UASFM segments that were subsequently revised (summer 2018) in response to the author's intervention. The segments overlay the Palo Alto Airport (KPAO) (upper-right segment), and the Stanford University Hospital helipad (lower-left segment). The lower right segment abuts Moffett Federal Airfield (KNUQ) UASFM segments. Consider the following examples:

Example 1: Helicopter LPV Final Approach Course Intersecting LAANC Airspace

LPV instrument approach to Stanford University Hospital helipad[76]—thru UASFM segments active at 400 ft. AGL. Operational considerations: LPV approach (Figure 11) transits several UASFM segments with published altitudes of 400 ft. AGL, and yet approach decision altitude (DA) is 238 ft. AGL (Figures 11 and 12). Path Forward: The author advised NorCal TRACON of this problem in the context of developing this proposal. NorCal promptly requested that KPAO ATCT seek UASFM revision. Nonetheless, the underlying situation illustrates a national safety problem—shared by both regulators and operators[77]/pilots—that the proposal can help mitigate by providing enhanced awareness to manned aircraft pilots.

Figure 11 - Hospital Copter Approach	Figure 12 - Conflicting UASFM Segments
	

**

Example 2: Helipad Approach through LAANC Airspace
Stanford University Hospital to KPAO—UASFM segment active at 400 ft. AGL (Figure 10, lower center segment). Assume marginal VFR conditions - 1,000 ft. AGL ceiling. Operational considerations: (i) safety preference for lower altitude flight from hospital to best achieve autorotation speed; (ii) adhering to VFR ceiling separation requirements; and (iii) need for timely descent to the SW quadrant of KPAO for refueling that may challenge safe separation from the 400 ft. AGL UASFM segments.[78]

Excessively steep stair-step altitudes between adjacent UASFM segments should be avoided or eliminated (increments greater than 50-100 ft.) in the design of adjacent UASFM segments. Awareness of proximate and conflicting UASFM segments on approach would improve situational awareness and, where practicable, avoid such hazards. Where applicable, such awareness would also enable pilots to apprise their certificate holders and seek assistance from ATC to revise UASFM segment altitude anomalies.

**

Example 3: Marginal LAANC Airspace Buffer Inside FAF

Aircraft on GPS approach to KPAO (Figure 13)—with an adjacent airport's (Moffett Federal Airfield - KNUQ) UASFM segments under and abeam the approach. Operational considerations: KNUQ's airspace includes a 300 ft. AGL UASFM segment less than 1.5 NM from KPAO's runway threshold, below the KPAO GPS RWY 31 final approach, and an adjacent KNUQ 400 ft. AGL segment immediately to the west[79] (Figure 14). The KPAO GPS approach minimums are 460 ft. MSL (457 ft. AGL).

Figure 13 - KPAO GPS Final Approach

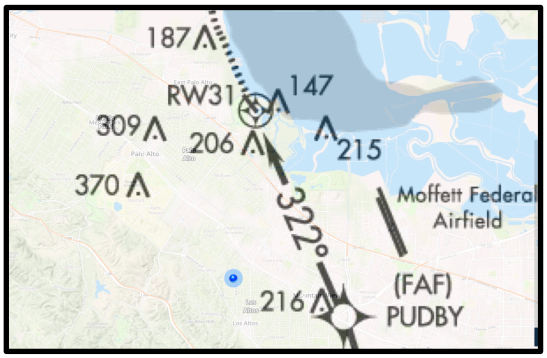
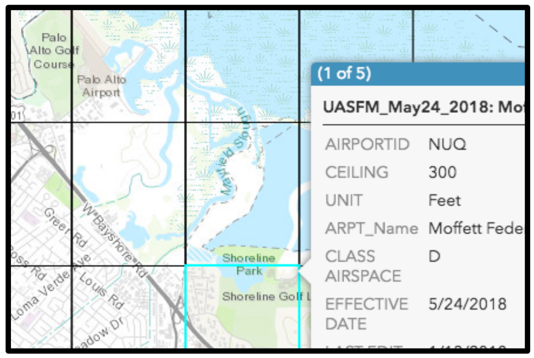


Figure 14 - Abutting Airport Segments



This situation is not inconsistent with that of many other adjacent LAANC-enabled airports nationally. It underscores the further need for robust coordination among adjacent facilities in developing UASFMs. Non-LAANC-enabled satellite airports adjacent to LAANC-enabled airports also require attention. For example, Martin Field (7K8) adjacent to LAANC-enabled airspace for the Sioux Gateway Airport (KSUX) has a 400 ft. AGL UASFM segment situated ~.1nm south of the approach end of Martin's runway 32—thereby violating its traffic pattern and runway exclusion zone. Its airport manager was unaware of LAANC. Awareness of the proximity of these UASFM segments on approach might encourage pilots to remain as high as practicable, seek greater coordination, or perhaps, when safe, to skew their flight path or select a nonconflicting runway for maximum avoidance.

**

Example 4: Final Approach Path Without LAANC Buffer

RNAV (GPS) RWY 17L at Centennial Airport, Englewood, CO (KAPA). The flight path inside the FAF (CENTN - Figure 15) and within the primary visual approach landmark for base-to-final turn to Runways 17L/17R (the Cherry Creek Reservoir) conflicts with UASFM segments authorized to 400 ft. AGL (Figure 17). The LNAV MDA of 6,220 ft. MSL and 397' AGL is at the same altitude as multiple adjacent UASFM segments at and inbound from the FAF (Figure 16).

Figure 15 - KAPA RNAV FAF to Airport

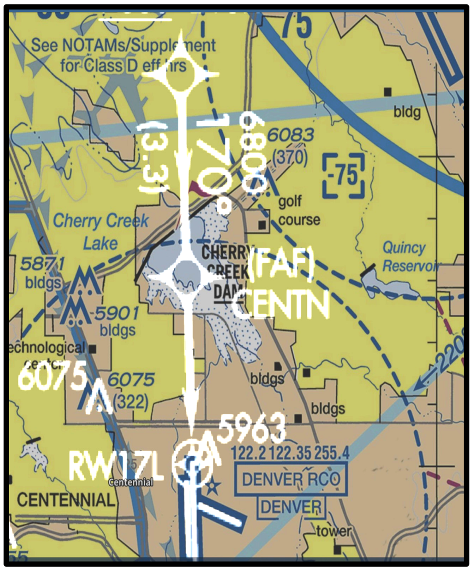


Figure 16 - KAPA RNAV (GPS) 17L MDA

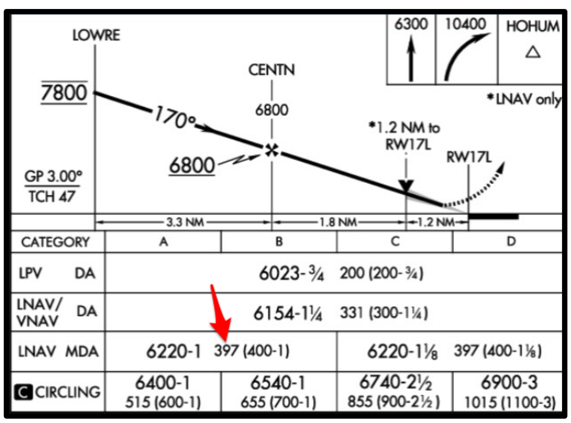
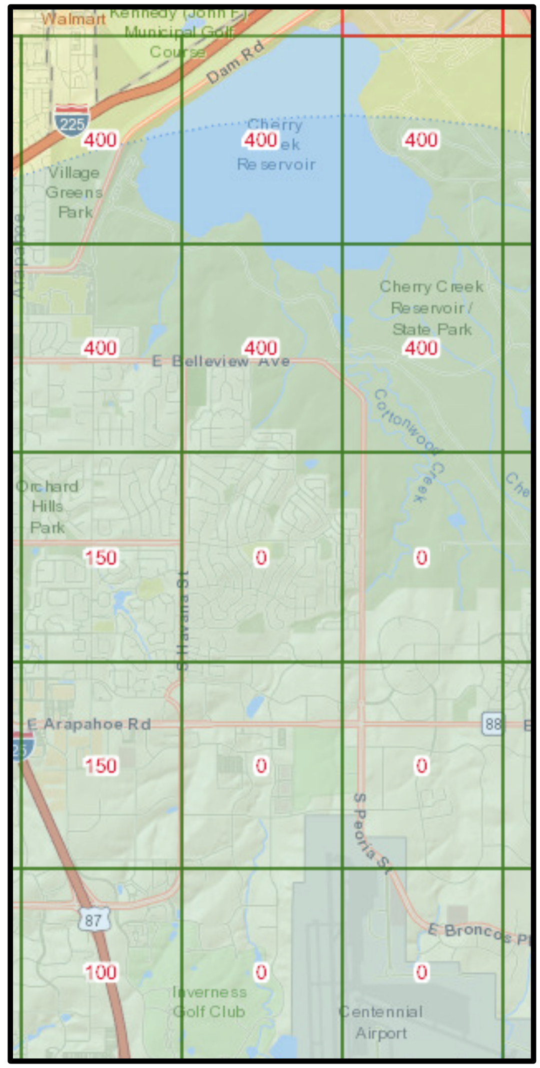


Figure 17 - KAPA LAANC UASFM Segments



Operational Consideration: The Centennial Airport example raises an additional characteristic of certain UASFM segments: that no explicit buffer is required or recommended between manned aircraft and UASFM segments.[80] Awareness of the lack of a buffer on this approach might influence pilots, where safe, to avoid “dive and drive” flight within the FAF, or request an alternative runway.

**

Example 5: IFR to Adjacent VFR Airport Transition
Transition from the IFR airport approach at Rogue Valley International Airport, Medford, OR (KMFR) to the adjacent VFR-only airport at Ashland, OR (S03). See Figures 18 and 19. Assume marginal VFR conditions—1,000 ft. AGL ceiling. In Figure 19, all UASFM segments from the central segment (cyan-colored) thru the most SE segments near Ashland are 400 ft. AGL. Under such conditions, manned pilots transitioning from an instrument approach at KMFR to land VFR at Ashland might endure, at best, 100 ft. separation from UASFM segments. Not unlike many areas, terrain between Ashland and Medford is uneven (hilly), the route transitions multiple times between populated and unpopulated areas (thus varying ground clearance altitude requirements),[81] and transits both controlled and uncontrolled airspace.

As a practical matter, identification and consideration of recognized or frequently-used transitional routes should be required for approval of UASFM nationally.[82] In the interim, the situational awareness value of the proposal is obvious. <u>Operational Consideration</u>: Awareness of active LAANC airspace between these airports might influence pilots planning transitions under such conditions to land at the primary IFR airport instead.

Figure 18 - Medford to Ashland Transition - Sectional

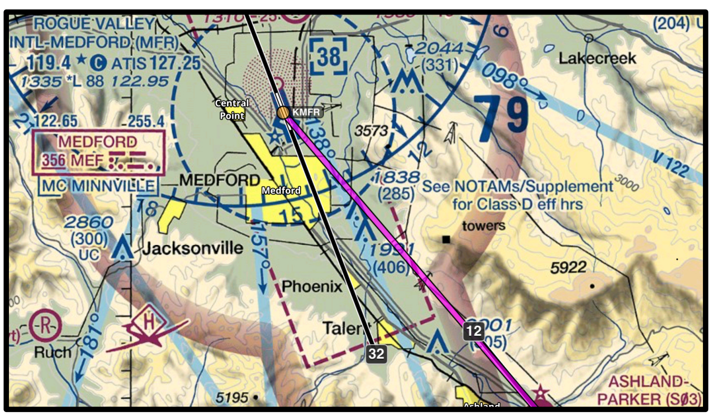
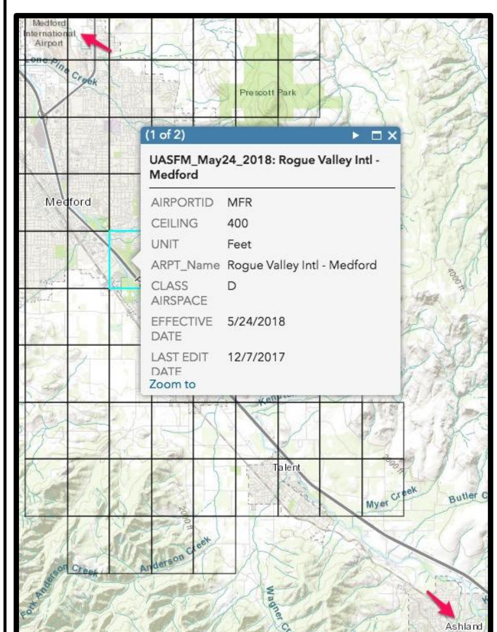


Figure 19 - Medford to Ashland Transition - UASFM



**

Example 6: Dulles Int'l Airport (KIAD) Final Approach Conflict

RNAV (GPS) RWY 12 Approach MDA of 680 ft. MSL, 370 ft. AGL starting 4.2nm from the runway threshold at FAF JETMO (Figure 20). The flight path abuts or conflicts with a UASFM 400 ft. AGL segment ~2.3nm from the Runway 12 threshold (Figure 21).[83] Operational consideration: Awareness of the lack of sUAS buffer on this approach might influence pilots to avoid "dive and drive" flight within the FAF, modestly delay descent within the FAF to the extent a stabilized approach is maintained, or request an alternative runway—provided safety is assured.

Figure 20 - KIAD RNAV (GPS) Rwy 12

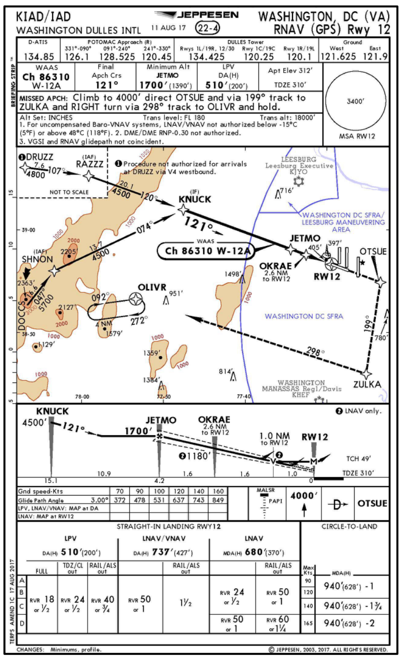
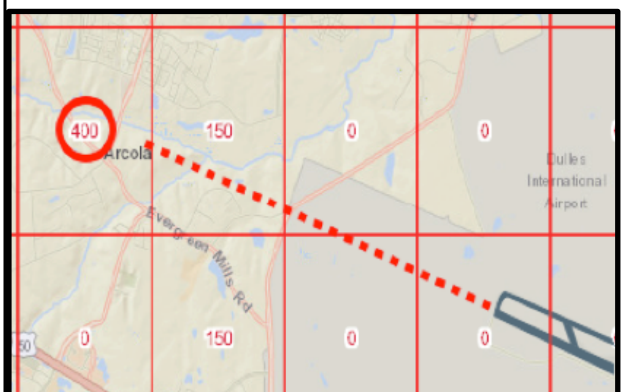


Figure 21 - Intersecting UASFM Segment



**

Example 7: South Shore Helicopter Route Abeam JFK Int'l Airport
The heavily travelled helicopter "South Shore" route along Long Island's south shore is situated below the KJFK Bravo's 500 ft. AGL/MSL shelf (Figure 22). Absent Bravo clearance, most helicopters (and fixed-wing aircraft) typically transition this airspace at "300-500 ft. and banner towing aircraft around 200 ft."[84] notwithstanding the underlying 400 ft. UASFM segments (Figure 23). Operational consideration: Awareness of the lack of buffer on this corridor might influence pilots to seek a Bravo clearance, or avoid the route.

Figure 22 - South Shore Helicopter Route Below KJFK Bravo

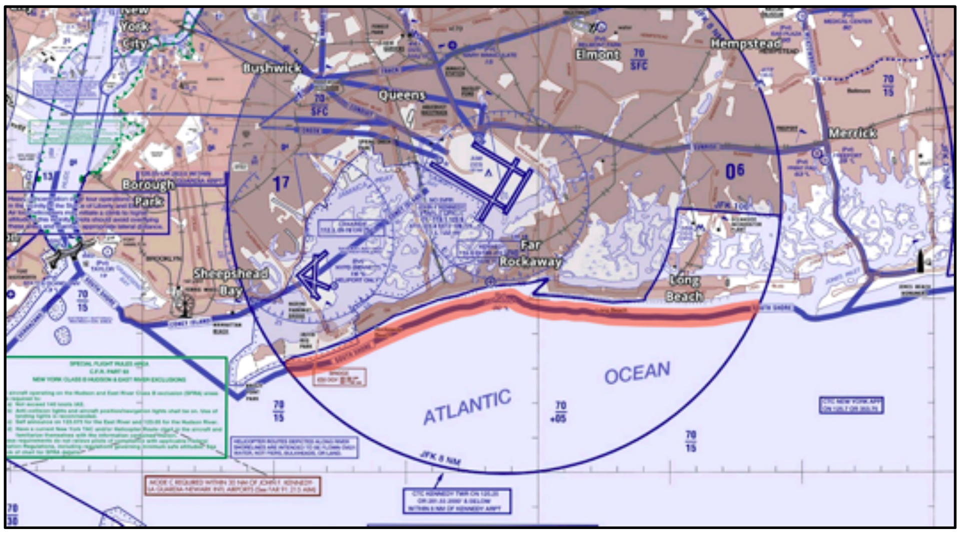
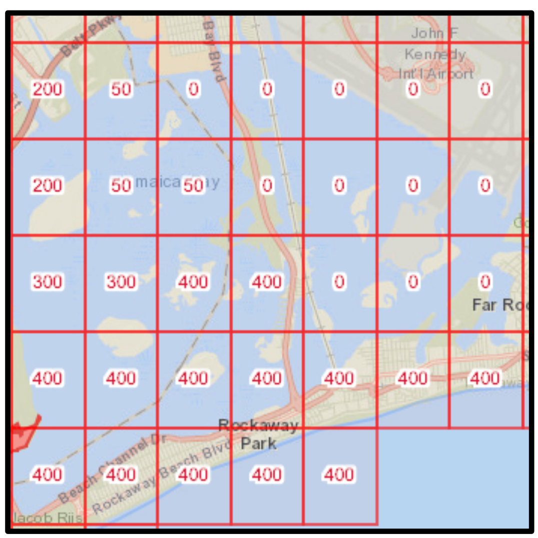


Figure 23 - UASFM Segments Below KJFK Bravo Airspace



**

Example 8: LAANC Segment Saturation

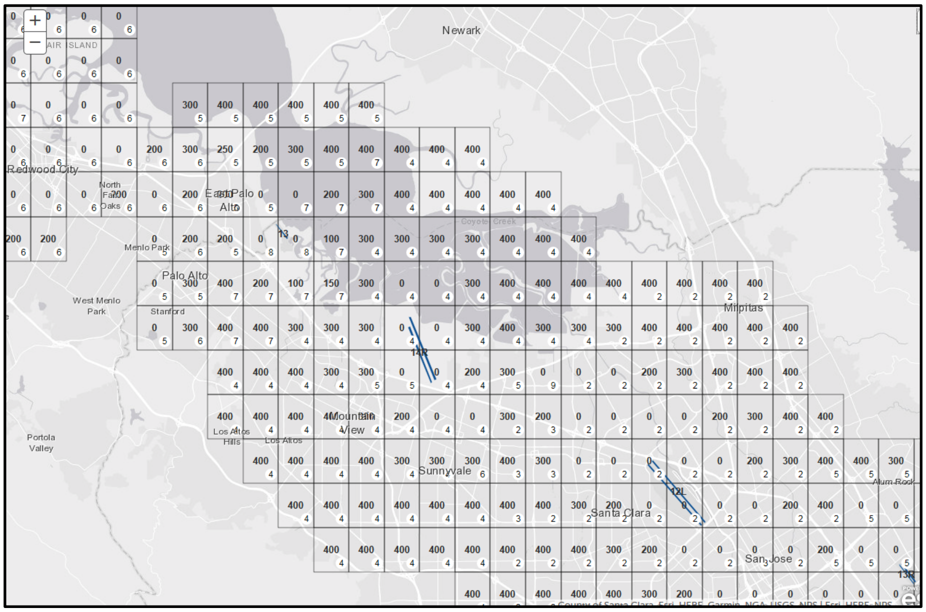
The LAANC rules do not restrict the number of sUAS authorized to operate simultaneously in a single UASFM segment.[85] The rules assume that when a segment's airspace approaches saturation, sUAS pilots/operators will recognize the situation and discontinue operations.

- Does see-and-avoid effectiveness and the "big sky" safety paradigm break down prior to typical sUAS operator/pilot cognition of and response to segment saturation?
- Might sUAS pilots confronting such challenges under exigent circumstances act to avoid imminent collision by departing authorized LAANC airspace—potentially causing even a greater hazard to manned aircraft?
- Should a threshold number of simultaneously authorized operations within a segment trigger ATC to issue a cautionary message to manned aircraft pilots or temporarily prohibit further dense simultaneous sUAS operations?
- To what extent might transmission interference cause fly-aways (e.g., where lost link protocols malfunction or are inadequate) and loss of separation with manned aircraft during such unrestricted (segment saturated) simultaneous operations?[86]
- To what extent might an unrestricted number of sUAS in an UASFM exceed the capacity of detection functions of CAS systems onboard manned aircraft (where installed)?[87]

These situations were not addressed in the underlying LAANC safety risk management (SRM) documents. Moreover, consider that DJI provides the following "important" guidance to its customers: "To prevent transmission interference, do not operate more than three aircraft in the same area."[88] Awareness of segment saturation, or at least, the number of simultaneous operations might aide manned aircraft pilot decision-making.[89]

The following Figure 24 presents a screenshot from the FAA's LAANC administrative tool of the San Francisco Bay Area. The tool is not intended for the operational separation of traffic. Each UASFM segment includes a number encircled in its lower-right corner representing the total number of sUAS that have been authorized for simultaneous operation within that segment, including sUAS operations authorized via waiver. With modification, perhaps this tool could also be helpful in the cockpit.

Figure 24 - FAA LAANC Administrative Tool



The effectiveness of this proposal would be further enhanced if LAANC authorizations granted for multiple days, weeks, or longer (such as for certain public safety and research purposes via waiver/COA) required that pilots/operators supplement their authorizations with a timely pre-flight notification where practicable.[90] Furthermore, consider the utility of presenting the total number of waivers/COAs *separately* from active LAANC authorizations within each grid square of the LAANC Administrative Tool—since only a fraction of the open waivers/COAs would have active flight operations underway at a particular time. Such density/saturation information would assist both controllers and pilots.

**

Appendix 2. ***Service Protocols and Message Format Overview***

A standard graphical UASFM segment product would benefit this proposal. If practicable, appropriate reuse/extension of an existing data product should reduce time-to-implementation and costs. Alternatively, developing a new UASFM segment product appears feasible and permissible under current standards. For example, the FAA provides that "[o]ptional products may be added to the basic FIS-B product suite."[91] Indeed, available RTCA standards specify a class of "Text with Graphical Overlay FIS-B Products" (TWGO) that "employs an encoding framework that *contains flexibility to represent graphic objects not currently present* in FIS-B uplink products."[92] Their potential extensibility for this proposal and other product/data sets are considered in turn.

Figure 25, below, presents "basic"[93] products[94] that were considered to help enable this proposal (primarily Product ID #8, NOTAM). Additionally, SUA-Status (Product ID # 13), a form of NOTAM, was initially considered and rejected because: (i) it lacked an uplinked graphical record—that is, no TWGO capability;[95] (ii) it is an unofficial source of SUA status with recognized inconsistencies; (iii) FAA NOTAMs received over FIS-B may modify SUA status; and (iv) the characterization of LAANC airspace is independent of SUA-defined airspace.[96]

Figure 25 - FIS-B Products by Product Class[97]

Product Class	Product ID #	Product Name	Recommended Product Title	Product Description Reference
Generic Text	413	METAR	"METAR"	FMH-1
		TAF	"TAF"	NDS 10-8
		PIREP	"PIREP"	NDS 10-8
		WINDS	"WIND & TEMPS"	NDS 10-8
Global Block Representation	63	Regional NEXRAD	"Regional NEXRAD"	APPENDICES A and E
	64	CONUS NEXRAD	"CONUS NEXRAD"	APPENDICES A and E
Text with Graphical Overlay	8	NOTAM-D	"NOTAM-D"	APPENDIX A
		NOTAM-FDC	"NOTAM-FDC"	APPENDIX A
		NOTAM-TFR	"NOTAM-TFR"	APPENDIX A
		FIS-B Product Updates Unavailable	"Unavail FIS-B Prods"	APPENDIX A
	11	AIRMET	"AIRMET"	NDS 10-8
	12	SIGMET	"SIGMET"	NDS 10-8
		WST	"Convective SIGMET"	NDS 10-8

Product ID # 8, NOTAM: The NOTAM (D) with its graphical overlay record, flexible subject-matter content,[98] widespread implementation, and relevance to this proposal presents a helpful option for evaluating effective methods to display active UASFM segments. The digital NOTAM system provided some structured qualifier fields and is being transformed into fully structured, standardized data sets and services that may support the transfer of sUAS operation data from service providers to FIS-B data servers and other communication resources.[99]

The proposed graphical UASFM segment using or extending a NOTAM includes the following considerations:

- The required bandwidth is minimal and mitigates impact on the provision of FIS-B basic products.[100]
- There is significant and increasing demand for enhanced situational awareness tools to mitigate separation risks.
- The update interval of "as available" and a transmission interval of ten minutes for NOTAM services provides acceptable latency.[101]

Product ID - A new Product ID code for UASFM segments might help ensure that aircraft avionics fully parse and display the subject data properly. Also, given the projected volume of LAANC-enabled airspace authorizations, a new Product ID will improve information management.[102]

For discussion purposes only, example prototypes of NOTAMs addressing active LAANC UASFM segments are presented below—Figure 26 for FAA Domestic NOTAMs, and Figure 27 for ICAO NOTAMs. The string "UASFMID: 816" is explained in Section 6.f. Human-Readable Waypoints.

Figure 26 - Prototype FAA Domestic NOTAM for UASFM Segment
(*Example – For discussion only***)**

!PAO x/xxxx Palo Alto, CA (KPAO) Airspace unmanned aircraft system WI an area defined as .1 Nautical miles radius of 3726.5020N12210.3020W (.3 W PAO; UASFMID: 816) surface-400' above ground level avoidance advised 1300-1400 Sept 14, 2018

Figure 27 - Prototype ICAO NOTAM for UASFM Segment
(*Example – For discussion only***)**

A1234/18 NOTAMN
Q) KZOA/QQFAZ/IV/000/004/372650.20N12285020W001
A) KPAO
B) 1809141300
C) 1809141400
E) [*Insert UASFM segment polygon parameters & altitude* **as alternative]**

Figure 27 Decoded:[103]

A1234/18 NOTAMN
- **A**=Series
- 1**234**=NOTAM number
- **18**=Year
- **NOTAMN**=New NOTAM

Q) KZOA/QQFAZ/IV/000/004/3726.5020N12210.3020W001
- **Q)**=Qualifier
- **KZOA**=Oakland Flight Information Area (FIR)
- Q=Start of 5 letter code beginning with "Q"
- **QF**=Aerodrome
- [Alt.: **QWULW** - UAS (WU) Will Take Place (LW) -- an Int'l Qcode]
- **AZ**=Aerodrome traffic zone (ATZ) [*Future: Designate new 2-letter LAANC Code?*]
- **IV**=Significant for IFR and VFR traffic
- **000/004**=Lower/upper limits expressed as flight level
- [*Alt. "000" since altitudes not MSL – and instead AGL specified in E)**, below***]
- **372650.20N12285020W**=Geographical center of UASFM segment
- [*from FAA LAANC arcgis map: "Lat 37.4417, Lon 122.1417"*]
- **001**=Radius of 1 nm (approximates UASFM segment rectangular dimension)
- [*temp: Discuss standard UASFM polygon shapefile*][104]

A) KPAO Scope=Aerodrome-Palo Alto Airport, California
B) 1814091400=UTC Time NOTAM becomes effective
C) 1814091400=UTC Time NOTAM ceases to be effective
E) TBD

Keywords

All NOTAM (D)s require a keyword.[105] The keyword *Airspace* is described as "an airspace restriction or *activity warning* which impacts, restricts or precludes use of airspace."[106] Here, Airspace NOTAMs are best characterized as providing an activity warning to manned aircraft pilots of LAANC-enabled airspace. Since such NOTAMS would be actionable for pilots and may affect chosen routes of flight, their use and purpose appear consistent with the underlying purpose of the NOTAM.

