



USAF Airborne Sense and Avoid (ABSAA) Airworthiness and Operational Approval Approach

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1 Introduction

1.1 Executive Overview

This report describes an airworthiness and operational approval approach and its risks for an Airborne Sense and Avoid (ABSAA) system on a USAF Unmanned Aerial System (UAS).

The approach follows the existing USAF airworthiness process to provide airworthiness approval of ABSAA-equipped UAS, and the approach is independent of the ABSAA technology. The artifacts developed as part of the Tailored Airworthiness Certification Criteria (TACC) or Modified Airworthiness Certification Criteria (MACC) for a UAS with ABSAA will be sufficient for both airworthiness and operational approval, provided that the artifacts associated with the operational path are mapped to appropriate airworthiness criteria.

For operational approval, the ABSAA program should assist RTCA with developing a civil standard for ABSAA, work with the FAA to gain acceptance of the standard including any regulatory or policy changes if needed, and then the platform should follow the existing USAF Communications Navigation Surveillance/Air Traffic Management (CNS/ATM) process to enable Major Command (MAJCOM) operational approval and civil airspace access. Once a civil standard is available and accepted by the FAA, the current USAF CNS/ATM and operational approval processes require no further FAA review if the civil standard covers the desired operations.

The primary risk associated with this civil standards-based approach is schedule. RTCA will not complete its draft Minimum Operational Performance Standards (MOPS) for ABSAA until July 2015 and the final MOPS by July 2016 at the earliest.¹ The Federal Aviation Administration (FAA) must then decide whether to accept all, some, or none of these MOPS as a civil standard (i.e., Technical Standard Order and Advisory Circular) and possibly make a regulatory change which could take several more years. This timeline may not meet USAF needs.

It is also unclear whether the civil standards-based process can be executed absent a change to 14 CFR Part 91 regulations since UAS may not be able to use sensors to see-and-avoid,² in which case operational approval cannot be obtained through the civil standards-based process until the needed regulatory change is made.

If operational approval cannot be granted through the civil standards-based process, the ABSAA program should prepare for a risk mitigation approach option or “off-ramp.” If the primary approach is not feasible, the program should work with stakeholders to develop a military standard for ABSAA approved by the USAF Technical Airworthiness Authority (TAA), then work with the FAA to obtain operational approval either through a Certificate of Waiver or Authorization (COA) or regulatory exemption. Current negotiations between the FAA and the Department of Defense (DoD) on operational approvals for UAS using Ground-Based Sense And Avoid (GBSAA) should inform the feasibility of this risk mitigation approach option.

The decision to proceed with the COA process versus a regulatory exemption as a risk mitigation approach option will depend on the scope of the operational need for ABSAA in the NAS. If

¹ RTCA SC-228 Terms of Reference, <http://www.rtca.org/Files/Terms%20of%20Reference/SC-228%20May%202013%20TOR.pdf>

² Changes to 14 CFR Part 91 are being considered by the UAS Aviation Rulemaking Committee (ARC) upon request by the FAA. More detail of the rule change is in Section 3.3.

operating at a limited number of sites, the COA process would likely be more expeditious. For larger scale fielding, a regulatory exemption should be considered. The COA process can collect data and operational experience and become a precursor to a regulatory exemption.

1.2 Purpose

This purpose of this report is to be a roadmap for ABSAA airworthiness and operational approval and to facilitate communication between stakeholders. This report summarizes current policies and procedures for airworthiness and operational approval and indicates how ABSAA can fit within their scope. The report will help stakeholders in establishing the formal airworthiness and operational approval path for ABSAA and help establish the roles and responsibilities for each stakeholder.

1.3 Related Documents

Air Force Instruction (AFI) AFI 11-202, Volume 3, “GENERAL FLIGHT RULES”,
22 Oct 2010

AFI 62-601, “USAF AIRWORTHINESS”, 11 June 2010

AFI 63-101, “ACQUISITION AND SUSTAINMENT LIFE CYCLE MANAGEMENT”,
08 April 2009

AFI 63-137, “ASSURANCE OF COMMUNICATIONS, NAVIGATION,
SURVEILLANCE/AIR TRAFFIC MANAGEMENT (CNS/ATM), NAVIGATION
SAFETY, AND NEXT GENERATION AIR TRANSPORTATION SYSTEM
(NEXTGEN) PERFORMANCE”, 29 Mar 2012

FAA Notice N 8900.227, “Unmanned Aircraft Systems (UAS) Operational Approval”, July 2013

MIL-HDBK-516B, “Airworthiness Certification Criteria”, 29 Feb 2008

Title 14 Code of Federal Regulations (CFR) Part 11

Title 14 Code of Federal Regulations (CFR) Part 91

Title 10 United States Code (USC)

2 Background

2.1 Airworthiness

For UAS, the ABSAA system acts as a replacement for the see and avoid capability of the pilot onboard a manned aircraft. The performance and integrity of the ABSAA system must be shown to be acceptably safe for NAS operations as an alternate means of compliance with 14 CFR 91.113(b)³ and/or 91.181(b)⁴ or as a means of compliance with future modified regulations. This report assumes that airworthiness approval of the ABSAA system onboard a USAF UAS is the sole responsibility of the USAF under Title 10.⁵ The first FAA Sense-and-Avoid (SAA) Workshop—which included participation from the USAF and other Services—concluded that:

All equipment used as part of the SAA system, whether solely or partially used for that purpose, must be certified as airworthy (by applicable airworthiness authorities) to perform its SAA intended function under foreseeable operating conditions.

FAA and DOD develop airworthiness regulations which require that any Sense-and-Avoid equipment be subject to an airworthiness approval process.

The second caucus of the SAA Workshop (which again included USAF and other Service participation) concluded that:

Existing airworthiness and operational approval processes, in general, are appropriate for fielding of UAS SAA systems.

Therefore, this report will focus on understanding the existing USAF airworthiness and operational approval processes and how they might be leveraged to field ABSAA on a USAF UAS.

2.2 Operational Approval and Safety Cases

This report also assumes that both USAF and FAA operational approvals are required to fly a USAF UAS in the NAS. It is through the operational approval process that the original requirement for a “safety case” emerged. FAA Interim Operational Approval Guidance 08-01 for UAS issued in 2008 stated, “...if the applicant makes a *safety case* and presents sufficient data for an alternate means of compliance, then this data should be taken into consideration and evaluated for possible approval.” This guidance has been replaced by FAA Notice N 8900.227 “Unmanned Aircraft Systems (UAS) Operational Approval” (issued in January 2013 as 8900.207 and updated in July 2013 as 8900.227) which states, “Proponents proposing see-and-avoid strategies in lieu of visual observers (VOs) are required to support proposed mitigations with *system safety cases* which indicate the operations can be conducted safely.” While FAA Notices are not binding on the military Services, it should be noted that they are a statement of FAA

³ 14 CFR 91.113(b): “When weather conditions permit, regardless of whether an operation is conducted under instrument flight rules or visual flight rules, 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.”

⁴ 14 CFR 91.181(b): “...However, this section does not prohibit 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.”

