U.S. DEPARTMENT OF ENERGY | Office of Science

DOE/SC-ARM-19-022

ARM-Related Unmanned Aerial System (UAS) and Tethered Balloon System (TBS) Operational Requirements and Approval

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August 2019

ARM

DISCLAIMER

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Work supported by the U.S. Department of Energy,
Office of Science, Office of Biological and Environmental Research

Acknowledgments

The authors acknowledge the contributions of the following persons, without which this procedure would not have been possible.

- Mike Hubbell, PNNL, AAF Director of Flight Operations
- Darielle Dexheimer, SNL TBS subject-matter expert
- Jasper Hardesty, SNL Atmospheric Sciences

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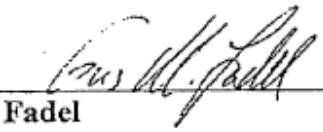

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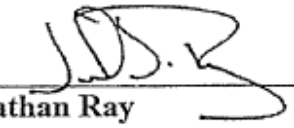

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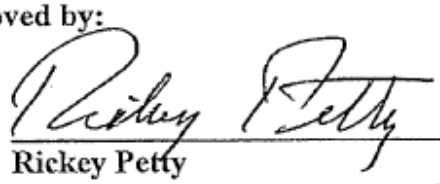

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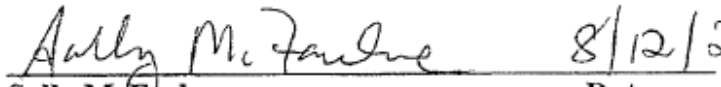

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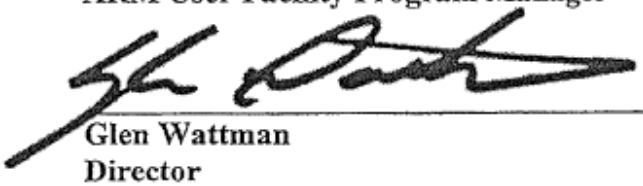

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Acronyms and Definitions

A&P	airframe and powerplant
ADP	Aviation Deconfliction Plan
Aerostat	A balloon that is stabilized with a skirt.
AFC	ARM field campaign
AGL	above ground level
ANL	Argonne National Laboratory
AOPA	Aircraft Owners and Pilots Association
ARM	Atmospheric Radiation Measurement
ARM Site Manager	Person responsible for an ARM site.
ARM-supported	An activity supported by ARM or conducted at an ARM site or ARM-managed airspace.
ASP	Aviation Safety Plan
ATC	Air Traffic Control (FAA)
Automated Flight Service Station	Service proved by the FAA for filing NOTAMs, Flight Plans, and Pilot Reports, and obtaining weather information.
Aviation Safety Officer	Person responsible to oversee aviation operations, typically within a national laboratory.
Balloon	A flexible bag inflated with a lighter-than-air gas. For this document, the term encompasses aerostats and helikites.
BER	Biological and Environmental Research (DOE Office of Science)
BVLOS	beyond visual line of sight
CAA	Civil Air Authority
CBT	computer-based training
CFR	Code of Federal Regulations
CG	center of gravity
COA	Certificate of Waiver or Authorization (FAA)
CTAF	Common Traffic Advisory Frequency
DOE	U.S. Department of Energy
DOE SC Aviation Safety Manager	Person assigned to oversee Office of Science aviation operations
DOE Site Aviation Safety Manager	Site Office person responsible for oversight of aviation operations at a DOE facility or national laboratory
DOE Site Office Manager	Person in charge of a DOE Field Office or Site Office
DVD	digital versatile disc
EE	Engineering Evaluation
FAA	Federal Aviation Administration

FAR	Federal Aviation Regulation
GCS	ground control station
GPS	Global Positioning System
GSA	General Services Administration
Helikite	A balloon that uses an attached kite structure to increase lift and stabilize the balloon
IMB	Infrastructure Management Board (ARM)
IMC	Instrument Meteorological Conditions
IOP	Intensive Observational Period
LAANC	Low Altitude Authorization and Notification Capability
LANL	Los Alamos National Laboratory
NOAA	National Oceanic and Atmospheric Administration
NOTAM	Notice to Airmen
OAM	Office of Aviation Management (DOE)
O	Operator (TBS)
PI	principal investigator
PNNL	Pacific Northwest National Laboratory
POC	point of contact
RAC	Risk Analysis Code
Requesting Organization	The organization proposing to use ARM funds or an ARM site to conduct a UAS or TBS operation
RPIC	Remote Pilot In Command – Properly certificated person directly responsible for, and the final authority as to, the operation of a UAS
RSO	Range Safety Officer
SC	Office of Science
SGP	Southern Great Plains
SME	subject-matter expert
SNL	Sandia National Laboratories
sUAS	small Unmanned Aeerial System (i.e., Tier V or less)
Tier I UAS	UAS with a gross weight above 12,400 pounds
Tier II UAS	UAS with a gross weight above 500 pounds but less than 12,500 pounds
Tier III UAS	UAS with a gross weight above 250 pounds but less than 500 pounds with a less than $100,000 in acquisition cost
Tier IV UAS	UAS with a gross weight above 50 pounds but less than 250 pounds with less than $100,000 in acquisition cost
Tier V UAS	UAS with a gross weight above 0.55 pound but less than 55 pounds with less than $100,000 in acquisition cost

TBS	Tethered Balloon System comprised of a balloon, tether, and winch
TFR	Temporary Flight Restriction
UAS	Unmanned Aerial System
UV	ultraviolet
VLOS	visual line of sight
VMC	Visual Meteorological Conditions
VO	visual observer
ZULU	Greenwich Mean Time (GMT)

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1.0 Overview

This procedure addresses the requirements and process for obtaining approval for Unmanned Aerial System (UAS) and Tethered Balloon System (TBS) operations at DOE Office of Science (SC) Atmospheric Radiation Measurement user facility observatories (ARM sites), ARM-supported training flights, atmospheric instrument development flights, and campaigns at non-ARM sites. ARM sites include both ARM observatories and ARM mobile facility deployments. The protection of people, property, and the environment during UAS and TBS operations is the foundation of executing a successful mission using UAS or TBS.

This procedure is designed to facilitate safe mission execution. It does not address obtaining approval for ARM-supported research, which is approved through the ARM Field Campaign (AFC) or Engineering Evaluation (EE) processes. Approval of UAS and TBS operations is a prerequisite for final approval of an AFC or EE by the Infrastructure Management Board (IMB) and may be conducted in parallel with preparation and submittal of the AFC or EE proposal to the IMB. This procedure addresses UAS and TBS requirements; mission planning; documentation; maintenance; risk assessment; airworthiness determination; operation approval; training and qualification requirements and responsibilities for UAS remote pilots; TBS operators; visual observers; maintenance technicians; and A&P mechanics. It also addresses the responsibilities of ARM site managers, the Office of Science Aviation Safety Manager, principal investigators, requesting organizations, and Range Safety Officers.

This procedure is derived from DOE O 440.2C, *Aviation Management and Safety*, and Federal Aviation Administration (FAA) Regulations (FARs), 14 CFR 107, and 14 CFR 101. It contains two sections: Section 3.0 addresses UAS operations; Section 4.0 addresses TBS operations.

2.0 Applicability

This procedure applies to:

- DOE national laboratories (e.g., PNNL, SNL, ANL, LANL)
- A contractor to a national laboratory
- ARM-supported users

when any of the above entities are operating owned or leased/contracted UAS or TBS for ARM-supported operations, AFCs, intensive operational periods (IOPs,) or EEs at:

- ARM sites or non-ARM sites (domestic and international)
- DOE/ARM-managed Restricted Area or Warning Area airspace
- Special Use Airspace

AND non-ARM-supported users operating at an ARM site or within ARM-managed Special Use Airspace.

In the context of this procedure, UAS include all categories of unmanned aircraft (i.e., fixed wing and rotary wing no matter what size or capability) that are operated from a ground base under direct operator control, or semi-autonomously or autonomously under the supervision of an operator. A 14 CFR 107 operator contracted to perform a sUAS operation for ARM for the sole purposes of the government, or operating under the DOE Blanket COA,[1] is a Public UAS Operation.[2] Anytime a contract operator is performing a public UAS operation, the contracting entity shall provide the contract operator with a written statement that identifies the UAS operation as a Public Operation. TBS includes moored balloons such as aerostats and helikites and the associated winch. TBS do not include systems using balloons smaller than 115 cubic feet in volume or less than 6 feet in diameter.

Exceptions to the requirements and approval process defined in this procedure may be granted. Each exception will be described and justified in the Aviation Safety Plan (ASP) as follows:

1. Describe the exception being requested referencing the specific requirement or approval process step.
2. Explain the reason for requesting the exception and justify the request.
3. Discuss the risk mitigations applied.
4. Assess the risk to the UAS or TBS operation if the exception is granted or not granted.

Exceptions will be adjudicated during the ASP approval process. The exception may be approved; may not be approved; or it may be approved with conditions.

3.0 UAS Operations

3.1 Applicability

All ARM-supported UAS operations require an approved Aviation Safety Plan (ASP) and ARM Infrastructure Management Board (IMB) authorization. Operations within a Restricted Area or a Warning Area do not require a FAA Certificate of Waiver or Authorization (COA) for each mission but must adhere to the limitations of the Restricted Airspace or Warning Area (e.g., altitude, dimensions). If not conducted in accordance with the DOE Blanket COA, UAS operations outside a Restricted Area or Warning Area require a COA appropriate to the mission. Authorization for sUAS operations in some controlled airspace (e.g., within 5 nm of an airport) may be accomplished using the FAA Low Altitude Authorization and Notification Capability (LAANC) system.[3] Anytime a sUAS operator uses the LAANC system it must be understood the operation becomes a commercial operation and the RPIC is using their Part 107 license and therefore is not entitled to any privileges extended to a public operation. Additionally, if the RPIC is a certificated airplane or rotorcraft pilot they place their FAA pilot's certificate at risk during all Part 107 operations (i.e., a Part 107 violation may result in suspension or loss of aircraft or rotorcraft pilot certification). International UAS operations require approval of the

[1] Blanket Area sUAS Class G COA (DOE) 2017-AHQ-901-COA.
[2] FAA Advisory Circular AC 00-1.1a, Section 8.b
https://www.faa.gov/documentLibrary/media/Advisory_Circular/AC_00-1_1A.pdf
[3] https://www.faa.gov/uas/programs_partnerships/data_exchange/

applicable aviation authorities of the country in which the operation will occur. International operations may require additional documentation or certificates not addressed herein. UAS Remote Pilots, Visual Observers, Maintenance Technicians, and Airframe and Powerplant (A&P) Mechanics must be trained on the specific UAS to be operated.

3.2 Privacy

ARM use of UAS does not inherently increase the chances of personal privacy being violated, but it does raise the visibility of privacy concerns. UAS using cameras or other forms of surveillance equipment (e.g., thermal imaging, infrared sensors) must abide by the Privacy Act of 1974 (5 U.S.C. 552a)[4] and the Presidential Memorandum dated 15 February 2015,[5] Use of UAS with cameras and/or imaging devices requires a legal review by the requesting organization for privacy issues and a determination if imaging device data storage needs to be addressed.[6]

3.3 Requirements

The requirements concerning roles and responsibilities; training and qualification; UAS documentation, capabilities, and procedures; mission planning; and Aviation Safety Plans and approval are described in this section.

3.3.1 Roles and Responsibilities

Each UAS flight requires a Remote Pilot in Command (RPIC) and a Visual Observer (VO). A Maintenance Technician is required to repair or modify a sUAS (Tier V) UAS. An A&P Mechanic is required to repair or modify all other UAS (i.e., Tier I through Tier IV). The requirement for an A&P Mechanic cannot be waived for Tier I and II UAS and for Tier III and IV operations over people and in other than class G or special use airspace. Maintenance Technician functions can be performed by the Remote Pilot or the Visual Observer prior to flight, if trained and qualified to do so. During flight, the Remote Pilot and the Visual Observer shall not have other duties assigned to them. The Remote Pilot and Visual Observer shall maintain a personal flight logbook in which they record UAS-specific training (such as may be provided by the UAS manufacturer) and information pertinent to each flight (e.g., date, UAS identification (manufacturer; N-number), purpose of the flight, duration of the flight, and location of the flight). The A&P mechanic shall record modifications and repairs to a UAS, its control station, and software in a UAS maintenance log specific to the airframe and ground control station (GCS). A Maintenance Technician who is trained on a specific Tier I, Tier II, Tier III, or Tier IV UAS can perform maintenance on the specific UAS under the supervision of a similarly trained and certified A&P mechanic.

[4] https://www.justice.gov/opcl/privacy-act-1974
[5] https://obamawhitehouse.archives.gov/the-press-office/2015/02/15/presidential-memorandum-promoting-economic-competitiveness-while-safegua
[6] NOAA has an excellent UAS privacy policy that may be used for reference: https://www.cio.noaa.gov/itmanagement/pdfs/Signed_UAS_PrivacyPolicy.pdf

The science aspects of an AFC or EE shall be directed by the AFC or EE principal investigator (PI) when a PI is assigned. When a PI is assigned, they should be independent from the UAS flight crew. The Remote Pilot in Command[7] (RPIC) shall always retain full responsibility for the safe conduct of flight operations and this responsibility cannot be designated or transferred to other individuals. The PI has no authority to direct the RPIC to perform any flight-related activity the RPIC does not deem safe. PIs are cautioned to not attempt to push or influence RPIC to perform flight operations near or outside their comfort level, the UAS capability, or near or outside the operation limits described in the Aviation Safety Plan.

3.3.1.1 ARM Site Manager

The applicable ARM Site Manager or designee:

- Verifies the training and qualification of the RPIC, VO, maintenance technician, A&P mechanic, and RSO.
- Coordinates with the RPIC for Notices to Airmen (NOTAMs) and Restricted Area or Warning Area use.
- Serves as the point of contact (POC) for users conducting UAS operations at the ARM site.
- Coordinates the site infrastructure needed by users to conduct UAS operations, including frequency spectrum approval.
- Reviews ASPs and resolves issues with the requesting organization.
- Develops or approves an Aviation Deconfliction Plan if concurrent UAS, TBS, or fixed- or rotary-wing aircraft operations are planned.
- Distributes approved ASPs, ADPs, and the summary section of ASPs.
- Determines the need for and assigns a RSO and RSO duties for a specific UAS operation, if required.
- Where applicable, develops and forwards to the Office of Science by December 31 annually a fiscal year FAA 7400 2G Utilization Report for DOE-managed Restricted and Warning Area Airspace for which the site manager has been delegated management by DOE OAM.
- Ensures compliance with this procedure.