Graphical Overlay Record and Prototype Implementation

The following considers some high-level FIS-B implementation issues where NOTAM structure would transport UASFM segment data. To do so, it examines the possible content of a prototype graphical overlay record configured for such purpose (see Figures 28 and 29). This exercise is for discussion purposes only.

Figure 28 - Graphical Overlay Record [Ref. *DO-358*]

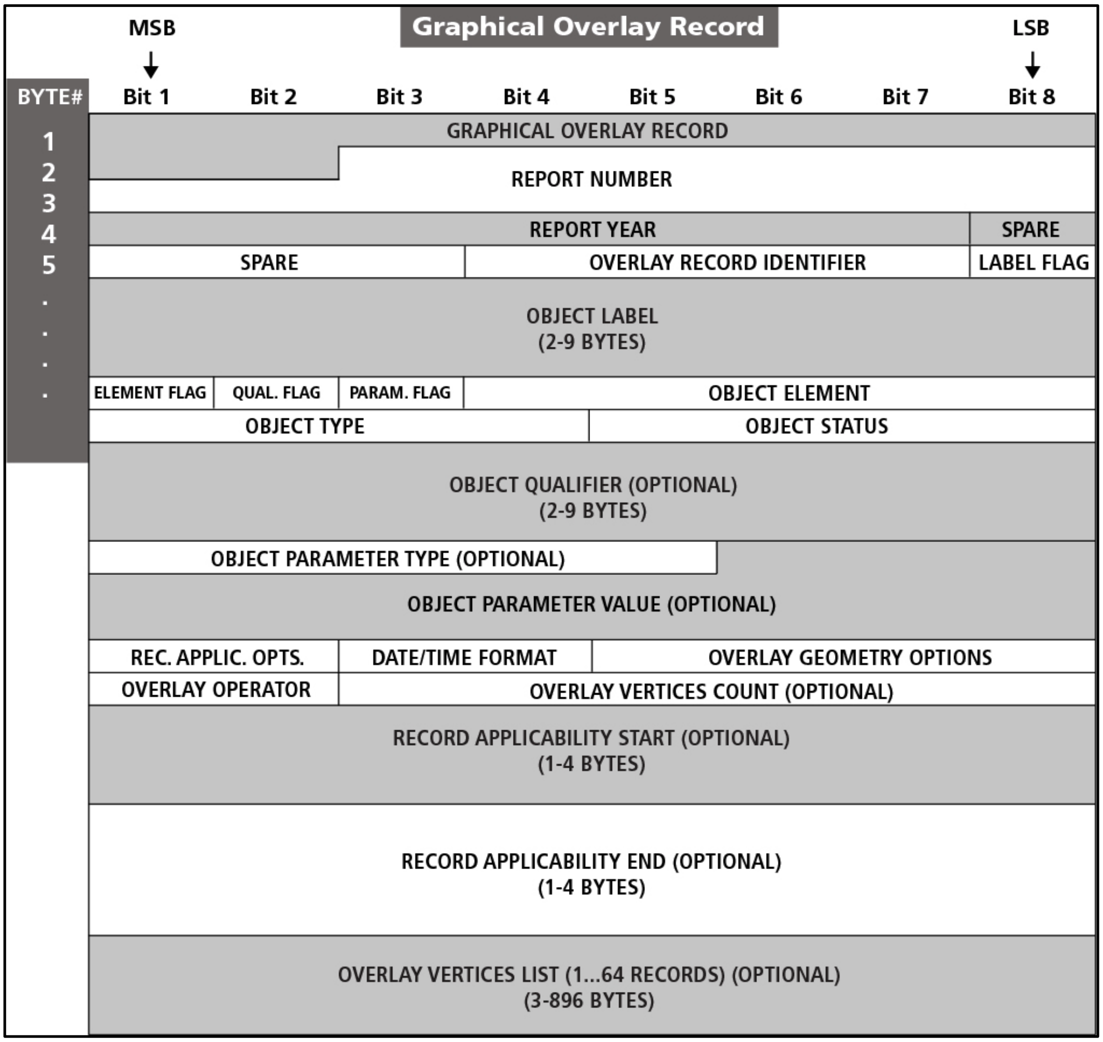


Figure 29, below, informed by *DO-358*, identifies each material component of the Graphical Overlay Record, possible associated value(s), and relevant considerations in support of this proposal. This exercise seeks to assist development of an initial overlay record for the proposal (to the extent a derivation of the NOTAM product is found efficacious).

Figure 29 - Prototype Graphical Overlay Record - Element Analysis

Element	GOR Value(s)	Proposed Values	Comment (Ref. DO-358)
Overlay Record Length	[10 bits]:		A.3.3.2.3.1
Report Number	[14 bits]:		Used to determine rpt. uniqueness. A.3.3.1.3.2. § B.3
Report Year	[7 bits]:	**“19”**	Last 2 digits of year rpt. originated. A.3.3.2.3.3
Spare	[bit 8 of byte 4]:		Reserved for future use - ignore. A.3.3.1.3.4
Spare	[bits 1-3 of byte 5]:		Reserved for future use - ignore. A.3.3.1.3.4
Overlay Record Identifier	[4 bit sequence]:		Identifies each of potentially 15 related overlay records. Decoding requires that a one (1) be added to the Overlay Record Identifier value to get the decimal value. A.3.3.1.3.5
[object] Label Flag	(0) numeric (1) alphanumeric	**“1”**	A binary field. For FIS-B avionics conforming to this std., “O”=no Object Label; “1”= text label is an airport LocID. A.3.3.1.3.6
Object Label (2-9 bytes)	Object Label Flag (0): 2 bytes; Object Label Flag (1): 9 bytes	**“A26”**	For FIS-B avionics interpretation of Object Label. If “0” GOR process to ignore Object Level field; if “1”, represents LocID (airport or airspace) using DLAC character set. A.3.3.1.3.7
[object] Element Flag	(1): used (0) not used		Denotes if Object Element Field is used. A.3.3.1.3.9.
[Object] Qualifier Flag	Present (1) Not Present (0)	**“0”**	
[Object] Parameter Flag	Present (1) Not Present (0)	**“0”**	Indicates whether the Object Parameter Type and Object Parameter Value fields are present. A.3.3.1.3.13
Object Element	TFR: (0) Future Use: 1-15	**“1”**	Provides a particular feature or element of an Object Type of interest. A.3.3.1.3.10
Object Type	Aerodrome (0) Airspace (14) Future use (1-13, 15)	**“14”** (or future use)	Notable parts of an airport or airspace environment. Collection of regions or things that can impact flight ops. if they become hazardous, fail or unavailable. A.3.3.1.3.8
Object Status	In Effect: 15 Future Use - 14	**“15** (future use)”	Values other than 15 should be discarded by FIS-B avionics.
Object Qualifier (opt.3 bytes)			Indicates whether Object Qualifier field is used.
Object Parameter Type (optional)			

Object Parameter Value (optional)			
Record Applicability Options	No times given (0) Start time only (1) End time only (2) Start & end times (3)	"3"	Info of timing of the reported event. A.3.3.1.3.14 The DAM requires both start and end times.
Date/Time Format	No Date/Time Used (0) Mo., Day, Hr., Min. (1) Day, Hours, Mins. (2) Hours, Mins. (3)	"2"	Provides format for Record Applicability fields, enabling a subset of date/time info to be sent.

Overlay Geometry Options	Extended Range 3D Polygon (AGL)[Value 4]	"4"	Supports both LAT/LON and altitude dimensions.
Overlay Operator	No operator (0) Future Use 1-3	"0"	For "0", Graphical Overlay Records are independent A.3.3.1.3.18
Overlay Vertices Count (optional)		"4"	
Record Applicability Start (optional) (1-4 bytes)	Ignore field: (0) See comment: (1) If (2) or (3):only spec.	"0""4""15""55"	Indicates period the data are in effect. A.3.3.1.3.16 Controls inclusion of Record Applicability Start & End field. Format stipulated in Date/Time Format field (above). When Date/Time Format field set to one (1), Record Applicability field is broken down into 4 one-byte sub-fields for mo., day, hr. & min. *See* Std. Fig. A-29.
Record Applicability End (Optional) (1-4 bytes)	See above row.	"0""4""17""55"	See above row.
Overlay Geometry Options	Extended Range 3D Polygon (AGL): Value 4, Vertices Count Range 1-64	"4"	Whether or not a geometry is explicitly defined. Provides the geometry **type, resolution and vertex** encoding used. A.3.3.1.3.17. See Std. Table A-21. Extended Range Polygon A.3.3.1.3.17.1
Overlay Vertices List (1-64 records (Optional) (3-896 bytes)	LONG: (19 bits) (0-180 LAT: (19 bits) (90-90) z: (10 bits) (100 ft)	[variable]	See Std. Table A-22 for Overlay Geometry Encoding Resolution of LONG LAT (0.000687 deg.) Requires four sets of vertices to form a rectangle.

DO-358 includes "Overlay Geometry Options" (see Figure 29) providing "the geometry type, resolution and vertex encoding to be used."[107] One such option is the "Extended Range 3D Polygon (AGL)"[108] providing "a connect-the-dot geometry independent of the record Reference Point . . . useful in defining various airspace objects in the airport terminal or en route domains and may simplify avionics processing requirements."[109] It provides for use of Lat/Lon, and altitude coordinates providing 100 ft. resolution.[110]

Furthermore, *DO-358* describes the NOTAM text record elements, to include:

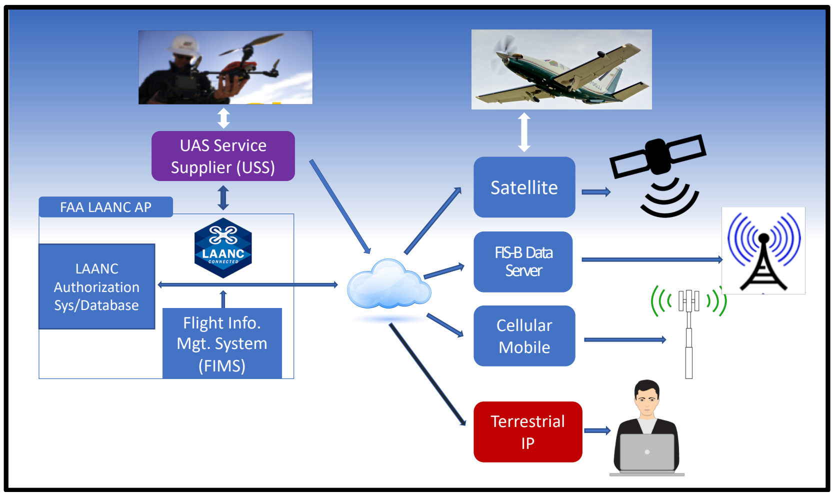
- Product Type: NOTAM-D[111]
- Location ID: XXXX.MM/### for NOTAM-D where XXXX is the four-letter airport identifier, MM is the report month as indicated in the APDU header, and ### is the last three digits of the NOTAM-D report number[112]

**

Appendix 3. *System Architecture*

Figure 30 presents an initial high-level, notional representation of the architecture supporting the proposal. Some of the systems and approaches presented are discretionary, evolving and future-looking. Thus, it is offered for discussion only. Certain considerations are presented below.

Figure 30 - Notional System Architecture



Active UASFM segment data would flow directly from the FAA's LAANC Automation Platform (LAANC-AP) via FIMS or possibly from a UAS Service Supplier (USS)[113] to a third-party service provider, or via supplementary data service providers (SDSP) supporting in-the-cockpit display to manned aircraft pilots. The schema embodied in the proposed method could be implemented, non-exclusively, as follows.

1. A prospective USS is approved and "onboarded" by the FAA.[114]
2. A sUAS pilot/operator subscribes to a USS for LAANC services, and then submits a request via the USS for LAANC authorization for a flight operation within one or more UASFM segments.
3. Following submission of such request by the sUAS pilot/operator for authorization, the USS submits it through the LAANC gateway/FIMS for FAA approval.[115]
4. If approved, the authorization is made available to airspace users.[116]
5. Prior to the start time of the authorized flight operation, service provider[117] pulls (or otherwise obtains) the LAANC authorization via FIMS Aeronautical Common

Services (ACS)[118]/FIMS and makes it available[119] including to a FIS-B Data Server,[120] satcom, cellular service,[121] and IP service providers.

6. When approaching (within ~100 nm) of the low altitude service volume of airspace within which the LAANC-authorized active UASFM segment(s) is situated, the subject aircraft receives and may display such UASFM segment(s).[122]

**

Appendix 4. *Abbreviations*

3GPP	3rd Generation Partnership Project
AAS	Airborne Access System
ABSAA	Airborne Sense and Avoid
AC	Advisory Circular
ACAS	Airborne Collision Avoidance System
ACI	Aviators Code Initiative
ACS	Aeronautical Common Services
ADS-B	Automatic Dependent Surveillance - Broadcast
ADS-B In	Automatic Dependent Surveillance - Broadcast In
ADS-B Out	Automatic Dependent Surveillance - Broadcast Out
ADS-R	Automatic Dependent Surveillance - Rebroadcast
AeroMACS	Aeronautical Mobile Airport Communication System
AIM	Aeronautical Information Manual
AIMM	Aeronautical Information Management Modernization
AIXM	Aeronautical Information Exchange Model
ANSP	Air Navigation Service Providers
AP	LAANC automation platform
APDU	Application Protocol Data Unit
Appn.	appendix
ABOV	Area-Based Operation Volume
ARC	Aviation Rulemaking Committee
ASSURE	Alliance for System Safety of UAS though Research Excellence
ASTM	ASTM International
ATAR	air-to-air radar
ATC	air traffic control
ATCRBS	Air Traffic Control Radar Beacon System
ATCT	air traffic control tower
ATIS	Alliance for Telecommunications Industry Solutions
ATM	aircraft traffic management
BVLOS	beyond visual line of sight
CA	collision avoidance
CAA	civil aviation authority
CAS	collision avoidance system(s)
CDTI	cockpit display of traffic information
C.F.R.	U.S. Code of Federal Regulations
COA	Certificate of Waiver or Authorization
CONOPS	concept of operations
COTS	commercial off-the-shelf
CVFP	charted visual flight procedures
DA	decision altitude
DAA	Detect and Avoid [or Detect, Alert, and Avoid]
DAC	Drone Advisory Committee
DLSP	Data Link Service Provider
ESS	Essential Service System
EFB	Electronic Flight Bag
EUROCAE	European Organization for Civil Aviation Equipment

FAA	US Federal Aviation Administration
FAF	final approach fix
FF-ICE	Flow Information for a Collaborative Environment
FESSA	FAA Extension, Safety, and Security Act of 2016
FIMS	Flight Information Management System
FIS-B	Flight Information Services—Broadcast
FIXM	flight information eXchange model
FMRA	FAA Modernization and Reform Act of 2012
FNS	Federal NOTAM System
FRA	FAA Reauthorization Act of 2018
FSS	Flight Service Station
GAO	U.S. General Accountability Office
GB	Global Block Representation Products
GBDAA	ground-based detect and avoid
GBSAA	ground-based sense and avoid system
GCS	ground control station
GIS	Geographic Information System
GML	Geography Markup Language
GOMR	Geographic Information System (GIS) Data and Maps
GOR	graphical overlay record
HEMST	Helicopter Emergency Medical Services Tool (HEMS Weather Tool)
ICAO	International Civil Aviation Organization
ICD	Interface control document
IFR	instrument flight rules
IP	Internet Protocol
kts	knots
LAANC	Low Altitude Authorization and Notification Capability
LAANC Airspace	LAANC-enabled airspace
LAANC-AP	LAANC Automation Platform
LAANC-MOA	LAANC Memorandum of Agreement
LPV	Localizer Performance with Vertical Guidance
LSB	least significant bit
MASPS	Minimum Aviation Systems Performance Standards
MDA	minimum descent altitude
MFD	multi-function display
MNO	mobile network operator
MOA	Military Operations Area
MOPS	Minimum Operational Performance Specifications
MSB	most significant bit
MSL	mean sea level
NAS	National Airspace System
NASG	NAS Enterprise Security Gateway
NDS	NOTAM Distribution Service
NEMS	NAS Enterprise message service
NextGen	Next Generation Air Transportation System
NOTAM	Notice to Airmen
NSRR	NAS Service Registry and Repository
OPD	Official Protraction Diagrams
ops	operations
OSA	Operational Safety Assessment

Part 101	14 C.F.R. § 101
Part 107	14 C.F.R. § 107
PHA	Preliminary Hazard Analysis
PII	personally identifiable information
Proposal	This proposed method to improve manned aircraft pilot awareness of sUAS
proposed method	This proposed method to improve manned aircraft pilot awareness of sUAS
RA	resolution advisory
RPAS	Remote Pilot Aircraft System
RTCA	Radio Technical Commission for Aeronautics
RWC	Remain Well Clear
SAA	special activity airspace (includes special use airspace)
SAE	SAE International
SARP	UAS Science and Research Panel
SBS	Surveillance and Broadcast Services
SBSS	Surveillance and Broadcast Services System
SC-228	RTCA Special Committee 228, MOPS for Unmanned Aircraft Systems
SDSP	Supplementary Data Service Provider
SFR	special flight rules
SGAD	UAS DAA Alerting Guidance
SID	standard instrument departure
SMS	safety management system(s)
SOBD	Supplemental Official OCS Block Diagrams
SRM	safety risk management
STAR	standard terminal arrival route
SUA	special use airspace
sUAS	small unmanned aircraft system(s)
sXux	ACAS Xu for small UAS
SWIM	System-Wide Information Management
TA	traffic advisory
TAC	Terminal Area Chart
TBOV	Transit-Based Operation Volumes
TCAS	Traffic Alert and Collision Avoidance System
TCL	Technical Capability Level
TEM	Threat and Error Management
TIS-B	Traffic Information Services - Broadcast
TFR	temporary flight restriction
TRA	tremporary restricted area
TRACON	terminal radar approach control facilities
TSO	Technical Standard Orders
TWGO	text with graphical overlay
UA	unmanned aircraft
UAM	Urban Air Mobility
UAS	unmanned aircraft system(s)
UASCA ARC	UAS Controlled Airspace Aviation Rulemaking Committee
UASFM	LAANC UAS Facility Map
UAT	universal access transceiver
U.S.C.	United States Code
USS	UAS Service Supplier
UTM	unmanned aircraft system traffic management
UTM-B	UTM-Broadcast

VFR	visual flight rules
VMC	visual meteorological conditions
VVL	Very Low Level
WG	Working Group or Work Group
Xu	ACAS variant for unmanned aircraft

**

Appendix 5. *Glossary of Selected Terms*

[Quoted Selectively]

Aeronautical Study—Means a study conducted to identify the impact of a special use airspace proposal on the safe and efficient use of airspace and ATC procedures. If may also refer to a staff study required to identify and document the need to establish or modify a Class B airspace area.[123]

Aeronautical Information Exchange Model (AIXM)—an international standard developed jointly by the FAA and EUROCONTROL to achieve neutrality against applications and their local view of aeronautical information to manage and distribute aeronautical information services (AIS) data via a common exchange model in digital format. AIXM contains an extensive temporality model, including support for the temporary condition information communicated by a NOTAM, and is aligned with ISO standards for geospatial information.[124]

automatic dependent surveillance-broadcast In (ADS-B In)— An automatic dependent surveillance-broadcast system enabling properly equipped aircraft to receive from proximate aircraft and ground stations (via ADS-R) both TIS-B (traffic), and FIS-B (aeronautical information) content.

automatic dependent surveillance-broadcast Out (**ADS-B Out)**— An automatic dependent surveillance-broadcast system with the ability to transmit information from the aircraft to ground stations and other equipped aircraft. The foundational component of FAA's transition to the Next Generation Air Transportation System (NextGen), primary mechanism for aircraft surveillance, and aeronautical services. Its data transmission includes geoposition, pressure altitude, velocity, ID, and integrity information. The FAA mandates that all aircraft be equipped by 2020 to fly in controlled airspace designated in 14 C.F.R. § 91.225. Data transmission is facilitated via 1090 ES and UAT (978 MHz) equipage.

automatic dependent surveillance-rebroadcast (ADS-R)—An automatic dependent surveillance system with the ability to rebroadcast position and aeronautical information (both TIS-B and FIS-B) on 1090 MHz received on the ground from UAT-equipped aircraft and rebroadcast 1090 MHz data to UAT equipped aircraft.

beyond visual line of sight (BVLOS)—A means of flying the UAS without the direct, unaided visual supervision of the aircraft [by the person manipulating the flight controls]. "Operations where the pilot is not capable of using his or her vision to determine the location or orientation of the UA, hazards in the airspace, or potential of the UA to endanger life or property of another."[125]

Chart Supplement U.S. (AF/D)—A FAA publication serving as a pilot's operational manual. It contains aerodromes open to the public, communications data, navigational facilities, and certain special notices and procedures -- issued in seven volumes by geographic areas.[126]

collision avoidance system (CAS)—an airborne system designed to reduce the incidence of mid-air collisions (MACs) between aircraft. It monitors the airspace around an aircraft for other aircraft equipped with a corresponding active transponder or other recognized beacon], independent of air traffic control and warns pilots of the presence of other such aircraft which may present a threat of MAC.[127]

concept of operations (CONOPS)—A user-oriented document that describes systems characteristics and limitations for a proposed system and its operation from a user's perspective;[128] and describes the user organization, mission, and objectives from an integrated systems point of view; and communicates overall quantitative and qualitative system characteristics and operational procedures to stakeholders.

control station (CS)—The equipment or interface used to maintain control of, communicate with, guide, or otherwise pilot an unmanned aircraft.[129] "Apparatus for hosting the remote pilot and her/his device to operate the UAS." *Cf.*, **ground control station**.[130]

controlled airspace—An airspace of defined dimensions within which air traffic control service is provided to IFR flights and to VFR flights in accordance with the airspace classification. In the US, controlled airspace is a generic term that covers Class A, Class B, Class C, Class D, and Class E airspace.[131]

cooperative aircraft—Aircraft utilizing a mode A/C or S transponder and/or ADS-B out.

detect and avoid (DAA)—The capability of an unmanned aircraft to remain a safe distance from other airborne aircraft to avoid collisions.[132] Includes both [self-separation] [Remain Well Clear] and collision avoidance capabilities. Synonymous with Sense and Avoid (SAA) as used herein. The proposed method is not a DAA capability.

detect and avoid (DAA) system—Appliance that fulfills the requirements of 14 C.F.R. § 91.113. Includes Remain Well Clear (RWC) and Collision Avoidance (CA) components. The proposed method is not a DAA system. Selected CAS and DAA standards and concepts are compared below for the limited purpose of identifying limitations regarding very low altitude terminal airspace (with a focus on LAANC-enabled airspace), and how the proposed method might modestly complement such capabilities.

Figure 31 - Selected CAS and DAA Standards and Concepts

[To be moved to endnotes in the final version]

	Standard Title	Application/Description
ACAS X_u	*Minimum Performance Standards for Unmanned Aircraft Systems* (Rev 5) (Mar. 22, 2018)[133]	• Successor to TCAS, supports NextGen • Requires transponder and ADS-B • Requires air-to-air radar for non-cooperatives
ASTM F38 [DAA WG] [draft]	*Standard Specification for Detect, Alert, and Avoid System Performance Requirements* [expected 20__]	• For protection of manned aircraft at low altitude • Not for UA-to-UA • Within "Lower-risk" airspace • Within LAANC-enabled airspace • Class G & E < ~1,200 ft. AGL • Class B, C, & D below ~400-500 ft. AGL • UAS <55 lbs. and generally <254 Lbs. • <100 kts • No commercial fixed-wing traffic • Assumes no ATC separation services
RTCA DO-365 DAA [Phase 1 - 2017]	*Minimum Operational Performance Standards (MOPS)* for *Detect and Avoid Systems* (May 2017)[134]	• UAS >55 lbs. & >500 ft. AGL • Permits UAS ops transitioning Class A or SUA • UAS traversing Class D, E, & G in the NAS • Inapplicable to VFR traffic pattern ops • Inapplicable to normal Part 107 ops
RTCA DO-365 DAA [2020]	*Minimum Operational Performance Standards (MOPS)* for *Detect and Avoid Systems* [expected 2020]	• Extended ops in Class D, E, & G • Transitioning Class B & C • Enables approach/departure in terminal airspace in Class C, D, E, & G, & off-airport locations

		• Does not support ops in visual traffic pattern • [insert altitudes]
sXu	*Concept of Use for the Airborne Collision Avoidance System Xu for Small UAS (sXu)* (ver. 0, Rev. 2, Nov. 30, 2018)	• DAA capability/protection for sUAS • Aligns with, but not limited to ASTM F38 • UAS <254 Lbs. & possibly larger • Assumes sUAS without transponders / ADS-B Out • Assumes no ATC separation services • Protection based on CA volumes—not well clear • On-board sensor(s) optional • Dynamic scaling by intruder type • sUAS (directive) DAA Alerting & Guidance (SDAG)

electronic flight bag (EFB)—Any device, or combination of devices, actively displaying EFB functions. An EFB hosts applications, which are generally replacing conventional paper products and tools, traditionally carried in the pilot's flight bag. EFB applications include natural extensions of traditional flight bag contents, such as replacing paper copies of weather with access to near-real-time weather information. To qualify as an EFB function, the failure effect must be considered a minor hazard or have no safety effect. Acceptable EFB functions are listed in Appendices A and B, FAA, *Advisory Circular AC 120-76D*. These EFB applications may be overlaid or integrated. EFBs cannot replace any installed equipment required by operational or airworthiness regulations. EFB functions have no certification requirements for installation under aircraft type design (refer to AC 20-173).[135]

Flight Information Management System (FIMS)—"[A] gateway for data exchange between UTM participants and FAA systems [and the] FAA also uses this gateway as an access point for information on operations."[136] "FIMS supports information exchanges and protocols for Operators to cooperatively share information and to access needed FAA provided information for common situational awareness among all UTM stakeholders (Operators, other government agencies, and the FAA) and will be a core component of the overall UTM ecosystem."[137]

Flight Information Service-Broadcast (FIS-B)—A ground broadcast service provided over the 978 MHz frequency Universal Access Transceiver (UAT) data link, providing properly equipped (ADS-B In) aircraft with a cockpit display of certain aviation weather and aeronautical information for advisory-only use.[138]

Flight Information Exchange Model (FIXM)—Standardized model capturing flight and flow information.[139]

fly-away—Flight outside of operational boundaries (altitude/airspeed/lateral limits) as the result of a failure, interruption, or degradation of the control station or onboard systems, or both.[140]

ground based sense and avoid system (GBSAA)—Ground-based means of detecting airborne traffic and providing the necessary intelligence to a UAS to mitigate or provide an alternate means of see and avoid compliance; includes sensors, correlation and fusion, communications, networks, logic, procedures, and user interfaces.[141]

ground control station (GCS)—A land- or sea-based control center that provides the facilities for human control of sUA.[142] *See* **control station.**

lost link—A situation where the control station has lost either or both of the uplink and downlink contacts with the UA and the remote pilot can no longer manage the aircraft's flight. "Occurrence in which the control station has lost the ability to maintain positive control of the sUA because of the degradation, loss, or interruption of the C2 link for longer than deemed safe depending on the circumstances."[143]

Low Altitude Authorization and Notification Capability (LAANC)—A collaboration between FAA and Industry providing [sUAS] access to controlled airspace near airports through near real-time processing of airspace authorizations below approved altitudes in controlled airspace.[144]

mid-air collision—Aircraft coming in contact with each other while in flight.

non-cooperative aircraft—Aircraft that has neither obtained [LAANC or UTM] authorization nor is transmitting its position and identity (whether via broadcast or network). It includes UAS that are neither network nor broadcast equipped nor otherwise not equipped with a means of providing electronic surveillance information. Alt.: "Aircraft that do not have an electronic means of identification (i.e., a transponder) or not operating such equipment due to malfunction or deliberate action."[145]

non-cooperative system—One that does not rely on intruder-supplied information (such as TCAS or ADS-B Out). *Cf.*, **cooperative aircraft.**

non-equipped—*See* **non-cooperative aircraft.**

proposed method—*Improving Manned Aircraft Pilot Awareness of Small Unmanned Aircraft Systems (sUAS) in Unmanned Traffic Management (UTM)-Enabled Airspace,* as described in this proposal.

remain well clear (RWC)—[*temp*] For sUAS inside VLL airspace, [recommended] as 2000 ft horizontally and ±250 ft vertically, with no tau; and for sUAS outside of VLL airspace [RTCA SC-228] a 35 second tau, a 4,000 ft. horizontal DMOD and ±450 vertical distance. [*ed.* - These parameters are in play.]