⁵ USC Title 10, Subtitle D, Part 1, Chapter 803, § 8013(b)

policy. The Notice provides a list of required safety case information (see paragraph 17 of N 8900.227) and acceptable hazard analysis tools and techniques that should be included in a safety case taken from Table 3.1 of the FAA Air Traffic Organization (ATO) Safety Management System (SMS) Manual. These include standard airworthiness analyses such as Preliminary Hazard Assessment, Failure Mode and Effect Analysis, Fault Tree Analysis, etc. The Notice references the FAA Safety Risk Management process and states “Low-risk hazards may still warrant recommended safety requirements.” We infer from this statement that the ATO SMS risk matrix will be used to assess the risks—which is more stringent than the analog found in MIL-STD-882E⁶—and that the FAA believes that SAA risks should be mitigated to the “Low” level or eliminated altogether.

Seeking an exemption from 14 CFR 91.113 and/or 91.181 regulations in accordance with 14 CFR 11.15, 11.63, and 11.81 also requires some type of “safety case.” The FAA website states the following in regard to petitioning for an exemption:

*Your petition for exemption must include... The specific section or sections of Title 14 of the Code of Federal Regulations (CFR) from which you seek an exemption; The extent of relief you seek and the reason you seek the relief; How your request would benefit the public as a whole; **Reasons why the exemption would not adversely affect safety, or how the exemption would provide a level of safety at least equal to the existing rule;** . . . Any additional information, views, or **arguments available to support your request;** . . . You may, but are not required to, include safety risk analyses conducted as part of your organization's SMS.⁷*

When a civil standard exists, the FAA normally publishes a Technical Standard Order (TSO) and/or Advisory Circular (AC) explaining the types of safety evidence (i.e. “safety case”) that will be needed for FAA approval. These types of evidence are factored into civil standards-based approval processes as described below. Because of the ambiguous nature of the term “safety case”, this report will instead recommend that appropriate artifacts be added to the TACC or MACC to support the operational approval path chosen. An overview of the safety artifacts is listed in Table 1.

⁶ DoD Standard Practice for System Safety. 11 May 2012.

⁷ http://www.faa.gov/regulations_policies/rulemaking/petition/#exemptions. This is derived from questions listed in 14 CFR 11.81.

Table 1: Artifacts for Operational Approval

Operational Approval Path	“Safety Case” Artifacts Source	USAF Artifacts
Civil standards-based approval (Approach used in this document)	TSO/AC/regulations as implemented in USAF CNS/ATM process (Generic Performance Matrix)	TACC and Airworthiness Basis (includes USAF CNS/ATM letter of compliance)
COA (Risk mitigation approach option)	FAA Notice N 8900.227	TACC, Airworthiness Basis, and COA application with supporting data
Exemption (Risk mitigation approach option)	Petition for Exemption IAW 14 CFR 11.81 and subsequent negotiation with FAA. Lessons learned from previous exemptions.	TACC, Airworthiness Basis, and 14 CFR 11.81 Petition for Exemption with supporting safety data

2.3 GBSAA Efforts

The Marine Corps GBSAA approval at Marine Corp Air Station (MCAS) Cherry Point and Air Force GBSAA approval at Cannon Air Force Base will provide more details on the COA process for sense-and-avoid systems. An advantage of obtaining a COA is that it could be used to gather additional information to support lifting of restrictions or petitioning for an exemption down the road. The Air Force plans on operating under a COA initially. While the future ABSAA approval process may be different, the GBSAA efforts should provide additional information and a useful learning experience.

3 USAF Policies on Airworthiness and Operational Approval

Relevant USAF polices and processes were reviewed to determine how they can support airworthiness and operational approval of ABSAA on a USAF UAS for flight in the NAS. A primary focus for this review was to examine the organizational roles and responsibilities that lead to airworthiness and operational approval. Key excerpts from these instructions are provided in Appendix A.

3.1 Relevant Air Force Policies

Table 2: Summary of Relevant Air Force Policies

Document Number	Title	Date	Policies
AFI 11-202, Volume 3	GENERAL FLIGHT RULES	22 Oct 2010	The MAJCOM is responsible for operational approval of CNS/ATM and navigation systems. A UAS user must obtain a FAA Certificate of Waiver or Authorization (COA) through their MAJCOM if the COA option is being pursued.
AFI 62-601, with AFMC Supplement	USAF AIRWORTHINESS	11 June 2010, 12 May 2011	The Technical Airworthiness Authority (TAA) in AFMC is responsible for approving technical airworthiness standards, and the system program manager (PM) is responsible for executing the airworthiness process.
AFI 63-137	ASSURANCE OF COMMUNICATIONS, NAVIGATION, SURVEILLANCE/AIR TRAFFIC MANAGEMENT (CNS/ATM), NAVIGATION SAFETY, AND NEXT GENERATION AIR TRANSPORTATION SYSTEM (NEXTGEN) PERFORMANCE	29 Mar 2012	The USAF CNS/ATM Center of Excellence (COE) is recognized as the organization that uses civil standards to develop performance requirements for USAF CNS/ATM systems in support of the MAJCOM operational approval. The PM is responsible for ensuring these requirements are tailored properly. (Note: The current CNS/ATM COE is AFMC AFLCMC/HBA.)
AFI 63-101	ACQUISITION AND SUSTAINMENT LIFE CYCLE MANAGEMENT	08 April 2009	The PM is responsible for ensuring operational safety of their systems by working with appropriate stakeholders.
AFI 63-1201 Change 1	LIFE CYCLE SYSTEMS ENGINEERING	12 Sept 2011	The PM is responsible for directing integration of risk management and systems engineering in accordance with MIL-STD-882().

Document Number	Title	Date	Policies
AFI 91-202	THE US AIR FORCE MISHAP PREVENTION PROGRAM	1 Aug 1998	The USAF Safety Center conducts independent safety reviews and assists the PM in developing quantitative safety criteria for the program.
AF Mission Directive 27	AIR FORCE FLIGHT STANDARDS AGENCY (AFFSA)	28 Nov 2011	AFFSA is responsible for facilitating UAS operations in the NAS by developing operations, procedures and standards in coordination with MAJCOMs, other services, the FAA, and others.

3.2 Safety Stakeholders

From this review, it is apparent that there are many stakeholders responsible for flight safety. We note that the USAF policies show that the Program Manager has the largest role in establishing safety standards for SAA and coordinating them with all stakeholders. Airworthiness approval is provided through the TAA in AFMC. The existing USAF process is sufficient for supporting airworthiness approval of a UAS with ABSAA. However, the existing guidance, such as MIL-HDBK-516(), needs to be modified with specific SAA criteria.⁸ Because the TAA has the responsibility for approving the airworthiness basis, it is recommended that specific airworthiness criteria and standards for SAA be coordinated with the relevant safety stakeholders, added to the airworthiness basis for the UAS platform equipped with ABSAA, and approved by the TAA. In researching this report, we spoke with the USAF Airworthiness Office (AFLCMC/EZ⁹) and learned that ABSAA is viewed differently than GBSAA in terms of scope (see Figure 1, extracted from a presentation by AFLCMC/EZ).

⁸ Paragraph 1.2.1 of MIL-HDBK-516B Change 1 states in part, “Not all of the airworthiness criteria apply to every type of air vehicle; also, platform-unique, previously undefined criteria may need to be added to fully address safety aspects of unique configurations. . . . Tailoring rules are as follows . . . (d) Develop additional criteria, as appropriate, for any capabilities or systems not fully addressed by the criteria contained in this handbook.”