3.3.1.2 Remote Pilot in Command (RPIC)

The RPIC is a required crewmember for every ARM UAS operation. The RPIC is directly responsible for and is the final authority as to the operation of the UAS. The RPIC must be designated prior to flight of the UAS. If there is a plan for the RPIC to be relieved during a flight, the following requirements shall be met:

1. There must be a previously approved relief plan;

[7] RPIC is the UAS designation for the person responsible and accountable for UAS operations.

2. Both the primary and the relief RPIC shall have participated in all preflight briefings; and,

3. At the time of relief, there must be a positive exchange of the controls and a declaration by the relieving RPIC that they have control of the UAS. The primary RPIC shall acknowledge transfer of control to the relieving RPIC by stating "You have control of the UAS."

The RPIC may not act as the Visual Observer while acting as the RPIC.

It is the responsibility of the RPIC to ensure that the UAS operation poses no undue hazard to people, aircraft, property, or the environment in the event of a loss of control of the UAS for any reason. The RPIC is solely responsible and accountable for assuring compliance of UAS operations with applicable Federal Aviation Regulations (FARs), provisions of the applicable COA(s); Air Traffic Control (ATC) directions, site regulations, and the approved Aviation Safety Plan (ASP) and Aviation Deconfliction Plan (ADP), if required. The RPIC accountability shall not be delegated.

The RPIC:

- Assures the safety and compliance of UAS operations with this procedure, applicable regulations (i.e., 14 CFR 91 and 14 CFR 107 as applicable to the specific flight) and site requirements, and the applicable ASP and ADP (if required).
- Coordinates Restricted Area or Warning Area Airspace use with the applicable site manager or POC.
- Requests the FAA to activate Restricted Area or Warning Area airspace when applicable.
- Obtains a LAANC authorization number when using a LAANC approval for sUAS operations conducted under 14 CFR 107
- Requests the FAA to issue NOTAMS within 48 to 72 hours before UAS operations when a NOTAM is required.
- Ensures that the local aviation community is notified of UAS operations when appropriate.
- Coordinates international UAS deployments through the responsible in-country representatives.
- Coordinates and communicates flight and aircraft deconfliction plans with the RSO (if assigned) and other remote pilots, operators, or pilots concurrently operating UAS, TBS, or fixed- or rotary-wing aircraft at the same site to ensure deconfliction of operations.
- Determines the required crew for each AFC, EE, or UAS flight and assigns duties to crew members.
- Obtains a weather report, Temporary Flight Restriction (TFR) status, and Notices to Airmen (NOTAMs) pertinent to the UAS flight.

  Note: The RPIC must be familiar with all airports, navaids, airways, military training routes, and any other aviation assets that may be used by manned aircraft in the vicinity (e.g., within 10 miles) of the UAS operation.

- Verifies readiness to conduct flights, including:
  - UAS airworthiness
  - Payload attachment

  - Weight and balance within limits
  - Ground station control and operability
  - Lost-link functionality
  - Sufficiency of fuel or battery for the aircraft to return from its furthest distance from the landing point and safely land plus an additional 10% of fuel or battery
  - Readiness[8] and qualifications of each crew member to perform their assigned duties
  - Activation of the Restricted Area and Warning Area (if used)
  - COA approval and ability to comply with COA requirements
  - A LAANC authorization number has been obtained when using a LAANC approval for sUAS operations conducted under 14 CFR 107
  - Applicable NOTAMs have been posted on the FAA website
- With the PI, defines the flight patterns required to achieve the AFC or EE objectives.
- Conducts a Plan-of-the Day Briefing with the flight crew, site manager or designee (or Site POC if operations are not at an ARM site), PI, and RSO (if assigned) reviewing the science objectives, flight patterns, emergency response procedures, weather, UAS and instrumentation readiness, flight crew readiness, and any other factor important to safe execution of the day's flights such as deconfliction with other flight operations.
- Conducts a preflight briefing with the flight crew and RSO (if assigned) before each flight covering flight patterns, deconfliction, emergency response, and readiness to conduct the flight.
- When using more than one Visual Observer (VO) to extend the UAS range:
  - Ensures VOs are properly trained
  - Ensures the transition/handoff procedures between VOs is thoroughly briefed and understood
  - Ensures there is adequate overlap of the visual range between VO positions.
- Assures that proper approval has been obtained for each flight, mission or campaign.
- Announces the start and end of UAS daily operations on the appropriate Common Traffic Advisory Frequency (CTAF) as required.
- Monitors the CTAF during UAS operations as required.
- Executes each UAS flight (i.e., controls, or monitors the control of, the UAS through all phases of flight).
- Provides for the safe execution of PI inputs during the flight to facilitate achieving the science objectives in accordance with the approved ASP.

[8] All UAS flight crew members, the maintenance technician, the A&P mechanic, the RSO, and the PI are prohibited from participating in a UAS operation if he or she has consumed any alcoholic beverage within the preceding 8 hours, is under the influence of alcohol, is using a drug, including over-the-counter drugs, that affects the person's mental or physical capabilities, or has a medical condition that creates an undue risk.

- Maintains communication capability with the Visual Observer(s) during the flight.
- Conducts post-flight briefings to identify opportunities for improvement.
- Records entries in the applicable Flight Log.
- Records and maintains a one-year record of the LAANC authorization number(s) when operating sUAS under Part 107 with a LAANC authorization.
- Reports incidents/accidents.

3.3.1.3 Visual Observer (VO)

The VO has the responsibility to advise the RPIC of eminent hazards to flight. The VO must be able to see the UAS with vision that is unaided by any device other than corrective lenses throughout the entire flight. The VO:

- Watches the UAS location (attitude, altitude, direction of flight) and watches for approaching aircraft and notifies the RPIC when other aircraft are seen that may pose a hazard/conflict.
  - Aids to vision such as binoculars may be used on a short-term basis, but not as a method to increase the line-of-sight distance.
  - Has authority to recommend the RPIC to alter course and/or altitude to mitigate traffic conflicts.
- Observes weather and visibility conditions and warns the RPIC of approaching weather adverse to UAS operation; e.g., wind speed aloft and at ground level, frontal movement, lightning, declining visibility.
  - Has the authority to recommend the RPIC to land the unmanned aircraft if conditions appear to exceed UAS limitations.
- Maintains effective communication via direct voice or radio with the RPIC at all times.
  - Cell phones may be used, but the phone must be continuously connected to the RPIC during the entire flight. This is the least desirable choice and should not be the primary method of communication.
- May not act as VO for more than one UAS at a time.
- May not act as VO and RPIC simultaneously.

3.3.1.4 Maintenance Technician (sUAS/Tier V)

- Repairs and modifies sUAS and ground control station and software.
- Attaches and removes payloads to sUAS
- Attests to sUAS airworthiness, including weight and balance for the duration of each flight, after payload installation or removal, repair, replacement, maintenance, or modification.
- Records maintenance and/or modifications in the sUAS maintenance log.

3.3.1.5 A&P Mechanic (Tier I through IV UAS)

- Repairs and modifies the UAS and ground control station and software as applicable.
- Attaches and removes payloads to the UAS.
- Assures weight and balance remains within the weight and balance envelope of the UAS after repair, modification, or attachment or removal of payloads.
- Certifies airworthiness of the UAS after repair or modification.
- Maintains a UAS-specific maintenance log, recording repairs, scheduled and unscheduled maintenance, modifications, instrument attachment and removal, inspections, and airworthiness certification.
- Conducts condition inspections annually (and as-needed after modifications or repairs) of the UAS and certifies its airworthiness, recording the inspection and certification in the UAS-specific maintenance log book.

3.3.1.6 Principal Investigator (PI)

- Establishes the science objective for each flight and conveys the objectives to the RPIC.
- In conjunction with the RPIC determines the flight paths needed to safely achieve the AFC or EE science objectives.
- In conjunction with the RPIC establishes both the minimum and optimum weather requirements for flight in advance of the campaign.
- Verifies and monitors payload operability and data transmission before and during flight as applicable.
- Provides input/requests to the RPIC during each flight regarding changes that may be needed in the flight pattern (e.g., altitude; loitering) to facilitate achieving the science objectives.

3.3.1.7 Range Safety Officer (RSO)

***Note**: If a RSO is not assigned to a specific UAS AFC or EE, then the responsibilities listed below are to be assigned by the Site Manager (ARM site operations) or by the requesting organization (non- ARM site operations) to other crew members.*

- Reviews and ensures implementation of the ASP for each UAS-related operation to be conducted at their assigned site.
- Oversees flight operations:
  - Assures deconfliction of concurrent UAS, TBS, and fixed- and rotary-wing aircraft operations
  - Monitors human performance factors during operations.
- Is authorized to halt operations to ensure safety.

3.3.1.8 Office of Science Aviation Safety Manager

- Reviews each ASP and consults with OAM and the applicable DOE site Aviation Officer as needed.
- Obtains ASP approval.

3.3.2 Qualification and Training Requirements

The minimum qualifications of the personnel participating in UAS operations at an ARM site or for an AFC or EE are listed below. The RPIC, VO, maintenance technician, and A&P mechanic's organization(s), and the RSO's organization must maintain qualification and training records in accordance with DOE O 243.1B, Chg. 1, Records Management Program.

All participants in UAS operations must to adhere to 14 CFR 91.17 and 91.19.

- No person may act or attempt to act as a flight crew member of a UAS:
  - Within 8 hours after the consumption of any alcoholic beverage;
  - While under the influence of alcohol; or while experiencing the physiological and psychological effects of alcohol consumption (e.g., hangover).
  - While using any drug, including over-the-counter medication, that affects the person's faculties in any way contrary to safety; or
  - While having an alcohol concentration of 0.04 or greater in a blood or breath specimen. Alcohol concentration means grams of alcohol per deciliter of blood or grams of alcohol per 210 liters of breath.
- On request of a law enforcement officer, flight crewmembers shall submit to a test to indicate the alcohol concentration in the blood or breath, when:
  - The law enforcement officer is authorized under state or local law to conduct the test or to have the test conducted; and
  - The law enforcement officer is requesting submission to the test to investigate a suspected violation of state or local law governing the same or substantially similar conduct prohibited by paragraph (a)(1), (a)(2), or (a)(4) of 14 CFR Part 91.17.

  Note: Flight crew members shall be placed in their organization's substance abuse testing program.

3.3.2.1 Remote Pilot in Command (RPIC)

- 14 CFR 107 remote pilot certificate required.
- Manufacturer's training program completion, if available.
- Site-specific training.
- 18 years old.

The RPIC must hold a valid 14 CFR 107 Remote Pilot Certificate and meet the requirements of 3.3.2.1.1 and 3.3.2.1.2, as applicable. In addition, the RPIC must have made three manual takeoffs/launches and

recoveries/landings within the 90 days preceding the UAS operation with the specific UAS stated in the ASP to qualify as the RPIC for the UAS operation. Simulation trainers will not satisfy this requirement.

3.3.2.1.1 sUAS RPIC

- Training on the specific sUAS described in the ASP shall be documented[9] and maintained with respect to:
  - Airworthiness
  - Flight characteristics
  - Weight and balance
  - Lost communication procedure
  - Loss of GPS/auto pilot
  - Manual flight/control
  - ground control station (GSC) operation
  - Initialization/checkout
  - Frequencies and frequency mitigation/deconfliction
  - Launch, landing/flight termination
  - Normal and emergency procedures
  - Limitations.
- Demonstrated competency by completing 15 hours of manual control of each sUAV (5 hours of which may be logged via simulator), including an actual 20 manual take-offs and landings (i.e., not simulated); and documenting these items in the RPIC's personal logbook.

Note: *A person who is not qualified as a RPIC may operate the sUAS under the direct supervision of a qualified RPIC if the qualified RPIC can immediately take direct control of the sUAS (e.g., using a buddy cord and separate control box).*

3.3.2.1.2 UAS (Tier I thru Tier IV) RPIC

Flying UAS greater than 55 pounds increases the risk to persons and property on the ground as well as other air traffic, and therefore increased training is required on the part of the RPIC.

Documented training from the original equipment manufacturer (OEM) stating the person is qualified to act as a RPIC. UAS-specific training shall include at a minimum:

- Airworthiness
- Set up and teardown of the aircraft
- Engine/motor
- Fuel/battery system
- Hydraulic system
- Control interfaces
- Normal and emergency procedures
- Weight and balance

[9] Completion of training should be recorded in the RPIC's personal logbook.

- Payload and payload interfaces
- Launch and recovery procedures
- Limitations
- Autopilot and software
  - Flight planning
  - Frequencies and frequency mitigation/deconfliction
  - Calibrations
  - Lost communication
- Ground control station
  - Set up and tear down
  - Communication.

3.3.2.2 Visual Observer (VO)

The VO is a required position that provides increased situational awareness and safety to a UAS operation. The primary role of the VO is to see other traffic and hazards and report them to the RPIC. The VO fulfills the requirements set forth in 14 CFR Parts 91.111 and 91.113. The VO must have 20/20 (corrected) vision. VO training shall include:

- Site-specific training (e.g., site characteristics and requirements, COA, Special Use Airspace)
- Instruction on the flight characteristics and limitations described in the Aviation Safety Plan for the UAS they will be observing
- Identifying weather changes and trends that could impact UAS operations
- Understanding cloud clearances, VFR minimums, minimum ceiling and visibility requirements based on the operating airspace and the ASP weather minimums
- Communications to the RPIC
- Radio procedures and discipline
- Identification of traffic and hazards to the RPIC with relative position and altitude
  - During circling flight, the compass method is recommended
  - During straight flight, the clock method is recommended
- CTAF and aircraft pattern entries and positions in a traffic pattern
- Demonstrated competency by directly observing at least 1 hour of UAS flights prior to serving as a VO.

3.3.2.3 Maintenance Technician (sUAS/Tier V)

The maintenance technician maintains sUAS in airworthy condition per the OEM, FAA, and/or Airworthiness Statement.