Remote ID Display Applications—[*temp*] Applications that ingest broadcast remote ID data and/or interact with a Net-RID Display Provider and present the information to end users.

risk—Composite of predicted severity and likelihood of the potential effect of hazards.[146]

see-and-avoid—Use of the visual capability of a person to identify intruding aircraft so that the sUA can be maneuvered and the safe conduct of the flight can be maintained.[147]

sense-and-avoid—Use of a sensor system to identify intruding aircraft so that the UA can be maneuvered and the safe conduct of the flight can be maintained. [F3196]

small Unmanned Aircraft System (sUAS)—Composed of the small unmanned aircraft (sUA) and all required on-board subsystems, payload, control station, other required off-board subsystems, any required launch and recovery equipment, and command and control (C2) links between the sUA and the control station; synonymous with the term small Remotely Piloted Aircraft System (sRPAS), and small Remotely Piloted Aircraft (sRPA).[148]

small unmanned aircraft, *sUA*, *n*—Unmanned aircraft weighing less than 55 lb (25 kg) on takeoff, including everything that is on board or otherwise attached to the aircraft.[149]

special use airspace (SUA)—[C]onsists of airspace of defined dimensions identified by an area on the surface of the earth wherein activities must be confined because of their nature, or wherein limitations are imposed upon aircraft operations that are not a part of those activities, or both.[150]

supplemental data service provider (SDSP)—Service provider of essential or enhanced services (e.g. terrain and obstacle data, specialized weather data, surveillance, constraint information) [not already provided by the FIMS], communicated via UTM or non-UTM networks.[151]

sXu—A modular, tunable, and scalable DAA solution for sUAS that is an extension of the ACAS Xu.[152]

Type B EFB function—Has a failure condition classification considered minor; may substitute or replace paper products of information required for dispatch or to be carried in the aircraft; may not substitute for or replace any installed equipment required by airworthiness or operating regulations; and require specific authorization for operational authorization for use (*i.e.*, each Type B EFB application must be authorized by the FAA in applicable OpSpecs or MSpecs).[153]

UAS Service Supplier—*see* **Unmanned Aircraft Systems (UAS) Service Supplier (USS).**

UASFM segments—Rectangular divisions of a UASFM each representing 1 min. latitude and 1 min. longitude. [154]

Universal Access Transceiver (UAT)—Automatic Dependent Surveillance-Broadcast (ADS-B) equipment operating on frequency of 978 MHz.[155]

unmanned [aircraft] [aerial] system (UAS)—Unmanned aircraft and associated elements (including communication links and the components that control the unmanned aircraft) that are required for safe and efficient operation in a national airspace system.

unmanned aircraft (UA)—An aircraft operated without the possibility of direct human intervention from within or on the aircraft.[156]

Unmanned Aircraft System (UAS) Service Supplier (USS)—"An entity that provides services to support the safe and efficient use of airspace by providing services to the operator in meeting UTM operational requirements."[157]

Unmanned Aircraft System (UAS) Traffic Management (UTM)—A set of services and an all-encompassing framework managing multiple UAS Operations."[158] A traffic management ecosystem for uncontrolled, low-altitude operations of unmanned aircraft systems, separate but complementary to air traffic management (ATM).[159]

U-space—An "enabling framework" and set of "services and procedures designed to support safe, efficient and secure access to airspace or large number of drones."[160] Not a defined volume of airspace.

UTM—*see* **Unmanned Aircraft System (UAS) Traffic Management (UTM)**

Very Low Level (VLL)—

> Airspace 500 ft. AGL and below—"not [a] hard value, but initial value [and] starting point for discussion . . . . airspace where manned aircraft operations are very in-frequent. VLL airspace excludes Class A, B, C, D, E, and F airspaces, and airport environments." [JARUS][161]
>
> Alt.: Airspace from the surface upwards, where it is reasonable to expect manned aviation will not operate except by permission from a competent authority—typically below minimum altitudes for VFR.[162]
>
> Alt.: Airspace between approximately 300 to 1,200 ft. AGL (with 500 ft AGL used as a common default) to the ground where manned aircraft are not commonly found except around airports. [WK 62668]

well clear—*see* **remain well clear**.

**

Appendix 6. *Selected References*

14 C.F.R. Part 93, Special Use Airspace, *available at,* https://www.law.cornell.edu/cfr/text/14/part-73

14 C.F.R. Part 107, *Small Unmanned Aircraft Systems, available at,* https://www.law.cornell.edu/cfr/text/14/part-107

3rd Generation Partnership Project (3GPP); Technical Specification Group Radio Access Network; *Study on Enhanced LTE Support for Aerial Vehicles* (Rel. 15) 3GPP TR 36.777 v15.0.0 (Dec. 2017), www.3gpp.org/ftp/Specs/archive/36_series/36.777/36777-f00.zip ["*3GPP-Release 15*"]

3rd Generation Partnership Project (3GPP); Technical Specification Group Services and System Aspects; *Study on Remote Identification of Unmanned Aerial Systems (UAS)*, Stage 1 (Rel. 16), 3GPP TR 22.8de V1.0.0 (May 2018) ["*3GPP-Release 16*"]

3rd Generation Partnership Project (3GPP); Technical Specification Group Services and System Aspects; *Unmanned Aerial System support in 3GPP;* Stage 1 (Rel. 16), 3GPP TS 22.125, v0.2.0 (Dec. 2018) ["*3GPP-UAS Support*"]

A Report from the ADS–B In Aviation Rulemaking Committee to the Federal Aviation Administration, *Recommendations to Define a Strategy for Incorporating ADS–B In Technologies into the National Airspace System*, § 4.4.5.4, p. 78 (Sept. 30, 2011), https://www.faa.gov/nextgen/programs/adsb/media/ADSB%20In%20ARC%20Report%20with%20transmittal%20letter.pdf [*"ADS-B IN ARC"*]

AN INTRODUCTION TO UNMANNED AIRCRAFT SYSTEMS, 2nd Ed. (Douglas M. Marshall, et al., eds. CRC Press, 2016)

ANSI, *Standardization Roadmap for Unmanned Aircraft Systems*, Ver. 1.0 (Dec. 2018), https://share.ansi.org/Shared%20Documents/Standards%20Activities/UASSC/ANSI_UASSC_Roadmap_December_2018.pdf ["*ANSI-Roadmap*"]

arcGIS, *UAS Facility Map Data*, https://faa.maps.arcgis.com/apps/webappviewer/index.html?id=9c2e4406710048e19806ebf6a06754ad

Mark Askelson & Henry Cathey, ASSURE, *Small UAS Detect and Avoid Requirements Necessary for Limited Beyond Visual Line of Sight (BVLOS) Operations* (May 19, 2017), http://assureuas.org/projects/deliverables/a2/Final_Report_A2_sUAS_BVLOS_Requirements.pdf [*"ASSURE-Askelson"*]

ASSURE, *Research Results*, http://assureuas.org/projects/research-results.ph

ASTM F38, *Standard for DAA Performance Requirements Terms of Reference*, (Mar. 2018), www.astm.org

ASTM F38, [F38.02 Draft - WK63418] *Standard Specification for Information Exchange between UAS Service Suppliers used in providing UAS Traffic Management Services* (Jan. 4, 2019), www.astm.org

ATIS, *Support for UAV Communications in 3GPP Cellular Standards*, ATIS-1-0000069 (Oct. 2018), https://access.atis.org/apps/group_public/download.php/42855/ATIS-I-0000069.pdf [*"ATIS-2018"*]

ATIS, *Unmanned Aerial Vehicle (UAV) Utilization of Cellular Services, Enabling Scalable and Safe Operations* (2017), https://access.atis.org/apps/group_public/download.php/36134/ATIS-I-0000060.pdf [*"ATIS-2017"*]

Jennifer Bewley, et al., *Federal NOTAM System General Rules for All Event Scenarios*, CNA, IES-2012-U-003512 (Dec. 2012), http://notamdemo.aim.nas.faa.gov/fnshelp/FNSGeneralRulesEventScenarios.pdf ["*Bewley*"]

Vishwanath Bulusu, et. al., *Cooperative and Non-Cooperative UAS Traffic Volumes* (2017), http://unmanned.berkeley.edu/assets/papers/Vishwa_ICUAS17.pdf

Bureau of Ocean Energy Management, *GOMR Geographic Information System (GIS) Data and Maps*, https://www.boem.gov/GOMR-GIS-Data-and-Maps/

Ewen Denney, et al., *Safety Considerations for UAS Ground-based Detect and Avoid*, (DASC 2016), https://utm.arc.nasa.gov/docs/Denney_DASC_1570263561.pdf

DOT, Office of the Inspector General, Audit Report, *Greater Adherence To ADS-B Contract Terms May Generate Better Performance And Cost Savings For FAA*, Rpt. No. AV2017075 (Sept. 5, 2017), https://www.oig.dot.gov/sites/default/files/FAA%20ADS-B%20Contract%20Final%20Report%5E9-5-17.pdf ["*DOT Audit Report*"]

EUROCAE, [Draft] ED-258, *Operational Services and Environment Description for Detect and Avoid [Traffic] in Class D-G Airspace under VFR/IFR*, (___, 2018), [URL-tbd]

EUROCONTROL and FAA, *AIXM Digital NOTAM Event Specification, Increment 1, Ver. 5.1* (2011), https://www.eurocontrol.int/sites/default/files/content/documents/information-management/20101010-digitalnotam-event-specification-increment1.pdf

FAA Extension, Safety, and Security Act of 2016 (PL 114–190; 130 Stat. 615, 49 U.S.C. 40101 note - July 15, 2016), https://www.congress.gov/114/plaws/publ190/PLAW-114publ190.pdf ["*FESSA*"]

FAA, *Advisory Circular AC 00-63A, CHG 1*, Subj: Use of Flight Deck Displays of Digital Weather and Aeronautical Information (Jan. 6, 2017), https://www.faa.gov/regulations_policies/advisory_circulars/index.cfm/go/document.information/documentID/1024126 ["*AC 00-63A*"]

FAA, *Advisory Circular AC 107-2*, Subj: Small Unmanned Aircraft Systems (sUAS) (June 21, 2016), https://www.faa.gov/regulations_policies/advisory_circulars/index.cfm/go/document.information/documentID/1019962 ["*AC 107-2*"]

FAA, *Advisory Circular AC 20-149*, Subj: Installation Guidance for Domestic Flight Information Service - Broadcast (Dec. 21, 2015), https://www.faa.gov/documentLibrary/media/Advisory_Circular/AC_20-149B.pdf

FAA, *Advisory Circular AC 20-173*, Subj: Installation of Electronic Flight Bag Components (Sept. 27, 2011), https://www.faa.gov/regulations_policies/advisory_circulars/index.cfm/go/document.information/documentID/1019524

FAA, *Advisory Circular AC 23.1311-1C*, Subj: Installation of Electronic Display (Dec. 17, 2011), https://www.faa.gov/documentLibrary/media/Advisory_Circular/AC%2023.1311-1C.pdf

FAA, *Advisory Circular AC 90-48D*, CHG 1, Subj: Pilots Role in Collision Avoidance (June 28, 2016), https://www.faa.gov/documentLibrary/media/Advisory_Circular/AC_90-48D_CHG_1.pdf ["*AC 90-48D*"]

FAA, *Advisory Circular AC 90-114A*, CHG 1, Subj: Automatic Dependent Surveillance-Broadcast Operations (Mar. 7, 2016), https://www.faa.gov/documentLibrary/media/Advisory_Circular/AC_90-114A_CHG_1.pdf ["*AC 90-114A*"]

FAA, *Advisory Circular AC 91-78,* Subj: Use of Class 1 or Class 2 Electronic Flight Bag (EFB) (July 20, 2007), https://www.faa.gov/documentLibrary/media/Advisory_Circular/AC_91_78.pdf

FAA, *Advisory Circular AC 120-76D*, Subj: Authorization for Use of Electronic Flight Bags (Oct. 27, 2017), https://www.faa.gov/documentLibrary/media/Advisory_Circular/AC_120-76D.pdf ["*AC 120-76D*"]

FAA, *Aeronautical Data Delivery Service* (Website), http://ais-faa.opendata.arcgis.com/, https://faa.maps.arcgis.com/apps/webappviewer/index.html?id=9c2e4406710048e19806ebf6a06754ad

FAA, *Aeronautical Information Manual* (2018), https://www.faa.gov/air_traffic/publications/ ["*AIM*"]

FAA, *Automatic Dependent Surveillance—Broadcast (ADS–B) Out Performance Requirements To Support Air Traffic Control (ATC) Service,* 75 Fed. Reg. 30160 (May 28, 2010), https://www.federalregister.gov/documents/2010/05/28/2010-12645/automatic-dependent-surveillance-broadcast-ads-b-out-performance-requirements-to-support-air-traffic

FAA, *Automatic Dependent Surveillance—Broadcast (ADS–B) Out Performance Requirements To Support Air Traffic Control (ATC) Service; Technical Amendment*, 75 Fed. Reg. 37711-37712 (June 30, 2018), https://www.govinfo.gov/content/pkg/FR-2010-06-30/pdf/2010-15852.pdf

FAA, *Concept of Use for the Airborne Collision Avoidance System Xu for Small UAS (sXu)*, Ver. 0, Rev. 2, ACAS_COS_1 9_001_V0R2 (Nov. 30, 2018), https://www.dropbox.com/s/4odbwiq345vc4kn/sXu-Concept-of-Use.pdf?dl=0 ["*sXu Concept of Use*"]

FAA, *Digital - AIM | Federal NOTAM System*, https://notams.aim.faa.gov/#Applications

FAA, *Digital Products*, https://www.faa.gov/air_traffic/flight_info/aeronav/digital_products/

FAA, *Interpretation of the Special Rule for Model Aircraft*, Discussion of the Interpretation, https://www.faa.gov/uas/educational_users/media/model_aircraft_spec_rule.pdf

FAA, *Introduction to TCAS II*, Ver. 7.1 (Feb. 28, 2011), https://www.faa.gov/documentLibrary/media/Advisory_Circular/TCAS%20II%20V7.1%20Intro%20booklet.pdf

FAA, *LAANC Data Dictionary* (and associated files), https://github.com/Federal-Aviation-Administration/LAANC

FAA, *LAANC Operations and Maintenance (O&M) Approach*, V.2 (Sept. 28, 2018)

FAA, *Low Altitude Authorization and Notification Capability (LAANC) Concept of Operations*, V1.1 (May 12, 2017), [v. 0.92 Feb. 14, 2017] https://faaco.faa.gov/index.cfm/attachment/download/75780 ["*LAANC CONOPS"*]

FAA ATO, *Low Altitude Authorization and Notification Capability (LAANC), USS Operating Rules,* Ver. 1.3 (Dec. 14, 2018), https://www.faa.gov/uas/programs_partnerships/data_exchange/laanc_for_industry/media/FAA_sUAS_LAANC_Ph1_USS_Rules.pdf ["*USS Operating Rules"*]

FAA, *Memorandum of Agreement Between FEDERAL AVIATION ADMINISTRATION (FAA) Low Altitude Authorization and Notification Capability (LAANC) Automation Platform (AP) And* ___(Dec. 7, 2018), v2.1, https://www.faa.gov/uas/programs_partnerships/data_exchange/laanc_for_industry/media/FAA_LAANC_AP_MOA.pdf ["*LAANC-MOA"*]

FAA, NextGEN, *Unmanned Aircraft Systems (UAS) Traffic Management (UTM) Concept of Operations,* v. 1.0 (May 28, 2018), https://www.utm.arc.nasa.gov/docs/2018-UTM-ConOps-v1.0.pdf ["*UAS-UTM CONOPS"*]

FAA, Surveillance and Broadcast Services (SBS) Program Office, *Surveillance and Broadcast Services Description Document*, SRT-047, Rev. 03 (Oct. 2017), https://www.dropbox.com/s/in7hc058o6cizea/SBS_Description_Document_Rev3.pdf?dl=0 ["*SBS*"]

FAA, *NOTAM Search*, https://notams.aim.faa.gov/notamSearch/

FAA, *ORDER 7110.65X, CHG 1*, Subj: Air Traffic Control, Unmanned Aircraft System (UAS) Activity Information (Oct. 12, 2017), https://www.faa.gov/documentLibrary/media/Order/7110.65X_w_CHG_1_3-29-18.pdf ["*JO 7110.65X*"]

FAA, *ORDER N JO 7210.909*, Subj: Low Altitude Authorization Notification Capability – LAANC (Apr. 30, 2018), https://www.faa.gov/documentLibrary/media/Notice/N_JO_7210.909_LAANC.pdf

FAA, *ORDER JO 7200.23A*, Subj: Unmanned Aircraft Systems, A-1 (Aug. 1, 2017), https://www.faa.gov/documentlibrary/media/order/jo_7200.23a_unmanned_aircraft_systems_(uas).pdf

FAA, *ORDER JO 7400.2M*, *CHG 1*, Subj: Procedures for Handling Airspace Matters (Oct. 12, 2017), https://www.faa.gov/regulations_policies/orders_notices/index.cfm/go/document.current/documentNumber/7400.2 ["*JO 7400.2M*"]

FAA, *ORDER JO 7400.10*, Subj: Special Use Airspace (Feb. 16, 2018), http://www.faa.gov/documentLibrary/media/Order/FAA_Order_JO_7400.10_Special_Use_Airspace.pdf ["*JO 7400.10*"]

FAA, *ORDER JO 7400.11B*, Subj: Airspace Designations and Reporting Points (Aug. 3, 2017), https://www.faa.gov/documentLibrary/media/Order/JO_7400.11B.pdf

FAA, *ORDER 7930.2R*, Subj: Notices to Airmen (NOTAM) (Jan. 5, 2017), https://www.faa.gov/documentLibrary/media/Order/7930.2R_basic_dtd_1_5_17_(2).pdf ["*ORDER 7930.2R*"]

FAA, *ORDER 8260.3B CHG 26*, Subj: United States Standard for Terminal Instrument Procedures (TERPS) (Feb. 24, 2014), https://www.faa.gov/regulations_policies/orders_notices/index.cfm/go/document.information/documentID/11698 ["*TERPS*"]

FAA, *ORDER 8900.1, Vol. 4, Ch. 15*, Subj: Electronic Flight Bag Evaluation and Authorization (Oct. 27, 2017), http://fsims.faa.gov/PICResults.aspx?mode=EBookContents&restricttocategory=all~menu

FAA, *Preparation of Interface Document*, FAA-STD-025f (Nov. 30, 2007), http://www.tc.faa.gov/its/worldpac/standards/faa-std-025f.pdf

FAA, *TSO-C157b*, Subj: Flight Information Services- Broadcast (FIS-B) Equipment (May 28, 2015), https://www.faa.gov/nextgen/programs/adsb/media/TSO-C157b.pdf

FAA, *NAS Service Registry/Repository (NSRR),* https://nsrr.faa.gov/all-services

FAA, *Preliminary Hazard Analysis (PHA) for Low Altitude Authorization and Notification Capability (LAANC)* - Safety Risk Management Document, Ver. 1.0 (Oct. 23, 2017) ["*LAANC-PHA*"]

***[FAA, AJV-5, *Standard Operating Procedures for UASFMs,* (TBD)]

FAA & NASA, Unmanned Aircraft System Traffic Management (UTM) Research Transition Team (RTT), Concept Working Group, *Concept & Use Cases Package #2 Addendum: Technical Capability Level 3*, Ver. 1.0, Doc. No. 20180007223 (July 2018), https://ntrs.nasa.gov/search.jsp?R=20180007223 [*"TCL 3"*]

FAA, *Safety Risk Management Guidance for System Acquisitions* (SRMGSA) (June 2018), https://www.faa.gov/air_traffic/publications/media/srmgsa.pdf

FAA, FAA Safety Risk Management Panel, Emerging Tech. Team, AJV-115, *Title 14 Code of Federal Regulations Part 107 Small Unmanned Aircraft System Rule: Conditions and Limitations for Allowing Operations in Class E Surface Area Safety Risk Management Document*, ver. 1.0 (Aug. 26, 2016) [“*SRMD*”]

***FAA ATO, *Low Altitude Authorization and Notification Capability (LAANC), Automation Platform (AP) Phase 1 System Requirements,* v.1.3 (June 9, 2017)

FAA, Surveillance and Broadcast Services (SBS Program, *SBS TIS-B/FIS-B Essential Services Specification*), FAA-E-3006, Ver. 2.0 (Feb 9, 2010), https://faaco.faa.gov/index.cfm/attachment/download/16532 [“*SBS TIS-B/FIS-B ESS”*]

FAA, *SWIM Controlled Vocabulary,* https://www.faa.gov/air_traffic/technology/swim/vocabulary/#SWIM-enabled-program

FAA, *SWIM Users Forum Documents*, https://www.faa.gov/air_traffic/technology/swim/users_forum/

FAA, *UAS Data Delivery Service*, http://uas-faa.opendata.arcgis.com/ [“*UAS Data Delivery Service”*]

FAA, UAS Identification and Tracking (UAS ID) Aviation Rulemaking Committee (ARC), UAS ID ARC, *Recommendations, Final Report* (Sept. 30, 2017), https://www.faa.gov/regulations_policies/rulemaking/committees/documents/media/UAS%20ID%20ARC%20Final%20Report%20with%20Appendices.pdf [*“UAS ID ARC”*]

FAA, *USS Onboarding, Low Altitude Authorization and Notification Capability (LAANC)*, (Feb. 2018), https://www.faa.gov/uas/programs_partnerships/data_exchange/laanc_for_industry/media/LAANC_UAS_Service_Supplier_onboarding_information.pdf [*“USS Onboarding”*]

***FAA, *USS-FAA Authorizations and Notifications Interface Control Document* (ICD), Ver. 1.6

FAA Reauthorization Act of 2018, H.R. 302, § 348 [Amending Ch. 2 of title 18 U.S.C. by inserting § 39A, Unsafe Operation of Unmanned Aircraft], https://docs.house.gov/billsthisweek/20180924/HR302.pdf, and [https://www.congress.gov/115/bills/hr302/BILLS-115hr302enr.pdf [“*FRA*”]

Lisa Fern, et al., *An Exploratory Evaluation of UAS Detect and Avoid Operations in the Terminal Environment*, p. 16, 2018 Avi. Tech., Integration, & Ops. Conf. (Atlanta – 2018), https://humansystems.arc.nasa.gov/publications/TOPS_AIAA_Paper.pdf

GAO, *Small Unmanned Aircraft Systems, FAA Should Improve Its Management of Safety Risks* (May 2018), https://www.gao.gov/assets/700/692010.pdf [“*GAO”*]

Garmin, *GDL 90 Data Interface Specification***,** Doc. 560-1058-00 Rev A (June 5, 2017), https://www.faa.gov/nextgen/programs/adsb/Archival/media/GDL90_Public_ICD_RevA.PDF

Guterres, R. Michael, et al., MITRE, *ADS-B Surveillance System Performance with Small UAS at Low Altitude,* American Institute of Aeronautics and Astronautics (2017) https://www.mitre.org/sites/default/files/publications/16-4497-AIAA-2017-ADS-B.pdf

ICAO, *Address and Spectrum Issues for Small UAS* (prepared by Doug Arbuckle), SP3-ASWG8-WP/15, 3rd Mtg. of the Surveillance Panel (Sept. 24, 2018), https://www.dropbox.com/s/ommqcbyvd002zlz/SP3-ASWG8-WP15-Address%20and%20Spectrum%20Issues%20for%20Small%20UAS.pdf?dl=0 [*“ICAO-Arbuckle”*]

ICAO, Annex 10, Aeronautical Telecommunications, *UAT and Mode S Extended Squitter Standards and Recommended Practices (SARPs),* www.icao.int

ICAO, Annex 15, Aeronautical Telecommunications, *Aeronautical Information Services,* www.icao.int

ICAO, Doc 4444-ATM/501, *Procedures for Air Navigation Services: Air Traffic Management* (Nov. 22, 2007)**,** https://www.icao.int/EURNAT/Other%20Meetings%20Seminars%20and%20Workshops/FPL%202012%20ICAO%20EUR%20Region%20Plan/Documentation%20related%20to%20FPL%202012%20Amendment/Amendment%201%20Doc4444.EN.pdf

Frank Matus, Dir. Strategy & Bus. Dev., et al., Thales, *Addressing the Need for a Near-Term Solution to UAS Integration* (2018), *available at,* https://issuu.com/atca_org/docs/thales_paper_acy/5

Brian Patterson, [Draft] *Proposed Small Unmanned Aircraft Systems Detect and Avoid Safety Performance Metric for Very Low Level and Beyond Visual Line of Sight Operations*, MITRE, Case No. 18-3937 (Nov. 2018)

RTCA, DO-185B, *Minimum Operational Performance Standards for Traffic Alert and Collision Avoidance System II (TCAS II), Ver. 7.1, Vol 1* (June 19, 2018), www.rtca.org ["*DO-185B*"]

RTCA, DO-260B, *Minimum Operational Performance Standards for 1090 MHz Extended Squitter Automatic Dependent Surveillance – Broadcast (ADS-B) and Traffic Information Services–Broadcast (TIS-B)* (Dec. 2, 2009), www.rtca.org

RTCA, DO-264, *Guidelines for Approval of the Provision and Use of Air Traffic Services Supported by Data Communications,* www.rtca.org

RTCA, DO-267, *Minimum Aviation System Performance Standards (MASPS) For Flight Information Services-broadcast (FIS-B) Data Link* (Apr. 2004), www.rtca.org ["*DO-267"*]

RTCA, DO-282B, *Minimum Operational Performance Standards for Universal Access Transceiver (UAT), Automatic Dependent Surveillance-Broadcast (ADS-B)* (Dec. 2, 2009), www.rtca.org ["*DO-282B"*]

RTCA, DO-317, *Minimum Operational Performance Standards (MOPS) for Aircraft Surveillance Applications (ASA) System*, Rev. B (June 17, 2014), www.rtca.org ["*DO-317"*]

RTCA, DO-358, *Minimum Operational Performance Standards (MOPS) for Flight Information Services Broadcast (FIS-B) with Universal Access Transceiver (UAT)* (Mar. 24, 2015), www.rtca.org ["*DO-358"*]

RTCA, DO-365, *Minimum Operational Performance Standards (MOPS)* for *Detect and Avoid Systems* (May 2017), www.rtca.org ["*DO-365*"]

RTCA, *Improving Graphic Temporary Flight Restrictions in the National Airspace System* (Dec. 2016), *available at,* https://download.aopa.org/advocacy/FINAL_Graphical_TFR_Report.pdf?_ga=2.103034816.1907030135.1524580232-1585595406.1513274841 ["*RTCA-GTFR"*]

Peter Sachs, Altiscope, *A Quantitative Framework for UAV Risk Assessment*, Vol. 1, Rpt. TR-008 (Sept. 13, 2018), https://altiscope.us17.list-manage.com/track/click?u=fcbb6c28439061a34affe5b67&id=0af0cc2d29&e=503e457f66

Peter Sachs, et al., Altiscope, *Effectiveness of Preflight Deconfliction in High-Density UAS Operations,* Rpt. TR-009 (Oct. 3, 2018), https://drive.google.com/file/d/1oTz1mzrt-CWDOp1IDXELc9qVLAJswMtp/view ["*Sachs-Deconfliction*"]

Asma Tabassum, et al., *UAT ADS-B Data Anomalies and the Effect of Flight Parameters on Dropout Occurrences*, Data, Vol. 3(2) (June 8, 2018), https://res.mdpi.com/data/data-03-00019/article_deploy/data-03-00019.pdf?filename=&attachment=1, and https://www.mdpi.com/2306-5729/3/2/19

**

Acknowledgements

The Aviators Code Initiative Permanent Editorial Board:

Don Arendt, PhD, CFI, ATP
Michael S. Baum, JD, MBA, ATP
Ric Peri
Michael Radomsky, CFII
Bill Rhodes, PhD
Stan Rose
Rusty Sachs, JD, DhE, MCFI
Don Steinman, Capt., AA (Ret.), ATP, CFII

The Reviewers:

We gratefully acknowledge the editorial input and valuable assistance of a number of subject matter experts. Their input does not necessarily represent the opinions of their employers, nor do all reviewers concur with all positions taken. Some reviewers may not have seen the latest updates prior to publication. Thanks to all, including those not listed who requested anonymity.