⁹ Mr. Frank Grimsley, AFLCMC/EZI, who created the referenced presentation

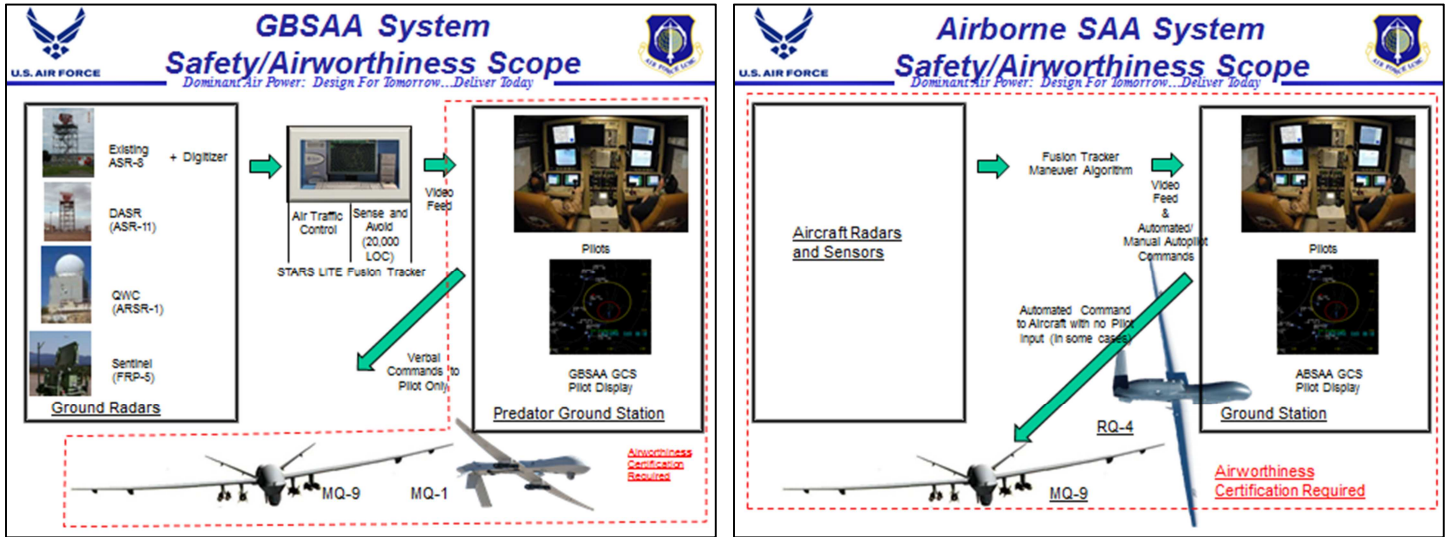


Figure 1: GBSAA and ABSAA Airworthiness Scope

For ABSAA, the USAF Airworthiness Office views all components of SAA system as subject to airworthiness approval. This is different than for GBSAA, as many elements are not subject to airworthiness approval (e.g., sensors, tracker, and algorithms reside off-board the UAS platform and external to the ground control station). For the GBSAA implementation at Cannon AFB, the USAF is pursuing a separate “safety case” issued by the USAF Safety Center to provide safety evidence for those items outside of the airworthiness scope. Given the contrast in Figure 1, the TACC or MACC for ABSAA would include all of the safety artifacts needed for airworthiness approval. To that end, Chapter 11 of MIL-HDBK-516 “Avionics” states that “Avionics certification criteria apply to manned air vehicle avionics, as well as airborne and ground segment avionics for UAV/RPA.”¹⁰ The first criterion in chapter 11 states in part, “11.1.1 Avionics subsystems. Verify that the number and type of sensors, data processors, data buses, controls and displays, and communications devices are adequate for SOF [safety of flight] considerations.” The supporting documents for this criterion include references to “...military performance requirements necessary for safe access to civil airspace.” Therefore, it is believed that the standards and methods of compliance for this criterion (and others) can and should include the required artifacts to achieve operational approval. Thus, for a USAF UAS equipped with ABSAA, the TACC or MACC would be sufficient to support airworthiness and operational approval provided that the artifacts associated with the operational path chosen are mapped to appropriate airworthiness criteria.

3.3 Civil Standards-Based Operational Approval

Figure 2 diagrams the key steps, described in this section, in the civil standards-based operational approval approach for an ABSAA system on a USAF UAS.

¹⁰ MIL-HDBK-516B Change 1 Chapter 11.