The Technician should be familiar with the basic operation of the sUAS, and the technical documents and requirements to repair and maintain airworthiness of the sUAS. Training on the specific sUAS described

in the ASP with respect to construction, repair techniques, system functions, troubleshooting, airworthiness criteria, operation, and flight dynamics and limitations. Training may be provided by the sUAS manufacturer or by the maintenance technician reading the sUAS manufacturer's manuals and procedures.

3.3.2.4 Airframe & Powerplant Mechanic (Tier I-IV UAS)

UAS greater than 55 pounds (Tiers IV, III, II, and I) increases the risk to persons and property on the ground as well as other traffic and therefore increased training is required. Organizations using Tier I–IV UAS shall adopt 14 CFR 91 maintenance practices at a minimum.

Each A&P mechanic for UAS greater than 55 pounds shall have:

- FAA Certification as an A&P mechanic.
- Documented training from the original equipment manufacturer (OEM) stating the person is qualified to maintain, repair, modify, assemble, and disassemble the UAS described in the ASP. The training documentation shall be maintained by the organization operating the UAS. Training should include the following:
  - Assembly and disassembly
  - Powerplant
  - Power system (fuel; battery)
  - Electrical system
  - Propellers
  - Communications and links
  - Image-capture airborne and ground-based systems
  - Required on-screen display and telemetry/control links
  - Actuators and servos
  - Flight controls, servos, and autopilot
  - Brakes and wheels (as required)
  - Hydraulic system (as required)
  - Weight and balance
  - Scheduled and unscheduled maintenance
  - Repair
  - Ground control station hardware, software, and firmware as applicable.

3.3.2.5 Range Safety Officer (RSO)

- ARM site-specific training.
- Current 14 CFR Part 107 Certificate (required) or a private pilot certificate or higher (desired).

- Aviation Safety Officer certification by the General Services Administration (GSA) Interagency Committee for Aviation Policy, or equivalent education and experience[10] approved by the Office of Science Aviation Safety Manager.

3.3.3 UAS Requirements

All UAS must be registered in accordance with 14 CFR 47 or 48 and have identification markings in accordance with 14 CFR 45, Subpart C. Tier I, II, III, and IV UAS operations shall comply with the applicable 14 CFR 91 and 14 CFR 43 requirements when operating outside of Restricted Airspace.

3.3.3.1 Documentation

- Current registration certificate, which must be kept with the ground control station (GCS) and available for inspection.
- Statement of Airworthiness showing compliance with FAA Order 8130.34D if no Certificate of Airworthiness has been issued by the FAA.
- Documented weight/balance envelope showing center of gravity (CG) limits
- For Tier I through Tier IV UAS:
  - Remote Pilot's Operating Handbook for the specific UAS that covers:
    - Description of the airframe and powerplant
    - Limitations such as those involving airspeed, powerplant, and weight and load distribution flight limits, placards (on the aircraft and GCS)
    - Emergency procedures
    - Normal procedures
    - Weight and balance
    - Equipment list
    - Systems description
    - Service and maintenance
    - Supplements (e.g., GCS manufacturer's operating manual, autopilot manual)
  - Maintenance records including airframe, powerplant, and propeller logs.

3.3.3.2 Capabilities

- Sufficiency of fuel or battery for the aircraft to return from its furthest distance from the landing point and safely land plus an additional 10% of fuel or battery.
- A way to monitor the amount of fuel or battery remaining at the GCS.

[10]The purpose of this requirement is to ensure that Range Safety Officers understand aviation safety, risk management, and safety management systems. In lieu of Aviation Safety Officer certification, an adequate level of both formal safety training or certification (e.g., CSP; CIH; CSMS) and formal aviation training (e.g., FAA private pilot written exam) is required. Alternate training may be approved by the Office of Science Aviation Safety Manager.

- A procedure to recover the UAS in the event of a Lost Link, Lost Communications, or Loss of GPS.
- A way to monitor the link strength at the GCS.
- A way to monitor GPS signal at the GCS.
- During automated flight, the capability for the RPIC to change the flight path and land the aircraft using the GCS or take control of the UAS manually.
- UAS limitations (e.g., max winds, range, minimum fuel or battery for return to base).

3.3.3.3 Procedures

Each organization using a UAS for an AFC or EE or using an ARM site shall have documented procedures for the following:

- Pre- and post-flight briefing
- Payload installation and removal
- Determining weight and balance
- Flight planning
- Verifying GCS command and aircraft response
- Verifying flight readiness:
  - Aircraft assemble checklist
  - GCS hookup checklist
  - Preflight checklist
  - Post-flight checklist
- Routine and preventive maintenance procedures
- Procedures for maintaining records of routine and preventive maintenance, repair or replacement of components, control system hardware and software changes or replacement
- RPIC, VO, Maintenance Technician, and A&P Mechanic training
- Verifying control functionality after software, hardware, or system changes
- Management of software and hardware (e.g., ground control station, payload, aircraft) changes; i.e., a Software Quality Assurance Plan and a Management of Change process
- Manual control or abort procedures for takeoff and landing
- Emergency procedure checklists for:
  - Lost link/lost communications
  - Loss/degradation of GPS
  - Autopilot malfunction
  - Loss of visual sight of the UAS
  - Mishap response
    - Reporting
    - Causal analysis

- Corrective action determination and tracking
- Lessons learned.

3.4 Mission Planning

Planning for a UAS mission must be carefully coordinated between the PI, the RPIC, and the Site Manager (or designee) or the Site POC for operations at a non-ARM site to ensure that the planned operation complies with all governing policies, procedures, regulations, and the ASP and still safely accomplishes the science goals. A government entity that chooses to operate a sUAS under Part 107 makes itself a civil operator and must meet all the 14 CFR 107 requirements for operation including airspace limitations and pilot requirements for every flight and is subject to civil enforcement for violations of Federal Aviation Regulations. Government entities may conduct operations in either public or civil status, depending on the location and circumstance of the mission. However, each flight must begin and end in the same status.

An individual flight is either conducted:

1. Pursuant to a Public Aircraft Operation (PAO) COA and its statutory and stated limitations, OR,
2. Conducted pursuant to 14 CFR 107, with its requirements and limitations.

A flight cannot be both PAO and Part 107 nor can it change status mid-flight. It is the RPIC's responsibility to know which set of requirements apply to each flight before it begins. Proper logging of flights as PAO or Part 107 is required. A government entity that claims to be conducting a PAO and fails (for example) to have a valid governmental function cannot suddenly claim the flight is actually Part 107. Nor can a Part 107 flight that exceeds the Part 107 altitude limit (for example) suddenly be said to be conducted under a COA that gives the entity broader operating authority.

The RPIC shall ensure that the following are well defined and included in mission planning:

- Primary and alternate science objectives
- Mission location and airspace to be used as noted on a VFR Sectional Chart
- Logistics (e.g., transportation of equipment and materials to the site; required support at the site)
- UAS to be used, its limitations, flight characteristics, and accompanying procedures
- Payload
- Flight crew (names, positions, qualifications, currency)
- VO locations(s) and communication plan, including:
  - Loss of visual contact with the aircraft
  - Loss of communication between the RPIC and the VO
  - Handoff procedures when more than one VO is used
- POCs (e.g., site manager, emergency response, FAA)
- Regulatory environment (e.g., COA, Restricted Airspace, Warning Area; site requirements; privacy concerns)

- Payload/instrumentation including frequency spectrum analysis and approval, as required
- Meteorological preferences and limitations
- Flight plan (track, altitude, speed, maximum distance from base, duration)
- Hazard identification
  - Operational and mission hazards including concurrent UAS, TBS, or fixed-/rotary-wing operations
  - Hazard Controls including an Aviation Deconfliction Plan for concurrent UAS, TBS, or fixed-/rotary-wing operations
- Emergency Response including:
  - Lost link
  - Lost communications
  - Loss of GPS signal
  - Injury
  - Environmental insult
- Mishap response and reporting
- Preflight checklist
- Preflight briefing
- Post-flight briefing
- Reporting/flight log
- Record maintenance.

3.5 Aviation Safety Plan

3.5.1 Purpose

An Aviation Safety Plan (ASP) provides the information needed for the safe conduct and approval of ARM-supported flights, AFCs, or EEs that use a UAS, and non-ARM supported activities that use a UAS at an ARM site. In accordance with the DOE Office of Aviation Management (OAM) guidance, the level of approval is placed at the lowest level commensurate with the level of risk (i.e., the Risk Analysis Code) determined in the ASP. It is therefore important that all sections of the ASP (Section 3.5.3) be completed in detail so the ASP approver(s) can understand the UAS operations, risk, and controls.

3.5.2 Applicability

An ASP is required for all ARM-supported flights, AFCs, and EEs that use a UAS, and all non-ARM supported activities that use a UAS at an ARM site.

3.5.3 ASP Format

An ASP shall contain:

a. **A brief summary** that describes the proposed UAS mission in narrative form including:
   i. Identification of the organization conducting the mission including the requesting organization, and name, address, email, and telephone number of the requesting organization POC
   ii. The purpose/science objectives of the mission
   iii. Flight location supported by a VFR Sectional chart showing the location of the UAS flights, dates, maximum altitude, anticipated daily time aloft, and operational restrictions
   iv. Regulatory basis (e.g., COA, Special Use Airspace, 14 CFR 107, privacy concerns)
   v. UAS to be used (size, instrumentation, and data link type and frequencies)
   vi. Flight crew names, positions, qualifications, and experience
   vii. Operational and mission hazards and controls
   viii. Risk Analysis Code (RAC) determination
   ix. Exceptions to the requirements of Section 2 (if none, so state; otherwise, state the exceptions, reason/justification for each exception, and the risk to UAS operations if each exception is granted or not granted).

b. **Description of the mission** in sufficient detail to establish the boundary of the significant parameters to be encountered during the accomplishment of the mission. The description should include:
   i. Science objectives
   ii. Expected number and duration of flights
   iii. Maximum altitude
   iv. Operational restrictions (e.g., daylight only; visual or instrument meteorological conditions; maximum wind speed and cross wind)
   v. Privacy considerations
   vi. Map of the flight area and proposed track of flights
   vii. Class of airspace
   viii. CTAFs to be used
   ix. Nearest airport, heliport, navaids, airways, special use airspace, any other aviation assets within 10 nm of the UAS operation.

   Note: If a FAA Certificate of Authorization (COA) or approval from an international authority has been obtained, the COA or approval document should be included as an attachment to the ASP.

c. **Detailed description of the UAS** to include:
   i. Manufacturer
   ii. Powerplant
   iii. GCS manufacturer
   iv. Autopilot manufacturer
   v. Flight characteristics and limitations of the UAS
   vi. Flight endurance and zero wind range
   vii. Instrumentation payload

viii. Data and control link frequencies used.

Note: Photos of the UAS should be provided.

d. **Spectrum analysis and approval**

The Site Manager should be contacted to obtain approval for the frequencies to be used, and the approval attached to the ASP. The following frequencies are typically used for UAS operations:

- GCS and instrument data link frequencies: 900-928 MHz and/or 400-405 MHz
- Aviation Transceiver 108-137 MHz.

e. **Airworthiness determination and documentation**

The FAA allows for self-certification for sUAS and therefore sUAS airworthiness determinations may consist of a letter certifying airworthiness. For Tier I to IV UAS, ARM requires a FAA certified airframe and power plant mechanic's certification, or documentation from the manufacturer, or documentation from the requesting organization management certifying airworthiness. The FAA has no airworthiness standards for UAS. The UAS RPIC is responsible to ensure that the UAS is in a safe and airworthy condition in accordance with the manufacturer's documentation. The airworthiness documentation shall be attached to the ASP as an appendix.

f. **Flight crew positions** (including responsibilities), and the qualifications, training, currency, and experience of the flight crew and alternates, by name (Sections 2 and 3).

g. **Identification and analysis of hazards** to air traffic, ground obstructions, flight crew, persons not directly involved in flight operations, and to the environment (Section 3.7).

h. **Identification of engineered and administrative controls** that mitigate the identified hazards (Section 3.7).

i. **Qualitative assessment of the risk** to the flight crew, other persons, property, the environment, and mission success (Section 3.7).

j. **Preflight readiness verification** to include:
   i. Crew briefing guide on the specific flight parameters, mission, objectives, emergency procedures, crew member responsibilities, crew member coordination, and weather
   ii. Verification of crew ability to support the mission
   iii. Verification of the readiness of the UAS for flight using checklists that are attached as appendices to the ASP.

k. **Emergency procedures and reporting**

Each UAS operation shall have an emergency response plan that identifies the actions to be taken and persons to be contacted in case of injury; collision with aircraft, structures, or people; adverse weather conditions; and environmental insult. The emergency response plan shall include the criteria outlined below for reporting accidents:

- Report the accident within 12 hours to the applicable ARM Site Manager or designee or Site POC (if UAS operations are not an ARM site), the Office of Science Aviation Safety Manager, and the DOE Office of Aviation Management if the accident meets any of the following thresholds:
  - Results in an injury that:
    - Requires in-patient hospitalization for any duration, commencing within 7 days from the date the injury was received.
    - Results in a fracture of any bone (except bone chips, simple fractures of fingers, toes, or nose, or a minor chipped tooth).
    - Causes severe hemorrhages or severe damage to nerves, muscles, tendons, or ligaments. (**Note**: Severe damage is generally considered to have occurred if surgery is required to correct the damage.)
    - Damages any internal organ.
    - Causes 1) a concussion or 2) loss of consciousness due to an impact to the head, or
    - Causes second- or third-degree burns, affecting more than five percent of the body surface.
  - Results in property damage, other than the cost of the UAS, exceeding $500 to repair or replace the property or repair environmental damage.

3.6 Mission Approval

Mission approval follows the chart for UAS operations at an ARM site (Figure 1) **or** the chart for UAS operations **not** conducted at an ARM site (Figure 2), in accordance with the following procedures, respectively. Requesting organizations should expect 10 working days for approval after submittal of the ASP to the Office of Science Aviation Safety Manager.