Rex Alexander, Five-Alpha, LLC

Tom Bleier, Insitu

Olivier Bellehumeur-Genier, Transport Canada

Craig Bloch-Hansen, Transport Canada

Scott Blum, Ph.D., Jeppesen

Fred Borda, Aerial Innovation

Ralph Britton, PE

Tim Bruner, Kansas State Polytechnic

Scott S. Burgess, Ph.D., ERAU

Gabriel Cox, Intel

Greg Deeds, Technology Exploration Group, Inc.

Rune Duke, AOPA

Paul C. Fiducia, Small Aircraft Manufacturers Assn

Brian Fisher, FAA

Nicholas T. Flom, NPUASTC

Mike Gadd, Altitude Angel

Stephen M. George, FAA

Rich Hanson, AMA

Brad Hayden, Robotic Skies

Lynette M. Jamison, FAA

Phil Kenul, Chair, F38, ASTM Int'l

Kristy M. Kiernan, Ph.D., ERAU

Steven Kleiman, POH Performance, LLC

Christopher T. Kucera, AGI

Leonard Ligon, Whitefox

Joe Little, SEND Solutions

Doug Marshall, JD, TrueNorth Consulting LLC

Frank Matus, Thales

Stacey Maye, SERCO

Thann McLeod, FAA

Jason Miller, ForeFlight

Mohammad Moallemi, Ph.D., ERAU

Brandon Montellato, DJI

Jorge Moya, NASA ASRS

Johnathan J. Pesce, ERAU

Christian Ramsey, uAvionix

Jeffrey Richards, NATCA

Steven Silverman, Icarus Instruments

Tyler Spence, Ph.D., San Jose State University

David St. George, DPE, MCFI, SAFE

Jon Standley, L3 Harris

Werner von Stein, SF Drone School

Capt. Scott Strimple, United Airlines

Attila Takacs, Ericsson

John Tree, Jeppesen

Thomas P. Turner, ATP, Mastery Flight Training

Dan Tzur, Ph.D, Facebook

Thatch VandenBergh, Jeppesen

Ryan Wallace, Ed.D, ERAU

David White, ATP, Stanford Life Flight

Heidi Williams, NBAA

Harrison Wolf, WEF

Mark Wuennenberg, ATP, ICAO

Gilead Wurman, Ph.D., ENGEO

**

Endnotes

[1] FAA, *Low Altitude Authorization and Notification Capability (LAANC) Concept of Operations*, V1.1, § 5.3, p. 14 (May 12, 2017) [*temp*: v. 0.92 Feb. 14, 2017], https://faaco.faa.gov/index.cfm/attachment/download/75780 ["*LAANC CONOPS*"]. *See* ICAO, *The Role of FF-ICE* [*Flight and Flow Information for a Collaborative Environment* - webpage], https://www.icao.int/airnavigation/FFICE/Pages/Role-Of-FFICE.aspx ("Ensure that all actors have a common view of a flight and have access to the most accurate data available.").

[2] **General -**

- This document and the described *method to enhance manned aircraft pilot awareness of* is abbreviated herein as the "proposal", "proposed method", or "Proposal".
- The use of this proposed method would be advisory only (i.e., not compulsory such as a TCAS resolution advisory (RA)), not to replace or substitute for proper flight planning, required or recommended communications, or requirements for the visual acquisition of sUAS when in visual meteorological conditions (VMC). Loss or non-receipt of data associated with services implementing this method would have no regulatory impact.
- The main body of this paper was kept intentionally brief with detailed support added as endnotes. To accommodate an eclectic audience of both manned and unmanned aircraft experts, as well as both technical and policy professionals, the endnotes are purposefully robust.
- In citing works, "[*Italicized, bracketed text*]" denotes abbreviations of citations referenced elsewhere in the document.
- The term "LAANC airspace" selectively abbreviates "LAANC-enabled airspace". Neither of these terms denotes a distinct, regulatory creation of a new species of airspace. *See* note 6.
- The proposed method is *not* a Detect and Avoid (DAA) system. DAA is mentioned in this proposal for the limited purposes of providing perspective, and considering the extent to which the proposed method might complement DAA.
- The term "*temp*", "*TEMP*", or "TBD" means that the corresponding note is either temporary or requires editing. References to draft standards will be removed before final publication of this proposal.

[3] "[A]ctive" means that the subject UASFM segment(s) (defined below note 6) has been authorized for current/immediate sUAS flight operations, and therefore where sUAS are likely operating. It does not mean that sUAS necessarily occupy such airspace. *Cf.*, FAA ATO, *Low Altitude Authorization and Notification Capability (LAANC), USS Operating Rules,* Ver. 1.3, p. 8 (Dec. 14, 2018), https://www.faa.gov/uas/programs_partnerships/data_exchange/laanc_for_industry/media/FAA_sUAS_LAANC_Ph1_USS_Rules.pdf ("A 'true' flag means that LAANC is active (accepting authorization submissions) for the associated UASFM grid and facility.") ["*USS Operating Rules*"]. FAA, *O&M White Paper for LAANC*, Ver. 2, § 5.3.2 (Sept. 28, 2018) ("'Active' means the authorization has been issued, remains valid, and the operation has not yet concluded (according to the time window listed on the authorization).").

Cancellation - While there is not an express obligation of the holder (pilot/operator) of a LAANC authorization to cancel such authorization if not exercised, cancellation is (or should be) the preferred protocol. *See* FAA, NextGEN, *Unmanned Aircraft Systems (UAS) Traffic Management (UTM) Concept of Operations,* v. 1.0 (May 28, 2018) ["*UAS-UTM CONOPS*"] ("Operators and USSs also facilitate prompt release of unused airspace [such as] when a flight ends earlier than projected." *Id.* § 2.7.3); and *USS Operating Rule*s, § 3.4.8 (operator cancellation prior to the designated operation start time facilitated). *Compare* IFR cancellation practices. FAA, *Aeronautical Information Manual* (Sept. 13, 2018), § 5-1-14, https://www.faa.gov/air_traffic/publications/atpubs/aim_html/index.html ["*AIM*"] (f. cancellation required "where there is no functioning control tower").

[4] **Unmanned Traffic Management (UTM)** - A traffic management ecosystem for uncontrolled, low-altitude operations of unmanned aircraft systems, separate but complementary to air traffic management (ATM). *See* FAA, *Unmanned Aircraft System Traffic Management (UTM)* webpage, https://www.faa.gov/uas/research_development/traffic_management/. UTM scope and purposes continue to evolve and solidify. The proposed method's coverage may transcend LAANC. *See, e.g.,* Proposal, § 6.e (Display of Ad Hoc UTM Corridors).

[5] **Facility Maps** - *See* FAA, *FAA UAS Data Delivery System*, http://uas-faa.opendata.arcgis.com/ (hosting published UASFM) ["*UAS Data Delivery System*"]; and FAA, *UAS Facility Maps*, https://www.faa.gov/uas/commercial_operators/uas_facility_maps/ (presenting the UAS Facility Maps). Also called an "authorization map". FAA, *Preliminary Hazard Analysis (PHA) for Low Altitude Authorization and Notification Capability (LAANC)* - Safety Risk Management Document, Ver. 1.0, p. 3 (Oct. 23, 2017) ["*LAANC-PHA*"].

UASFM Segments - "Segments" are rectangular divisions of a UASFM each representing 1 min. latitude and 1 min. longitude. *See* FAA, *ORDER 7200.23A*, Subj: Unmanned Aircraft Systems (Aug. 1, 2017), https://www.faa.gov/documentlibrary/media/order/jo_7200.23a_unmanned_aircraft_systems_(uas).pdf ["*JO 7200.23A*"]. UASFM segments are also called "grid cells". *USS Operating Rules*, § 3.3.1., p. 5.

[6] **Low Altitude Authorization and Notification Capability (LAANC**) - LAANC is the term for the software used to automate sUAS operator requests for access to airspace and receive FAA issued authorizations for Part 107 operations. FAA, *ORDER N JO 7210.909*, Subj: Low Altitude Authorization Notification Capability - LAANC (April 30, 2018), https://www.faa.gov/documentLibrary/media/Notice/N_JO_7210.909_LAANC.pdf. sUAS operations are provided for in 14 C.F.R. Part 107 – which under Part 107.41 requires an ATC authorization in certain airspaces. The use of LAANC and the UASFMs is limited to a method of compliance per Part 107.41. LAANC is generally understood to be a UTM implementation, and "the broad term for an enterprise capability to automate to the maximum extent possible the ability for FAA to grant authorization to Part 107 operators" for operations near airports. *LAANC CONOPS,* § 4.1*.* Upon implementation of the *FAA Reauthorization Act of 2018*, such authorizations will include model aircraft operations. *FAA Reauthorization Act of 2018*, 49 U.S.C. 44890 (P.L. 115-254), § 348 [amending Ch. 2 of title 18 U.S.C. by inserting § 39A, Unsafe Operation of Unmanned Aircraft], https://docs.house.gov/billsthisweek/20180924/HR302.pdf, and https://www.congress.gov/115/bills/hr302/BILLS-115hr302enr.pdf ["*FRA"*]. *See* FAA, *FAA Facilities Participating in LAANC*, https://www.faa.gov/uas/programs_partnerships/data_exchange/laanc_facilities/#all (LAANC-enabled airport list).

LAANC-Enabled Airspace - Officially there is no "LAANC" or "UTM" airspace. Airspace is precisely categorized as Class A, B, C, D, E, or G (and F although not used in the United States). These airspace classes have specific purposes, definitions and geometry. However, LAANC has resulted in a de facto recharacterization of low altitude airspace near airports, and may affect terminal operations whether or not formally defined/recognized.

[7] *See* 14 C.F.R. § 91.103 Preflight action.

Threat and Error Management - Moreover, the recognized precepts of Threat and Error Management (TEM) underscore the immutable need to engage *all* parties/available resources responsively—*including manned aircraft pilots*. "Threat management provides the most proactive option to maintain margins of safety in flight operations, by voiding safety-compromising situations at their roots. As threat managers, *flight crews are the last line of defense to keep threats from impacting flight operations*." Capt. Dan Maurino, Coordinator, Flight Safety and Human Factors Programme - ICAO, *Threat And Error Management (TEM*), Canadian Aviation Safety Seminar (CASS), Vancouver, BC, p. 2 (Apr. 18-20, 2005), https://flightsafety.org/files/maurino.doc (emphasis added). "Flight crews must, as part of the normal discharge of their operational duties, employ countermeasures to keep threats, errors and undesired aircraft states from reducing margins of safety in flight operations." *Id.* p. 6 (citing "Airborne Collision Avoidance System (ACAS) as a "'hard' resource[] that flight crews employ as systemic-based countermeasures"); and consider the collision avoidance function "as a safety net support[ing] the pilot's responsibility for the safety of the flight in all airspace classes, and requir[ing] capability against cooperative and non_cooperative targets." ICAO, *Non Segregated UAS Operations*, AN-Conf/13-WP/41, § 4.1, p.3 (Aug. 21, 2018), https://www.icao.int/Meetings/anconf13/Documents/WP/wp_041_en.pdf.

[8] **See and Avoid (SAA) and Remain Well Clear (RWC)** - Pilot obligations to see and avoid and to remain well clear are expressed or implicated in the following rules:

- 14 C.F.R. § 91.103 Preflight action. (familiarity with all available information concerning the flight),
- 14 C.F.R. § 91.111 Operating near other aircraft. ("(a) No person may operate an aircraft so close to another aircraft as to create a collision hazard."),
- 14 C.F.R. § 91.113 Right-of-way rules except water operations. ("(b) . . . vigilance shall be maintained by each person operating an aircraft so as to see and avoid other aircraft. When a rule of this section gives another aircraft the right-of-way, the pilot shall give way to that aircraft and may not pass over, under, or ahead of it unless well clear."), and
- 14 C.F.R. § 91.181 Course to be Flown. (For IFR operations within controlled airspace, permits "(b) . . . maneuvering the aircraft to pass well clear of other air traffic or the maneuvering of the aircraft in VFR conditions to clear the intended flight path both before and during climb or descent.").

Associated sUAS pilot obligations are expressed in 14 C.F.R. § 107.37 Operation near aircraft; right-of way rules. (sUAS must "(a) . . . must yield the right of way to all aircraft . . . . giv[ing] way to the aircraft or vehicle and may not pass over, under, or ahead of it unless well clear . . . . (b) No person may operate a small unmanned aircraft so close to another aircraft as to create a collision hazard." Additionally, FAA, *Advisory Circular AC 107-2*, Subj: Small Unmanned Aircraft Systems (sUAS), § 5.12 (June 21, 2016), https://www.faa.gov/regulations_policies/advisory_circulars/index.cfm/go/document.information/documentID/1019962 ["*AC107-2*"] ("5.12 Remaining Clear of Other Aircraft. "A remote PIC has a responsibility to operate the small UA so it remains clear of and yields to all other aircraft. This is traditionally referred to as "see and avoid." To satisfy this responsibility, the remote PIC must know the location and flight path of his or her small UA at all times. The remote PIC must be aware of other aircraft, persons, and property in the vicinity of the operating area, and maneuver the small UA to avoid a collision, as well as prevent other aircraft from having to take action to avoid the small UA.").

RWC has also been defined as "[t]he ability to detect, analyze and maneuver to avoid potential conflicting traffic by applying adjustments to the current flight path in order to prevent the conflict from developing into a collision hazard [and] consists of two components: maintain DWC and regain DWC." RTCA, DO-365, *Minimum Operational Performance Standards (MOPS)* for *Detect and Avoid Systems* (May 2017), Appn. B.2 Definitions ["*DO-365*"]. It is generally understood to represent "a separation standard between airborne traffic." *Id.* Appn. C, p. C-2. The proposed method is *not* a Detect and Avoid (DAA) system.

As a practical matter, the quantified values of well clear presented in DAA standards and recommendations are greater than the available airspace separation provided for LAANC operations (*see, e.g., DO-365,* Appn. C-3 & C-4 presenting two well clear recommendations that include the following vertical minimums: SARP-700 ft., and SC-228/FAA-450 ft.). *See also* Dallas Brooks, et al., UAS Excom, *Science and Research Panel (SaRP) Update,* Presentation at AUVSI, XPONENTIAL (April 2017) (recommending 2000 ft. horizontal, and +/-250 ft. vertical distance for safe separation between sUAS and manned aircraft); Andrew Weinert, et al., *Well-Clear Recommendation for Small Unmanned Aircraft Systems Based on Unmitigated Collision Risk*, J of Air Transp., Vol. 26, No. 3 (2018), pp. 113-122, https://arc.aiaa.org/doi/10.2514/1.D0091; FAA, *Advisory Circular, AC 90-WLCLR*, Subj: Well Clear Definition for Small Unmanned Aircraft Systems Operating Beyond Visual Line of Sight (DRAFT-Dec. 2018), https://www.faa.gov/aircraft/draft_docs/media/afs/AC_90-WLCLR_Coord_Copy.pdf, and https://www.faa.gov/aircraft/draft_docs/afs_ac/ ("horizontal distance of 2,000 feet or a vertical distance of 250 feet" for BVLOS "operating at low altitudes away from airports"); Graham Warwick, et al., *NASA Pushes To Enable Wider UAS Operations in National Airspace*, Aviation Week (June 22, 2018), http://aviationweek.com/future-aerospace/nasa-pushes-enable-wider-uas-operations-national-airspace (mentioning well-clear recommendation of

2,000 ft. horizontal by 250 ft. vertical separation); Marcus Johnson, et al., *Characteristics of a Well Clear Definition and Alerting Criteria for Encounters between UAS and Manned Aircraft in Class E Airspace*, NASA Ames Research Center, 11th USA/Euro. Air Traffic Mgt. Research and Dev. Seminar (ATM 2015), https://www.aviationsystemsdivision.arc.nasa.gov/publications/2015/ATM2015_Johnson.pdf; and Seung Man Lee, et al., NASA Ames, *Investigating Effects of "Well Clear" Definitions on UAS Sense-And-Avoid Operations*, https://www.aviationsystemsdivision.arc.nasa.gov/publications/2013/AIAA-2013-4308.pdf. Additionally, there is "empirical evidence that the Phase 1 DAA well clear definition, alerting and guidance is insufficient to support safe UAS terminal operations" and even a new well clear definition accommodating terminal operations "should refrain from alerting against traffic in the VFR traffic pattern . . . ." Lisa Fern, et al., *An Exploratory Evaluation of UAS Detect and Avoid Operations in the Terminal Environment*, p. 16, 2018 Avi. Tech., Integration, & Ops. Conf. (Atlanta – 2018), https://humansystems.arc.nasa.gov/publications/TOPS_AIAA_Paper.pdf.

Separately, the 3rd Generation Partnership Project (3GPP) provides that "UAVs are considered separated if they are at a horizontal distance of at least 50m or vertical distance of [30]m or both." 3GPP, Technical Specification Group Services and System Aspects; *Unmanned Aerial System support in 3GPP;* Stage 1 (Rel. 16), 3GPP TS 22.125, v0.2.0, § 5.3, p. 8 (Dec. 2018) ["*3GPP-UAS Support*"].

Detect and Avoid (DAA) - DAA systems provide situational awareness, alerting and flight guidance to maintain safe flight operations relative to other aircraft. *See generally,* Dallas Brooks & Stephen P. Cook, *Detect and Avoid*, in AN INTRODUCTION TO UNMANNED AIRCRAFT SYSTEMS, 2nd Ed. (Douglas M. Marshall, et al., eds. CRC Press, 2016). Despite significant technical progress, extraordinary equipage to support ubiquitous DAA capability remains technically impracticable and cost prohibitive for most sUAS. And, DAA standards (including those in development) contain or contemplate altitude limitations that challenge LAANC coverage. *See* Appen. 5-*Glossary of Selected Terms* (defining DAA and listing relevant standards).

[9] GAO, *Small Unmanned Aircraft Systems, FAA Should Improve Its Management of Safety Risks*, pp. 11-12 (May 2018), https://www.gao.gov/assets/700/692010.pdf ["*GAO*"] ("FAA explained . . . pilots can have difficulty positively identifying objects as small UAS, given their small size, their distance from the observed position, the speeds at which a manned aircraft and a UAS are operating, or the various factors competing for the pilot's attention."). *See* 14 C.F.R. §§ 107.31 (visual line of sight operations), & 107.37 (operations near aircraft, right-of-way rules).

[10] For example, specialized radar equipment is not generally practicable. Additionally, DAA systems may operate with reduced performance in the airport environment at altitudes just above the ground. EUROCAE, [Draft] ED-258, *Operational Services and Environment Description for Detect and Avoid [Traffic] in Class D-G Airspace under VFR/IFR*, § 1.1 (___, 2018), [URL-tbd].

[11] Indeed, "due to the assumption that sUAS will not be equipped with transponders or ADS-B Out, manned and large UAS intruders will be unable to perform DAA . . . the entire burden for DAA is on the sUAS since the other aircraft will not be able to detect the sUAS." FAA, *Concept of Use for the Airborne Collision Avoidance System Xu for Small UAS (sXu)*, Ver. 0, Rev. 2, ACAS_COS_1 9_001_V0R2 (Nov. 30, 2018), § 2.5, p. 15, *available at,* https://www.dropbox.com/s/4odbwiq345vc4kn/sXu-Concept-of-Use.pdf?dl=0 ["*sXu Concept of Use*"]. *See generally,* FAA, *Advisory Circular AC 90-114A*, Subj: Automatic Dependent Surveillance-Broadcast Operations (Mar. 7, 2016), https://www.faa.gov/documentLibrary/media/Advisory_Circular/AC_90-114A_CHG_1.pdf ["*AC 90-114A*"]; and FAA, *Automatic Dependent Surveillance-Broadcast (ADS-B)* webpage, https://www.faa.gov/nextgen/programs/adsb/.

[12] Generally, ADS-B for sUAS is either not required or prohibited. For LAANC operations, "there are no separation requirements and *no equipment for class of airspace requirements*." *JO 7200.23A*, Appn. A, p. A-3 (emphasis added). "Part 107 operations are exempt from the Part 91 rules that define VFR and IFR operations . . . and require no separation or services by ATC." *Id. at* NOTE-1. Additionally, sUAS waivers tend to prohibit use of ADS-B Out. *See, e.g.,* FAA, *Certificate of Waiver, No. 107W-2018-17032* (Effec. Dec. 12, 2018 to Dec. 31, 2022), https://www.faa.gov/uas/commercial_operators/part_107_waivers/waivers_issued/media/107W-2018-

17032_Kailene_Cloud_CoW.pdf ("12. ADS-B out (1090/978 MHz) may not be transmitted from the sUAS when operating pursuant to this Waiver").

Despite the benefits of a beacon designed to transmit a UAS ID and possibly support deconfliction, significant challenges remain. *See* FAA's UAS Identification and Tracking (UAS ID) Aviation Rulemaking Committee (ARC), UAS ID ARC, *Recommendations, Final Report,* § 6.6.1 (Sept. 30, 2017), https://www.faa.gov/regulations_policies/rulemaking/committees/documents/media/UAS%20ID%20ARC%20Final%20Report%20with%20Appendices.pdf ["*UAS ID ARC*"] (challenges include congestion and interference). *Cf.,* Christian Ramsey, below note 31 (addressing ADS-B power/traffic density saturation issues/limitations).

Remote UAS ID standards development seeking to respond to the ARC report is underway. *See, e.g.,* ASTM F38.01, [draft-WK27055], *New Practice for UAS ID and Tracking* (2018), https://www.astm.org/COMMIT/SUBCOMMIT/F3801.htm. The FAA plans to issue UAS ID performance requirements Spring 2019. Earl Lawrence, [former] Exec. Dir., UAS Integration Office, FAA, presentation at the Drone Advisory Committee meeting (Santa Clara, July 17, 2018). It may take at least a few years thereafter to stand-up such capabilities and achieve substantial implementation.

[13] **Enhanced Risks Near Airports** - LAANC is implemented in airport environments. Airports are where most manned aircraft must take-off and land; the density of aircraft traffic and pilot workload are highest; manned aircraft are generally closest to obstacles (including the ground); it is where pilots have the least margin for error, narrow stall-margin, and the least practical/safe options for maneuvering to avoid sUAS. *See* FAA, *FAA Safety Briefing* (2018), https://www.faa.gov/news/safety_briefing/2018/media/SE_Topic_18_08.pdf (more than 25% of general aviation fatal accidents result from maneuvering); and Peter Sachs, Altiscope, *A Quantitative Framework for UAV Risk Assessment*, Vol. 1, Rpt. TR-008 (Sept. 13, 2018), https://drive.google.com/file/d/1KNk8eHkvlRUpbxtyUsGi4deGoxstIkqJ/view, https://altiscope.us17.list-manage.com/track/click?u=fcbb6c28439061a34affe5b67&id=0af0cc2d29&e=503e457f66 ("Operations in proximity to manned aircraft . . . are subject to more stringent risk thresholds to comply with higher target levels of safety associated with manned aircraft (that is, the risk calculation must take into account lethality as a primary harm . . .)"). Additionally, it is expected that Urban Air Mobility (UAM - air taxis) will intensively interconnect with airports, creating further traffic density with this new [category] of aircraft. UAM is considered "[t]he highest risk area for VLL." [draft] EUROCAE § 2.3.6.

Aircraft (and particularly rotorcraft) may approach and depart in diverse vectors often unanticipated by other pilots. *See* FAA, *Order 8260.56*, Subj: Diverse Vector Area (DVA) Evaluation (Aug. 2, 2011), https://www.faa.gov/documentLibrary/media/Order/Order%208260.56.pdf. Rotorcraft tend to operate at extremely low altitudes (at least) until above autorotation speed. There are more than 15,000 helicopters in the US within the top three vertical markets alone (oil and gas, air medicine, and air tours), representing more than 2 million operations annually. Stan Rose, CEO, Helicopter Safety Alliance (Aug. 2, 2018). Also, pilots on an approach may "dive and drive" to avoid weather or traffic—all possibly placing the aircraft in closer proximity to LAANC-enabled airspace than anticipated. *See* Appn. 1, Examples 3, 4, & 6.

See AC 107-2, § 5.8.1.2 ("the FAA expects that most remote PICs will avoid operating in the vicinity of airports because their aircraft generally do not require airport infrastructure, and the concentration of other aircraft increases in the vicinity of airports."). *Cf.,* FAA, *Operation and Certification of Small Unmanned Aircraft Systems, Discussion of the Final Rule*, § III.E.2.a, p. 121, https://www.faa.gov/uas/media/RIN_2120-AJ60_Clean_Signed.pdf ("Because of the limits on their access to airspace that is controlled . . . small unmanned aircraft will avoid busy flight paths and are unlikely to encounter high-speed aircraft that would be difficult for the remote pilot to see-and-avoid."). 14 C.F.R. § 107.43 Operation in the vicinity of airports*,* prohibits operation of a sUA "in a manner that interferes with operations and traffic patterns at any airport, heliport, or seaplane base."

Use of counter-UAS systems in the airport environment may create untenable risks, including with regard to radio, ATC, and operational interference, geography, cost, and false positives. *See generally,* FAA, Letter to Airport Sponsor[s] from John R. Dermody, PE, Dir. of Airport Safety and standards (July 19, 2018), https://www.faa.gov/airports/airport_safety/media/Counter-UAS-Airport-Sponsor-Letter-July-2018.pdf ("FAA does not endorse or advocate for the use of countermeasures in the airport environment . . .").