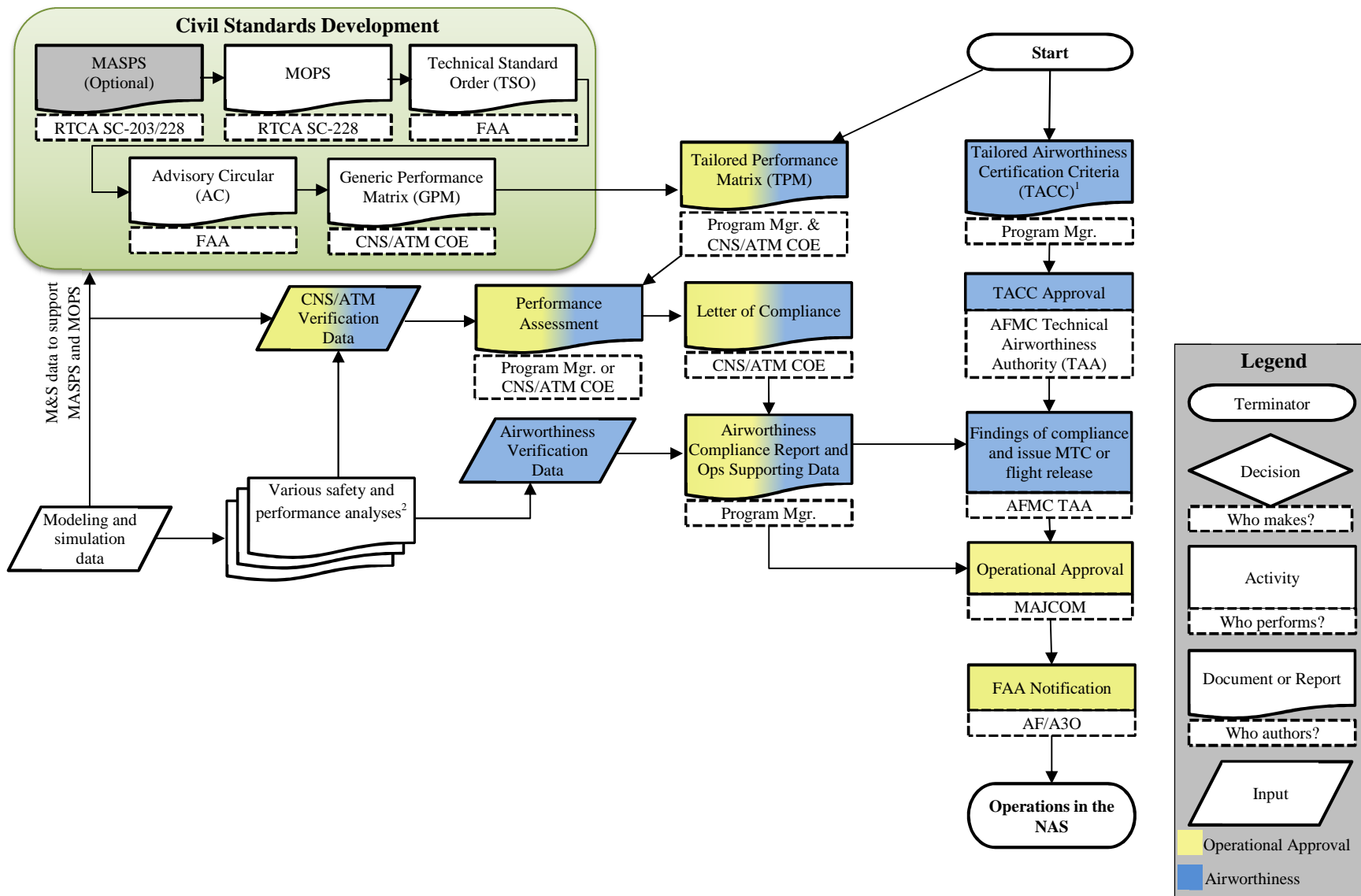


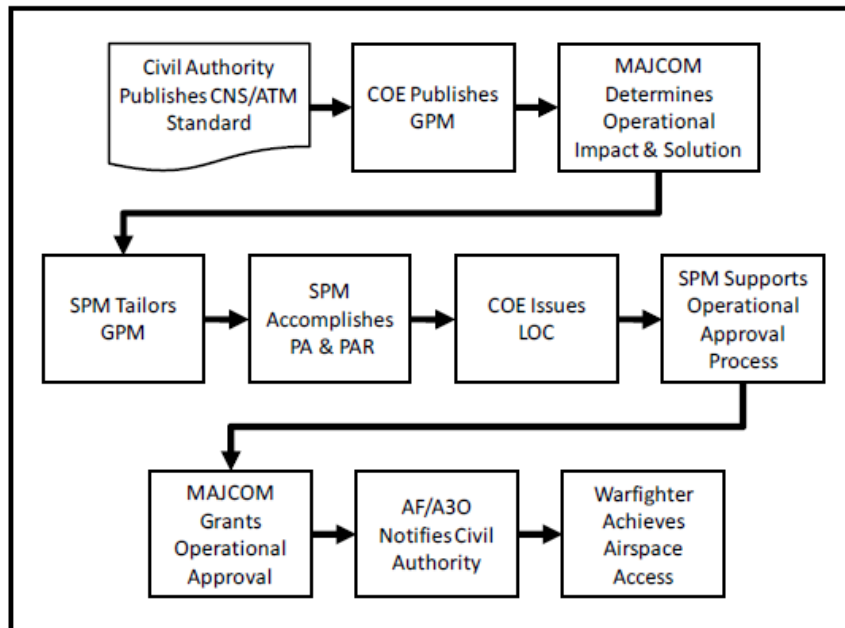
Figure 2: ABSAA Civil Standards-Based Airworthiness and Operational Approval Approach

Figure 2 Notes:

- 1 Could also be Modified Airworthiness Certification Criteria (MACC) for an existing platform
- 2 Safety analyses could include those from ATO SMS Manual Table 3.1 such as Preliminary Hazard Analysis (PHA), Operational Safety Assessment (OSA), Comparative Safety Assessment (CSA), Fault Hazard Analysis (FHA), Failure Mode, Effects, and Criticality Analysis (FMECA), Cause-Consequence Analysis, and Fault Tree Analysis (FTA). Performance analysis of the system could include AICA (Accuracy, Integrity, Continuity, and Availability) Analysis, Clutter and Interference (e.g. precipitation, clouds) backscatter characterization, Radar Operating Characteristic (ROC) verification, Spectrum Analysis, as well as other system performance assessments in normal and degraded modes. The analyses required will also depend on the revisions to MIL-HDBK-516().

The standard USAF CNS/ATM and operational approval processes are predicated on having an existing civil standard. Figure 3¹¹ shows that the first step in the civil standards-based operational approval process is “Civil Authority Publishes CNS/ATM Standard”. Currently there is no civil performance standard for ABSAA, but one is under development.

Figure 3.1. CNS/ATM Capability Standard to Operational Approval Process.



Note: This figure does not capture airworthiness certification processes. Reference AFI 62-601, *USAF Airworthiness*, 11 June 2010, for information regarding airworthiness processes.

Figure 3: Civil standards-based operational approval process from USAF AFI 63-137

RTCA Special Committee 228 is leading an effort to define a civil ABSAA performance standard (e.g., MOPS) no earlier than July 2015 with final MOPS due in July 2016. Once MOPS are published, the FAA then must decide whether to accept all, some, or none of the MOPS as the basis for a TSO and AC. This process may take between five months¹² to several years. The USAF could trade schedule risk for performance risk by utilizing draft versions of the MOPS for development and testing while waiting on the FAA-accepted versions for actual airworthiness and operational approval.

After the civil standard is available, the CNS/ATM Center of Excellence (COE), established within AFMC AFLCMC/HBAG, will create a Generic Performance Matrix (GPM) with the SAA performance requirements. This GPM is then tailored with the platform program office to form a Tailored Performance Matrix (TPM), which is used as the basis for CNS/ATM compliance determination in a Letter of Compliance (LOC) that is used for both the TAA airworthiness approval and MAJCOM operational approval.

This approach allows the USAF to exercise the proper due diligence per Title 10 CFR responsibilities and keep the airworthiness and operational approval within USAF agencies without burdening the FAA with additional risk analysis. This civil standards-based process is

¹¹ Figure 3.1 from USAF Instruction 63-137

¹² It took 5 months for publication of TSO-C166b and AC 20-165 after the publication of RTCA DO-260B.

already used for operational approval of technologies like TCAS and Data Communications on manned aircraft without the need for FAA approval.

This approach also paves the way for easier approval of the ABSAA system on platforms beyond the first integration since the standards are published and accepted. Another advantage of this process is that it is an established process with a track record of success for providing operational approval of CNS/ATM technologies for USAF aircraft. Additionally, approvals are good indefinitely and do not require renewal, unless the ABSAA system or related components are modified. If there is a safety issue that arises, the ABSAA system would need modifying and therefor would require a renewal of the CNS/ATM LOC and airworthiness approval.

However, it is currently unclear whether the civil standards-based process can be executed for ABSAA absent a change to 14 CFR 91.113 and other rules in Part 91.¹³ Some stakeholders believe that a change is needed since sensors cannot be used to “see,” and use the example of the need for a rule change to enable reduced minimums for Enhanced Flight Vision Systems (EFVS).¹⁴ Others argue that a SAA system can meet the Part 91 regulations as currently written. If changes to these regulations are required for the USAF to execute the civil standards-based process, this approach may not be a feasible path to obtain timely operational approval for a UAS to operate with ABSAA. A working group has been established under the UAS Aviation Rulemaking Committee (ARC) to recommend changes to 14 CFR 91.113 to “enable (not preclude) Unmanned Aircraft System (UAS) operations.”¹⁵ Even if the regulations are not changed, the civil standards can still be leveraged to facilitate a streamlined COA or regulatory exemption FAA approval.

This approach assumes that the scope of the civil standards will sufficiently cover ABSAA operations planned by the USAF. The Terms of Reference (TOR) for SC-228 define the scope of the Phase 1 MOPS as being limited to operations transiting through Class D, E, and G airspace to/from, and operations in, Class A or Special Use Airspace. The scope is also limited to larger UAS flying Instrument Flight Rules (IFR).¹⁶ If the civil standards do not cover the operations planned by the USAF, then the risk-mitigation operational approach option described in section 3.4 would be necessary.