3.6.1 Approval Procedure for ARM Site UAS Operations

Activity	Responsibility	Action
1. Review the Aviation Safety Plan.	ARM Site Manager or designee	**IF** the ASP is to be conducted in accordance with the DOE Blanket COA; does not involve concurrent flight operations; is RAC III (low risk); and the operations are within the applicable DOE Site Office Approval, **THEN:** a. Review the ASP and resolve any issues in the ASP with the requesting organization and the applicable Aviation Safety Officer. i. Verify that the operations are consistent with the airspace requirements and comply with the applicable COA, regulations, and site requirements b. Approve the ASP. c. Distribute the approved ASP:

Activity	Responsibility	Action
		- Requesting organization - Site Aviation Safety Official - DOE site Aviation Safety Officer - Office of Science Aviation Safety Manager. d. Distribute the summary section of the ASP: - Office of Science BER POCs - OAM. e. Proceed to Activity 4. **IF** the ASP involves concurrent flight operations; is RAC I or II (medium risk); or the operations are not within the DOE Site Office Approval, **THEN**: a. Review the ASP and resolve any issues in the ASP with the requesting organization and the applicable Aviation Safety Officer. i. If concurrent operations are scheduled, create a "Aircraft Deconfliction Plan" (ADP) describing how deconfliction will be achieved for the concurrent operations and obtain concurrence with the ADP from all concurrent operators and the applicable Aviation Safety Officers of the organizations scheduling concurrent operations. ii. Verify that the operations are consistent with the airspace requirements and comply with the applicable COA, regulations, and site requirements. b. Transmit the final ASP (and ADP, if required) to the DOE Office of Science Aviation Safety Manager.
2. Review and approval of the UAS Aviation Safety Plan.	DOE Office of Science Aviation Safety Manager	a. Review the UAS ASP and ADP (if required) and resolve any issues with the ARM Site Manager or designee. i. Consult with the DOE Office of Aviation Management (OAM). ***Note:*** *OAM may call a Flight Readiness Review Board and retain final approval for RAC I (high risk) missions.* ii. Consult with the applicable DOE site Aviation Manager. b. Obtain ASP and ADP (if required) approval, which may include approval of the ASP by the applicable DOE Site Office Manager or designee, if required.

Activity	Responsibility	Action
		c. Submit the approved ASP and ADP (if required) to the applicable ARM Site Manager or designee.
3. Distribute approved ASP.	ARM Site Manager or designee	a. Distribute the approved ASP and ADP (if required): - Requesting organization - Site Aviation Safety Official - DOE site Aviation Safety Manager. b. Distribute the summary section of the ASP and the ADP (if required): - OAM - Office of Science BER POCs.
4. Enter Approved ASP in ARM ServiceNow.	Requesting organization	Enter the approved ASP and ADP (if required) into the ARM ServiceNow website.
5. Authorize the UAS operation.	ARM Infrastructure Management Board (IMB)	Verify ASP and ADP (if required) approval. For ARM facility user proposals, follow the existing field campaign approval process and communicate the authorization decision to the applicable science liaison for transmittal to principal investigator (PI), if applicable. **Note:** The field campaign approval process may be conducted in parallel with approval of the ASP.

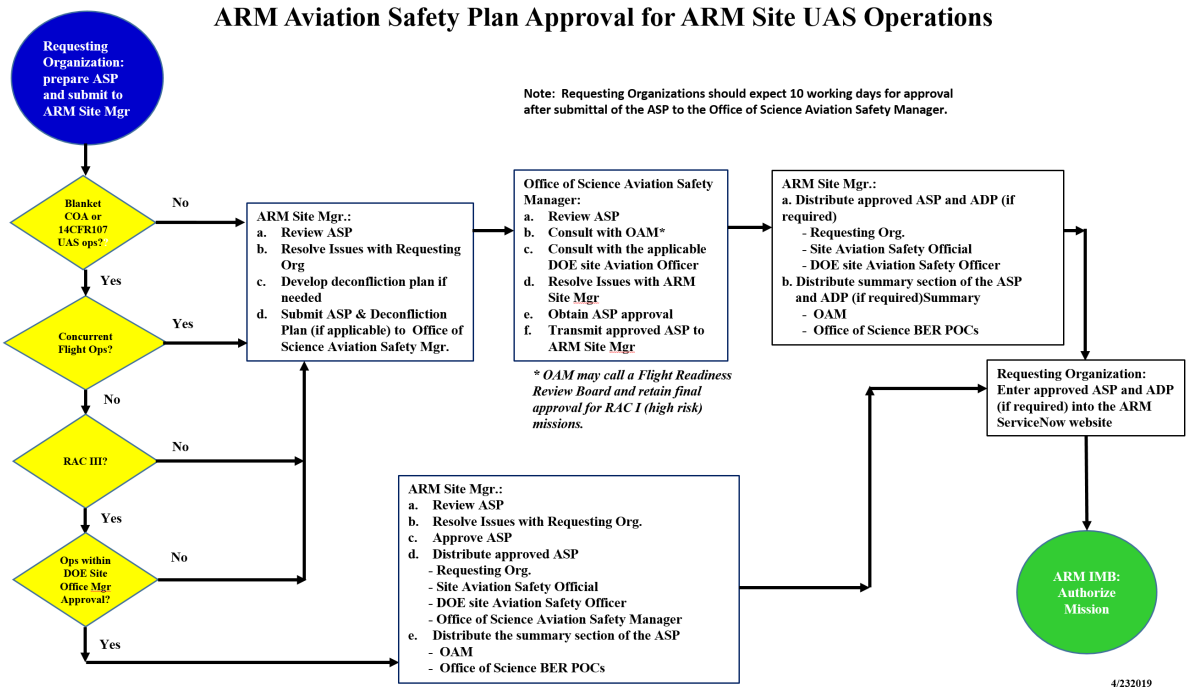

Figure 1. ARM Aviation Safety Plan approval for ARM site UAS operations.

3.6.2 Approval Procedure for ARM-Supported UAS Operations at Non-ARM Sites

Activity	Responsibility	Action
1. **Review the Aviation Safety Plan.**	Requesting organization	**IF** the ASP is to be conducted in accordance with the DOE Blanket COA; does not involve concurrent flight operations; **and** is RAC III (low risk), **THEN:** a. Consult with the Office of Science Aviation Safety Manager and resolve any issues. b. Transmit the ASP to the Site POC. **IF** the ASP involves concurrent flight operations **or** is RAC I or II or is not conducted in accordance with the DOE Blanket COA, **THEN** transmit the ASP to the Site POC.
	Site POC	**IF** the ASP is to be conducted in accordance with the DOE Blanket COA; does not involve concurrent flight operations; **and** is RAC III (low risk), **THEN:** a. Review the ASP. b. Resolve Issues with the requesting organization c. Approve the ASP. d. Transmit the approved ASP to the requesting organization

Activity	Responsibility	Action
		IF the ASP is **not** conducted in accordance with the DOE Blanket COA; involves concurrent flight operations; **or** is RAC I (high risk) or II (medium risk), **THEN:** 1. Review the ASP. 2. Resolve Issues with the Requesting Org. 3. Develop an Aviation Deconfliction Plan (ADP) if needed 4. Submit the ASP and ADP (if required) to the Office of Science Aviation Safety Manager.
2. Review and approval of the UAS Aviation Safety Plan.	DOE Office of Science Aviation Safety Manager	a. Review the UAS ASP and ADP (if required) and resolve any issues with the Site POC or requesting organization, as appropriate. i. Consult with the DOE Office of Aviation Management (OAM). ***Note:*** *OAM may call a Flight Readiness Review Board and retain final approval for RAC I (high risk) missions.* ii. Consult with the applicable DOE site Aviation Manager. b. Obtain ASP and ADP (if required) approval, which may include approval of the ASP by the applicable DOE Site Office Manager or designee, if required. c. Transmit the approved ASP and ADP (if required) to the requesting organization.
3. Distribute approved ASP.	Requesting organization	a. Distribute the approved ASP and ADP (if required): - Site POC - DOE site Aviation Safety Manager b. Distribute the summary section of the ASP and ADP (if required): - OAM - Office of Science BER POCs.
4. Enter Approved ASP in ARM ServiceNow.	Requesting organization	Enter the approved ASP and ADP (if required) into the ARM ServiceNow website.

Activity	Responsibility	Action
5. Authorize the UAS operation.	ARM Infrastructure Management Board (IMB)	Verify ASP and ADP (if required) approval. For ARM facility user proposals, follow the existing field campaign approval process and communicate the authorization decision to the applicable science liaison for transmittal to principal investigator (PI), if applicable. **Note:** The field campaign approval process may be conducted in parallel with approval of the ASP.

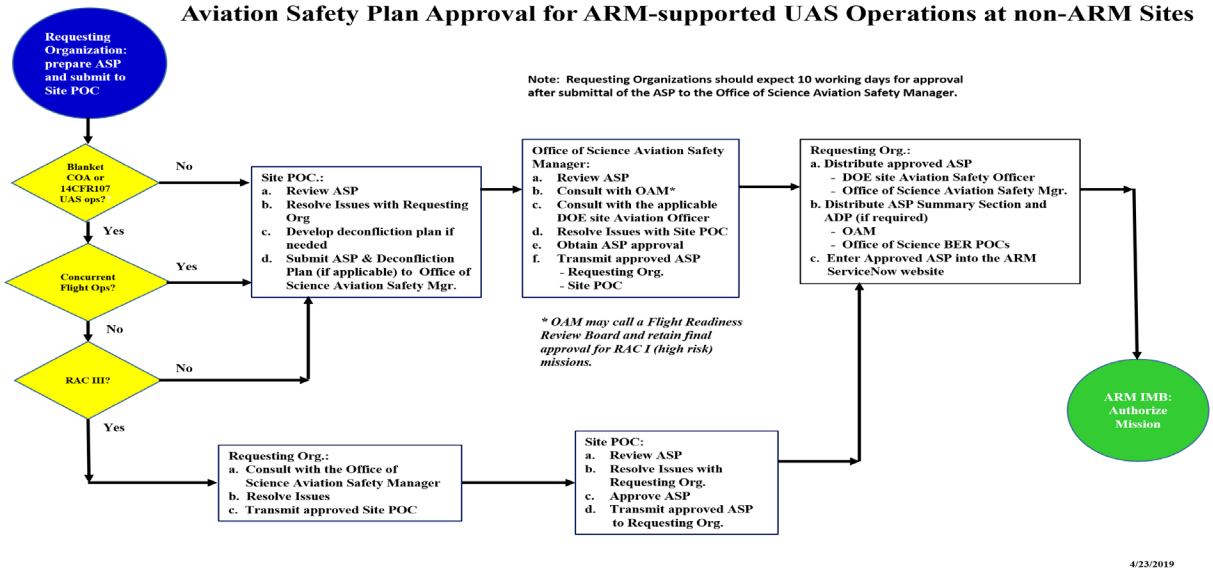

Figure 2. Aviation Safety Plan approval for ARM-supported UAS operations at non-ARM sites.

3.7 UAS Risk Analysis

Risk analysis considers the severity of a mishap and the likelihood that the mishap will occur. The combination of severity and likelihood results in a "Risk Analysis Code" (RAC). The RAC helps identify the risk of UAS operations and ensures that missions are reviewed and approved at management levels appropriate to the risk. In developing the risk scenarios consider the following:

- What is the UAS required to do?
- What is the environment in which the UAS and the ground control station will be working?
- What are the hazards in the entire system (UAS, instrument payload, flight crew, procedures, checklists, flight environment (e.g., weather, location, obstacles) and how could they impact the flight and mission?

It is helpful in risk analysis to develop risk statements in an "If/Then" format: If (a failure, mishap, or event occurs), Then (the worst-case consequence that could occur). For example, "**If** GPS signal is lost during flight, **then** the UAS may crash into a structure, causing damage to the structure." A risk statement

leads to estimating the likelihood that the risk will occur and identifying the control that prevents the risk from occurring or the mitigation that eliminates or reduces the consequence. Engineered controls are preferable to administrative controls (e.g., procedures, training).

3.7.1 Hazards to Be Considered

Operational and mission hazards are to be evaluated to identify those hazards to be included in the risk analysis. Each included hazard should be evaluated with respect to severity of the worst-case consequence to people, property, the environment, and mission from the hazard, likelihood that the hazard will occur, and controls to prevent the hazard or reduce the likelihood. The hazards listed below are the minimum to be considered.

1. Operational hazards to be evaluated:
    a. Loss of UAS functionality such as broken servos, power system failure, etc.
    b. Loss of control link or GPS
    c. Ground control system failure
    d. Operations over water or ice
    e. Collision with other aircraft
    f. Terrain and building/structure collision
    g. Crew error.
2. Mission hazards (i.e., a hazard that would impact the ability to achieve the AFC or EE objectives or the ability to continue ARM operations) to be evaluated:
    a. Radiation, biological, or chemical contamination
    b. Electrical fire
    c. Inclement weather
    d. Degraded modes of data collection because of instrument or ground station malfunction or failure
    e. Crew fatigue due to high-cycle operations, hours of operation, weather conditions, etc.
    f. Crew member incapacitation.

3.7.2 Mishap Severity

Mishap severity is an assessment of the consequences of the most credible mishap that could be caused by a specific hazard. Mishap severity (Table 1) categorization provides a qualitative measure of the most credible mishaps resulting from flight crew error, environmental conditions, design inadequacies, procedural deficiencies, or UAS component failure or malfunction. **Rationale for the selection of hazards and the associated most credible mishap shall be documented in the risk analysis section of the ASP.**

Table 1. Severity definitions.[11]

Minimal **5**	**Minor** **4**	**Major** **3**	**Hazardous** **2**	**Catastrophic** **1**
Negligible effects.	• Physical discomfort to persons. • Slight damage to UAS. • Damage to a facility or structure causing the loss of its use no more than one day. • Non-reportable spill.	• Injury to a worker or user resulting in one or more lost work days. • Substantial damage to UAS. • Reportable spill or environmental damage. • Damage to a facility or structure causing the loss of its use for up to 3 months.	• Non-permanent serious injury to workers, users, or members of the public resulting in hospitalization. • Mission cancellation due to UAS loss. • Adverse, but recoverable, impact to the environment. • Damage to a facility or structure causing the loss of its use for 3 to 6 months.	• Death or debilitating permanent injury to workers, users, or members of the public. • Permanent, irrecoverable damage to the environment. • Damage to a facility or structure causing the loss of its use for 6 months or more.

3.7.3 Mishap Likelihood

Mishap likelihood (Table 2) is the assessment of the frequency that a mishap will occur during the duration of the flight. Likelihood can be derived from historical data, or, for new UAS missions (e.g., a new UAS, new or modified GCS, instrument payload; flight location), or from extrapolation of similar operations. **Rationale for assigning mishap likelihood must be documented in the risk analysis section of the ASP.**

[11] Modified from FAA Order 8040.4B, *Safety Risk Management Policy,* for ARM UAS operations.