See FAA, *More than 50,000 LAANC Applications processed,* https://www.faa.gov/news/updates/?newsid=92273 (last visited Nov. 21, 2018); Presentation by Earl Lawrence, note 12 ("The close and personal nature of UAS is what is different."). The LAANC national roll-out is substantially complete; and FAA, *When is LAANC Coming to Me?*, https://www.faa.gov/uas/programs_partnerships/uas_data_exchange/ (presenting the phased-in schedule for LAANC). "We're adding millions more operations . . . it is now a super highway that used to be a dirt road." Earl Lawrence, *id.* Additionally, more than 100,000 remote Pilot Certificates were issued since August 2016. FAA, *FAA Hits 100K Remote Pilot Certificates Issues*, https://www.faa.gov/news/updates/?newsId=91086. *See FAA Aerospace Forecast* (FY 2018-2038), https://www.faa.gov/data_research/aviation/aerospace_forecasts/media/FY2018-38_FAA_Aerospace_Forecast.pdf.

[14] **NOTAMs** - The Notice to Airmen system provides "[t]ime-critical aeronautical information which is of either a temporary nature or not sufficiently known in advance to permit publication on aeronautical charts or in other operational publications [that] receives immediate dissemination via the National NOTAM System." *AIM,* § 5-1-3.a. *See generally,* FAA, *ORDER 7930.2R*, Subj: Notices to Airmen (NOTAM) (Jan. 5, 2017), https://www.faa.gov/regulations_policies/orders_notices/index.cfm/go/document.information/documentID/1030286 ["*ORDER 7930.2R"*]; and FAA, *NOTAM Search*, https://notams.aim.faa.gov/notamSearch/. *Cf., "*NOTAM. A notice distributed by means of telecommunication containing information concerning the establishment, condition or change in any aeronautical facility, service, procedure or hazard, the timely knowledge of which is essential to personnel concerned with flight operations." ICAO, *Annex 15*, Ch. 1. Definition. "A NOTAM shall be originated and issued promptly whenever the information to be distributed is of a temporary nature and of short duration or when operationally significant permanent changes, or temporary changes of long duration are made at short notice, except for extensive text and/or graphics." ICAO, *Annex 15*, Ch. 5.1.1. "Recommendation.— The need for origination of a NOTAM should be considered in *any other circumstance* which may affect the operations of aircraft." ICAO, *Annex 15*, Ch. 5.1.1.2 (emphasis added). The number of UAS NOTAMS is significant, as high as 1,200 but typically around 700 concurrently; and 87.8% of all UAS NOTAMs are for altitudes of 400 ft and below. Email from Lynette M. Jamison, US NOTAM Governance and Operations to M. Baum (Aug. 31, 2018).

Outside of LAANC, NOTAMs may be required such as: where Part 107 waivable rules are invoked; for Part 91 UAS operations; and for exemptions or certificate of waiver or authorization (COA). *See ORDER 7930.2R*, § 6-1-5.c.2, Other Airspace NOTAMs - Unmanned Aircraft Operations. *See also, JO 7200.23A*, 14 C.F.R. Part 107, and FAA, *DOT/FAA854, Requests for Waivers and Authorizations Under 14 CFR Part 107 System of Records Notice*, 81 Fed. Reg. § 50789-92 (Aug. 2, 2016), https://www.gpo.gov/fdsys/pkg/FR-2016-08-02/pdf/2016-18208.pdf.

[15] Though the FAA and ICAO are working to improve coverage, many NOTAMs do not provide sufficient information for graphical (TWGO) capability. Graphical NOTAMs are not comprehensive, the graphical NOTAM database is not all-inclusive, and there are many gaps in the current system. *See* Appn. 2. Service Protocols and Message Format Overview (addressing TWGO).

Private facilities are not normally included in the NOTAM system, except those with special instrument procedures. Heliports are probably the most susceptible to NOTAM exclusions. Based on a recent review of the FAA 5010 airport master record database, 5,842 public and private heliports are on record in the U.S and yet only 94 or 1.6% have verified NOTAM services. Of these 94 heliports, 60 are pubic use. FAA, *Airport Data & Contact Information* (website), https://www.faa.gov/airports/airport_safety/airportdata_5010/ (contains airport master record database). In such records, contact information has never been verified by the FAA for accuracy and currency. "In several cases information was found to be 10, 20, and even 30+ years out of date." Email from Rex Alexander, Five-Alpha, LLC to M. Baum (Nov. 2, 2018).

NOTAMs concerning UAS airspace usage are not filed automatically—they require the affirmative action of the unmanned aircraft pilot—and thus may lack consistent availability and continuity. Moreover, FIS-B aeronautical information (including NOTAMs) is limited to the past 30 days. *See* note 28 and accompanying text (introducing FIS-B). Additionally, FIS-B uplink is not an FAA-approved source for NOTAMs. FAA, *TSO-C157b*, Subj.: Flight Information Services-broadcast (FIS-B) Equipment (May 28, 2015), https://www.faa.gov/nextgen/programs/adsb/media/TSO-C157b.pdf. It thus does not fulfill all requirements for preflight action required by 14 C.F.R. § 91.103. *See* FAA, *Advisory Circular, AC 00-63A, CHG 1*, Subj: Use of Flight Deck Displays of Digital Weather and Aeronautical Information, Appn. 1 (Jan. 6, 2017), https://www.faa.gov/regulations_policies/advisory_circulars/index.cfm/go/document.information/documentID/1024126 ["*AC 00-63A*"], and FAA, *InFO 18008*, Subject: Flight Information Systems – Broadcast (FIS-B) Notice to Airmen (NOTAM) Guidance and Policy Updates (Jul. 16, 2018), https://www.faa.gov/other_visit/aviation_industry/airline_operators/airline_safety/info/all_infos/media/2018/InFO18008.pdf. "We do not display NOTAMs graphically now, save for TFRs, but plan to do more of that over time. Barrier is the parsing of the mess that is today's NOTAM system, our app is ready to display all kinds of data once the data is available. Email from Jason Miller, CTO, ForeFlight, to M. Baum (Nov. 26, 2018). *See* Robert Sumwalt, Chairman, NTSB (2018), https://www.youtube.com/watch?v=LWLPDOXF7e4 (asserting that "NOTAMS are just a bunch of garbage that nobody pays any attention to"). *See* P.L. 112-153, *Pilot's Bill of Rights*, § 3, Notices to Airmen, https://www.gpo.gov/fdsys/pkg/PLAW-112publ153/pdf/PLAW-112publ153.pdf (This proposal appears consistent with the U.S. legislative mandate to improve NOTAMs). One noteworthy NOTAM reform initiative has reduced the number of NOTAM published in the *Notices to Airmen Publication* (NTAP) effective Feb. 28, 2019. NTAP, Forward, Part 1 (Jan. 3-30, 1019), https://www.faa.gov/air_traffic/publications/atpubs/ntap/foreword.html.

[16] 14 C.F.R. Part 107.49(a) (preflight familiarization, inspection, and actions for aircraft operation); and *LAANC CONOPS*, § 5.3, p. 14. Note that many DROTAMS are operative for as long as a year, precluding use as timely notification of airspace conflict.

[17] **ATCT and Separation** - ATCT operational personnel are neither generally furnished information about active UASFM segments, nor do they generally know the exact location of sUAS activity therein, impeding effective advisories to manned aircraft pilots. *JO 7200.23A*, § 2.3.a-b. *See* FAA, *ORDER 7110.65X, CHG 1*, Subj: Air Traffic Control, § 2-1-22, Unmanned Aircraft System (UAS) Activity Information (Oct. 12, 2017), https://www.faa.gov/documentLibrary/media/Order/7110.65X_w_CHG_1_3-29-18.pdf ["*JO 7110.65X*"] (ATC requirement to provide UAS advisory information when in the controller's judgement proximity warrants); and *JO 7110.65X,* § 2-1-1(e) ("e. Air Traffic Control services are not provided for model aircraft operating in the NAS."). Consequently, ATCT advisories might be less effective than the mitigations provided by the proposal, since ATCT most likely cannot electronically or visually surveil sUAS. *See also,* FAA, *Advisory Circular AC 90-48D*, *CHG 1*, Subj: Pilots Role in Collision Avoidance, § 4.6.7, Remember Controller Limitations (June 28, 2016), https://www.faa.gov/documentLibrary/media/Advisory_Circular/AC_90-48D_CHG_1.pdf ["*AC 90-48D*"].

Consider that the FAA assumes that "**[t]here are portions of *each* facility's airspace at very low altitudes that a sUAS could operate (sic] without impacting IFR or VFR operations.**" *JO 7200.23A*, App. A: Map Design, § 3.a (emphasis added). Notwithstanding, "[e]ven if UTM services are provided in airspace below 500 feet, they cannot exist in isolation, since there are existing manned airspace users active in that airspace." ICAO, *Non Segregated UAS Operations*, AN-Conf/13-WP/41, § 3.3, p.2 (Aug. 21, 2018), https://www.icao.int/Meetings/anconf13/Documents/WP/wp_041_en.pdf. Moreover, sUAS: are generally not certificated aircraft; their altitude reporting capability, if any, is not necessarily accurate; the ability of a sUAS pilot to visually ascertain the altitude of his sUAS varies considerably; many sUAS are without redundant systems (although that is changing); use protected (licensed) spectrum infrequently for command and control; are not required to maintain radio communication with other aircraft; the potential for a fly-away or other flight condition that compromises separation is heightened; and reporting of sUAS incidents and mishaps is neither consistent nor comprehensive. *See, e.g.*, Samuel M. Vance, Ryan J. Wallace, et al., *Detecting and Assessing Collision Potential of Aircraft and Small Unmanned Aircraft Systems (sUAS) by Visual Observers*, IJAAA, Vol. 4 (2017), https://commons.erau.edu/ijaaa/vol4/iss4/4/. Moreover, "[t]he relative rates of [Class E and Class E surface area] NMACs are not well-known." FAA Safety Risk Management Panel, Emerging Tech. Team, AJV-115, *Title 14 Code of*

Federal Regulations Part 107 Small Unmanned Aircraft System Rule: Conditions and Limitations for Allowing Operations in Class E Surface Area Safety Risk Management Document, ver. 1.0, § 2.1, p. 6 (Aug. 26, 2016) ["*SRMD*"].

[18] **Safe Altitudes** - UAS facility maps are not intended to specify safe operating altitudes for sUAS. Rather, the UASFMs display the maximum altitudes around airports where the FAA *may* authorize Part 107 UAS operations without additional safety analysis. *JO 7200.23A.* For LAANC, it is arguable that the UASFM represent either minimum safe operating altitudes for small UAS or vertical separation criteria for small UAS operations in the terminal environment. *LAANC-PHA*, Appn. B, p.12, Dissenting Opinion by Stephen M. George. "UASFM altitudes are not defined or characterized as 'safe' altitudes. They are more generally described as altitudes at a specific location where ATC [may issue] automatic authorizations (e.g. use of LAANC) without further coordination with the ATC facility." Email from Stephen George, FAA to M. Baum (Dec. 8, 2018). *See* 14 C.F.R. § 91.119, Minimum Safe Altitudes: General, § 6.d, Terrain Risk Data Integration; and note 31 (presenting vagaries of GPS-derived altitude). *Cf.,* note 56 of this proposal (MOA vs. UASFM Separation).

[19] UASFM segment altitudes for Class E surface areas are designated at FAA Headquarters, and LAANC requests for operations in such airspace "are processed at Headquarters [and] Headquarters coordination with [local] facilities will not be required . . ." *JO 7200.23,* Ch. 4 A.1.c.

The Order (*JO 7200.23A*) presents only a single example, using an airport unrepresentative of urban or complex airport environments, whose segment altitudes, with one exception are "0" feet only for segments abutting runways. As a practical matter, such guidance (or lack thereof), together with the Order's apparent assumption that *each* airport has some airspace to relinquish (*see* note 17), implicitly may communicate a government policy of aggressive UAS integration by local ATCT managers charged with completing/submitting UASFMs. This may unintentionally result in an overzealous or incautious response. There has been observation of sensitivity to "potential consequences of schedule slippage of initial [LAANC] deployment." *LAANC-PHA*, Appn. B, p. 2, Dissenting Opinion by Stephen M. George. "The method by which the safe operating altitudes were established may not have a thorough basis nor established by the appropriate organizational responsibility within the Federal Aviation Administration. . . . Procedures may not have been established or validated to minimize human error and ensure consistency in the process of establishing safe operating altitudes in the UAS FM as the basis of granting authorizations." *LAANC-PHA*, Appn. B, p. 6. *Cf.*, SARP collision risk airspace classification of *high-risk* includes very low altitude "VLL in/over/around Class B, C, or D airports", and *medium-risk* "VLL in/over/around Class E, F, or G airports." [*draft*] Brian Patterson, *Proposed Small Unmanned Aircraft Systems Detect and Avoid Safety Performance Metric for Very Low Level and Beyond Visual Line of Sight Operations*, MITRE, Case No. 18-3937 (Nov. 2018), §§ 6.1 & 6.2.

An analysis of several nearby airports that have implemented LAANC with nearly identical conditions (traffic, terrain, runways, airspace, etc.) indicates significant and inexplicable variation in the designation of segment altitudes. M. Baum, ACI, *The Low Altitude Authorization & Notification Capability (LAANC) and its Risk Analysis*, Unpublished White Paper (June 6, 2018). Moreover, the fact that these altitude anomalies have not been mitigated effectively since the program roll-out suggests need for a system-wide internal review and updated validation procedures. Nonetheless, any such improvements cannot substitute for also providing traffic awareness to manned aircraft pilots.

Stakeholder Engagement - LAANC has not required (or obtained) adequate stakeholder (such as local pilot and operator) consultation. *See, e.g.,* Appn. 1, Example 1 (re: failure to include heliport facility/operator stakeholders). Compare the benefits of informal airspace meetings preceding certain airspace actions where "[e]very effort must be made to notify all interested aviation organizations and/or persons and groups that may be affected by the proposed action." FAA, *Order JO 7400.2M*, Subj: Procedures for Handling Airspace Matters, § 2-5-4 (Oct. 12, 2017), https://www.faa.gov/regulations_policies/orders_notices/index.cfm/go/document.current/documentNumber/7400.2 ["*JO 7400.2M*"]. Note that the FAA's Flight Standards Service (AFS) was not a member or participant on the

LAANC Safety Risk Management Panel despite its responsibility to establish "separation standards, safe operating altitudes, and terminal instrument procedures (TERPS)." *LAANC-PHA*, Appn. B-1.

[20] *FAA Modernization and Reform Act of 2012* (49 U.S.C. 40101 note) ["*FMRA"*], § 336(b), Special Rule for Model Aircraft codified in 14 C.F.R. § 101(E), https://www.ecfr.gov/cgi-bin/retrieveECFR?gp=&SID=cb5fe1fa0f75cdcad197502057a7c99d&mc=true&n=sp14.2.101.e&r=SUBPART&ty=HTML ("When flown within 5 miles of an airport, the operator of the aircraft provides the airport operator and the airport air traffic control tower (when an air traffic facility is located at the airport) with prior notice of the operation."). Notwithstanding, airport and ATCT managers are sometimes unavailable, not trained to respond, lack resources, have not effectively published their phone numbers, and lack integration of this activity into their safety management systems (SMS). An "airport" is defined as "an area of land or water that is used or intended to be used for the landing and takeoff of aircraft, and includes its buildings and facilities, if any." 14 C.F.R. 1.1.

[21] *FRA,* § 39A. The utility of this proposal should further increase with hobbyist sUAS pilots' obtaining LAANC authorization (rather than merely providing notification) for operations in controlled airspace near airports. The *FRA* repealed *FMRA* § 336, aligning certain hobbyist sUAS pilot requirements with their Part 107 counterparts. The FAA had earlier anticipated facilitating notifications within LAANC for model aircraft operations (under 14 C.F.R. Subpart E §§ 101.41 & 101.43 - Special Rule for Model Aircraft) upon completion of air traffic procedures and Paperwork Reduction Act compliance. FAA ATO, *LAANC Phase 1 USS Operating Rules,* v1.2, § 3.4 (Feb. 28, 2018).

Enforcement - Recent legislative enforcement initiatives may further bolster sUAS pilot/operator LAANC compliance, and the efficacy of this proposal. For example, the *FRA* provides substantial penalty for knowing or reckless interference with a manned aircraft (§ 384. Unsafe operation of unmanned aircraft, amending 18 U.S.C. Ch. 2), and articulating the Sense of Congress that the "Administrator should pursue all available civil and administrative remedies . . . including referrals to other government agencies for criminal investigations" regarding unauthorized UAS operations (§ 362(5)); and the *FAA Extension, Safety, and Security Act of 2016*, 49 U.S.C. 46320 (July 15, 2016), https://www.congress.gov/114/plaws/publ190/PLAW-114publ190.pdf ["*FESSA*"]. If sUAS operators were confident that obtaining authorization was an effective safety mitigation, they might be incented to better comply with authorization requirements. Despite progress, enforcement need further attention. *See, e.g., GAO*, pp. 32-33 (urging, *inter alia*, educating and enabling local law enforcement).

[22] *LAANC CONOPS*, § 5.3, p. 14 (emphasis added) (and recognizing "the ranges of UAS physical, flight performance, and operational characteristics").

Shared Awareness/Intent - This proposal provides near-term support for shared awareness and shared intent, key UTM features/requirements. "Low altitude manned aircraft operating in both uncontrolled and controlled airspace, have access to, and are encouraged to utilize UTM services to gain situational awareness of nearby UTM operation." *UAS-UTM CONOPS*, § 2.7.1, p. 20. Such use of the UTM by manned aircraft is considered permissible "passive participation". *UAS-UTM CONOPS*, § 1.2, p. 2. "At minimum, manned aircraft Operators should access UTM shared intent data to gain awareness of UAS operations planned along their route of flight." *UAS-UTM CONOPS*, § 2.5.1, p. 11. It provides "multiple layers of separation assurance to ensure the safe conduct of operations. . . . The sharing of operation intent . . . and supplemental data sharing are key supporting features of UTM that reduce the need for tactical separation management and/or reduce the likelihood of in-flight intent changes . . . ." *UAS-UTM CONOP,* § 1.2, p. 2 (extending beyond manned to unmanned operators, *Id*. § 2.7.1, p. 17). *See* Joseph Rios, et al., *UAS Reports (UREPs): Enabling Exchange of Observation Data Between UAS Operations*, NASA/TM-2017-219462 (Feb. 2017), https://ntrs.nasa.gov/archive/nasa/casi.ntrs.nasa.gov/20170003878.pdf). Moreover, as a collateral benefit, "cooperation can also greatly reduce computational complexity for airborne CDRA [collision, detection, resolution, and avoidance] systems by minimizing the sizes of multi-aircraft deconfliction problems." Vishwanath Bulusu, et. al., *Cooperative and Non-Cooperative UAS Traffic Volumes* (2017), http://unmanned.berkeley.edu/assets/papers/Vishwa_ICUAS17.pdf.

The proposal's capability may also provide particular benefit to "a class of VFR pilots who choose not to talk to air traffic control [as a] target audience for [graphical TFR in the cockpit] intervention." RTCA, *Improving Graphic*

Temporary Flight Restrictions in the National Airspace System (Dec. 2016), p. 12, *available at,* https://download.aopa.org/advocacy/FINAL_Graphical_TFR_Report.pdf?_ga=2.103034816.1907030135.1524580232-1585595406.1513274841.

[23] Paul McDuffee *quoted in,* Bill Carey, *Enter The Drones, The FAA and UAVs in America* (Schiffer 2016), p. 120 ("We don't believe there's going to be a one-size-fits-all solution to any of this."). Effective solutions will likely be multifaceted, requiring both cooperative and non-cooperative technologies, and engaging/supporting both manned and unmanned aircraft operations. Indeed, "there remain many complex issues to be addressed in order for the potential of drone technology to be fully realized, most of which are centered around non-interference with manned aviation and ensuring the safety of the flying public." ANSI, *Standardization Roadmap for Unmanned Aircraft Systems*, Ver. 1.0 (Dec 2018), § 1.1, https://share.ansi.org/Shared%20Documents/Standards%20Activities/UASSC/ANSI_UASSC_Roadmap_December_2018.pdf ["*ANSI-Roadmap*"].

[24] **Current LAANC UASFM Segment Coverage** - LAANC is deployed at "nearly 300 air traffic facilities covering approximately 500 airports," FAA, *UAS Data Exchange (LAANC)*, https://www.faa.gov/uas/programs_partnerships/data_exchange/, and covers most of the largest and busiest facilities. *See* FAA, *FAA Facilities Participating in LAANC*, https://www.faa.gov/uas/programs_partnerships/data_exchange/laanc_facilities/*;* and FAA, *FAA UAS Data on a Map*, https://faa.maps.arcgis.com/apps/webappviewer/index.html?id=9c2e4406710048e19806ebf6a06754ad (graphical presentation of CONUS LAANC-enabled airspace). Public airports with LAANC represent nearly 40 million flight operations and 38% of public airport operations annually. Email from Rex Alexander, Five-Alpha, LLC (Jan. 22, 2019). Anticipated expansion in 2019, including to include contract towers, may contribute to materially greater coverage.

Gap Coverage - The remaining coverage gap might be materially reduced to the extent supplemental mitigations are implemented, including, for example:

- Connected device position data - *See* § 6.b.
- Traffic sensor data integration - *See* § 6.c.
- LAANC Expansion - Further phases of LAANC deployment.
- UTM deployment.
- Local government webform data fusion for sUAS notifications & permissions. *See, e.g.*, County of San Mateo, Public Works, *San Carlos and Half Moon Bay Airport - sUAS Operators*, https://publicworks.smcgov.org/webforms/san-carlos-half-moon-bay-airport-suas-operators.
- UASFM overlays at non-LAANC-enabled airports - *See* § 6.g.

Incentive to Equip - This proposal may also help incent low-end general aviation to equip per the ADS-B Out mandate. *See* 14 C.F.R. § 91.225, Automatic Dependent Surveillance-Broadcast (ADS-B) Out equipment and use, https://www.gpo.gov/fdsys/granule/CFR-2011-title14-vol2/CFR-2011-title14-vol2-sec91-225. There are an estimated 80,000 - 85,000 ADS-B In receivers on the market. Aircraft Electronics Assn (July 18, 2018). About 127,000 of the 260,000 general aviation aircraft are transponder-equipped; and there are some 300,000 pilots. *See* FAA, *Current [ADS-B] Equipage Levels* (as of Aug. 1, 2018), https://www.faa.gov/nextgen/equipadsb/installation/current_equipage_levels/.

[25] *See* Appn. 5, *Glossary of Selected Terms* (defining EFB). EFB solutions, particularly for the "last mile" (and perhaps more) of datalink can be implemented per Advisory Circulars. FAA, *Advisory Circular AC 120-76D*, Subj: Authorization for Use of Electronic Flight Bags (Oct. 27, 2017), https://www.faa.gov/documentLibrary/media/Advisory_Circular/AC_120-76D.pdf ["*AC 120-76D*"], and FAA, *Advisory Circular AC 20-173*, Subj: Installation of Electronic Flight Bag Components (Sept. 27, 2011),

https://www.faa.gov/regulations_policies/advisory_circulars/index.cfm/go/document.information/documentID/1019524 [*"AC 20-173"*] (at a declining expense, e.g., leveraging new technologies, including WiFi-via-SAT technologies). *See also,* FAA, *Advisory Circular, AC 91-78*, Subj: Use of Class 1 or Class 2 Electronic Flight Bag (EFB), https://www.faa.gov/documentLibrary/media/Advisory_Circular/AC_91_78.pdf. Moreover, consider data-conversion to ARINC 633 format (air-ground protocol for ACARS and IP networks used for aeronautical operational control (AOC) data exchanges between aircraft and the ground) already widely used in EFB domains, and use of pre-existing data-delivery mechanisms that cover much of this information (including geo-referenced polygons) in the EFB industry domain.

[26] **Diverse Networks Compared** - *See* notes 27-29 (satcom, FIS-B, and cellular, respectively). *Cf., e.g., UAS ID ARC*, § 5.1.3, *Analysis of viable technology solutions.*

Source Data Availability - UASFM status source data that affects safety of flight should be made available non-exclusively, including via the LAANC gateway, the FAA's Aeronautical Common Services (ACS - *see* note 118), UAS Service Suppliers (USSs), Flight Service, and, when available, the System Wide Information Management (SWIM) infrastructure, and other sources. Some reviewers of this proposal suggested that SWIM would be "complex", "incompatible", and "expensive". *See* note 115 (SWIM and Flight Service); and note 36 (proposing data limitations regarding personally identifiable information and USS proprietary data).

[27] **SATCOM** - Satellite-enabled *safety and regularity of flight* data options are expanding. *See, e.g.,* Iridium, https://www.iridium.com/ (presenting *Iridium NEXT*, providing low-cost high-speed service in both L-Band (1-2 GHz) and K-band (26.5-40 GHz)); and Bill Carey, Aviation Week, *Iridium Eyes Mid-2019 for Certus Connectivity* (Oct. 17, 2018), http://aviationweek.com/connected-aerospace/iridium-eyes-mid-2019-certus-connectivity.

[*See* ICAO, Doc. 9965, *Manual on Flight and Flow—Information for a Collaborative Environment* (1st Ed., 2012) (FF-ICE), § 6.3, https://www.icao.int/Meetings/anconf12/Documents/9965_cons_en.pdf; ICAO, FF-ICE website, https://www.icao.int/airnavigation/FFICE/Pages/default.aspx (expanding facilitation of aircraft intent data and longitudinal availability and recognizing air/ground data communication SWIM connectivity). Consider a GA analog to use of AeroMACs (aeronautical mobile airport communication system) supplemented by satellite-based updates; and EUROCONTROL, *AeroMACS*, https://www.eurocontrol.int/articles/airport-surface-data-link-aeromacs (Airport Surface Data Link recommended by ICAO).]

[28] **FIS-B** - FIS-B is a ground broadcast service provided over the 978 MHz frequency Universal Access Transceiver (UAT) data link, enabling properly equipped (ADS-B In) aircraft to display meteorological and aeronautical information for advisory-only use. RTCA, DO-358, *Minimum Operational Performance Standards (MOPS) for Flight Information Services Broadcast (FIS-B) with Universal Access Transceiver (UAT)* (Mar. 24, 2015) ["*DO-358*"]; *AC 00-63A,* Appn. 1, Fig. A-3, UAT Product Parameters For Low/Medium/High Altitude Tier Radios; and FAA, *ADS-B In Pilot Applications* (webpage), https://www.faa.gov/nextgen/programs/adsb/pilot/#fisb. FIS-B "supports interoperability between providers of ground and airborne FIS processing systems by defining a broadcast protocol that may be used in any broadcast medium." RTCA, *Minimum Aviation System Performance Standards (MASPS) For Flight Information Services-broadcast (FIS-B) Data Link* (Apr. 2004), www.rtca.org ["*DO-267"*]. *See AC 90-114A*, p. 3 (recognizing FIS-B's capability of "enhancing the user's situational awareness (SA) and improving the overall safety of the NAS.").