3.4 Risk Mitigation Operational Approval Option

If the civil standards-based process cannot be completed either due to schedule or absence of a needed rule change, an alternate risk mitigation approach option for USAF operational approval would be to pursue approval through the AFMC TAA and a FAA COA or exemption. In this “off-ramp,” the USAF would develop a military standard for ABSAA performance (e.g., Target Level of Safety, Risk Ratios, etc.) approved by the AFMC TAA and included in the TACC or MACC. The basis for the military standard may be in a revision to MIL-HDBK-516() or any civil standards that had been developed at the time. For USAF operational approval, avionics subject matter experts in AFMC could provide a letter to the Program Manager recommending

¹³ SC-228 Terms of Reference: “The Phase One DAA MOPS will be developed assuming that the requirements for UAS DAA operation while the UAS is in Class A airspace will be specified outside of the MOPS (e.g. through rulemaking)”

¹⁴ See Notice of Proposed Rulemaking 78 FR 34935. <https://federalregister.gov/a/2013-13454>

¹⁵ UAS ARC 14 CFR Part 91 working group Terms of Reference draft (15 July 2013)

¹⁶ RTCA SC-228 Terms of Reference

MAJCOM fielding of the system, as has been done for Reduced Vertical Separation Minima (RVSM) on other aircraft.¹⁷

FAA operational approval would also need to be obtained through either the COA process or a regulatory exemption¹⁸ from 14 CFR 91.113 and/or 91.181. Either of these paths (COA or regulatory exemption) would require negotiation with the FAA to show that the risks have been mitigated to acceptable levels. As noted earlier, differences between military and civil system safety processes could create instances of risks being acceptable under military criteria that would not be deemed as acceptable by the FAA.¹⁹ Current negotiations between the FAA and DoD on FAA operational approvals for UAS using GBSAA may inform the feasibility of this path and guide the contents of safety artifacts that should be added to the TACC or MACC.

The FAA may require operations under a COA to collect operational data prior to approving an exemption. The decision to proceed with the COA process versus a regulatory exemption as a risk mitigation approach option will depend on the scope of the operational need for ABSAA in the NAS. If operating at a limited number of sites, the COA process would likely be more expeditious. For larger scale fielding, a regulatory exemption should be considered.

In the absence of a civil standard, it is not well understood whether an ABSAA system built to a military standard would have the performance necessary to fly in the areas of the NAS for which the system is designed without additional mitigations. However, if the military standard used was based on a MOPS or draft MOPS, the risk of the standard not being acceptable by the FAA is lessened.

This risk mitigation option is diagrammed in Figure 4.

¹⁷ For the case of RVSM, the DoD Policy Board for Federal Aviation formally coordinated with the FAA to obtain recognition of its military approval of its aircraft to meet RVSM performance standards.

¹⁸ 14 CFR §11.15, CFR §11.63, and CFR §11.81 describe this process. We note that USAF Instruction 11-202, Volume 3 specifies that a COA is currently required.

¹⁹ These differences include incongruities in hazard severity definitions, quantitative hazard likelihoods, and risk acceptance authorities.

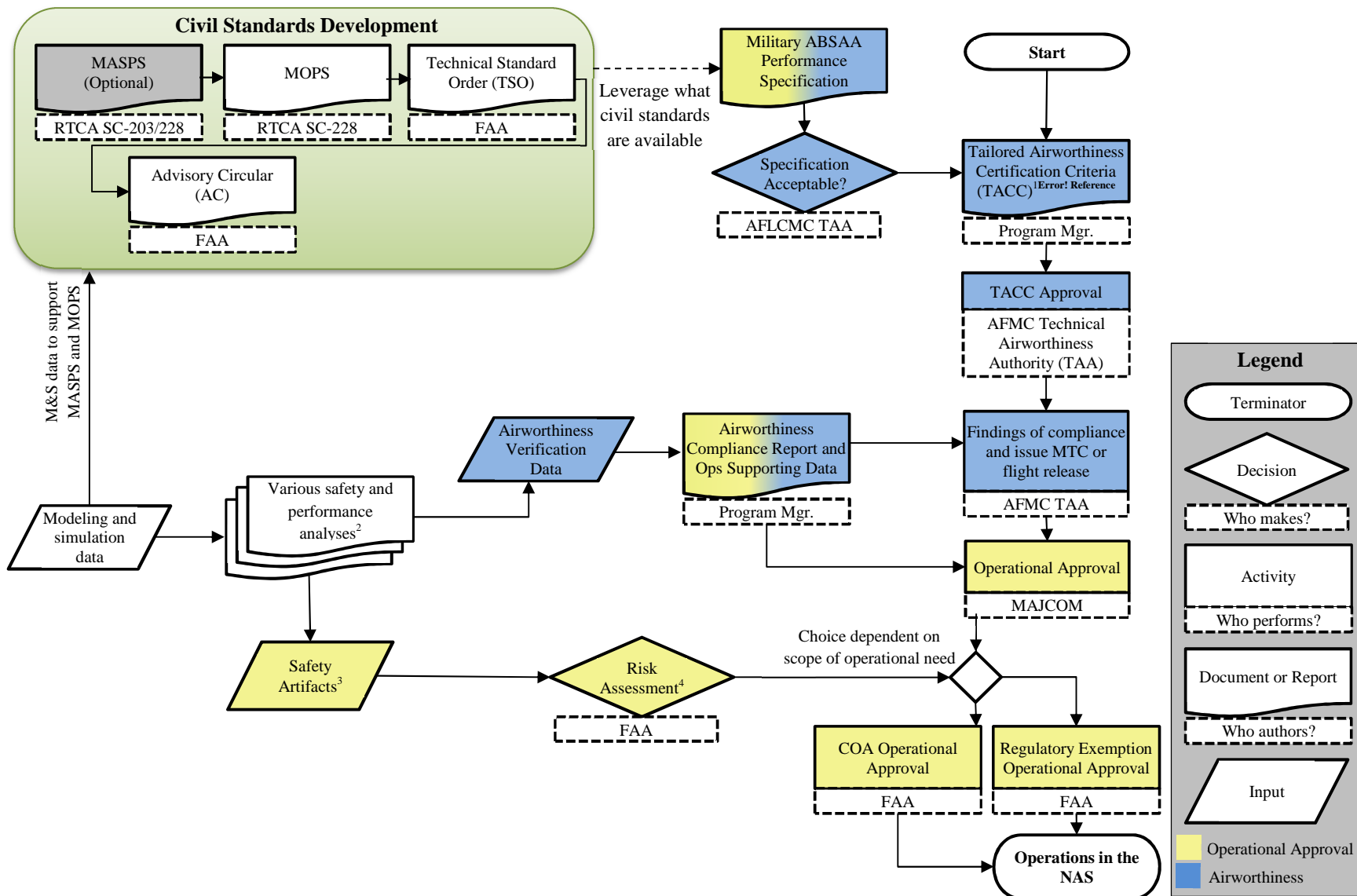


Figure 4: ABSAA Risk Mitigation Airworthiness and Operational Approval Approach Option

Figure 4 Notes:

- 1 Could also be Modified Airworthiness Certification Criteria (MACC) for an existing platform
- 2 Safety analyses could include those from ATO SMS Manual Table 3.1 such as Preliminary Hazard Analysis (PHA), Operational Safety Assessment (OSA), Comparative Safety Assessment (CSA), Fault Hazard Analysis (FHA), Failure Mode, Effects, and Criticality Analysis (FMECA), Cause-Consequence Analysis, and Fault Tree Analysis (FTA). Performance analysis of the system could include AICA (Accuracy, Integrity, Continuity, Availability) Analysis, Clutter and Interference (e.g. precipitation, clouds) backscatter characterization, Radar Operating Characteristic (ROC) verification, Spectrum Analysis, as well as other system performance assessments in normal and degraded modes. The analyses required will also depend on the revisions to MIL-HDBK-516().
- 3 System Safety Case data is described in FAA Notice N 8900.227 or Regulatory Exemption petition data described in 14 CFR 11.81
- 4 Risk Assessment is conducted IAW ATO SMS Risk Matrix

3.4.1 Certificate of Waiver or Authorization (COA)

Using the COA process, the MAJCOM operating the UAS would apply for a COA from the FAA. The FAA is authorized to grant waivers and authorizations under 14 CFR 91.903 and 91.905. The COA would be limited to a specific platform and specific locations. Safety artifacts would need to be provided in accordance with FAA Notice N 8900.227 paragraph 17. These would be reviewed through the FAA's SMS process by the Safety Risk Management Panel (SRMP).

An advantage of the COA process is that there is an established and documented path for operation approval. This path is being used by DoD UAS today, by the USAF Cannon GBSAA project, and by the Cherry Point GBSAA program. Additionally, there is no public comment period required, which reduces the approval timeline.

The primary disadvantage of using the COA process is the results are limited to the initial locations and platform integrating ABSAA. The use of ABSAA by additional platforms or in additional locations would require a repetition of the entire COA process. The COA must also be renewed every one to two years, as determined by the FAA.

3.4.2 Regulatory Exemption

Using the regulatory exemption process, AF/A3O in coordination with the MAJCOM operating the UAS would petition for an exemption from all or parts of 14 CFR 91.113 and/or 91.181.²⁰ The regulatory exemption process would be conducted in accordance with 14 CFR 11.15, 11.63 and 11.81. As with the COA process, the FAA would have to review the safety artifacts in accordance with the FAA's SMS process. The duration of the exemptions can vary from a few years to no expiration; however, the majority of the exemptions require renewal after 2 years.

The FAA has granted DoD exemptions from 14 CFR 91.209 (Night Vision Goggle (NVG) lights out training in Military Operating Areas (MOAs)), 14 CFR 91.81 (altimeter settings in MOAs and restricted areas), 14 CFR 105.17 and 105.19 (unlighted night parachute operations), 14 CFR 91.117, 91.159, and 91.209 (speed, VFR cruising altitudes, and aircraft lighting for drug interdictions), and 14 CFR 91.119 (IFR operations along all-weather low-altitude routes).²¹

The history of the exemption from 14 CFR 91.209 related to NVG operations without external lights (FAA Exemption 7960) is detailed in Appendix B as it most closely relates to UAS SAA operations since NVG operations limit the See and Avoid capability. Little empirical data or safety artifacts were provided by the USAF to justify the lights out operations. This is unlikely to be the case with ABSAA approval due to the higher political visibility and the FAA's recently instituted SMS process. The FAA did take into account the USAF's "sufficient operational experience" in granting the exemption. Also, the FAA, in issuing the exemption, imposed additional restrictions on the operations beyond those proposed by the USAF, which may also be the case with an ABSAA exemption. However, unlike existing UAS COAs, the lights out exemption applies to a large number of MOAs, but additional activities, such as establishing a Letter of Agreement with nearby ATC facilities, are required for each MOA used.

²⁰ This paper assumes the existing regulations remain in place for the Risk Mitigation Operational Approval Option. Work is ongoing in the UAS Aviation Rulemaking Committee (ARC) to explore the possibility of a rule change, in which case the process for operational approval may change.

²¹ FAA exemption numbers 7960E, 2861A, 9294C, 5100J, and 2396. Accessed through <http://aes.faa.gov>.

The advantage of the regulatory exemption approach is the exemption could be broadly applied to other platforms with the ABSAA system or possibly other ABSAA systems that comply with the military standard.

The disadvantage is the length of time required to obtain an exemption. A public comment period is required which could be politically sensitive. The regulatory exemption from parts of 14 CFR 91.209 for NVG lights out training in MOAs took a year and a half to complete.

4 Conclusions

This report set out to investigate existing USAF airworthiness and operational approval processes and how they might be leveraged to field ABSAA on a USAF UAS for flight in the NAS. It also explored the concept of a safety case that may be needed for airworthiness and operational approval.

We find that the existing USAF airworthiness process is appropriate to provide airworthiness approval of ABSAA assuming the civil standards operational approval process is used, and that the artifacts developed as part of the TACC (or MACC) for a UAS with ABSAA can be sufficient to support both airworthiness and operational approval if properly tailored.

We recommend that SAA-specific criteria and standards should be added to the TACC and that USAF policies place the responsibility on the platform PM to coordinate these criteria and standards with all relevant safety stakeholders.

The optimal approach for obtaining operational approval for fielding ABSAA on a USAF UAS for flight in the NAS is to assist RTCA with developing a civil standard for ABSAA, work with the FAA to gain their recognition and acceptance of the standard, and then follow the existing USAF civil standards-based operational approval process. This approach has low technical risk, the advantage of being a proven process, and the most flexibility for the USAF with the fewest FAA restrictions. However, this approach carries schedule risk and the risk of the civil standard not sufficiently covering the operations planned by the USAF.

The alternate approach option involves working with safety stakeholders to develop a military standard for ABSAA approved by the USAF TAA, and then work with the FAA to obtain operational approval through a COA or regulatory exemption to sections of 14 CFR Part 91. Most of the same safety artifacts needed for the civil standards-based process can be used for a COA or regulatory exemption.

We recommend laying the ground work for this option in case a platform has an operational need whose deployment schedule is ahead of the civil standard's availability and the availability of a 14 CFR Part 91 rule change (if needed).

5 Proposed Next Steps

Because ABSAA is viewed as a new technology, this report can serve as a starting point for the ABSAA PM to develop a Memorandum of Understanding (MOU) between USAF safety stakeholders to formalize roles and responsibilities for USAF airworthiness and operational approvals.

The platform PM should ensure that the safety case artifacts in FAA Notice N 8900.227 are incorporated into the airworthiness plan for the ABSAA-enabled UAS platform. Existing and ongoing work on MIL-HDBK-516 updates in regards to UAS and SAA should also be included in the airworthiness plan.

Robust ABSAA program office participation in RTCA activities to develop civil standards for ABSAA will ensure the scope and assumptions in the standard are compatible with USAF UAS operations. The program office should also follow the work of the UAS ARC to understand the impact and schedule of a possible Part 91 rule change. The ABSAA PM should work to ensure appropriate FAA participation in RTCA activities to enable timely acceptance of RTCA MOPS in FAA TSO(s) and AC(s).

With regard to the risk mitigation approach option, the ABSAA PM should coordinate USAF safety stakeholder participation in planned Office of the Secretary of Defense SAA Science and Research Panel activities. This will familiarize military airworthiness authorities with the findings of the SAA Workshop report, which will support the goal of establishing a military performance standard for ABSAA. These standards would then be added to the airworthiness plan and included in the TACC (or MACC). Additionally, the ABSAA Program Office should track developments of negotiations between DoD and the FAA for operational approval of GBSAA systems for possible application to ABSAA.