Table 2. Likelihood definitions.[12]

	Qualitative	Quantitative – Time/Calendar-based Occurrences Domain-wide/System-wide
Frequent A	Expected to occur routinely	Expected to occur more than 100 times per year (or more than approximately 10 times a month)
Probable B	Expected to occur often	Expected to occur between 10 and 100 times per year (or approximately 1-10 times a month)
Remote C	Expected to occur infrequently	Expected to occur one time every 1 month to 1 year
Extremely Remote D	Expected to occur rarely	Expected to occur one time every 1 to 10 years
Extremely Improbable E	Unlikely to occur, but not impossible	Expected to occur less than one time every 10 years

3.7.4 Risk Analysis Chart[13]

The Aviation Risk Analysis Chart is used to assign a RAC to the UAS operation described in the ASP.

Severity / Likelihood	Minimal 5	Minor 4	Major 3	Hazardous 2	Catastrophic 1
Frequent A	[Green]	[Yellow]	[Red]	[Red]	[Red]
Probable B	[Green]	[Yellow]	[Yellow]	[Red]	[Red]
Remote C	[Green]	[Green]	[Yellow]	[Yellow]	[Red]
Extremely Remote D	[Green]	[Green]	[Green]	[Yellow]	[Red] 3A / [Yellow]
Extremely Improbable E	[Green]	[Green]	[Green]	[Green]	[Yellow]

High Risk [Red]
Medium Risk [Yellow]
Low Risk [Green]

* High Risk with Single Point and/or Common Cause Failures

Risk is binned into the following Risk Analysis Codes (RACs):

- High Risk = RAC I
- Medium Risk = RAC II
- Low Risk = RAC III

Note: When referencing a RAC, the Consequence/Likelihood that resulted in the specific RAC should be denoted. For example, RAC I (Ca/F) would indicate a Catastrophic, Frequent event; a RAC II (Ma/R) would indicate a Major, Remote event.

[12] FAA Order 8040.4B, *Safety Risk Management Policy*
[13] FAA Order 8040.4B, *Safety Risk Management Policy*

4.0 TBS Operations

4.1 Applicability

All ARM-supported TBS operations or TBS operations at ARM sites require an approved Aviation Safety Plan (ASP) and ARM Infrastructure Management Board (IMB) authorization. Operations within a Restricted Area or a Warning Area do not require a FAA Certificate of Waiver or Authorization (COA) for each mission but must adhere to the limitations of the Restricted Airspace or Warning Area (e.g., altitude, dimensions). If not conducted in accordance with 14 CFR 101, TBS operations outside a Restricted Area or Warning Area require a FAA Certificate of Wavier or Authorization (COA) appropriate to the mission. International TBS operations require approval of the applicable authority of the country in which the operation will occur, which may require additional documentation or certificates not addressed herein. TBS Operators, Observers, Payload Specialists, and Maintenance Technicians must be trained on the specific TBS to be used.

4.2 Privacy

Use of TBS does not inherently increase the chances of personal privacy being violated, but it does raise the visibility of privacy concerns. TBS using cameras or other forms of surveillance equipment (e.g., thermal imaging, infrared sensors) must abide by the Privacy Act of 1974 (5 U.S.C. 552a)[14] and the Presidential Memorandum dated 15 February 2015.[15] Use of TBS with cameras and/or imaging devices require a legal review by the requesting organization for privacy issues and a determination if imaging device data storage needs to be addressed.[16]

4.3 Requirements

The requirements concerning roles and responsibilities; training and qualification; TBS documentation, capabilities, and procedures; mission planning; and Aviation Safety Plans are described in this section.

4.3.1 Roles and Responsibilities

Each TBS flight requires an Operator. The Operator may assign a dedicated Payload Specialist or an Observer (or both) to a specific AFC or EE. A Maintenance Technician is required to repair or modify a TBS. The Maintenance Technician functions can be performed by the Operator or the Payload Specialist prior to flight if they are appropriately trained. The Operator or Payload Specialist may perform Observer responsibilities if doing so does not adversely impact safety and they are appropriately trained. Operators and Payload Specialists shall maintain a personal flight logbook in which they record TBS-specific training and information pertinent to each flight (e.g., date, TBS identification, purpose of the flight, duration of the flight, location of the flight). The Maintenance Technician shall record modifications and

[14] https://www.justice.gov/opcl/privacy-act-1974

[15] https://obamawhitehouse.archives.gov/the-press-office/2015/02/15/presidential-memorandum-promoting-economic-competitiveness-while-safegua

[16] NOAA has an excellent privacy policy that may be used for reference: https://www.cio.noaa.gov/itmanagement/pdfs/Signed_UAS_PrivacyPolicy.pdf

repairs to a TBS winch, tether, and balloon in a maintenance logbook specific to each winch, tether, and balloon.

The science aspects of an AFC or EE shall be directed by the AFC or EE principal investigator (PI) when a PI is assigned. When a PI is assigned, they should be independent from the TBS crew. The TBS Operator shall maintain full responsibility for the safe conduct of flight operations. The PI has no authority to direct the TBS Operator to perform any flight-related activity the Operator does not deem safe. PIs are cautioned to not attempt to push or influence TBS Operators to perform flight operations near or outside their comfort level or the TBS capability or near or outside the operation limits described in the Aviation Safety Plan.

4.3.1.1 ARM Site Manager[17]

The applicable ARM Site Manager or designee:

- Serves as the Point of Contact (POC) for users conducting TBS operations at the manager's ARM site.
- Coordinates the site infrastructure needed by users to conduct TBS operations, including frequency spectrum approval when required.
- Reviews ASPs and resolves issues with the requesting organization.
- Develops an Aviation Deconfliction Plan if concurrent TBS, UAS, or fixed- or rotary-wing aircraft operations are planned.
- Verifies the training and qualification of the TBS Operator, Payload Specialist, Observer, and RSO.
- Coordinates with the TBS Operator for Notices to Airmen (NOTAMS) and Restricted Area or Warning Area use.
- Verifies the accuracy and posting of NOTAMs pertaining to the planned TBS operation.
- Distributes approved ASPs, ADPs, and the summary section of ASPs.
- Determines the need for and assigns a RSO and RSO duties for a specific TBS operation, if required.
- Where applicable, develops and forwards to the Office of Science by December 31 annually a fiscal year FAA 7400 2G Utilization Report for DOE-managed Restricted and Warning Area Airspace for which the site manager has been delegated management by DOE OAM.
- Ensures compliance with this procedure.

4.3.1.2 TBS Operator

The TBS Operator is a required crewmember for every ARM-related TBS operation. The Operator is responsible for, and is the final authority regarding, operation of the TBS. The Operator must be

[17] If the TBS operations are to be conducted at a non-ARM site, these responsibilities shall be carried out by the requesting organization in coordination with the site point of contact.

designated prior to flight of the TBS. If there is a plan for the Operator to be relieved during a flight, there:

1. Must be a previously approved relief plan;
2. Both the primary and the relief Operator shall have participated in all preflight briefings; and,
3. At the time of relief, there must be a positive exchange of the controls and a declaration by the relieving Operator that they have control of the TBS. The primary Operator shall acknowledge transfer of control to the relieving Operator by stating "You have control of the TBS" and the relieving Operator shall respond by stating "I have control of the TBS".

The Operator may not act as any other crew member while the balloon is ascending or descending.

It is the responsibility of the TBS Operator to ensure that the TBS operations pose no undue hazard to people, aircraft, property, or the environment in the event of a loss of control of the TBS for any reason. The TBS Operator is solely responsible and accountable for assuring compliance of TBS operations with the applicable Federal Aviation Regulations (FARs), provisions of applicable COA(s); Air Traffic Control (ATC) directions, NOTAMs, site requirements, and the approved Aviation Safety Plan (ASP) and Aviation Deconfliction Plan (ADP), if required. The TBS Operator authority and accountability shall not be delegated.

The TBS Operator:

- Determines the required TBS crew for each AFC or EE and assigns duties to crew members. In some instances, crew positions may be combined at the discretion of the TBS Operator.
- Conducts a Plan-of-the-Day Briefing with the flight crew, site manager or designee (or Site POC if operations are not at an ARM site), PI (if assigned), and RSO (if assigned) reviewing the science objectives, flight, emergency response procedures, weather, TBS and instrumentation readiness, flight crew readiness, and any other factor important to safe execution of the day's flights such as deconfliction with other flight operations.
- Conducts a preflight briefing with the flight crew, Site Manager or designee (or Site POC if operations are not at an ARM site) or designee, PI (if applicable), and RSO (if assigned) reviewing the science objectives, flight patterns, emergency response procedures, weather forecast, TBS and instrumentation readiness, flight crew readiness, and any other factor important to safe execution of the flight such as deconfliction with other concurrent flight operations.
- Assures the safety and compliance of TBS operations with this procedure and applicable regulations and site requirements.
- Coordinates Restricted Area or Warning Area use with the site manager or POC when applicable.
- Serves as the FAA point of contact for Notices to Airmen (NOTAMS) and Restricted Area or Warning Area use.
- Requests NOTAMS to be issued for TBS operations as appropriate.
- Requests the FAA to activate Restricted Area or Warning Area when applicable.
- Ensures that the local aviation community is notified of TBS operations when appropriate.
- Coordinates international TBS deployments through the responsible in-country representatives.

- Coordinates and communicates flight and aircraft deconfliction plans with the RSO (if assigned) and other Remote Pilots, Operators, or Pilots concurrently operating UAS, TBS, or fixed- or rotary-wing aircraft at the same site to ensure deconfliction of operations.
- Obtains a weather report, Temporary Flight Restriction (TFR) status, and Notices to Airmen (NOTAMs) and other information pertinent to the TBS flight.
- Verifies readiness to conduct flights, including:
  - TBS airworthiness
    - Ensures that the TBS lift capacity and tether strength will not be exceeded for each installed payload under all anticipated flight conditions.
  - readiness[18] and qualifications of each crew member to perform their assigned duties
  - payload attachment
  - winch operability
  - emergency deflation device (EDD) functionality
  - operational condition of all required safety hardware as indicated in the approved ASP
  - activation of Restricted Area and Warning Area (if used)
  - COA approval and currency (if a COA is required).
- With the PI (if applicable), defines the flight patterns required to achieve the AFC or EE objectives.
- Announces the start and end of daily operations on the appropriate Common Traffic Advisory Frequency (CTAF) or other frequency for aircraft communications for the location of operations.
- Monitors the CTAF or other appropriate frequency during operations.
- Executes each TBS flight (i.e., controls the tethered balloon through all phases of flight).
- Provides for the safe execution of designated PI (if applicable), inputs during the flight to facilitate achieving the science objectives in accordance with the approved ASP.
- Maintains communication capability with flight crew members during the flight.
- Conducts post-flight briefings to identify opportunities for improvement.
- Records entries in the applicable Flight Log.
- Reports accidents.

[18] All crew members, the RSO, and PI (if applicable) are prohibited from participating in a TBS operation if he or she has consumed any alcoholic beverage within the preceding 8 hours, is under the influence of alcohol, is using a drug, including over-the-counter drugs, that affects the person's mental or physical capabilities, or has a medical condition that creates an undue risk.

4.3.1.3 Observer

- Watches the balloon position and watches for aircraft approaching the balloon and notifies the TBS Operator when other aircraft are seen that may pose a hazard/conflict.
- Observes weather and visibility conditions and warns the Operator of approaching weather adverse to TBS operation; e.g., wind speed aloft and at ground level, frontal movement, lightning, declining visibility.
  - Has the responsibility to inform and provide recommendations to the Operator of developing conditions that, in the Observer's judgement, may require return of the TBS to the ground.
- Maintains continuous visual or radio contact with the Operator.

4.3.1.4 Payload Specialist

- Installs and removes instruments on the balloon or tether.
- Installs and removes streamers and lights on the tether as required.

4.3.1.5 Maintenance Technician

- Repairs the balloon envelope and winch system.
- Replaces the tether, apex and handling lines, and carabiners.
- Enters repairs, modifications, and updates into the TBS-specific maintenance log.
- Attests to the TBS airworthiness after repair, replacement, maintenance, or modification.

4.3.1.6 Principal Investigator

- Establishes the science objective for each flight and conveys the objectives to the TBS Operator.
- Suggests to the Operator the flight paths desired to achieve the AFC or EE science objectives.
- Suggests to the Operator the acceptable weather requirements for flight in advance of TBS operations.
- Verifies and monitors payload operability and data transmission before and during flight.
- Provides input/requests to the Operator during each TBS flight regarding changes that may be needed in the flight pattern (e.g., altitude; loitering) to facilitate achieving the science objectives.

4.3.1.7 Range Safety Officer (RSO)

***Note**: If a RSO is not assigned to a specific TBS AFC or EE, then the responsibilities listed below are to be assigned by the Site Manager (ARM site operations) or by the requesting organization (non-ARM site operations) to TBS crew members.*

- Reviews and ensures implementation of the ASP.
- Oversees daily TBS operations

  - Assures deconfliction of concurrent UAS, TBS, and fixed- and rotary-wing aircraft operations
  - Monitors human performance factors during operations.
- Is authorized to halt operations to ensure safety.

4.3.1.8 Office of Science Aviation Safety Manager

- Reviews each ASP and consults with OAM and the applicable DOE site Aviation Officer as needed.
- Obtains ASP approval.

4.3.2 Qualification and Training Requirements

4.3.2.1 TBS Operator

- Site-specific training
- Familiarity with 14 CFR 101 Subparts A and B
- Training on airspace, aviation communications, sectional charts, and NOTAMs for flights above 150 ft AGL.[19]
- Training on the specific TBS[20] described in the ASP with respect to:
  - balloon design and construction
  - balloon flight characteristics and lift capacity
  - balloon rigging
  - balloon filling
  - airworthiness determination
  - winch construction and operation
  - tether strength and the effect of wind and payload on tether load
  - EDD operation
  - emergency procedures
  - balloon launch and retrieval.
- Complete 10 hours of flights including five ascents and descents and documenting these flights in the Operator's logbook.

  Note: A person who is not qualified as an Operator may operate the TBS under the direct supervision of a qualified Operator **if** the qualified Operator is able to immediately take direct control of the TBS.