ADS-B - *See* RTCA, DO-260B, *Minimum Operational Performance Standards for 1090 MHz Extended Squitter Automatic Dependent Surveillance – Broadcast (ADS-B) and Traffic Information Services – Broadcast (TIS-B)*, www.rtca.org [RTCA DO-260B CORR 2011-DEC-13 Corrigendum 1]; FAA, Surveillance and Broadcast Services (SBS) Program Office, *Surveillance and Broadcast Services Description Document*, SRT-047, Rev. 03 (Feb. 10, 2017), https://www.dropbox.com/s/in7hc058o6cizea/SBS_Description_Document_Rev3.pdf?dl=0 ["*SBS*"] (describing aeronautical telecommunications infrastructure to support ADS-B). In 2007 the FAA awarded a multiyear contract (now reorganized/renamed) to L3 Harris Technologies, to develop and deploy the ADS-B ground infrastructure and broadcasting services. The FAA does not own or maintain the hardware, software, or other ground infrastructure. DOT, Office of the Inspector General, Audit Report, *Greater Adherence To ADS-B Contract Terms May Generate*

Better Performance And Cost Savings For FAA, Rpt. No. AV2017075 (Sept. 5, 2017), https://www.oig.dot.gov/sites/default/files/FAA%20ADS-B%20Contract%20Final%20Report%5E9-5-17.pdf. [“*DOT Audit Report”*]

[29] **Cellular** - Cellular communications supporting this proposal will be limited initially to those using Airborne Access Systems (AAS). *See* note 121. Commercial cellular networks were not designed for airborne use and are impeded due to interference caused by altitude, velocity, power management and other factors. Notwithstanding, methods have been identified to mitigate cellular interference during low-altitude sUAS operations, including: use of directional antennas, beamforming, intra-site coherent JT CoMP [Coordinated Multi-Point with Joint Transmission], LTE Release-13 coverage extension techniques, enhanced power control mechanisms, and coordinated data and control transmission schemes that “could include signaling for indicating the dedicated DL [downlink] resource, option for cell muting/ABS, procedure updates for cell (re-)selection and acquisition to apply to the coordinated cell, and cell ID for the coordinated cell.” 3GPP, Technical Specification Group Radio Access Network, *Study on Enhanced LTE Support for Aerial Vehicles* (Release 15), 3GPP TR 36.777, v15.0.0, § 8, Conclusions (Dec. 2017), www.3gpp.org/ftp/Specs/archive/36_series/36.777/36777-f00.zip [“*3GPP-Release 15*”]. Some of these mitigations are already supported in LTE and thus do not require specification enhancement. The study “concluded that LTE networks are capable of serving Aerial UEs [user equipment].” *Id. See generally,* ATIS, *Support for UAV Communications in 3GPP Cellular Standards*, ATIS-1-0000069 (Oct. 2018), https://access.atis.org/apps/group_public/download.php/42855/ATIS-I-0000069.pdf [“*ATIS-2018”*]; and ATIS, *Unmanned Aerial Vehicle (UAV) Utilization of Cellular Services, Enabling Scalable and Safe Operations* (2017), https://access.atis.org/apps/group_public/download.php/36134/ATIS-I-0000060.pdf [“*ATIS-2017”*]. “The LTE/5G technology itself could provide connectivity for the use case [of this proposal]. The question is more towards the telecom operators, if they are ready to do the extra configuration and potential antenna deployments and resource sharing that are needed for large scale reliable support of the service.” Attila Takacs, Dir. Head of Ericsson Garage, Silicon Valley, Ericson Research (March 5, 2019).

The specifications for, and testing of cellular communications for sUAS has largely been focused on altitudes under 300m AGL and velocities no greater than 100 km/h [89.4 kts.]. The minimum requirements for manned aircraft pilot direct air-to-ground cellular service to support the proposed method are likely modest, and might include:

• **Vicinity**: Terminal environments.

• **Altitude**: ~2,500 AGL - providing manned aircraft pilots an average of ~2 minutes to descend to a pattern altitude of ~1,000 AGL at a 750 FPM descent rate—and a correspondingly sufficient reaction time to mitigate the risk. Compare *DO-365* requirement for a DAA system to generate an alert at least 20 seconds and no more than 75 “seconds prior to an intruder entering the preventative hazard zone . . . and with an average time to alert at least 55 seconds prior to intruders entering the preventive hazard zone . . .” *DO-365*, § 2.2.4.3.4.2, p. 70, Preventive Alert. “It is expected that the PIC, upon receiving a preventive alert, will maintain altitude unless necessary . . .” *Id.* pp. 69-70.

• **Maximum Velocity**: ~259.3 km/h [140 kts.] - this velocity is within 20 kts of TRACON expectations for operations into larger airports, and below the maximum supported speed of 320 kmph of the 3GPP Technical Specification. 3GPP; Technical Specification Group Services and System Aspects; *Unmanned Aerial System support in 3GPP;* Stage 1 (Rel. 16), 3GPP TS 22.125, v0.2.0, § 5.3, p. 8 (Dec. 2018) [“*3GPP-UAS Support*”].

• **Message Size**: Minimum of 450 bits - akin to the size of a digital NOTAM. This message size is well-below the cellular technical specification’s “message payloads limit of 50-1500 bytes, not including security-related message components(s).” *3GPP-UAS Support,* § 5.3, p. 8.

• **Reliability:** Low **-** the proposed method would be advisory only, supplemental, and have no regulatory impact. *See* note 2. Predictability requirements would be low-to moderate, are in contrast to those for

Command and Non-Payload Communications (CNPC) in the 5030-5091 MHz band and for "safety and regularity of flight" per 47 C.F.R. § 87.5, and specified in RTCA, *DO-362, Command and Control (C2) Data Link Minimum Operational Performance Standards (MOPS) (Terrestrial)* (Sept. 22, 2016), www.rtca.org.

• **Update Frequency**: ~5 minutes - assumes most sUAS pilots file and get LAANC authorization more than 5 minutes before planned flight operations.

Given the above-mentioned altitude constraints of the sUAS cellular communications study, its applicability to manned aircraft terminal operations is limited. Further research and additional mitigations are invariably needed to enable direct air-to-ground communications. That said, some of the mitigations identified in the 3GPP study may be found to be extensible to help support near-term low-altitude manned operations. And, of course, the implementation of 5G services, especially for dense/urban coverage, appears particularly promising.

[30] **Pilot Training** - Pilot training supporting this proposal would include recommended practices for pilot action upon observing "illuminated" active UASFM segment(s) in order to mitigate [risk of] loss of separation between manned aircraft and sUAS during terminal operations. Manned and unmanned aircraft pilot subject matter experts (SMEs) would develop responsive peer-reviewed training and guidance materials to advise manned aircraft pilots when, and to what extent to:

(a) seek a lateral offset from active UASFM segment(s), recognizing that UAS operations could be undertaken abeam UASFM segment boundaries,

(b) maintain current or a higher altitude and/or enhanced buffer as long as practicable,

(c) consider varying (and in towered environments, requesting varied) pattern operations or runway assignments,

(d) request ATCT advisories concerning sUAS (to the extent available and efficacious),

(e) learn and maintain proficiency in use of the proposed cockpit display applications and content layer, and

(f) recognize the associated risks and implement responsive mitigations.

[31] **ADS-B and Altimetric Limitations** - The traffic density within low-altitude airspace at many airports may challenge the capabilities of transponders and Traffic Information Services - Broadcast (TIS-B) equipage. Additionally, while the proposed method does not affirmatively denote whether a UAS is actually in an active UASFM segment, neither does TIS-B. *AC 90-114A*, § 2-4.c(3), p. 5 ("Not all ground and airborne traffic will appear on the traffic display"); and ADS-B Out requirements "do not apply to any aircraft that was not originally certified with an electrical system or that had not subsequently been certified with such a system installed, including balloons and gliders." *Id.* § 3-2, p. 8). Even if an ADS-B-supported DAA capability were to become available, "DAA will require additional validation of ADS-B traffic position with active surveillance data or radar data if the data is to be used to provide warning alerts. Nevertheless, "[c]orrective and preventive DAA alerts can be issued using unvalidated ADS-B tracks" *sXu Concept of Use*, § 2.9, p. 18. *See* note 80 ("altitude-measuring capabilities of sUAS operators are not ideal."). The Proposed Method is not a DAA system.

Radar Limitations - "For aircraft being tracked by radar only (non-cooperative aircraft), the altitude and vertical rate estimations may have large vertical uncertainties such that vertical predictions of altitude cannot be used for alerting purposes." *DO-365*, § 2.2.4.3.5.1. Thus, this proposal's graphical presentation of LAANC-enabled airspace may be preferable (compared, e.g., to TIS-B, at least in the near-term. Additionally, TIS-B, a traffic advisory service dependent on ground-based radar, has considerable limitations. *See* FAA, *AIM,* § 4-5-6 d. Limitations, https://www.faa.gov/air_traffic/publications/media/AIM.pdf. Moreover, TIS-B is on a trajectory towards decommissioning. Separately*, see* Christian Ramsey, Pres., uAvionix, *Inert and Alert: Intelligent ADS-B for UAS NAS Integration, Concept of Operations* (2017), http://uavionix.com/downloads/whitepapers/Inert-and-Alert-CONOPS.pdf (in part, addressing limitations and challenges of current ADS-B surveillance).

Altimetric Equipment - Altimetric equipment limitations may have a material impact on flight safety between sUAS and manned aircraft separation. For example, the ForeFlight Mobile Legends states, "As a result of the cumulative inaccuracies in pressure altitude systems, you should consider any target shown to be within 500 ft. vertically as potentially being at the same altitude as your aircraft." v9.4, p. 24, *et seq*., http://cloudfront.foreflight.com/docs/ff/9.6/v9.6%20-%20foreflight%20weather%20legends%20optimized.pdf. Additionally, FAA calibration requirements regarding the data correspondence of automatically reported pressure altitude data and the pilot's altitude reference is 125 feet (with 95% probability). 14 C.F.R. § 91.217. *See* 14 C.F.R. Appn. E to Part 43, Altimeter System Test and Inspection, *available at,* https://www.law.cornell.edu/cfr/text/14/appendix-E_to_part_43. Moreover, most sUAS use GPS geometric altitude whose error "is typically 3 times more than that for horizontal position, and is usually contained within 30-50m . . ." ICAO, *Use of Barometric Altitude and Geometric Altitude Information in ADS-B Message for ATC Applications*, SEA/BOB ADS-B WG/8 - WP/6, Agenda Item 5, § 2.2 (May 12, 2012), https://www.icao.int/APAC/Meetings/2012_SEA_BOB_ADSB_WG8/WP06_HKG%20AI.%205%20-%20Use%20of%20Barometric%20Altitude.pdf (also addressing GPS use of WGS84 ellipsoid as approximation to the MSL with possible errors between 100 and 70 m, depending on location). Finally, almost all sUAS are not equipped with radar altimeters. sUAS with pressure-adjustable altimeters exist, but are rare in commercial off-the shelf (COTS) sUAS.

[32] *LAANC-PHA*, § 4.3.1, p. 18 (Hazard PHA-01 - characterized as the "worst case scenario"). The SRM panel recognized such authorization as a "catastrophic event" and consensus was not reached that its likelihood equated to only a "Medium (1E) initial risk". *Id*. p. 19. *See* Dissenting opinion, *Id*. p. B-1 ("estimate of 'Extremely Improbable' as carried by majority vote of the panel members is unsubstantiated and under-values the resultant Safety Risk of an identified catastrophic hazard."); and *USS Operating Rules*, § 3.4.10, p. 16 ("The USS should handle invalid authorizations proactively and direct operators to cancel them so that they are not flown regardless of actions that may be taken by ATC or FAA systems."). Finally, the proposed method tolerates the possibility of "false clear" or "false positive" indications since it is a voluntary, supplemental advisory tool only—not a DAA system.

[33] **Data Size** - Discussion with relevant standards subcommittee leadership suggests that the proposal's data size requirements, that include the graphical UASFM segment shapefile, do not present an impediment (e.g., could be included in each discrete NOTAM (or new data product) communicated, rather than uploaded once to cockpit avionics and reused for each subsequent UASFM segment displayed.) That said, to the extent a single shapefile is deployed, its reuse in the cockpit for data economy may have benefits. *See* Appn. 2. *Service Protocols and Message Format Overview*; and note 48 (data economy).

Data Processing - Data processing requirements are not computationally intensive since the proposed method does not require real-time data, leverages the federated architecture of UAS Service Suppliers (USSs) to distribute processing burden, and tolerates considerable latency without materially diminishing the effectiveness of the proposed method.

[34] Including available overlay on fixed avionics displays such as a MFD, electronic flight information system (EFIS), and cockpit display of traffic information (CDTI).

Electronic Flight Bags - *RTCA-GTFR*, p. 10 (citing AOPA 2016) (random sample of active pilots suggested that 82% used EFBs "frequently or always in the cockpit"—and used to avoid TFRs). That percentage has since invariably increased.

[35] For example, waiver of 14 C.F.R. § 107.37, *Operation near aircraft; right-of-way rules*. *See* 14 C.F.R. § 107.205(f) (waiver of 14 C.F.R. § 107.37(a)), and FAA, *Waiver Safety Explanation Guidelines for Part 107 Waiver Applications*, https://www.faa.gov/uas/request_waiver/waiver_safety_explanation_guidelines/#risks.

[36] **Personally Identifiable Information (PII) -** No PII is required or disclosed. *See UAS ID ARC*, § 7.1.5, p. 47 ("Owners and operators have legitimate reasons to keep the locations, dates, and times of their UAS flights private . . . "); and *FRA*, § 357, *Unmanned Aircraft Systems Privacy Policy.*

USS Proprietary Data - There is an inherent tension between: (i) maintaining competition and USS/customer proprietary rights versus (ii) sharing data necessary to ensure interoperability and flight safety. The proposed method strikes that balance by:

- Sharing only UASFM segments geo-located with, and affecting flight safety [contributing to deconfliction] of the subject aircraft
- For preflight planning, sharing only UASFM segments in [and adjacent to] planned flights operations
- Adhering to inter-USS service standardized and recommended protocols preventing over-querying (e.g., *Request Flight*, *Request Status*, or *Request Position* UTM Flight Messages)

The obligation of USSs to share safety of flight data including UAS location data with manned aircraft deserves attention. To what extent should CAAs harmonize, set minimum standards, or otherwise regulate limitations to such sharing in privacy policies, or under the pretext of proprietary rights in other contractual instruments? To what extent will/should UAS Service Suppliers (USSs) charge for safety of flight-relevant UAS location data that would enhance manned aircraft separation from UAS? If this data service is monetized, would there be a carve-out for safety or flight data, otherwise, how would that square with the "free" ADS-B In model? Is a requirement of sharing for "situations where corrections cannot be made" or "off-nominal situations" sufficient? *UAS-UTM CONOPS*, § 2.5.6, p. 14.

[37] This may include Web services conforming to the REST architectural style, or RESTful web services. *See, e.g.,* FAA, *LAANC - REST [Representational State Transfer] Service Description Document (RSDD) 20170301.md*, https://github.com/Federal-Aviation-Administration/LAANC/blob/master/LAANC%20-%20REST%20Service%20Description%20Document%20(RSDD)%2020170301.md; FAA, *REST Service Description Document (RSDD)*, https://github.com/Federal-Aviation-Administration/LAANC/blob/master/LAANC%20-%20REST%20Service%20Description%20Document%20(RSDD)%2020170301.md#uass-in-fixm; FAA, *LAANC Data Dictionary* (and associated files), https://github.com/Federal-Aviation-Administration/LAANC; and *JO 7200.23A*, Appn. A.1.

[38] *See* FAA UAS Data Exchange (web page), https://www.faa.gov/uas/programs_partnerships/uas_data_exchange/. This may integrate with or migrate to the Flight Information Management System (FIMS). *See UAS-UTM CONOPS*, §§ 1 & 2.4.6 (characterized as "a gateway for data exchange between UTM participants and the FAA systems" - bridging/coordinating USS with ATM and the NAS); and note 37 (presenting REST— perhaps a basic REST service supporting the existing database would be acceptable and efficient—with endpoints residing on the same data exchange site).

[39] Via either 978 MHz (UAT) or 1090ES (1090 MHz transponder with extended squitter) equipped aircraft via ADS Rebroadcast (ADS-R) (within range of an ADS-B ground radio station) for receipt and decoding of ADS-B messages. *See* SBS, § 3.2.2, p. 132. Note that NAS situational awareness is not listed as an ADS-R supported SBS service. *SBS*, Table 1-2: ADS-B Applications, Services, and Functions, p. 11. Since ADS-B operates on both 978 and 1090 MHz, ADS-R translates, reformats, and rebroadcasts each aircraft's ADS-B information via ADS-B ground station. FIS-B information is broadcast over UAT protocols.

[40] Accommodating additional methods of communication may embrace "the FAA seek[ing] to foster a competitive environment for providers of Unmanned Aircraft Systems (UAS) and related services." *USS Operating Rules*, § 1.1, p. 1; and the Presidential Memorandum for the Secretary of Transportation, The White House, § 1 (Oct. 25, 2017), https://www.whitehouse.gov/presidential-actions/presidential-memorandum-secretary-transportation/.

[41] **Pre-flight Planning** - The most expedient (partial/initial) implementation of this proposal would provide simple access to LAANC authorizations to enhance pre-flight planning. Nonetheless, it is imprudent to expect all manned pilots/operators to assess LAANC traffic data fully during preflight. Indeed, the near-real-time authorization capability of LAANC compels many sUAS pilots/operators (perhaps more than 90%) to seek authorization shortly before the intended operation—after many manned aircraft flights have become airborne, thereby rendering

preflight checking alone inadequate. The data distribution method for internet-based access is sufficiently reliable and supported. SWIM is likely a good fit to support this, much like FIS-B is for in-flight purposes.

HEMST - For pre-flight planning purposes, LAANC authorization data could also integrate with certain low-altitude manned aircraft flight risk tools, such as an extension of the Helicopter Emergency Medical Services Tool to provide awareness of LAANC-enabled airspace. *See* AWS, *HEMS Tool* (web page), https://www.aviationweather.gov/hemst; and FAA, *Fact Sheet - Helicopter Safety* (web page), https://www.faa.gov/news/fact_sheets/news_story.cfm?contentKey=3803.

[42] The presentation of alert data should be a function of range and bearing from ownship.

Each type of communication service (e.g., cellular, FIS-B, and satellite) has differing availability characteristics. For FIS-B purposes, only low altitude (surface-3,000 ft.) ground stations are likely needed to support this proposal for LAANC. *See SBS*, App. C. FIS-B Tiering, Table C-1: Altitude Tiers; *DO-358*, Appn. D, FIS-B Radio Station Tiering; and *AC 00-63A*, Fig. A-2, UAT Altitude Tiers. This may provide a ~100 NM look-ahead range. *AIM*, Table 7-1-2, Product Parameters for Low/Medium/High Altitude Tier Radios. *Cf.,* FAA, *ADS-B Coverage Map* (presenting Advisory Service terminal and surface maps), https://www.faa.gov/nextgen/programs/adsb/coveragemap/.

[43] On either TSO'd or non-TSO'd equipage. *See TSO-C157b*, Subj: Flight Information Services-Broadcast (FIS-B) Equipment (May 28, 2015), https://www.faa.gov/nextgen/programs/adsb/media/TSO-C157b.pdf; and *AC 00-63A*.

[44] *See* note 5 (explaining UASFM segments). The proposal need not be limited to standardized rectangular polygons; however, rectangles conform to current LAANC specifications. The volume of airspace contained within a UASFM segment is generally greater than the distance most VLOS sUAS travel from launch position—an average distance ~1/10th statute mile. Email from Ryan Wallace, Ed.D. to M. Baum (Dec. 15, 2018).

[45] Analogously, consider an AOPA initiative to display Temporary Restricted Areas (TRAs) in the cockpit. *See* RTCA SC-205 SG-5, *Temporary Restricted Areas Over FIS-B UAT White Paper,* accompanying Letter from Eldridge Frazier, RTCA SC-206 Designated Federal Officer, Lead Engr., Weather Tech. in the Cockpit, FAA, NextGen Org., Weather Research Branch, ANG-C61 to Dr. Christopher Hegarty, Chairman RTCA (Feb. 14, 2018), https://download.aopa.org/advocacy/2018/180326_TRA_proposal.pdf?_ga=2.143517372.844974113.1532097725-540239824.1530980073 (SG-5 considering use of the SUA NOTAM structure as a viable short-term solution). *See* Dan Namowitz, AOPA, *FAA offers guidance on 'non-depicted' special airspace* (Mar. 27, 2018), https://www.aopa.org/news-and-media/all-news/2018/march/27/faa-offers-guidance-on-non-depicted-special-airspace (addressing uncharted, undepicted TRAs). [RTCA SC-206 Subgroup 5 to update DO-358A to DO-358B with the TRA implementation by March 2020, and kick-off documentation of implementation at the March 2019 Plenary] RTCA Paper No. 189-18/PMC-1785, *Terms of Reference, Special Committee (SC) 206*, Aeronautical Information and Meteorological Data Link Services (Rev. 14) (July 6, 2018), https://www.rtca.org/sites/default/files/sc-206_july_2018_tor.pdf; and RTCA Paper No. 111-18/SC206-149, *Summary of the 50th Meeting*, Special Committee 206, Aeronautical Information Services (AIS) and Meteorological (MET) Data Link Services (Apr. 17, 2018), https://www.rtca.org/sites/default/files/sc-206_mar_2018_summary.pdf.

[46] *See* Appn. 2, *Service Protocols and Message Format Overview* (considering, *inter alia,* NOTAM message products and formats, or a derivative thereof).

[47] Presumably, non-certified aeronautical information services, such as those provided by ForeFlight or Garmin, could expedite market introduction and adoption. To further reduce message size (if necessary), the altitude increments could be eliminated without materially diminishing safety to manned aircraft pilots since the mere identification of active UASFM segments at any LAANC altitude should generally elicit a similar response. *See* note 48.

[48] Color is not used "as the sole means of encoding traffic information"—rather, shape, size and border patterns are proposed. *See, e.g.*, FAA, *Advisory Circular AC 120-86*, Subj: Aircraft Surveillance Systems and Applications,

Appn. H, § 3.3, p. H-2 (Sept. 16, 2005), https://www.faa.gov/documentLibrary/media/Advisory_Circular/AC%20120-86.pdf [CANCELLED-tbd].

For simplicity and data economy, a single digit could represent the highest altitude authorized/notified in hundreds of feet. For example, 400 ft. AGL would be displayed as "4". If circumstances require display of a specific altitude, the display of unabridged altitudes is an option. For operations per waiver and COA that authorize flight above 400 ft. AGL, segments could display such (higher) altitudes or display unique coloration. An additional pilot-configurable option could display difference between the manned aircraft and UAS altitudes, typical of collision avoidance systems.

[49] The notional graphical representation of UASFM segments in Figure 1 would be transformed to conform with recognized standards for the presentation of relevant cockpit data. *See, e.g.,* SAE, ARP6467, *Human Factors Minimum Requirements and Recommendations for the Flight Deck Display of Data Linked Notices to Airmen (NOTAMs)* (Feb. 13, 2014), https://www.sae.org/standards/content/arp6467/ (facilitating basic minimum standards for usability).

[50] *See, e.g., DO-358*, § 2.2.4.3.5.5 (requiring display of the entire decoded text of an associated graphic NOTAM).

[51] *See* Appn. 1, *Example 8: LAANC Segment Saturation.* There is not yet a recognized quantitative definition for UASFM segment saturation. Defining saturation will face challenges since sUAS are diverse and vary from manned aircraft characteristics. Additional candidate events warranting notification could include UAS fly-away or lost link (perhaps denoted by distinct coloration or, if supported, flashing UASFM segments); or "sightings" that have an appropriate level of validation.

[52] *See* FAA, *LAANC Operations and Maintenance (O&M) Approach White Paper* (Sept. 28, 2018) (describing provision of health status and statistics endpoints to its current API, including enhanced outage reporting, and "rescinded awaiting").

[53] *See* § 6.e, Display of Ad Hoc UTM Corridors.

[54] It could further be preset/defaulted to "OFF" to prevent clutter and to inhibit any aural alert function (or lower priority alerts)—requiring affirmative pilot action to enable it. *See AIM*, § 7-1-10 a.4(e) (addressing awareness of effect of information overload and benefit of layered products). Responding to the *law of unintended consequences,* instruction/education should be provided to ensure this proposal does not contribute to complacency and a false sense of security.

See AC 120-76D (regarding minimizing flight crew member workload for use of EFBs); Swiss-wide U-Space, presentation [at time: 4:12] (Zurich - July 3, 2018), https://www.youtube.com/watch?v=-dRj428sJfw (advocating "layers upon layers upon layers of useful digital information . . . leveraging existing infrastructure"). The use of a Styled Layer Descriptor (SLD) for the appearance of the UASFM segment layer should be considered. *See, e.g.,* Open Geospatial Consortium (OGC), *Styled Layer descriptor*, http://www.opengeospatial.org/standards/sld/.

[55] *See generally, UAS-UTM CONOPS*.

[56] "Research has shown that the average person has a reaction time of 12.5 seconds. This means that a small or high-speed object could pose a serious threat if some other means of detection other than see and avoid were not utilized, as it would take too long to react to avoid a collision. *This is particularly important with small Unmanned Aircraft Systems (sUAS).*" *AC 90-48D,* § 4.2.1 (emphasis added). Such a reaction time would generally preclude responsive action for collision avoidance for sUAS-manned aircraft encounters associated with LAANC operations abutting manned aircraft traffic pattern operations. Additionally, consider that one study found that "[q]uadcopter platforms [such as the] DJI Phantom series are not likely to be seen by pilots until within 0.10 SM." John M. Loffi, et al., *Seeing the Threat: Pilot Visual Detection of Small Unmanned Aircraft Systems in Visual Meteorological Conditions,* IJAAA, ERAU, Vol.3(3), p. 19 (Sept. 12, 2016), http://commons.erau.edu/ijaaa/vol3/iss3/13?utm_source=commons.erau.edu%2Fijaaa%2Fvol3%2Fiss3%2F13&utm_medium=PDF&utm_campaign=PDFCoverPages.

Military Operations Areas (MOAs) - MOAs are airspace "established outside of Class A airspace to separate or segregate certain nonhazardous military activities from IFR traffic and to identify for VFR traffic where these activities are conducted." *AIM*, § 1.1; *see JO 7400.2M*, § 25-1-1., *et seq.* MOA activities include, air combat maneuvers, intercepts, and low altitude tactics. *Id.* § 25-1-2. Consider that MOAs must have "minimal adverse aeronautical effect" and "must exclude the airspace 1,500 feet AGL and below within a 3 NM radius of airports available for public use." *Id.* § 2-1-4. Temporary MOAs must be publicized "within 100 miles of the affected airspace. The publicity may be accomplished through the public media, pilot forums, distribution of information bulletins to known aviation interests, etc." *Id.* § 25-1-7. Such publication requirements should inform future LAANC policy. Compare guidance regarding military training routes (MTR). *AIM*, § 3-5-2 f. (Nonparticipating aircraft pilots "should contact FSS's (sic) within 100 NM of a particular MTR to obtain current information or route usage in their vicinity.").

Critical Infrastructure and Fixed Site Facilities - Separately, consider the efficacy of extending/designating LAANC-enabled airspace within § 2209, Applications for Designation (to prohibit or restrict the operation of an unmanned aircraft in close proximity to a fixed site facility) of the *FESSA*, § 40101 note. *FESSA,* § 2206(a) of that Act characterizes airports as critical infrastructure. Section 2209 includes "(iv) Other locations that warrant such restrictions", makes "aviation safety" a "Consideration"; and § 2206 conjoins "airports and other critical infrastructure". However, § 2209(d) provides a "Savings Clause" which includes "unmanned aircraft system, over, under, or within a specified distance from that fixed site facility for UAS."

MOA vs. UASFM Separation - In contrast to most LAANC-enabled airspace, ATC provides explicit separation minima of at least 500 ft. above/below the upper/lower limits of a MOA and certain other SAA. *JO 7110.65X*, § 9-3-2. Previously, for Part 91 COA operations, separation from the COA SAA boundary above the displayed operational area was 500 feet for Class B and C airspace. FAA, *Memorandum,* from Tony Mello, Acting Dir., Operations-Headquarters, AJT-2, Subj: Guidance for Part 91 sUAS Separation in Class B and C Airspace (June 16, 2017), https://www.dropbox.com/s/g7v1vygknfv5d3s/FAA-Melo-ClassB%26C-Separation.pdf?dl=0.