Appendix A Excerpts from USAF Instructions

- **USAF/A30, MAJCOM:** AIR FORCE INSTRUCTION 11-202, VOLUME 3 (22 October 2010) “GENERAL FLIGHT RULES”
 - “This instruction implements AFPD 11-2, Aircraft Rules and Procedures, by prescribing general flight rules that **govern the operation of USAF aircraft (manned and unmanned)**²² flown by USAF pilots, pilots of other services, foreign pilots, and civilian pilots. “
 - “**Operations of UAS** in the U.S. National Airspace System (NAS) outside of Warning and Restricted Areas require an **FAA Certificate of Authorization or Waiver (COA)**, to be obtained by the user unit through their MAJCOM.”
 - “**HQ USAF/A30 will provide waivers to this instruction** only upon an official MAJCOM request when an essential requirement makes a waiver necessary or compliance with a flight rule creates a hazard.”
 - “2.16.2. **Operational approval.** Lead **MAJCOMs approve operational use** of CNS/ATM and navigation safety systems.”
 - “5.4.2. **For UAS operations to comply with see and avoid requirements**, the RPA must have the **capability to detect/sense other traffic in sufficient time** to perform an avoidance maneuver.”
- **AFMC:** AIR FORCE INSTRUCTION 62-601 (11 June 2010, with AFMC Supplement 12 May 2011) “USAF AIRWORTHINESS”
 - “1.1. Airworthiness. Airworthiness is the verified and documented capability of an air system configuration to **safely attain, sustain, and terminate flight** in accordance with (IAW) the approved aircraft usage and operating limits. The **air system Program Manager (PM)** is responsible for planning and executing airworthiness programs for managed aircraft IAW AFPD 62-6 and this instruction.”
 - “**A design-based airworthiness assessment** shall be conducted when (a) an **airworthiness certification basis can be established consisting of a specified set of design criteria**, and (b) the **design of an air system can be assessed for compliance** with the specified criteria. This is the only path which will lead to military certification of the type design and airworthiness certification of individual aircraft.”
 - “1.3.1. Independent Airworthiness Approval. The TAA, or delegated official . . . **shall approve the basis for air system airworthiness certification**, tailored airworthiness certification criteria (TACC), and reportable modification airworthiness certification criteria (MACC) documents; make findings of compliance for program airworthiness certification applications; and issue Military Type Certificates (MTC), Military Experimental Flight Releases (MEFR), Military Restricted Flight Releases (MRFR), and non-design-based special flight releases.”

²² Red text was added by the authors for emphasis and does not appear in the original documents.

- “Technical Airworthiness Authority (TAA)—**The AF official authorized to define airworthiness standards**, approve the certification basis, issue findings of compliance, and issue Military Type Certificates and other flight releases.”
- **SAF/AQ, USAF CNS/ATM Center of Excellence:** AIR FORCE INSTRUCTION 63-137 (29 March 2012) “ASSURANCE OF COMMUNICATIONS, NAVIGATION, SURVEILLANCE/AIR TRAFFIC MANAGEMENT (CNS/ATM), NAVIGATION SAFETY, AND NEXT GENERATION AIR TRANSPORTATION SYSTEM (NEXTGEN) PERFORMANCE”
 - “1.1. Purpose. The purpose of this Instruction is to ensure **United States Air Force aircraft continue to safely operate** in worldwide airspace. “
 - “2.1. Assistant Secretary of the Air Force for Acquisition (SAF/AQ) shall . . . [2.1.1] **Establish guidance for acquisition of CNS/ATM capabilities.**”
 - “2.7. Air Force Flight Standards Agency (AFFSA) shall . . . [2.7.1] Evaluate and **standardize AF aircraft operational policies** and procedures to ensure compatibility with CNS/ATM performance requirements.”
 - “2.9. Major Commands (MAJCOMs) shall . . . [2.9.4] **Grant aircraft CNS/ATM operational approval** IAW AFI 11-202V3, General Flight Rules, after verification that aircraft conform with host nation CNS/ATM capability standards. Exceptions, restrictions, or **use of equivalent safety and performance requirements will be documented in the operational approval.**”
 - “2.10. CNS/ATM Center of Excellence (COE) shall . . . [2.10.3] Generate generic performance matrices (GPMs) from **applicable CNS/ATM capability standards.**”
 - “3.1.1. CNS/ATM capability standards are **created by national/international civil aviation authorities** and **recognized standards development organizations.**”
 - “2.11. Program Managers (PMs) shall . . . [2.11.2] Ensure GPMs are tailored to **define CNS/ATM performance requirements.**”
- **System Program Office (SPO):** AIR FORCE INSTRUCTION 63-101 (08 April 2009) “ACQUISITION AND SUSTAINMENT LIFE CYCLE MANAGEMENT”
 - “The primary mission of the Integrated Life Cycle Management (ILCM) Enterprise is to provide seamless governance, transparency and integration of all aspects of weapons systems acquisition and sustainment management.”
 - “**Program Managers (PM)**, including System Program Managers (SPM), will... [2.29.11] **Ensure and preserve the operational safety**, suitability, and effectiveness (OSS&E) throughout the life cycle of systems delivered to the user by working collaboratively with the user, test community, and other stakeholders...[2.29.40] Ensure that product/system-level performance, integrity, and **safety requirements** are maintained throughout the operational life of a product or weapon system.”
- **SAF/AQ, SPO, Safety Center:** AIR FORCE INSTRUCTION 63-1201 Change 1 (12 September 2011) “LIFE CYCLE SYSTEMS ENGINEERING”
 - “This instruction implements AFD 63-1, Capability Based Acquisition System, and AFD 63-12, **Assurance of Operational Safety**, Suitability, and Effectiveness (OSS&E).”

- “2.1. SAF/AQ will . . . [2.1.8] **Ensure use of MIL-STD-882D System Safety methodology** to integrate ESOH considerations into SE, in accordance with DoD policy.”
- “2.2. SAF/XC will . . . [2.2.2] Formulate policy for **modeling and simulation (M&S)** efforts, including but not limited to those performed in support of acquisition, T&E, training, and capability-based analyses. Ensure M&S efforts conducted as part of the SE process employ commonly accepted standards and procedures.”
- “2.6. HQ AFSC/AF/SE will . . . [2.6.2] **Provide guidance** to program SE personnel for reviewing and assessing safety analyses, and recommend potential areas for further investigation and analysis.”
- “2.10. Program Managers (PM) will . . . [2.10.12] **Direct integration of ESOH risk management and SE in accordance with MIL-STD-882D**. Risk acceptance decisions are to be made at the appropriate management level in accordance with DoDI 5000.2 or NSS 03-01.”
- **Safety Center, SPO: AIR FORCE INSTRUCTION 91-202 (1 August 1998) “THE US AIR FORCE MISHAP PREVENTION PROGRAM”**
 - “1.2. Determining Standards. Commanders, functional managers, supervisors, and individuals, with the host safety office’s help, identify rules, criteria, procedures, Occupational Safety and Health Administration (OSHA), Air Force Occupational and Environmental Safety, Fire Protection, and Health (AFOSH), explosive safety, or **other safety standards that could help eliminate unsafe acts** or conditions that cause mishaps.”
 - “9.3.4. AFSC [**Air Force Safety Center**] . . . [9.3.4.2] **Develops independent safety assessments** of issues, programs, and systems . . . [9.3.4.5] **Reviews Air Force technical and management documents** (operational requirement documents, program management directives, system safety program plans, hazard analyses, SSG charters) for proper system safety program identification.”
 - “9.3.5. **Program Manager** or System Safety Manager . . . [9.3.5.1] Establishes and maintain an appropriately tailored system safety program (SSP) according to **MIL-STD 882**. . . [9.3.5.10] **Develops quantitative system safety criteria** and operating limits in concert with the using or operational command.”
- **Air Force Flight Standards Agency: Air Force Mission Directive 27 (28 November 2011) “AIR FORCE FLIGHT STANDARDS AGENCY (AFFSA)”**
 - “This publication delineates the mission, chain of command and responsibilities of the Air Force Flight Standards Agency (AFFSA).”
 - “3.15 Promotes USAF aviation safety by . . . [3.15.4] **Facilitating unmanned aerial system and remotely-piloted aircraft (RPA) operations in the NAS by developing operations, procedures and standards** in coordination with MAJCOMs, other services, the FAA, joint and coalition entities as required, and ensuring ATCALs support this integration.”