[19] This training can be completed through the following (or a combination thereof): CBT (e.g. Online and DVD-based training available from sources such as the Aircraft Owners and Pilots Association (AOPA, http://www.aopa.org), Sporty's Pilot Shop (http://www.sportys.com), or King Schools (http://www.kingschools.com), and others, can be used to fulfill this requirement); classroom training (if available); self-study of manuals; one-on-one training with a knowledgeable individual. Training should be documented in the TBS Operator's personal logbook. This training element is not applicable if the TBS system is operating less than 150 ft AGL.

[20] This training may be obtained by study of the TBS (i.e., winch, tether, aerostat or helikite) manufacturer's manuals.

4.3.2.2 Observer

- ARM site-specific training.
- Instruction on the flight characteristics and limitations of the TBS described in the Aviation Safety Plan.

4.3.2.3 Payload Specialist

- Familiarity with 14 CFR 101 Subparts A and B
- Instruction[21] on the specific TBS described in the Aviation Safety Plan with respect to:
  - flight characteristics
  - balloon lift capacity
  - payload attachment
  - atmospheric monitoring instrumentation.

4.3.2.4 Maintenance Technician

Training on the specific TBS, including the winch, described in the ASP with respect to construction, repair techniques, system functions, controls, troubleshooting, airworthiness criteria, operation, and flight dynamics and limitations. Training maybe provided by the TBS manufacturer or by the maintenance technician reading the TBS manufacturer's manuals and procedures.

4.3.2.5 Range Safety Officer

- ARM site-specific training.
- 14 CFR Part 107 Certificate (required) or hold a current private pilot certificate or higher (desired).
- Aviation Safety Officer certification by the General Services Administration (GSA) Interagency Committee for Aviation Policy, or equivalent education and experience[22] approved by the Site Manager.

4.3.3 TBS Requirements

4.3.3.1 Aerostat or helikite

- Helium-filled envelope.

[21] Instruction can be provided by the Operator or the manufacturer of the TBS.

[22] The purpose of this requirement is to ensure that Range Safety Officers understand aviation safety, risk management, and safety management systems. In lieu of Aviation Safety Officer certification an adequate level of both formal safety training or certification (e.g., CSP; CIH; CSMS) and formal aviation training (e.g., FAA private pilot written exam) is required. Alternate training may be approved by the Office of Science Aviation Safety Manager.

- Capability to lift the combined weight of the payload and the tether at the intended operational altitude in calm wind with a 1.25 safety factor (e.g., a combined balloon, tether, and payload weight of 100 lb. would require a 125 lb. lift capability).
- GPS-activated emergency deflation device (EDD) that uses altitude and horizontal distance from the launch point limits, or a manually-activated EDD, or an altitude-activated valve that vents the balloon at a preset altitude.
- Individual instruments or a payload weighing 5 lbs. or more shall be attached to the tether or balloon at a minimum of 3 points.

4.3.3.2 Documentation

- Statement of airworthiness.
- Certification of tensile testing of the tether that exceeds the maximum load on the tether (i.e., balloon weight + tether weight at the maximum length of the tether + payload weight) under an 80-mph wind gust at sea level at 60°F.
- Documentation of a successful one-minute deadlift test of the winch system using a weight equal to the expected line pull on the balloon in a 40-mph wind at 60°F at the maximum tether length and payload and balloon weight.

4.3.3.3 Procedures

Each organization using a TBS with a balloon larger than 6 feet in diameter or greater than 115 cubic feet in volume for an AFC or EE or using an ARM site shall have documented procedures for the following:

- Rigging the aerostat or helikite
- Inflation and deflation
- Instrument/payload installation and removal
- EDD installation and verification of functionality
- Installation and removal of streamers and lights as required by 14 CFR 101.17
- Verifying flight readiness (e.g., a checklist)
- Winch operation
- Routine and preventive maintenance (e.g., winch, balloon)
- Repair of the balloon envelope
- Replacement of the tether, apex lines, guide lines, and carabiners
- Launch and retrieval
- Emergency response.

4.4 Mission Planning

Planning for a TBS mission must be carefully coordinated between the PI (if applicable), the Operator, and the Site Manager (or designee) or the Site POC for operations at a non-ARM site to ensure that the planned operation complies with all governing policies, procedures, regulations, and the ASP and still

safely accomplishes the science goals. The Operator shall ensure that the following are well defined and included in mission planning:

- Primary and alternate science objectives
- Mission location and airspace to be used as noted on a VFR Sectional Chart
- Logistics (e.g., transportation of equipment and materials to the site; required support at the site)
- TBS to be used and accompanying procedures
- Flight crew (names, positions, qualifications)
- POCs (e.g., site manager, emergency response, FAA)
- Regulatory environment (e.g., COA, Restricted Airspace, Warning Area; site requirements)
- Payload/instrumentation including frequency spectrum analysis and approval (when applicable)
- Meteorological limitations
- Maximum altitudes
- Hazard identification:
  - Operational and mission hazards including concurrent UAS, TBS, or fixed-/rotary-wing operations, when applicable
  - Hazard Controls including an Aviation Deconfliction Plan for concurrent UAS, TBS, or fixed-/rotary-wing operations, when applicable
- Emergency response including:
  - Broken tether
  - Winch failure
  - Injury
  - Environmental insult
- Preflight checklist
- Preflight briefing
- Post flight briefing
- Reporting/flight log
- Record maintenance.

4.5 Aviation Safety Plan

4.5.1 Purpose

An Aviation Safety Plan (ASP) provides the information needed for the safe conduct and approval of an ARM-supported AFC or EE that use a TBS and non-ARM supported activities that use a TBS at an ARM site. In accordance with the DOE Office of Aviation Management (OAM) guidance, the level of approval is placed at the lowest level commensurate with the level of risk (i.e., the Risk Analysis Code) determined in the ASP. It is therefore important that all sections of the ASP (Section 2.5.3) be completed in detail so the ASP approver(s) can understand the TBS operations, risk, and controls.

4.5.2 Applicability

An ASP is required for all ARM-supported AFCs and EEs that use a TBS and all non-ARM supported activities that use a TBS at an ARM site.

4.5.3 ASP Format

An ASP shall contain:

a. **A brief summary** that describes the proposed TBS mission in narrative form including:

   i. The organization conducting the mission including the requesting organization, and name, address, email, and telephone number of the requesting organization point of contact
   ii. The purpose/science objective of the mission
   iii. Flight location supported by a VFR Sectional Chart showing the location of the TBS operation, dates, maximum altitude, anticipated daily time aloft, operational restrictions
   iv. Regulatory basis (e.g., COA, 14 CFR 101, privacy concerns)
   v. TBS to be used (size, instrumentation, and data link type and frequencies)
   vi. Flight crew names, positions, and qualifications
   vii. Operation and mission hazards and controls
   viii. RAC
   ix. Exceptions to Section 4.3 requirements (if none, so state; otherwise, state the exceptions, the reason/justification for each exception, and the risk to TBS operations if each exception is granted).

b. **Description of the mission** in sufficient detail to establish the boundary of the significant parameters to be encountered during the accomplishment of the mission. The description should include:

   i. science objectives
   ii. expected number and duration of flights
   iii. maximum altitude
   iv. operational restrictions (e.g., daylight only; visual or instrument meteorological conditions; maximum wind speed and cross wind; privacy concerns)
   v. map of the flight area and proposed track of flights
   vi. class of airspace
   vii. CTAFs to be used
   viii. nearest airport.

   Note: If a FAA Certificate of Authorization (COA) or approval from an international authority has been obtained, the COA or approval should be included as an attachment to the ASP.

c. **Detailed description of the TBS** to include:

   i. Balloon manufacturer, volume
   ii. The flight characteristics and limitations of the TBS

iii. Winch description and characteristics
iv. Tether type, maximum length and strength
v. Instrumentation payload
vi. Data link frequencies used.

d. **Spectrum analysis and approval**

The Site Manager should be contacted to obtain approval for the frequencies to be used, and the approval attached to the ASP. The following frequencies are typically used for TBS operations:

- GPS-activated automatic deflation device: 1575.42 MHz
- Instrument data frequencies: 900-928 MHz and/or 400-405 MHz
- Aviation Transceiver 108-137 MHz.

e. **Airworthiness determination and documentation**

Airworthiness of a specific TBS must be verified before its first use, after modification or repair, and before each flight. While the FAA has no airworthiness standards for TBS, airworthiness must be established and maintained for TBS that are larger than 6 feet in diameter or greater than 115 cubic feet in volume that are used for ARM-supported TBS AFCs and EEs and for non-ARM supported TBS operations conducted by users at ARM sites. Verifying airworthiness before first use can be accomplished by a document from the using organization management attesting to its airworthiness, or a letter from the TBS manufacturer. The Operator is responsible to ensure that the TBS is airworthy before each flight. The Maintenance Technician is responsible for certifying airworthiness in the TBS maintenance logbook after each repair or modification. The original (before first use) airworthiness documentation should be attached to the ASP as an appendix.

f. **Flight crew positions** (including responsibilities), and the qualifications, training, and experience of the flight crew and alternates, by name.

g. **Identification and analysis of hazards** to air traffic, ground obstructions, flight crew, and persons not directly involved in flight operations, and to the environment (Section 4.7).

h **Identification of engineered and administrative controls** that mitigate the identified hazards (Section 4.7).

i. **Qualitative assessment of risk** to the flight crew, other persons, property, the environment, and mission success (Section 4.7).

j. **Preflight readiness verification** to include:

i. crew briefing on the specific flight parameters, mission, objectives, emergency procedures, and weather
ii. verification of crew ability to support the mission
iii. verification of the TBS readiness for flight using checklists that are attached as appendices to the ASP.

k. **Emergency procedures and reporting**

Each TBS operation should have an emergency response plan that identifies the actions to be taken and persons to be contacted in case of injury, broken tether, winch failure, balloon fill pressure system failure, balloon envelope rupture while aloft, collision with aircraft, structures, or people, adverse weather conditions, and environmental insult. The emergency response plan shall include the criteria outlined below for reporting accidents:

- Report the accident within 12 hours to the applicable ARM Site Manager or designee or Site POC (if UAS operations are not at an ARM site), the Office of Science Aviation Safety Manager, and the DOE Office of Aviation Management if the accident meets any of the following thresholds:
  - Results in an injury that:
    - Requires in-patient hospitalization for any duration, commencing within 7 days from the date the injury was received.
    - Results in a fracture of any bone (except bone chips, simple fractures of fingers, toes, or nose, or a minor chipped tooth).
    - Causes severe hemorrhages or severe damage to nerves, muscles, tendons, or ligaments. (Note: Severe damage is generally considered to have occurred if surgery is required to correct the damage.)
    - Damages any internal organ.
    - Causes 1) a concussion or 2) loss of consciousness due to an impact to the head, or
    - Causes second- or third-degree burns, affecting more than five percent of the body surface.
- Results in property damage, other than the cost of the TBS, exceeding $500 to repair or replace the property or repair environmental damage.

4.6 Mission Approval

Mission approval follows the chart for TBS operations at an ARM site (Figure 1) **or** the chart for ARM-supported TBS operations **not** conducted at a non-ARM site (Figure 2), in accordance with the following procedures, respectively. **Note: Requesting Organizations should expect 10 working days for approval after submittal of the ASP to the Office of Science Aviation Safety Manager.**

4.6.1 Approval Procedure for ARM Site TBS Operations

Activity	Responsibility	Action
1. Review the Aviation Safety Plan.	ARM Site Manager or designee	**IF** the ASP does not involve concurrent flight operations, is RAC III (low risk), and the operations are within the applicable DOE Site Office Approval, **THEN:**

Activity	Responsibility	Action
		a. Review the ASP and resolve any issues in the ASP with the requesting organization and the applicable Aviation Safety Officer. i. Verify that the operations are consistent with the airspace requirements and comply with the applicable COA, regulations, and site requirements. b. Approve the ASP. c. Distribute the approved ASP: - Requesting organization - Site Aviation Safety Official - DOE site Aviation Safety Officer - Office of Science Aviation Safety Manager. d. Distribute the summary section of the approved ASP: - Office of Science BER POCs - OAM. e. Proceed to Activity 4. **IF** the ASP involves concurrent flight operations, is RAC I (high risk) or II (medium risk), or the operations are not within the DOE Site Office Approval, **THEN**: a. Review the ASP and resolve any issues in the ASP with the requesting organization and the applicable Aviation Safety Officer. i. If concurrent operations are scheduled, create a "Aircraft Deconfliction Plan" (ADP) describing how deconfliction will be achieved for the concurrent operations and obtain concurrence with the ADP from all concurrent operators and the applicable site Aviation Safety Officers of the organizations scheduling concurrent operations. ii. Verify that the operations are consistent with the airspace requirements and comply with the applicable COA, regulations, and site requirements. b. Transmit the final ASP (and ADP, if required) to the DOE Office of Science Aviation Safety Manager.
2. Review and approval of the TBS Aviation Safety Plan.	DOE Office of Science Aviation Safety Manager	a. Review the TBS ASP and ADP (if required) and resolve any issues with the ARM Site Manager of designee. i. Consult with the DOE Office of Aviation Management (OAM).

Activity	Responsibility	Action
		Note: *OAM may call a Flight Readiness Review Board and retain final approval for RAC I (high-risk) missions.* ii. Consult with the applicable DOE site Aviation Manager. b. Obtain ASP and ADP (if required) approval, which may include approval of the ASP by the applicable DOE Site Office Manager or designee, if required. c. Submit the approved ASP and ADP (if required) to the applicable ARM Site Manager or designee.
3. Distribute approved ASP.	ARM Site Manager or designee	a. Distribute the approved ASP and ADP (if required): - Requesting organization - Site Aviation Safety Official - DOE site Aviation Safety Manager. b. Distribute the summary section of the ASP and the ADP (if required): - OAM - Office of Science BER POCs.
4. Enter Approved ASP in ARM ServiceNow.	Requesting organization	Enter the approved ASP and ADP (if required) into the ARM ServiceNow website.
5. Authorize the TBS operation.	ARM Infrastructure Management Board (IMB)	Verify ASP and ADP (if required) approval. For ARM facility user proposals, follow the existing field campaign approval process and communicate the authorization decision to the applicable Science Liaison for transmittal to the Principal Investigator, if applicable. **Note:** The field campaign approval process may be conducted in parallel with approval of the ASP.