In Figure 2, the FAA's "Assumption of Safety" is cited in *JO 7200.23*, Appn. A, 3.a, "[there] are portions of each facility's airspace at very low altitudes that a sUAS could operate without impacting IFR or VFR operations."

Airspace Policy - One national aviation association policy director stated, "Manned pilots should not be avoiding these [LAANC] areas or altering the way they fly to accommodate UAS. Our philosophy is UAS need to integrate with our operation and we shouldn't have to change how we [arrive] into airports. We would be drawing attention to normal operations, which I am not sure is FIS-B's purpose." Email from Anonymous (July 17, 2018). While manned aircraft pilots should not need to modify normal procedures to accommodate UAS integration within the NAS, the practical reality is that as a matter of flight safety, active LAANC UASFM segments are unavailable to manned aircraft. This has created a de facto recharacterization of the airspace and may affect terminal operations whether or not acknowledge officially. The proposal can complement the existing FIS-B toolbox that already includes graphical display of certain SAA status. *Cf.*, "SUA should be located to impose *minimum impact* on nonparticipating aircraft and ATC operations [and] *avoid . . . major terminal areas.*" *JO 7400.2M*, § 21-7-7 (emphasis added).

[57] It may also improve a pilot's ability to visually acquire certain UAVs. Safety assurance "is to be provided in the context of these overall measures for system safety." Ewen Denney, et al., *Safety Considerations for UAS Ground-based Detect and Avoid* (DASC 2016), § V.A, https://utm.arc.nasa.gov/docs/Denney_DASC_1570263561.pdf (GBDAA addressing two related safety barriers: surveillance and avoidance).

[58] *See AC 00-63A*, § 6.c, p. 7 (addressing relevant SWIM infrastructure). *See also* ICAO, System-Wide Information Management (SWIM), AN-Conf/13-WP/4 (Apr. 2, 2018), Presented at the 13th Air Nav. Conf., (Montreal Oct. 9-19, 2018), https://www.icao.int/Meetings/anconf13/Documents/WP/wp_004_en.pdf; and ICAO, *Manual on System Wide Information Management (SWIM) Concept*, Doc. 10039 (2015),

https://www.icao.int/safety/acp/ACPWGF/CP%20WG-I%2019/10039_SWIM%20Manual.pdf, and (ver. 2): https://duckduckgo.com/?q=ICA)+SWIM+Concept+-+Doc+10039&t=ffab&ia=web.

[59] **Service Providers** - As used herein, "service providers" are third-party entities providing aeronautical information services [primarily] to manned aircraft pilots and operators, whereas USSs are (to date) UAS-centric providers. Service providers include Supplementary Data Service Providers (SDSPs). *Cf., UAS-UTM CONOPS*, App. D - UAS Service Supplier, https://www.faa.gov/uas/programs_partnerships/data_exchange/ ("The USS serves a support role to Operators participating in UTM."). To assure a recognized level of service, non-USSs service providers could be required to assert or otherwise satisfy relevant USS quality of service metrics and assurances.

LAANC Data Availability to Service Providers - That portion of LAANC data supporting safety of flight is (or should be) declared public data and made available without fee and undue restriction. Moreover, the data necessary to support this proposal does not require use of personally identifiable data (PII). *See* note 36. The FAA (or applicable USSs) should remove any PII and make such data available to any service provider supporting this proposal via standard protocols (and, e.g., via SWIM, when available).

[60] RTCA, Tactical Operations Committee, *Improving Graphic Temporary Flight Restrictions in the National Airspace System* (Dec. 2016), p. 5, *available at,* https://download.aopa.org/advocacy/FINAL_Graphical_TFR_Report.pdf?_ga=2.103034816.1907030135.1524580232-1585595406.1513274841 (Arguably these additional mitigations are akin to recommendations of the RTCA Tactical Operations Committee in response to tasking, including, *inter alia*, provision for "Long Term TFRs" to be charted on Sectional and Terminal Area Charts).

[61] **Chart Supplement U.S. (A/FD)** - Chart Supplements have become an essential in-flight operational resource, particularly since their inclusion in various tablet apps, such as ForeFlight. To advance manned pilot awareness, applicable airport listings in Chart Supplements should state, for example: "Caution: Low altitude small unmanned aircraft activity in the terminal area." This would supplement a general LAANC notice in the "Special Notices" section of Chart Supplements. The Special Notices currently address diverse UAS operations *but not LAANC*. *See, e.g.,* FAA, *Chart Supplement SW, UNMANNED AIRCRAFT SYSTEMS (UAS) ACTIVITY OVER CRITICAL INFRASTRUCTURE* (Sept. 13, 2018 to Nov. 8, 2018), FAA, *Digital - Chart Supplement (d-CS)*, https://www.faa.gov/air_traffic/flight_info/aeronav/digital_products/dafd/ ("Pilots planning to fly at low altitudes or in uncontrolled airspace should consult Flight Service for current information on UAS operations."). Where appropriate, such notification could also be provided via the Automatic Terminal Information Service.

[62] **Aeronautical Charts** - UAS operational areas are not necessarily depicted. *See, e.g.,* FAA, *Chart Supplement U.S., NE*, Special Notices (Sept. 13, 2018 to Nov. 8, 2018) ("As is the case with other UAS Operations, specific *UAS infrastructure flight operating hours and areas may or may not be annotated on VFR aeronautical charts* or in other publications. Pilots planning to fly at low altitudes or in uncontrolled airspace should consult Flight Service for current information on UAS operations.") (emphasis added). And yet, LAANC activity is unavailable via Flight Service. Separately, consider that under the *FRA*, § 349(c)(1) [49 U.S.C. 44809] (Exception for limited recreational operations of unmanned aircraft), recreational UAS operations at a fixed site within Class B, C, or D airspace or within the lateral boundaries of the surface area of Class E airspace must be made known to the FAA.

Cf., Charting of Controlled Firing Areas - "CFAs are not depicted on aeronautical charts because the user terminates the activities when required to prevent endangering nonparticipating aircraft." *JO 7400.2M*, § 27-1-4. Whereas LAANC airspace is not charted because of an expectation that sUAS pilots will terminate operations when required to prevent endangering nonparticipating aircraft. *But see,* Appn. 1, Example 8: *LAANC Segment Saturation* (recognizing challenges to such a termination strategy).

For IFR operations, U.S. Terminal Procedures Publications could promote pilot awareness by including a section on LAANC-enabled airspace, https://www.faa.gov/air_traffic/flight_info/aeronav/digital_products/dtpp/ ("Hot Spots" and associated safety content are already included). For VFR operations, terminal area charts could target inclusion, https://www.faa.gov/air_traffic/flight_info/aeronav/productcatalog/vfrcharts/terminalarea/ (TAC "large-scale portrayal of selected metropolitan complexes" at 1:250,000 scale may be particularly suitable).

[63] **Advisory Circulars** - *See* FAA, *ORDER 1320.46D*, Subj: FAA Advisory Circular System, Ch. 3.1.a(7), p. 3-1 (Apr. 7, 2015), https://www.faa.gov/regulations_policies/orders_notices/index.cfm/go/document.information/documentID/1027306 (ACs are intended to "[e]xpand on standards needed to promote aviation safety, including the safe operation of airports"). The proposed AC could leverage (non-exclusively) the peer-reviewed guidance provided in the ACI's publication, *Flight Safety in the Drone Age*, http://www.secureav.com/Drone-Listings-Page.html (safety guidance for manned aircraft pilots operating near UAS). Additionally, a responsive update to the following AC would be helpful: FAA, *Advisory Circular AC 90-48D, CHG 1,* Subj: Pilots Role in Collision Avoidance (June 28, 2016), https://www.faa.gov/documentLibrary/media/Advisory_Circular/AC_90-48D_CHG_1.pdf.

[64] Such discussion should not be limited to UAS-specific section(s) of the *AIM*—to increase the likelihood that manned aircraft pilots/operators would read it. *See generally,* FAA, Aeronautical Information Services, Safety Alerts and Charting Notices, https://www.faa.gov/air_traffic/flight_info/aeronav/safety_alerts/.

[65] **Position Data** - Where available, certain position data (de-identified) could be ported from ground control stations (GCS), sUAS, and connected mobile devices or service providers. Such data would *not* be used as real time target data but instead converted to represent active UASFM segments. Additionally, since "sXu will be provided as a service of UTM, with SDAG [sUAS DAA Alerting and Guidance] calculated on the ground and transmitted to participating sUAS via the UTM sUAS telemetry link", it could supplement this proposal. *sXu Concept of Use*, § 3.2.3, p. 27.

Various sources of position data may not satisfy MOPS, other requirements, are non-certified, TSO'd, and therefore do not integrate into the FAA's traffic surveillance infrastructure. For example, radio frequency-based surveillance devices may produce excessive false positives or manifest other disqualifying limitations for such integration but might still have value to support this proposal if initially used for de minimis validation purposes, and later, following sufficient data collection, analysis and validation, be given greater significance (e.g., qualified display of non-cooperatives).

Cellular Position Data - *See, e.g., ATIS-2017*, § 4, p. 13-18, Location Technologies (overview of cellular location service support for UAS navigation); 3GPP, Technical Specification Group Services and System Aspects; *Study on Remote Identification of Unmanned Aerial Systems (UAS)*, Stage 1 (Rel. 16), 3GPP TR 22.8de V1.0.0 (May 2018) ["*3GPP-Release 16*"], § 5.2.1, p. 10, https://portal.3gpp.org/desktopmodules/Specifications/SpecificationDetails.aspx?specificationId=3527 (3GPP involvement "to provide accurate live positioning information into the UTM from the UAS or MNO, thereby offering a primary or complementary positioning solution able to allow an independent verification of the location reported by the UAS, if applicable, and to ensure timely feedback from the UTM to the UAS."); 3GPP, *Technical Specification*, Tech. Spec. Group Serv. & Sys. Aspects, UAS support in 3GPP, Stage 1, Rel. 16, 3GPP TS 22.125, (V0.2.0), pp. 6-7 (Dec. 2018) ("The 3GPP system should enable an MNO [mobile network operator] to augment the data sent to a UTM with the following: network-based positioning information of UAV and UAV controller [and] to update the UTM with the live location information of a UAV and its UAV controller."); and *3GPP-Release 15* (LTE Positioning Protocol; LTE and now 5G RAN, architecture/overview specifications).

Non-Equipped, Non-Network Participants - UAS Remote ID [draft] standards accommodate non-equipped network participants (e.g., sUAS without transponders or ADS-B Out, but with network connections), and may accommodate non-equipped, non-network participants who "are neither broadcast capable nor equipped to communicate with a Remote ID Service Provider during flight, such as most radio controlled model aircraft [such] non-equipped network participants report their operations (aircraft ID, location, operating times) in advance and can be included as static information in remote ID display applications." ASTM F38, [WK65041] *Draft Standard Specification for Remote ID and Tracking*, § 5 Conceptual Overview (Mar. 2, 2019). *See id.* § 6.3.2, Non-Equipped Network Participant to Net-RID Service Provider ("the operator can participate . . . by submitting an operation plan which identifies the location . . ."). Such accommodation of non-equipped, non-network participants is analogous to the proposed method's schema to denote LAANC authorizations to noncooperative sUAS, adding support for the efficacy of presenting "static information".

[66] For example, to the extent "participating sUAS platforms will have the ability to receive sXu DAA alerting and guidance as a service through UTM" [*sXu Concept of Use,* § 2.3, p. 15], such data could supplement LAANC authorization data for the limited purposes of this proposal. Under one scheme, "a DAA Service Module would be added to the UAS Service Supplier (USS), which would run one sXu logic instance per active equipage . . ." *sXu Concept of Use*, §3.2.3, p. 27. This might provide another conduit of traffic data to supplement this proposal. Nonetheless, the proposed method is not a DAA system.

[67] Source: AGI, *OneSky Blog*, https://onesky.blog/2017/08/23/how-onesky-is-working-with-faas-laanc-data/ (UASFM segment terrain changes "significantly in some areas which could risk [altitude busts] by quite a significant amount."). *See* note 31 (considering altimetric equipment limitations). Terrain variance can also be a factor in radio line-of-sight quality. *See ASSURE-Askelson*, § 2.2, p. 26.

[68] **Corridors, Generally** - *See, e.g.,* FAA & NASA, Unmanned Aircraft System Traffic Management (UTM) Research Transition Team (RTT), Concept Working Group, *Concept & Use Cases Package #2 Addendum: Technical Capability Level 3*, Ver. 1.0, Doc. No. 20180007223 (July 2018), §§ 1.2.4.2 & 2.2.4.2, Shared Information Across Actors, https://ntrs.nasa.gov/search.jsp?R=20180007223 [*"TCL 3"*]. Such data could include UTM flight planning / reservation data informed by airspace geofences and corridors (e.g., 4D operational volumes) that bound a flight path and include trajectory error.

Buffers vs. Operational Risk/Trajectory Conformance - *See, e.g.,* Jaewoo Jung, et al, *Applying Required Navigation Performance Concept for Traffic Management of Small Unmanned Aircraft Systems*, 30th Cong. of the Int'l Council of the Aeronautical Sciences (Deejeon, Korea – Sept. 25-30, 2016), https://ntrs.nasa.gov/archive/nasa/casi.ntrs.nasa.gov/20160011496.pdf (use of RNP concept for UTM traffic management).

[69] *sXu Concept of Use*, § 2.3, p. 14.

[70] *AIM,* § 10-1-4, The Gulf of Mexico Grid System, http://tfmlearning.faa.gov/Publications/atpubs/AIM/Chap10/aim1001.html; FAA, *U.S. Gulf Coast 32 VFR Helicopter Route Chart*, https://aeronav.faa.gov/content/aeronav/heli_files/PDFs/US_Gulf_Coast_Heli_32_P.pdf; and the Bureau of Ocean Energy Management, *GOMR Geographic Information System (GIS) Data and Maps*, https://www.boem.gov/GOMR-GIS-Data-and-Maps/ (presenting Official Protraction Diagrams (OPD) and Supplemental Official OCS Block Diagrams (SOBDs)). SOBDs are accessible at https://www.boem.gov/Official-Protraction-Diagrams/. Each such grid square is approximately 3x3 nm - ~5,760 acres. US Dept. of the Interior, Minerals Mgt. Serv., Gulf of Mexico OCS, *Oil and Gas Leasing Procedures Guidelines*, OCS Rpt. MMS-076, p. 32 (Oct. 2001), https://www.boem.gov/uploadedFiles/BOEM/Oil_and_Gas_Energy_Program/Leasing/Regional_Leasing/Gulf_of_Mexico_Region/2001-076.pdf.

[71] *AIM,* § 10-1-4.a.1. (dividing waypoints into sets of 3 columns with a 3-letter identifier signifying a left, center or right location within the grid cell of that column). Normalized operational pilot-controller communications regarding the proposed human-readable waypoints would require procedures and guidance for ATC in applicable CAA orders and guidance in the *AIM*.

To minimize confusion or conflict with standard waypoints, and to assure that the volume of UASFM segment waypoints do not overwhelm storage capacity of current FMS systems, a naming convention might adopt local, VFR-only referenced waypoints. *Cf.,* "floating waypoints" (airspace fixes not directly associated with conventional airways), FAA, *Instrument Procedures Handbook*, FAA-H-8083-16B, § 2-32 (2017), https://www.faa.gov/regulations_policies/handbooks_manuals/aviation/instrument_procedures_handbook/media/FAA-H-8083-16B.pdf.

A future LAANC update might want to consider implementing more granular (smaller) grid segments to improve situational awareness, more accurately identify the likely location of sUAS, expedite ATC-pilot communications, and provide more flexible "building blocks" to construct ad hoc corridors and irregularly shaped airspace structures. For example, while the initial application of this proposal delivers non-real time updates in 1 min. x 1 min. blocks, the same architecture could support smaller, higher precision areas, such as with quadtrees, and near-real-time usage information when available. *See, e.g.,* Altitude Angel, *Flight Reports with Airspace Alerts*, https://www.altitudeangel.com/drone-operators/flight-reports/.

[72] *See* ArcMap, *ArcGIS field data types - Global identifiers*, http://desktop.arcgis.com/en/arcmap/latest/manage-data/geodatabases/arcgis-field-data-types.htm#GUID-97064FAE-B42E-4DC3-A5C9-9A6F12D053A8. To further enhance situational awareness, each grid segment could contain information about distance and bearing. E.g., "GRID: 1220 at KIAD" could represent 1200M and 200 deg. bearing from KIAD. Email from Christopher Kucera, AGI to M. Baum (Dec. 1, 2018).

[73] For example, the Military Grid Reference System (MGRS) provides various levels of precision, including 1Km and 100m—airspace volumes relevant to LAANC. Nat'l Geospatial-Intelligence Agency, DMA Technical Manual 8358.1, http://earth-info.nga.mil/GandG/publications/tm8358.1/tr83581b.html#ZZ26.

[74] *See, e.g.,* Figure 24 - FAA LAANC Administrative Tool (a management rather than operational tool). LAANC is not an operational system, per se. It is the automation of an administrative process, and does not have the rigor applied in its development that would make it suitable as an ATC automation tool. Email from Stephen M. George, FAA (Dec. 7, 2018). Note that its "Help", "FAQ", "Training", and "UAS Reference Material" features are "under construction" and unavailable.

[75] *See* note 17 (ATC challenges and limitations). Compare available commercial tools, such as by AirMap. *See* AirMap, *UTM Dashboard and D-NAS Terms of Service*, § 3. Safety (July 13, 2018), https://www.airmap.com/utm-dashboard-dnas-terms-service/ ("the Services do not track the location of UAVs in real-time and do not verify the accuracy of Operator-submitted information . . . may contain inaccuracies . . . do not constitute an official aeronautical source . . . and may not be updated regularly"). Implementation may require addressing controller issues such as additional display "clutter", controller discretionary actions, acceptance of new responsibility and associated labor issues, and perceived liability concerns. *Cf., UAS ID ARC,* § 3, p. 5 ("FAA automation should be able to alert ATC personnel (e.g., Certified Professional Controller or Front-Line Manager) when an unexpected UAS enters airspace of interest to ATC operations."); and *Id.* § 6.6.1.2, pp. 44-45.

[76] Stanford University Hospital (15CA), Copter RNAV (GPS) 17 approach (Air Methods Corp., Charting Date: Jan. 26, 2018).

[77] Recognizing that Stanford Life Flight is contracted to the dominant national provider of EMS airlift services and a Part 135 certificate holder, consider that the provider's SMS is apparently not yet LAANC-aware. Furthermore, consider that there are 1,482 special instrument procedures identified by the FAA in the U.S.—most associated with hospital heliports. Since these procedures are proprietary, they are generally not published and thus unknown to the public or the aviation community at large. *See* FAA, *Flight Procedure Data, Special Instrument Approach Procedures* (website), https://www.faa.gov/air_traffic/flight_info/aeronav/aero_data/Flt_Procedures_Data/ (contains all known special instrument procedures in the U.S.).

Example 1 also indicates the need for government review of all relevant charts as an element of rigorous, standardized platting of all UASFM.

[78] *See* note 13 (addressing enhanced risks associated with rotorcraft).

[79] Perhaps the hazards of adjoining UASFM segments of differing ATCT jurisdictions (such as presented in Appn. 1, Example 3) parallel certain operational hazards identified by the LAANC SRM Panel as *catastrophic*: "OSA-8: ATM approves further coordination operation outside their jurisdiction/in another facility jurisdiction." *LAANC-PHA*, §

4.3, p. 13. Consider that "if LAANC were to issue an authorization within certain blocks of airspace on the approach end [of certain] runways, and assuming a normal distribution of the arrivals during the day, the probability of an aircraft being on a collision course with an arriving aircraft is approximately 6x10^{-2} per hour at each of the 600 airports." *LAANC-PHA*, Appn. B, p. 4. One additional mitigation would illuminate, selectively, the UASFM segment(s) adjacent to authorized active LAANC UASFM segment(s). Or, at least educate manned aircraft pilots to recognize that UAS operations (and sUAS pilot/operator skills) vary widely, that the polygons should be taken to be "fuzzy" (in all dimensions), and, most USS LAANC provider's maps are not government approved and thus may contain errors diminishing pilot assurances of operational compliance.

[80] **Buffer** - *See* Appn. 1, Example 6 (lack of buffer inside FAF at Dulles Int'l Airport). Consider that only an obstacle buffer is provided (limited to stair step altitudes for IFR aircraft). *For example:*

> [i]n Class E surface areas, IFR aircraft are required to operate 250 feet above obstacles in accordance with requirements stipulated in FAA Order 8260.3, *United States Standard for Terminal Instrument Procedures* (TERPS) (July 7, 1976), https://www.faa.gov/regulations_policies/orders_notices/index.cfm/go/document.information/documentID/11698. In order to maintain at least a 100-foot distance from IFR aircraft, an sUAS must operate no higher above an obstacle than 150 feet. However, since sUASs are not required to have altimeters, the panel felt it was more reasonable to limit the sUAS operation to 100 feet over an obstacle (since it may be difficult for the PIC to judge by the naked eye the actual altitude of the sUAS over the obstacle).

SRMD, §§ 3.1.1, p. 7; & 3.7.2, p. 13 ("altitude-measuring capabilities of sUAS operators are not ideal" *Id.*). Notwithstanding, consider the results of simulations described in one ASSURE report: "Challenges associated with maneuvering vertically to maintain well clear include *ballooning past 500 ft AGL* (Above Ground Level) when operating the UA manually . . . and the inability to remain vertically well clear with a simulated multi-copter while under waypoint control owing to the slowness of the maneuver." Mark Askelson, et al., ASSURE, *Small UAS Detect and Avoid Requirements Necessary for Limited Beyond Visual Line of Sight (BVLOS) Operations* (May 19, 2017), Exec Summary, p. xxi, http://assureuas.org/projects/deliverables/a2/Final_Report_A2_sUAS_BVLOS_Requirements.pdf [*"ASSURE-Askelson"*] (emphasis added). Additionally, consider that Part 107 has no operating limitations for vertical climb, descent, or acceleration rates. 14. C.F.R. § 107.51.

Buffer and "Lower-risk" Airspace - The characterization of LAANC-enabled airspace (directly or by implication) as "lower-risk" or "low-risk" appears as an assumption or assertion in various (draft or completed) LAANC and UTM standards and operational documents without material support—and thus requires closer scrutiny. *See, e.g., JO 7200.23A*, App. A: Map Design, § 3.a (portions of *each* facility's airspace available for LAANC); and ASTM, F38 WG, *Standard for UAS Service Supplier Technical Interoperability & Protocols, Terms of Reference* ("Lower-risk airspace").

[81] *See* 14 C.F.R. § 91.119 Minimum safe altitudes: General ((b) 1,000 ft. above congested areas; (c) 500 ft. over other than congested areas).

[82] This example also suggests the possible benefit of revising LAANC airspace rules to: (a) raise the permissible minimum ceiling from 1,000 ft. AGL to 1,500 ft. AGL (to ensure safe separation from general aviation traffic); (b) (temporarily) establish UAS-free corridors for such transitions; and/or (c) require sUAS operators to be in radio contact with the applicable ATCT when ceiling is less than 1,500 ft. AGL. *See, e.g., USS Operating Rules*, § 3.5 (automatic approvals not valid in Class E airspace when ceiling is less than 1,000 ft. AGL).

[83] "It is assumed that descent will begin *at the earliest point* the fix can be received. *Full obstacle clearance must be provided from this point* to the plotted point of the next fix." *TERPS*, § 288, Obstacle Clearance After Passing a Fix (Feb. 24, 2014), https://www.faa.gov/documentLibrary/media/Order/8260.3B_Chgs_1-26_rev.pdf (emphasis added). Chart reprinted with permission of Jeppesen.

[84] Telephone conversation with KJFK ATCT specialist (Dec. 23, 2018) (also noting marginal or loss of radar coverage below ~300 ft. AGL on that route).

[85] One exception is that each pilot/operator may operate only one sUAS at a time—thus, no swarming. 14 C.F.R. § 107.35, *Operation of multiple small unmanned aircraft.* Consider that "the FAA may issue directives/protocols limiting access to UTM airspace to resolve capacity/demand issues." *UAS-UTM CONOPS,* § 2.7.3.

[86] For example, "[a]s the density of both conventional and UAV users increases (e.g., in urban environments) LTE communication to UAVs can cause degradation in radio performance including interference on the uplink and downlink." Nonetheless, "[m]itigations were found for improving both uplink and downlink interference. Some of these utilize already standardized LTE capabilities." *ATIS*, § 3, p. 3 (reporting on experimental and simulation studies reported by 3GPP).

[87] *See* Peter Sachs, et al., *Effectiveness of Preflight Deconfliction in High-Density UAS Operations*, Rpt. TR-009 (Oct. 3, 2018), https://drive.google.com/file/d/1oTz1mzrt-CWDOp1IDXELc9qVLAJswMtp/view ("In high-density environments, we find that loss of separation events increase linearly with the effective flight rate.") [*"Sachs-Deconfliction"*]; and Altiscope, *Metrics to characterize dense airspace traffic*, Report TR-4, p. 18 (June 7, 2018), https://drive.google.com/file/d/1MFkErqOUzYiPj8zm-W7lc4O6GMjHk_3h/view (concluding that "*dense* operations occur at low absolute numbers of aircraft, if these aircraft are all on different headings"). *Cf., DO-185B*, § 1.3.1.3 (TCAS designed for maximum traffic density of 0.3 of transponder-equipped aircraft per square nautical mile). The Proposed Method is not a DAA system.

[88] DJI, *MAVIC PRO User Manual*, v2.0, p. 33 (Dec. 2017), https://dl.djicdn.com/downloads/mavic/20171219/Mavic%20Pro%20User%20Manual%20V2.0.pdf. *See* 47 C.F.R. § 15.5, https://www.law.cornell.edu/cfr/text/47/15.5 ("interference must be accepted that may be caused by the operation of an authorized radio station [or an intentional, unintentional] or by an incidental radiator.").

[89] *See* Proposal, § 6.h, ATCT Operational Tool Supplement. Compare high density considerations in UTM operations within uncontrolled airspace: "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." *TCL 3*, § 1.3.1.4, p. 15 (emphasis added). "High Density UTM Environment Notice" information could be used to supplement segment saturation data. *Id.* Additionally, UTM operational status information of "non-conforming" or "rogue" could also be shared accordingly. *Id.* § 1.3.2.1, p. 17. Indeed, there is an expectation that in UTM authorized areas of operation, "manned aircraft should anticipate a higher density of intended (and perhaps prioritized) use by UAS." *UAS-UTM CONOPS*, § 2.5.2, p. 11.

[90] One ATCT manager volunteered that he had thirteen authorized simultaneous sUAS operations within a single UASFM segment. Interview with anonymous (Dec. 14, 2018). Consider that "[t]he SRM panel also emphasized that caution should be exercised when granting authorizations for multiple days, weeks, or months and that a notification clause should be inserted when authorizing extended operations of this type." *SRMD*, Appn. B, Panel Recommendations, p. B-1. Additionally, LAANC authorizations may create an unintended level of sUAS pilot complacency whereby sUAS pilots may believe they've been granted airspace that is exclusive of other aircraft within which to operate and thereby diminish their surveillance.