Appendix B NVG Lights Out Training Regulatory Exemption

B.1 Initial Request

On 18 July 2001, Col Richard Packard, Commander of the Air Force Flight Standards Agency (HQ AFFSA/CC), requested from the FAA Flight Standards Service (hereafter just referred to as the FAA) an exemption from 14 CFR 91.209 parts (a)(1) and (b) to “conduct lights-out operations in specific Military Operations Areas (MOA).”²³ The request documented the need to conduct lights-out operations, listed the MOAs, and set forth a proposed set of restrictions for those operations. Those proposed restrictions were:

1. Operations conducted in MOAs during official times of use
2. A Letter of Agreement (LOA) must be established between the USAF flying unit and the FAA ATC facility having jurisdiction over the MOA
3. Airfields within 50 nm of the MOA are briefed on lights-out operations
4. NOTAM issued 24 hours prior to operations and messages placed on nearby ATIS recordings
5. Aircraft with onboard sensors (radars) will clear the area; MRU/RAPCON controllers, when available, will monitor the MOA; if a non-participant aircraft enters the MOA, operators will restrict light-out operations as necessary to ensure safety
6. Notices added to VFR charts near MOAs with lights-out operations to inform pilots of the operations and to contact local FSS to determine if MOA is active with lights-out operations

The request also answered the following questions from 14 CFR 11 regarding exemption requests:

- Why is the exemption in the public interest? How would it benefit the public as a whole?
- Why will the exemption not adversely affect safety? What is the equivalent level of safety?
- Will MOA access be lost?

In answering the equivalent level of safety question, AFFSA/CC included a minimal amount of empirical data beyond the mitigations listed in the 6 proposed restrictions. The empirical data related to the improved visual acuity of NVG technology over the unaided human eye at night. The claim was made that “the individual using NVGs can see 5-10 times more clearly than an individual who is flying an aircraft using unaided vision at night” and therefore “NVGs significantly increase (5-10 fold) the level of night VFR safety.” No modeling or simulation data was presented.

B.2 FAA Response

The FAA published a notice in the Federal Register on 29 October 2001 announcing the proposed USAF petition for exemption and requesting public comments to docket FAA-2001-10191 by November 8 (10 days, normal comment period is 20 days).

²³ All documents referenced in this appendix are located on the FAA Exemption website (<http://aes.faa.gov/>) by searching for exemption 7960 or in the FAA-2001-10191 docket folder (<http://www.regulations.gov/#!docketDetail;D=FAA-2001-10191>).

The FAA then granted FAA Exemption 7960 on 24 January 2003 after receiving 49 public comments including ones from Helicopter Association International (HAI) and Aircraft Owners and Pilots Association (AOPA). 42 of the comments opposed the exemption and 7 were in favor of the exemption.

The FAA addressed all of the comments in the Federal Register and granted the exemption to the USAF. The FAA specifically called out the “sufficient operational experience” the military has had with NVG operations in the NAS including those conducted under FAA exemption 5891, which “permits the USAF to conduct helicopter NVG flight training operations without lighted position or anticollision lights at or below 500 feet above ground level,” and FAA exemption 7687, which “permits NVG flight training at or above 18,000 feet in air traffic control assigned airspace areas.” The FAA also followed AOPA’s recommendation to add information to the Airman’s Information Manual (AIM).

The FAA did not agree with the USAF’s equivalent level of safety argument and imposed additional restrictions on approved lights-out operations. The FAA also modified some of the USAF’s proposed restrictions to make them even more restrictive. Specifically the FAA restrictions for lights-out operations were:

1. Operations must be in MOAs listed in the exemption
2. **Operations must be monitored by military personnel with a radar capable of detecting nonparticipating aircraft including those without transponders or with small radar cross-sections**
3. Participating aircraft must monitor a designated frequency with the monitoring military personnel, to enable pilots to restrict operations, return to normal lighting, and alter course if necessary if a non-participating aircraft enters the operational airspace
4. NOTAMs must be issued 48 hours in advance
5. USAF must brief civil airspace users within 100nm of the MOA annually; provide advisories to transient aircraft; and establish LOA with ATC responsible for MOA airspace
6. Military pilots must be familiar with the lights-out operational restrictions
7. Failure to comply can result in revocation or cancelation of the exemption

The exemption expired on 31 January 2005 (two years).

B.3 FAA Extensions and Amendments

The FAA granted an extension and amendment to exemption 7960 on 28 August 2004 (FAA exemption 7960A) based on a request from AFFSA on 7 July 2004. In addition to extending the exemption, the request also petitioned the FAA to allow aircraft from other military services to participate in lights-out operations while conducting joint operations.

The AFFSA request stated that were no changes to the conditions or reasons relative to the public interest or safety in the approval basis for the exemption. The FAA determined that since the amendment to the exemption would not set a precedent and any delay would be detrimental to the USAF, no summary of the petition had to be published in the Federal Register.

The exemption was extended to 31 January 2007 (two more years) and the conditions and restrictions of the original exemptions still applied.

The FAA again extended and amended FAA exemption 7960 on 27 July 2006 (FAA exemption 7960B) based on a request from the USAF on 21 June 2006. The amendment added another MOA (the Dolphin MOA) and extended the exemption until 31 January 2009 (2 more years).

AFSSA requested another amendment and extension on 7 November 2008. The request asked for additional MOAs to be listed along with changing the exemption expiration to 5 years. The FAA responded on 22 January 2009 with an amendment and extension (FAA exemption 7960C). The FAA again decided against publishing the petition in the Federal Register and added the requested MOAs. However, the FAA did not agree with the 5-year timeframe and instead extended the exemption until 31 January 2012 (3 more years). The FAA also changed the terminology from NVG to Night Vision Device (NVD).

On 5 January 2009, AFSAA requested an amendment to the exemption to allow FAA ATC personnel and radars to provide separation between participating USAF aircraft and non-participating aircraft. The FAA rejected this amendment on 11 May 2009 (FAA exemption 7960D) since primary radar must be used for separation, and FAA ATC personnel do not usually use primary radar and would be unable to provide separation from non-transponder, non-participating aircraft. Additionally, the FAA does not have the resources to separate non-participating aircraft.

The final amendment and extension was granted on 6 December 2011 by the FAA (FAA exemption 7960E). The amendment added additional MOAs and extended the exemption until 31 January 2015 (3 more years). The amendment also added one more restriction:

1. The exemption is not valid outside the U.S.

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