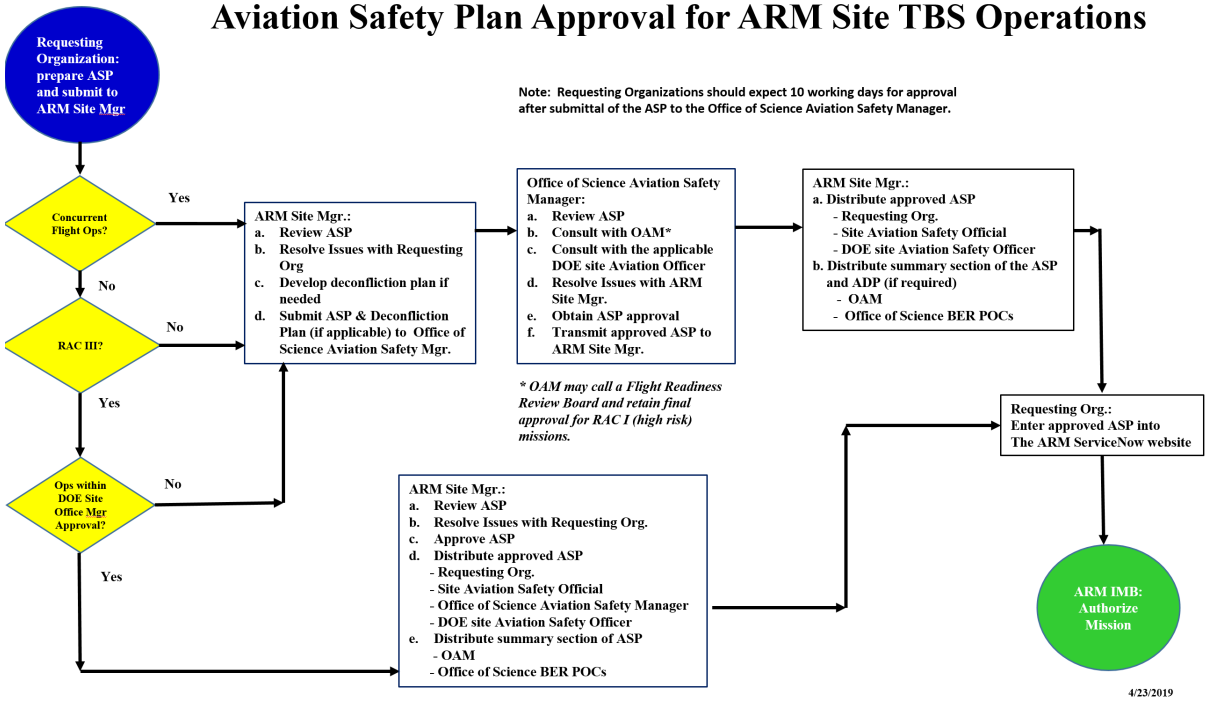

Figure 3. Aviation Safety Plan for ARM site TBS operations.

4.6.2 Approval Procedure for ARM-Supported TBS Operations at Non-ARM Sites

Activity	Responsibility	Action
2. Review the Aviation Safety Plan.	Requesting organization	**IF** the ASP does not involve concurrent flight operations **and** is RAC III, **THEN:** **a.** Consult with the Office of Science Aviation Safety Manager and resolve any issues **b.** Transmit the ASP to the Site POC. **IF** the ASP involves concurrent flight operations **or** is RAC I or II, **THEN** transmit the ASP to the Site POC.
	Site POC	**IF** the ASP does not involve concurrent flight operations **and** is RAC III, **THEN:** a. Review the ASP b. Resolve issues with the requesting organization c. Approve the ASP d. Transmit the approved ASP to the requesting organization.

Activity	Responsibility	Action
		IF the ASP involves concurrent flight operations **or** is RAC I or II, **THEN:** a. Review the ASP b. Resolve issues with the requesting organization c. Develop an Aviation Deconfliction Plan (ADP) if needed d. Submit the ASP and ADP to the Office of Science Aviation Safety Manager.
3. **Review and approval of the TBS Aviation Safety Plan**.	DOE Office of Science Aviation Safety Manager	Review the TBS ASP and ADP (if required) and resolve any issues with the Site POC or Requesting organization, as appropriate. a. Consult with the DOE Office of Aviation Management (OAM). ***Note:*** *OAM may call a Flight Readiness Review Board and retain final approval for RAC I (high-risk) missions.* b. Consult with the applicable DOE site Aviation Manager. c. Obtain ASP and ADP (if required) approval, which may include approval of the ASP by the applicable DOE Site Office Manager or designee, if required. d. Transmit the approved ASP and ADP (if required) to the requesting organization.
3. Distribute approved ASP.	Requesting organization	a. Distribute the approved ASP and ADP (if required): - Site POC - DOE site Aviation Safety Manager. b. Distribute the summary section of the ASP and the ADP (if required): - OAM - Office of Science BER POCs.
4. Enter Approved ASP in ARM ServiceNow.	Requesting organization	Enter the approved ASP and ADP (if required) into the ARM ServiceNow website.

Activity	Responsibility	Action
5. Authorize the TBS operation.	ARM Infrastructure Management Board (IMB)	Verify ASP and ADP (if required) approval. For ARM facility user proposals, follow the existing field campaign approval process and communicate the authorization decision to the applicable Science Liaison for transmittal to the principal investigator (PI), if applicable. **Note:** The field campaign approval process may be conducted in parallel with approval of the ASP.

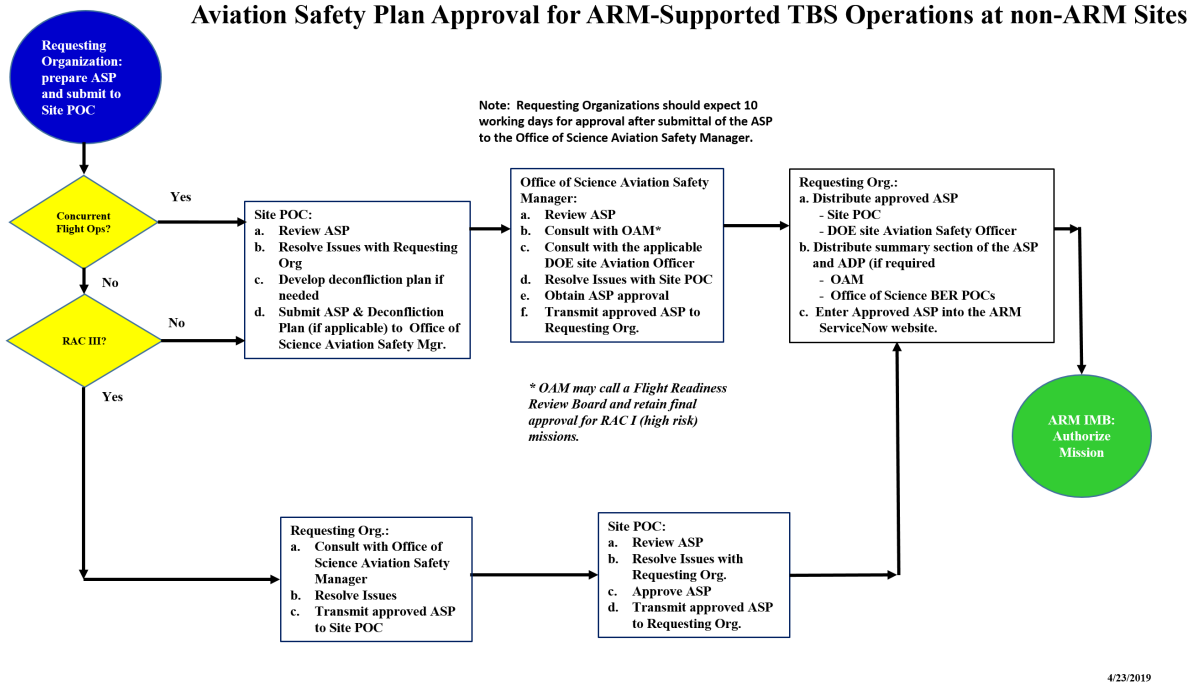

Figure 4. Aviation Safety Plan approval for ARM-supported TBS operations at non-ARM sites.

4.7 TBS Risk Analysis

Risk analysis considers the severity of a mishap and the likelihood that the mishap will occur. The combination of severity and likelihood results in a "Risk Analysis Code" (RAC). The RAC helps identify the risk of TBS operations and ensures that missions are reviewed and approved at management levels appropriate to risks. In developing the risk scenarios consider the following:

- What is the TBS required to do?
- What is the environment in which the TBS and ground support component will be working?
- What are the hazards in the entire system (balloon, winch, instrument payload, flight crew, procedures, checklists, flight environment (e.g., weather, location, obstacles) and how could they impact the flight and mission?

It is helpful in risk analysis to develop risk statements in an "If/Then" format: If (a failure, mishap, or event occurs), Then (the worst-case consequence that could occur). For example, "If the balloon tether breaks during flight, then the balloon may crash into a structure, causing damage to the structure". A risk statement leads to estimating the likelihood that the risk will occur and identifying the control that prevents the risk from occurring or the mitigation that eliminates or reduces the consequence. Engineered controls (e.g., GPS-activated EDD) are preferable to administrative controls (e.g., procedures, training).

4.7.1 Hazards to Be Considered

Operational and mission hazards are to be evaluated to identify those hazards to be included in the risk analysis. Each included hazard should be evaluated with respect to severity of the worst-case consequence to people, property, the environment, and mission from the hazard, likelihood that the hazard will occur, and controls to prevent the hazard or reduce the likelihood. The hazards listed below are the minimum to be considered.

a. Operational hazards to be evaluated:
    i. Loss of mechanical functionality of the TBS winch
    ii. Broken balloon tether or apex line(s)
    iii. Failure of the balloon envelope
    iv. Unattended TBS operation
    v. Unattended storage of an inflated balloon
    vi. Operations over water or ice
    vii. Loss of EDD functionality
    viii. Collision with other aircraft
    ix. Terrain and building/structure collision
    x. Crew error.
b. Mission hazards (i.e., a hazard that would impact the ability to achieve the AFC or EE objectives or the ability to continue ARM operations) to be evaluated:
    i. Radiation, biological, or chemical contamination.
    ii. Electrical fire.
    iii. Inclement weather.
    iv. Degraded modes of data collection because instrument or ground station malfunction or failure.
    v. Crew fatigue due to high-cycle operations, hours of operation, weather conditions, etc.
    vi. Crew member incapacitation.

4.7.2 Mishap Severity

Mishap severity is an assessment of the consequences of the most credible mishap that could be caused by a specific hazard. Mishap severity (Table 1) categorization provides a qualitative measure of the most credible mishap resulting from flight crew error, environmental conditions, design inadequacies, procedural deficiencies, or TBS component failure or malfunction. **Rationale for the selection of hazards and the associated most credible mishap must be documented in the risk analysis section of the ASP.**

Table 3. Severity definitions.[23]

Minimal 5	Minor 4	Major 3	Hazardous 2	Catastrophic 1
Negligible effects.	• Physical discomfort to persons • Slight damage to TBS • Damage to a facility or structure causing the loss of its use no more than one day. • Non-reportable spill.	• Injury to a worker or user resulting in one or more lost work days. • Substantial damage to TBS. • Reportable spill or environmental damage. • Damage to a facility or structure causing the loss of its use for up to 3 months.	• Non-permanent serious injury to workers, users, or members of the public resulting in hospitalization. • Mission cancellation due to TBS loss. • Adverse, but recoverable, impact to the environment. • Damage to a facility or structure causing the loss of its use for 3 to 6 months.	• Death or debilitating permanent injury to workers, users, or members of the public. • Permanent, irrecoverable damage to the environment. • Damage to a facility or structure causing the loss of its use for 6 months or more.

4.7.3 Mishap Likelihood

Mishap likelihood (Table 2) is the assessment of the frequency that a mishap will occur during the duration of the flight. Likelihood can be derived from historical data, or, for new TBS missions (e.g., a new TBS, winch, instrument payload; flight location), from extrapolation of similar operations. **Rationale for assigning mishap likelihood must be documented in the risk analysis section of the ASP.**

Table 4. Likelihood definitions.[24]

	Qualitative	Quantitative – Time/Calendar-based Occurrences Domain-wide/System-wide
Frequent A	Expected to occur routinely	Expected to occur more than 100 times per year (or more than approximately 10 times a month)
Probable B	Expected to occur often	Expected to occur between 10 and 100 times per year (or approximately 1-10 times a month)
Remote C	Expected to occur infrequently	Expected to occur one time every 1 month to 1 year
Extremely Remote D	Expected to occur rarely	Expected to occur one time every 1 to 10 years
Extremely Improbable E	Unlikely to occur, but not impossible	Expected to occur less than one time every 10 years

[23] Modified from FAA Order 8040.4B, *Safety Risk Management Policy,* for ARM TBS operations.
[24] FAA Order 8040.4B, *Safety Risk Management Policy.*

4.7.4 Risk Analysis Chart

The Aviation Risk Analysis Chart is used to assign a RAC to the TBS operation described in the ASP.

Likelihood \ Severity	Minimal 5	Minor 4	Major 3	Hazardous 2	Catastrophic 1
Frequent A	[Green]	[Yellow]	[Red]	[Red]	[Red]
Probable B	[Green]	[Yellow]	[Yellow]	[Red]	[Red]
Remote C	[Green]	[Green]	[Yellow]	[Yellow]	[Red]
Extremely Remote D	[Green]	[Green]	[Green]	[Yellow]	[Red] * / [Yellow]
Extremely Improbable E	[Green]	[Green]	[Green]	[Green]	[Yellow]

High Risk [Red]
Medium Risk [Yellow]
Low Risk [Green]

* High Risk with Single Point and/or Common Cause Failures

Risk is binned into the following Risk Analysis Codes (RACs):

- High Risk = RAC I
- Medium Risk = RAC II
- Low Risk = RAC III

Note: When referencing a RAC, the Consequence/Likelihood that resulted in the specific RAC should be denoted. For example, RAC I (Ca/F) would indicate a Catastrophic, Frequent event; a RAC II (Ma/R) would indicate a Major, Remote event.