[91] FAA, *SBS TIS-B/FIS-B Essential Services Specification,* FAA-E-3006, Ver. 2.0, § 3.2.1.2.5 (Feb. 9, 2010), https://faaco.faa.gov/index.cfm/attachment/download/16532 ["*SBS TIS-B/FIS-B ESS*"]. A new object type for UASFM segments (or an extension thereof) appears consistent with an object type that "provides the notable parts of an airport or airspace environment [and] comprise the collection of regions or things that can have an impact on flight operations if they become hazardous, if they fail, or if they are unavailable for some reasons." *DO-358*, § A.3.3.2.3.8.

[92] *DO-358*, § A.3.3 (emphasis added).

[93] "Basic" aeronautical information products (AIP) are required to be made available to FIS-B users. *SBS TIS-B/FIS-B ESS*, § 3.2.1.2.4.

[94] *DO-358*, § 2.2.4.3, *Text with Graphical Overlay Products*.

[95] "The FIS-B avionics are required to display the textual information for a NOTAM-D [and] can optionally associate the uplinked Airspace ID with that in an onboard database to display the area associated with a NOTAM-D indicating an active SUA outside its published time." *DO-358*, § 2.2.4.3.5.7 (Display of Special Use Airspace NOTAMs).

[96] *DO-358*, Appn. H, *Uplink of Special Use Airspace*. Other types of SAA and associated data structures were considered and found unsatisfactory, including within SUA status standards.

[97] *DO-358*, § 2.2.4, Table 2-1: FIS-B Products According to Product Class. *Cf.,* FAA, *SBS*, § 3.4.4., FIS-B Service, Table 3-17, http://adsbforgeneralaviation.com/wp-content/uploads/2011/12/SBS-Description-Doc_SRT_47_rev01_20111024.pdf (presenting FIS-B elements).

[98] "FAA-issued NOTAMs are categorized into TFR NOTAMs, D NOTAMs and FDC NOTAMs by the FIS-B Ground System." *DO-358*, § A.3.3.2.

[99] **FNS NOTAM Distribution Service (*FNS-NDS*)**: ". . . a web service that provides digital NOTAM messages in AIXM in response to requests by end users. The FNS NDS is a system-to-system interface that enables end systems to receive digital NOTAMs from FNS. . . . FNS NDS supports the distribution of all NOTAMs." The FNS is "an ecosystem of services and applications." FAA, *Digital - AIM | Federal NOTAM System*, https://notams.aim.faa.gov/#Applications.

[100] **Bandwidth Challenges, Generally** - Bandwidth capacity of each service option varies, affects implementation capabilities, and demands close scrutiny. Spectrum challenges transcend FAA and FCC regulation. *See, e.g.,* Letter from Keith Hill, Dir., Cong. Budget Office to the Hon. Dean Heller, U.S. Cong. (Apr. 21, 2015), https://www.cbo.gov/sites/default/files/114th-congress-2015-2016/reports/HellerLtrProceedsFromAuctions.pdf (efficacy of frequency spectrum auctions associated with Federal Executive action to reduce the Federal deficit—causing scarcity of Federal aviation spectrum resources); Presidential Memo. for the Heads of Exec. Depts. and Agencies, Subj: Developing a Sustainable Spectrum Strategy for America's Future (Oct. 25, 2018), https://www.whitehouse.gov/presidential-actions/presidential-memorandum-developing-sustainable-spectrum-strategy-americas-future/ (includes NTIA study/engagement re review of spectrum-dependent mission needs and how they might be met, including "through new technology and ingenuity"; consider opportunities to share spectrum among Federal and non-Federal entities, including 5G technologies); and NTIA, *Developing a Sustainable Spectrum Strategy for America's Future*, Docket No. 181130999–8999–01, 83 Fed. Reg. 65640 (Dec. 21, 2018), https://www.ntia.doc.gov/federal-register-notice/2018/request-comments-developing-sustainable-spectrum-strategy-america-s. *See FRA*, § 374 (Congressional study to include whether to permit sUAS to operate on L-band, 960-1164 MHz and C-band, 5030-5091 MHz); and *FRA*, § 371 (reallocation of 30 MHz of spectrum for non-federal and shared aviation use).

See A Report from the ADS–B In Aviation Rulemaking Committee to the Federal Aviation Administration, *Recommendations to Define a Strategy for Incorporating ADS–B In Technologies into the National Airspace System*, § 4.4.5.4, p. 78 (Sept. 30, 2011), https://www.faa.gov/nextgen/programs/adsb/media/ADSB%20In%20ARC%20Report%20with%20transmittal%20letter.pdf ["*ADS-B IN ARC*"]("Future mid- and far-term uses for ADS-B and other applications (for example FIS-B and aeronautical data Comm.) . . . would no longer suffer the current limitations for message data content and message update rates currently in place with the existing 1090 ADS-B system."). The ARC also underscored, "the business case for an ADS-B In application that requires digital aircraft transmissions must be very strong -- and stronger than that provided by other applications competing for additional ADS-B-Out message fields to those currently provided. *ADS-B IN ARC,* § 4.4.5, p. 77. The ADS-B IN ARC recommended continuing ongoing work to address 1090 MHz spectrum congestion "and determin[ing] the mitigations needed, based on expected traffic growth, to enable the range for the expected inventory of ADS-B In applications while also increasing the squitter rate above the current 6.2 per second average over a 60-second period . . .” *ADS-B IN ARC,* Recomm. 40, p. 79, https://www.aopa.org/-/media/Files/AOPA/Home/News/All-News/2011/November/To-buy-or-not-to-buy-ADS-B-In-group-says-let-pilots-choose/111117ADSB_In_ARC_Report_FINAL.pdf.

ADS-B bandwidth limitations are particularly challenging, for example, UAT has only 32 time slots, each with 430 bytes/channel/second. Perhaps the modest bandwidth requirements of this proposal coupled with spectrum-saving techniques, may offer a viable short-term fix. For example, aircraft approaching a terminal area from higher altitudes may benefit sufficiently from a brief “snapshot” (requiring low-bandwidth) to gain awareness of active LAANC airspace before reaching pattern altitudes.

Spectrum Saving Nature of TIS-B vs. FIS-B -TIS-B data is broadcast (via ADS-R) only when a client aircraft is in the vicinity of another non-ADS-B aircraft. In this way, spectrum is preserved. In contrast, FIS-B broadcasts continuously, to everyone - even when "everyone" is literally no-one. Some sort of "on-condition" broadcast analog to TIS-B would be beneficial. The underlying FIS-B infrastructure is much "dumber". It simply receives weather data, NOTAMS, etc. at regular intervals, and broadcasts at regular intervals. Perhaps a combination of the logic of TIS-B with similar data content of FIS-B would be helpful. Email from Christian Ramsey, Pres., uAvionix to M. Baum (Oct. 12, 2018). *Cf.,* ICAO, *Address and Spectrum Issues for Small UAS* (prepared by Doug Arbuckle), SP3-ASWG8-WP/15, 3rd Mtg. of the Surveillance Panel (Sept. 24, 2018), § 2.2.1, p. 2, https://www.dropbox.com/s/ommqcbyvd002zlz/SP3-ASWG8-WP15-Address%20and%20Spectrum%20Issues%20for%20Small%20UAS.pdf?dl=0 [*“ICAO-Arbuckle”*] (“RF experts within the FAA believe that avionics manufacturers cannot accurately control RF transmit power below 1W, nor can FAA/FCC effectively regulate RF transmit power levels below 1W.”).

[101] *See SBS TIS-B/FIS-B ESS*, Table 3-12, p. 77, FIS Product Update and Transmission Intervals.

FIS-B product update intervals for NOTAM and SUA status are “as available (Typically 20 minutes).” *SBS* § 3.3.4.2.3, Table 3-16. FIS-B NOTAM graphical records shall be available for display within 5 minutes of receipt. *DO-358*, § 2.2.4.3.5.6. Such latency appears suitable for the purposes of active UASFM segment notifications. Note that “FIS-B Service latency is measured from the time a product’s source-data is received until the product is ready for transmission to the aircraft/vehicle.” FAA, *SBS TIS-B/FIS-B ESS* § 3.1.10 (Less than 10 seconds (99%) for all products except less than 20 seconds (for the latency distribution) of the status of SUA. *SBS TIS-B/FIS-B ESS*, § 3.3.3.2). Note that USSs have 24 hours to update local copies of a UASFM, *Id.* § 3.3.1.

[102] There were 27,027 UAS NOTAMs issued in the United States between Sept. 2015 and August 2018: 28% for operations below 200 ft.; 55% for operations between 200-400 ft; 1% for operations below 400-500 Ft., and the remaining 15%, for operations above 500. US NOTAM Governance and Operations (Sept. 2018).

[103] *See* ICAO, Annex 15, *Aeronautical Information Services*, www.icao.int [*temp*: http://www.vat-air.dk/files/ICAO%20NOTAM%20format.pdf (ICAO Annex 15 NOTAM decode); and ICAO, *NOTAM Guidance*, AIS-AIMSG/5-SN/4 (31/10/11), https://www.icao.int/safety/ais-aimsg/aisaim%20meeting%20metadata/ais-aimsg%205/sn%204%20complete%20rev.pdf].

[104] *See* note 33 - considering the efficacy of incorporating by reference the standard shapefile for data economy.

[105] **Keywords** - *AIM*, Table 5-1-1. (following the location identifier), and § 5-1-3 1. If the keyword “AIRSPACE” were considered inaccurate or inappropriate for this proposal, the keyword “O” (“Other Aeronautical Information”) was until recently available for use by “any authorized source that *may be beneficial to aircraft operations* and does not meet defined NOTAM criteria.” *Id*. (emphasis added). Alternatively, a “FYI” keyword might suffice. Optionally, a new subordinate keyword (to “AIRSPACE”) should be developed that is unique to LAANC UASFM segments. *See ORDER JO 7930.2R*.

[106] *ORDER 7930.2R,* §§ 6 & 2. *Preparing NOTAMs for Dissemination* (emphasis added).

[107] *DO-358*, § A.3.3.1.3.17.

[108] **Extended Range 3D Polygon** - *See* text corresponding to note 109. The definition of this geometry should be consistent with SUA objects defined for non-Aerodrome applications (e.g., en route airspace) to simplify avionics processing requirements. . . . The location of each vertex in this geometry is defined using latitude and longitude and is not tied to the Record Reference Point." *DO-358*, § A.3.3.1.3.17.1.

[109] *DO-358*, § A.3.3.1.3.17.1.

[110] Reuse of the Extended Range 3D Polygon would, for LAANC purposes, require rounding the UASFM segment altitude to the nearest 100 ft AGL. For example, if 350 ft were the authorized UASFM altitude, then 400 ft would be invoked. *See DO-358*, § A.3.3.1.3.17.1. "In addition [to] being able to properly parse the geo-shape, we'd need parsable issued, effective, and expiration datetime values, along with floor/ceiling." Email from Jason Miller, CTO, ForeFlight to M. Baum (Nov. 26, 2018).

Global Block Representation Products - The *Global Block Representation Products* ("GB") (*DO-358*, § A.3.2, *et seq.*) were considered as an alternative to the Extended Range 3D Polygon. The GB appears to display a somewhat rectangular polygon representing a standardized 1 min. latitude and 1 min. longitude area (that may well-display UASFM segments). That is, the GB appears to reflect/conform to the relative geo-location of the standard UASFM polygon (rather than being a static rectangle) by undergoing dynamic conical or other transformation. Thus, the initial rectangles designated for UASFM segments in *JO 7200.23* are ultimately transformed/expressed as geo-based polygons. Finally, while the GB description appears limited to NEXRAD products, a SC-206 SG representative asserts that the GB "can be used anywhere needed." Email from [pending permission] to M. Baum (Aug. 26, 2018).

[111] *See* Figure 25 - FIS-B Products by Product Class, and *DO-358*, Table B1 - Relationship of FIS-B Reports to APDU and to Records, identifying the TWGO NOTAM as Product ID #8.

[112] *DO-358*, § A.3.3.2.4.1.2., Table A-25.

[113] An USS is "the primary interface to the UAS operator." FAA, *Memorandum of Agreement Between FEDERAL AVIATION ADMINISTRATION (FAA) Low Altitude Authorization and Notification Capability (LAANC) Automation Platform (AP) And* ___ (Dec. 7, 2018), v2.1, https://www.faa.gov/uas/programs_partnerships/data_exchange/laanc_for_industry/media/FAA_LAANC_AP_MOA.pdf ["*LAANC-MOA"*]. The intent of the current Memorandum of Agreement between the FAA and USSs may constrain USSs beyond serving that role. *Id*. Art. 1, § 1.2, p. 2. However, the LAANC MOU and USS Operating Rules neither [conclusively] limit USSs to USS-UAS operator services, nor appear to preclude USSs from serving an interface role for the purposes of this proposal. *See USS Operating Rules,* § 1.2 ("LAANC supports innovative USS business models beyond intermediary services to individual operators . . ."); and Email from Daniel Farrell, Contracting Officer, Acquisition & Grants, AAQ-630, FAA to M. Baum (Aug. 15, 2018) ("The permissible role(s) of USS are not defined [and are] being shaped by a combination of government and industry . . . ."). Subsequently released documents tend to expand the scope of permissible USS activities.

[114] **USS Onboarding** - Approval is conditioned on conformance to the onboarding process. Interconnection is via the LAANC-AP, the information technology equipment, service and practices providing LAANC services by the FAA. *See USS Onboarding* and its Attachment A: USS-FAA High-Level Exchange Model. "The USS must [] conform to the 'USS-FAA Authorizations and Notifications Interface Control Document' (ICD) version in effect. The ICD includes details on connecting to the FAA's LAANC system via the internet." *USS Operating Rules*, § 3.2.1.

[115] **LAANC-AP** - The LAANC-AP (LAANC Automation Platform) is a software system that includes "internet-oriented operational coordination capabilities and an authorization and notification repository." *LAANC-MOU,* § 1.2. The USS convey the FAA's automatic authorization of the sUAS operations via the LAANC-AP. "Gateway" is neither expressly mentioned in the LAANC-MOA, the *USS Operating Rules*, nor the *LAANC CONOPS*. Perhaps "LAANC Connected" is merely a descriptive label or badge. In the future highly federated UTM infrastructure, airspace authorizations may be fully resolved among USS.

Flight Service and SWIM - *See* FAA, *Data Products Available via SWIM*, https://www.faa.gov/air_traffic/technology/swim/products/. Methods of interface/integration by service providers may include Flight Service. *See* Flight Service, *Integrated Vendors*, https://www.1800wxbrief.com/Website/#!/partnerships. "The beauty of the FSS [Flight Service Station] prototype to allow these UAS operating areas to be shared via FSS was they weren't limited or relying on SWIM, AIXM, FIS-B equipage, etc. and yet, the info could still be easily ingested and shared by the marketplace without a million dollar connection to SWIM." Email from Heidi Williams, Dir., Air Traffic Services & Infrastructure, NBAA, to M. Baum (July 23, 2018).

[116] Also, because the underlying UASFM segment locations/boundaries are fixed, precision georeferencing and the comparatively high performance of complex [attributes of] active traffic systems (such as for TIS-B) are not required for the baseline use of this proposal.

[117] *See* note 59 (defining third party service providers) that include, e.g., Data link Service Providers (DLSP) that "deploy and maintain airborne, ground-based, and, in some cases, space-based infrastructure that support the transmission of AI/METI over one or more data links." *AC 00-63A*, § 6.a. *See UAS-UTM CONOPS*, 2.4.5, p. 9.

[118] **Aeronautical Common Services (ACS)** - ACS are a set of services that "ingest aeronautical data from authoritative sources and will then transform, validate (for integrated products), verify, store, and distribute the resultant [aeronautical information] to users and systems through [the FAA's Aeronautical Information Management (AIM)] enterprise web services . . ." FAA, *Aeronautical Common Services* (webpage), https://www.faa.gov/air_traffic/flight_info/aimm/acs/] (and defining four functional capabilities: Aeronautical Information Integration, Aeronautical Information Data Analytics, Aeronautical Information Subscription Services, and Spatial Information Mapping). Consider the efficacy/applicability of the following system: "AIMM Segment 2 will create a platform for future AIMM segments delivering greater access, integrity, and extensibility of AI systems to users across the NAS." *AIM Segment 2* (webpage), https://www.faa.gov/air_traffic/flight_info/aimm/aimms2/. AIMM Release 3 will "ingest and provide NOTAM." *Id.*

[119] ICAO is developing air to ground information exchange standards that could be applied to the dissemination of LAANC-type data. In the future, this effort could contribute to globally harmonized sUAS data publication across state boundaries. Under development by ICAO's Information Management Panel. *See, e.g.,* ICAO, AN-Conf/13-WP/4, System-wide Information Management (Swim) (Feb. 4, 2018), https://www.icao.int/Meetings/anconf13/Documents/WP/wp_004_en.pdf. "The standards governing SWIM are quite a long way from being developed and the actual implementation of A/G SWIM among regulators and then aircraft manufacturers do not even have a projected date yet." Scott Blum, PhD., Jeppesen (Dec. 2018).

[120] The FIS-B service is a component of the SBSS. *See* note 28 (describing FIS-B).

[121] **Cellular Communication Methods** - Two methods of cellular radio communication are considered herein—those that connect via:

> **(1) Airborne Access System (AAS)** - a low-power base station-like device certified by a CAA that controls the emissions of onboard personal electronic devices (such as cell phones) by keeping them at their lowest power level. Such systems are currently implemented primarily in commercial and air transport aircraft. AAS connect onboard wireless devices to terrestrial networks or satellites. Other related methods of connectivity may include, e.g., "4G LTE-based beamforming technology using . . . wireless spectrum [via] air-to-ground (ATG) platform of cell towers . . ." SmartSky Networks, LLC, https://www.smartskynetworks.com/# (describing the "Skytelligence™ technology framework"); and
>
> **(2) direct communication** with terrestrial cellular ground stations - direct connection presents regulatory and technical challenges—but research and trials offer promise. *See* note 29, and, e.g., Qualcomm Technologies, Inc, *LTE Unmanned Aircraft Systems Trial Report* v1.0.1 (May 12, 2017),

https://www.qualcomm.com/media/documents/files/lte-unmanned-aircraft-systems-trial-report.pdf. 5G services, as they become available, should provide further capabilities and options.

Cellular Regulation -

FAA: Certain mobile communication services enabling this proposal appear permissible to the FAA to the extent the aircraft operator determines that the portable electronic device "will not cause interference with the navigation or communications system of the aircraft on which it is to be used." 14 C.F.R. § 91.21, *Portable electronic devices* (seeking to prevent co-channel interference at multiple cell sites); and 47 U.S.C. 333 (prohibiting willful or malicious interference to licensed radio communication). *See Airborne Use of Cellular Telephones Report and Order*, 7 FCC Rcd at 23 ¶ 5, https://digital.library.unt.edu/ark:/67531/metadc1883/m1/40/; and FCC 13-157, *In the Matter of Expanding Access to Mobile Wireless Services Onboard Aircraft* (Dec. 13, 2013), https://transition.fcc.gov/Daily_Releases/Daily_Business/2013/db1216/FCC-13-157A1.pdf (NPRM addressing, in part, harmful interference among multiple simultaneous terrestrial cell sites).

FCC: Nonetheless, the FAA supports the Federal Communications Commission (FCC) prohibition of airborne operation of cellular telephones, 47 C.F.R. § 22.925, *available at,* https://www.law.cornell.edu/cfr/text/47/22.925, except for waived approved systems that do not interfere with ground-based networks. *Cf.,* 47 C.F.R. § 90.423(a)(1), https://www.law.cornell.edu/cfr/text/47/90.423 (permitting certain mobile operations in the 800 MHz SMR band "regularly flown at altitudes below 1.6 Km (1 mi) above the earth's surface"). The breadth of applicability of these rules will undergo scrutiny and may be satisfied by technical developments.

[122] The deliver/receive "pipe" connecting most EFB does not require the same design-assurance rigor as that to TSO'd cockpit avionics. Note that where direct cellular service is contemplated, regulatory restrictions may constrain altitude and other parameters.

[123] *See JO 7400.2M.2L*, §§ 21-6-1 & 15-3-2. An *aeronautical study* is a precondition to SUA approval "to identify the impact of the SUA proposal on the safe and efficient use of airspace and ATC procedures." *Id.* § 21-6-1. For Class B airspace, "[a] staff study is required to identify and document the need to establish or modify a Class B airspace area." *Id.* § 15-3-2. Current operations and aviation activities, including UAS activities must be described. *Id.* § 15-3-2.2(c). The airspace used for LAANC operations and its associated risks deserve study and possible recharacterization.

[124] FAA, AIXM - *Aeronautical Information Exchange Model* (webpage), Digital Notam Event Specification, Increment 1 (2011), http://aixm.aero/page/digital-notam. *See generally*, AIXM aixm.aero. Consider, e.g., the AIXM "Airspace Activation" class, that appears to contain most of what is needed to transfer necessary LAANC data (a block altitude, with airspace ID, and other relevant objects) to permit unambiguous designation of LAANC-relevant operations.

[125] *DO-365*, Appn. B.2; *see* 14 C.F.R. § 107.31.

[126] *AIM, Pilot/Controller Glossary*.

[127] *Cf., DO-185B,* § 1.8. *Cf.,* 14 C.F.R. § 125.224 Collision avoidance system, *available at,* https://www.law.cornell.edu/cfr/text/14/125.224.

[128] ASTM, F3178, *Standard Practice for Operational Risk Assessment of Small Unmanned Aircraft Systems (sUAS)*, www.astm.org.

[129] *See* 14 C.F.R. § 107.3.

[130] ASTM, F3266, *Standard Guide for Training for Remote Pilot in Command of Unmanned Aircraft Systems (UAS) Endorsement*, www.astm.org.

[131] 14 C.F.R. § 1.1.

132 *DO-365*, Appn. B.

133 ACAS X_u with completed MOPS planned for FY2020 (providing both vertical and horizontal advisories; and interoperability with TCAS). RTCA, Paper No. 099-18/PMC-1742, *Terms Of Reference*, SC-228, *Minimum Performance Standards for Unmanned Aircraft Systems* (Rev 5) (Mar. 22, 2018), https://www.rtca.org/sites/default/files/sc-228_tor_rev_5_approved_03-22-2018.pdf; and *sXu Concept of Use*.

134 *DO-365.*

135 *AC 120-76D*.

136 *UAS-UTM CONOPS*, § 2.4.6, p. 9.

137 *UAS-UTM CONOPS*, § 1.2, p. 3.

138 *DO-358*.

139 *See generally, FIXM*, https://www.fixm.aero; https://www.fixm.aero/releases/FIXM-4.1.0/FIXM_Core_v4_1_0_Primer.pdf (FIXM Primer); https://www.fixm.aero/documents.pl#Sec1 (model); and FAA, *REST Service Description Document (RSDD)*, https://github.com/Federal-Aviation-Administration/LAANC/blob/master/LAANC%20-%20REST%20Service%20Description%20Document%20(RSDD)%2020170301.md#uass-in-fixm (description of UAS in FIXM message format).

140 ASTM F38, F3298 *Standard Specification for Design, Construction, and Verification of Fixed-Wing Unmanned Aircraft Systems (UAS),* www.astm.org.

141 *See, e.g.*, Sarah K. Yenson, et al, *Ground-Based Sense and Avoid: Enabling Local Area Integration of Unmanned Aircraft Systems into the National Airspace System* (undated), https://apps.dtic.mil/dtic/tr/fulltext/u2/1034469.pdf; and, for example, the following product information: SRC, *GBSAA Radar System, An integrated, flexible and scalable approach that enables UAS flights in domestic airspace* (2018), https://www.srcinc.com/pdf/Radars-and-Sensors-GBSAA.pdf [non-cooperative surveillance of manned aircraft]; and Gryphon R1400 - 3-D Active Electronically Scanned Array (AESA) air surveillance radar, https://www.srcinc.com/pdf/Radars-and-Sensors-Gryphon-R1400-Radar-Air-Surveillance.pdf.

142 ASTM, F2909, *Standard Practice for Maintenance and Continued Airworthiness of Small Unmanned Aircraft Systems (sUAS),* www.astm.org.

143 ASTM F38, F3196, *Practice for Beyond Visual Line of Sight (BVLOS) Operations of Small Unmanned Aircraft Systems (sUAS),* www.astm.org.

144 FAA, UAS Data Exchange (LAANC) webpage, https://www.faa.gov/uas/programs_partnerships/uas_data_exchange/, and note 6.

145 *DO-365*, Appn. B. Query whether the focus should be on whether or not the aircraft is *operating* the requisite equipment rather than merely having installed such equipment. Indeed, many cases are document of manned aircraft pilots intentionally disabling transponders in airspace requiring their use.

146 ASTM, F3178, *Standard Practice for Operational Risk Assessment of Small Unmanned Aircraft Systems (sUAS*), www.astm.org.

147 ASTM, F3196, *Practice for Beyond Visual Line of Sight (BVLOS) Operations of Small Unmanned Aircraft Systems (sUAS),* www.astm.org.

148 ASTM F38, F2908, *Standard Specification for Unmanned Aircraft Flight Manual (UFM) for an Unmanned Aircraft System (UAS)*, www.astm.org.

[149] ASTM F38, F3196, *Practice for Beyond Visual Line of Sight (BVLOS) Operations of Small Unmanned Aircraft Systems (sUAS),* www.astm.org.

[150] 14 C.F.R. § 73.3, *available at*, https://www.law.cornell.edu/cfr/text/14/73.3; FAA, *Order JO 7400.10*, Subj: Special Use Airspace, § 73.3(a) (Feb. 16, 2018), http://www.faa.gov/documentLibrary/media/Order/FAA_Order_JO_7400.10_Special_Use_Airspace.pdf; and FAA SUA website, https://sua.faa.gov/sua/siteFrame.app. *See JO 7400.2M*, § 21-2-1, *et seq*. (SUA Legal Descriptions).

[151] *TLC 3*, § 2.2.3.3, p. 29; and *UAS-UTM CONOPS*, § 2.4.5, p. 9.

[152] *sXu Concept of Use*, p. 3. It is presumed such sUAS will not have transponders or ADS-B equipage. *Id.* p. 7.

[153] *AC 120-76D*.

[154] *See ORDER 7200.23A;* and Figure 1 of this Proposal.

[155] FAA, *TSO-C154c, Universal Access Transceiver (UAT) Automatic Dependent Surveillance-Broadcast (ADS-B) Equipment Operating on Frequency of 978 MHz,* https://www.federalregister.gov/documents/2002/10/02/02-25052/proposed-technical-standard-order-tso-c-154-universal-access-transceiver-equipment.

[156] ASTM F38, F3298 [draft - WK57659], *New Specification for Design, Construction, and Verification of Fixed-Wing Unmanned Aircraft System (UAS) Standard*, www.astm.org; and 14 C.F.R. § 107.3.

[157] *UAS-UTM CONOPS*, § 2.4.3.

[158] *UAS-UTM CONOPS*, § 2.1.

[159] *See* FAA, *Unmanned Aircraft System Traffic Management (UTM)* webpage, https://www.faa.gov/uas/research_development/traffic_management/.

[160] SESAR, *U-space Blueprint* (2017), https://www.sesarju.eu/u-space-blueprint.

[161] JARUS, *JARUS guidelines on SORA* [*Specific Operations Risk Assessment*], Annex I, Glossary of Terms, Doc. ID: JAR-DEL-WG6-D.04 (2017), http://jarus-rpas.org/sites/jarus-rpas.org/files/jar_doc_06_jarus_sora_annex_i_v1.0.pdf.

[162] Consider that "[s]tandards for UAS operations in VLL airspace should therefore *not exclude the presence of manned aircraft* although the manned traffic encounter probability is lower than when flying above this minimal height." EUROCAE, [Draft] ED-258, *Operational Services and Environment Description for Detect and Avoid [Traffic] in Class D-G Airspace under VFR/IFR*, § 2.2., (___, 2018), [URL-*tbd*].

****