Appendix A

UAS Visual Observer Training Guide

A UAS Visual Observer (VO) is used primarily to maintain a vigilant lookout for potential conflicting air traffic, ground obstacles, and indications of problematic weather developments. Because the Remote Pilot Command (RPIC) is so focused on the unmanned aircraft while in manual control, or monitoring performance data while the unmanned aircraft is in the auto pilot mode, the RPIC must have additional assistance with lookout to effectively enhance situational awareness[25].

A secondary role for VOs is extending the visual line of sight and enabling the unmanned aircraft to travel further from the RPIC. To be clear, Visual Line of Sight (VLOS) is unaided by any technology other than glasses or contact lenses. VLOS is a distance at which the VO can not only see the unmanned aircraft, but can distinguish changes in aircraft attitude, altitude, and direction. (i.e., the aircraft is more than a dot, it has distinguishable shape). To further extend the range of the unmanned aircraft, VOs may be used in a daisy chain fashion. This requires very specific training and procedures that are defined, trained, and briefed.

The following list consists of recommended VO training and topics with some very basic discussion:

1. Vision that is correctable to 20/20.
2. All VOs should have sunglasses with ultraviolet (UV) filtering. If prescription glasses are used for distance, it is recommended that the VO have prescription sun glasses available with UV filtering.
3. Type(s) of airspace in which the unmanned aircraft will be operated. VOs will also need to know the FAR cloud clearance requirements, and weather minimums in which the UAS operation can take place. A VFR Sectional or highway map should be used to identify an identifiable feature that is at the minimum acceptable visual range and verify that the VO can identify it once on site. It is further recommended that the ranges of 500', 1000', and 2000' be demonstrated. Cloud clearance requirements can be very subjective and a training exercise to demonstrate these distances will go a long way towards standardizing the evaluation of cloud clearance.
4. VOs must understand the UAS flight plan and be included in all preflight briefings. This means planning the briefing(s) so the VOs can be present at the briefing(s) and have time to deploy to their planned location(s).

[25] 14 CFR Part 107; 14 CFR Part 91.113; Advisory Circular 107-2 Small Unmanned Aircraft Systems.

- When disbursing VOs to different locations, the specific locations should be visited in advance to ensure visibility and associate the unmanned aircraft flight path with a map, ground hazards, and landmarks so the VO is afforded the best possible opportunity to both detect the aircraft being off course and avoid ground obstacles.
- VOs must report to the RPIC that they are on site and set up.
- RPIC should ensure VOs are informed of unmanned aircraft takeoff and landing.
- Expected position communications should be prearranged between the VOs and the RPIC.
- Where visual contact should be obtained and released when using more than 1 VO to extend the VLOS range and communication between VOs to implement and confirm the transfer.

5. Terminology for identifying air traffic and obstacles relative to the unmanned aircraft flight path.
    - Unmanned aircraft flying a circle/orbiting: Because the relative heading of the aircraft is constantly changing it is recommended that the relative compass direction be used. (e.g., N – NE – E – SE – S – SW – W – NW). Because the aircraft is always turning it is easy to get directions confused.
    - Some have used the following methods to create a quick reference on site. Once on site, use a map or compass to identify North.
        - Use a prominent land mark to identify North
        - Scrape a N-S-E-W cross in the dirt and label the cardinal headings.
        - Use large sticks and label N-S-E-W.
        - Make a N-S-E-W diagram and tape it to the hood of a vehicle.
        - Use two 2x4s crossed with a notch in the center to stabilize and label N-S-E-W.
        - Use four stakes with florescent surveyor's tape and label N-S-E-W.
    - When the unmanned aircraft is flying straight, use the clock method and the nose of the aircraft is always12 o'clock.
    - Traffic calls should always include relative location, flight path information, relative altitude, and closure rate.

        Location: Traffic is at 3 o'clock or Traffic is NE
        Flight path: on a 45-degree intercept – crossing in front
        Relative altitude: above – below – same altitude
        Closure rate: closing fast -
    - The VO should **not** call traffic if certain it poses no threat or hazard.
6. Scanning methods[26]. Just looking in a fixed direction may be hit or miss. Often the eye detects movement before it actually sees an object. Using a disciplined approach is recommended. A couple of different scanning methods generally work best: Scanning a line from near to far; identify a marker on the horizon to mark the location, extend the scan above the horizon, then shift the scan right and back down to the horizon, pick up a new marker and then repeat until a sector or a 360-degree scan is complete; or, identifying 2 markers on the horizon and scanning left to right then up and right to left and repeat 2-3 times. Then shift to the next sector. This is effective in scanning wider areas.
7. Radio discipline and how to use the radio. Business only on the radio. Pronounce words distinctly.

[26] FAA Flying Handbook, FAA H-8083-3B, Chapter 1 Collision Avoidance.

- Initiate each call with: who you are calling followed by who is transmitting (e.g., RPIC – VO 1)
- State the message or request succinctly – eliminate pauses and "uhs."[27]

8. Use terms like affirmative, negative, WILCO (meaning message received and I will comply), etc. Weather indicators must be recognized and conveyed to the RPIC such as:
    - Low clouds in the distance moving towards the operating area.
    - Visibility declining based on the visual marker set.
    - Significant downdrafts can be seen in fields with tall grass or crops; water and trees. When the surrounding areas are still and a portion of the areas is being blown; virga is occurring.
    - Blowing dust can be seen approaching.
    - Rain can be seen coming from the clouds.
9. Positioning of VOs is dependent on the flight path.
    - When the unmanned aircraft is to remain within VLOS of the RPIC, a VO is still required. The VO may be somewhat displaced from the RPIC but must have continuous communications with the RPIC.
    - When VOs are used to extend the range of the unmanned aircraft, the maximum distance the aircraft is visible must be overlapped:
        - Handoff procedures must be thoroughly briefed
        - Communications between the VOs and the RPIC must be immediately available at all times
        - Avoid use of cell phones – backup only (RPIC may only use cellphone in hands-free mode).
10. Emergency and contingency procedures for conditions like those outlined below, but not limited to:
    - Loss of visual contact – VO shall report immediately to RPIC.
    - Loss of aircraft control – RPIC shall report immediately to all VOs. If in a VO's sector, they will provide flight direction and altitude changes to RPIC.
    - Loss of GPS – RPIC shall report immediately to all VOs. VOs must be pre-briefed on anticipated UAV programmed response.
    - Collision – VOs shall report immediately to RPIC. All crew shall be briefed on and comply with mishap plan.
    - Battery low – RPIC shall report immediately to all VOs.
    - Lost link – RPIC shall report immediately to all VOs. VOs must be pre-briefed on anticipated UAV programmed response.
    - RPIC communications to all crew of changes, deviations, emergencies.
    - Visual contact not gained at hand-off.
    - Emergency deconfliction calls by VOs:
        - Traffic climb (or descend) immediately – Traffic, turn right 90 degrees immediately – Significant weather (type) reverse course immediately, etc.

[27] FAA Airman's Information Manual Section 2.

Appendix B

Example UAS Checklists

The checklists that follow are examples of UAS checklist that should be developed and used by each organization that operates a UAS.

Example Tier V sUAS Checklist

Date:	**Campaign:**	**Location:**	**Aircraft:**	**N Number:**
COA:	**Special Use Airspace:**	**Max Altitude**		

Personnel

RPIC		Part 107 Certificate current:		sUAS currency:	
RPIC		Part 107 Certificate current:		sUAS currency:	
RSO		Qualification current:			
VO		Training current:			
VO		Training current:			
VO		Training current:			
Maintenance Technician		Training current:			
PI					

Operations Checklist

	NOTAM filed and verified		Communication frequency	
	Special Use Air Space activated		UAS control frequency	
	Other required notifications			
			Fuel/battery checked	
			Radio checks	
	Frequency Management Plan		Controls checks	
	COA requirements review and met		Payload checked	
	Emergency equipment in place		Emergency procedure review	

	Maintenance review		Lost communication
	Weight and balance		Loss of control
	Aircraft preflight		Lost link
	Deconfliction Plan		Loss of GPS
	Crew brief time:		Loss of visual
	Crew debrief time:		Mishap Plan

Example Tier I-IV UAS Checklist

GENERAL

Date:	Squawk:
Aircraft:	RPIC:
N number:	VO(s):
Mission Altitude:	Mission Location:

CREW

Other:

Brief	Walk Down	Checklist	Takeoff	On Target	Crew Swap	Land
\	\	\	\			

DECONFLICTION:

Aircraft/Call Sign/Color	Time	Frequencies	Altitude

WEATHER:

Temperature:	Freezing Level:		**Forecast**
Dew Point:	Surface Winds:		Temperature:
Relative Hum:	Significant Wx:		Surface Winds:
Altimeter:	**Winds:**	3000:	Visibility:
Density Altitude:		6000:	Ceiling:
Visibility:		9000:	Significant Wx:
Ceiling:		12000:	

FLIGHT PLANNING **AIRCRAFT / AUTOPILOT**

Mission Objective	**Primary**		**Backup**	N/A
	Preflight	☐ Complete	Preflight	☐ Complete
Secondary Objective	W & B	☐ Complete	W & B	☐ Complete
	Payload 1:		Payload 1:	

Requested Airspace	Payload 2:		Payload 2:
	Empty Wt:		Empty:
NOTAMs / TFR's	Max Wt:		Max:
	Takeoff Wt :		Takeoff:
Restricted Airspace	Fuel:		Fuel:
	TO CG:	%	TO CG:
Bingo Fuel:	Zero CG:	%	Zero CG:

Aircraft / Ground Station Maintenance Performed Since Last Flight:

Aircraft Maintenance Issues (outstanding or current):

SAFETY

Alternate Landing Sites:	
MSL MIN: Terrain:	Line of Sight:
Control Changes:	
Wave-off Call:	
Sterile Cockpit:	Mission Checklist / Emergency's

EMERGENCY PROCEDURES

ENGINE FAILURE

PAYLOAD:
AIRSPEED:
NOSE CAMERA:
LANDING SITE:
LOST COMM FLIGHT PLAN:

ALTERNATOR FAILURE

PAYLOAD:
ENGINE:
NOSE CAMERA:

AIRSPEED/ ALTITUDE/ GYRO FAILURE

NOSE CAMERA:
PCB AUTOPILOT SWITCH:
DITCH POINT:
LOST COMM FLIGHT PLAN:

AUTOPILOT RESET

PCB AUTOPILOT SWITCH:
NOSE CAMERA:
AVIONICS/ FLIGHT/ ENGINE SYSTEMS:

MISSION DATA

T/O Time: _____	Crew Swap: _____	MC 1 Time: _____
Land Time: _____	Flight Time: _____	MC 2 Time: _____
Notes: _____	Static RPM 1: _____	Climb RPM: _____
	Static RPM 2: _____	Level RPM: _____

Appendix C

Example TBS Checklist

The checklist that follows provides an example of a TBS checklist that should be developed and used by each organization that operates a TBS. The example is specific to a unique winch and balloon and organization.

TBS Flight Checklist

Pilot In Command:	Balloon:	Date:
Crew Members:	Location:	
Winch:		

Authorization for flight in restricted airspace: (Required for flight in restricted airspace only, otherwise NA)

Authorized by:_____ **Title:**_____

A. Prior to preparation for flight

Important: Complete all check list items in the order they are presented. If you cannot check off an item **STOP!** and correct the problem before continuing.

No.	Item	Acceptable Condition	Sat.
1	Airspace	NOTAM posted online	
		Potential obstructions at and downwind of launch site identified	
2	Weather	1-min sustained wind from TBS shelter anemometer < 6 m/s for full-sized aerostat; < 11 m/s for helikite	
3	Handling Lines	Secured on trailer	
		Secured to balloon rings	
4	Apex Lines	Secured on trailer	
		Secured to balloon lines	
		Six screw-closure carabiners have been tightened with wrench	
		Main carabiner is locked	
5	Inflation	Confirmed correct for flight by PIC	
6	Leaks	None audible	
7	Hotwires	Adhered to balloon	
		Plugged into manual and GPS EDD	
8	EDD batteries	Fully-charged (Tenergy > 13V, Tracer = 5 LEDs lit)	
		Manual EDD plugged into power, GPS EDD not powered	
9	GPS transponder	Fully-charged Tracer battery (5 LEDs lit) plugged into transponder and green LED illuminated on transponder	
10	Diesel tank	>15 gallons fuel and valve is open	
11	Trailer	Hitch is locked to truck	
		Safety chains in place	
		Trailer brakes disengaged	
		Chocks removed	
12	Generator	Oil and coolant full	
13	Tires	Inflated to > 30 psi	
14	Winch	No visible leaks, wear, or damage	
15	Winch voltmeter	Voltage > 24V	

B. At Launch Site

No.	Item	Acceptable Condition	Sat.
1	Manual EDD	Tested for power up (orange LED illuminates and chime sounds)	
		Powered off	
		Placed on dashboard of command center vehicle	
2	GPS EDD	Plugged into battery with green LED illuminate.	
3	Helikite	Spar sections secured to each other and into sheath	
4	Trailer	Nose oriented into primary wind direction	
		Trailer wheels chocked	
		Trailer brakes engaged	
5	Handling lines	Ensure handling lines not tied to cleats underneath apex lines	
		Unlooped from cleats and free of impediments	
6	Apex lines	Cleanly coiled to prevent knotting upon launch	
		Not entangled with balloon rest arms, generator, or fuel tank	
		Main carabiner is locked and lines are seated in wide end of carabiner	
7	MOWs	All wearing climbing helmets with chin strap, safety glasses, gloves	
		Not standing on or entangled in handling lines	
		All understand assignments and are positioned for launch	
8	Weather	1-min sustained wind from TBS shelter anemometer < 6 m/s for full-sized aerostat; < 11 m/s for helikite	
READY FOR LAUNCH			
C. Upon launch			
No.	**Item**	**Acceptable Condition**	**Sat.**
1	Balloon	For aerostat: skirt billows away from balloon body if there is wind	
		For aerostat: skirt carabiner is in correct place vertically on the skirt line	
		For helikite: carabiner slides freely to neutral position on the apex strap and helikite does not oscillate on strap	
2	Generator & Battery Chargers	Generator starts and runs normally	
		Circuit breakers are turned on and red LEDs are illuminated	
		DC voltmeter for batteries on winch displays > 26 V	

READY FOR FLIGHT			
D. During flight			
No.	**Item**	**Acceptable Condition**	**Sat.**
1	Balloon	After ascending 150' lift is as expected and winch performs normally (no abnormal sounds or movements)	
2	Weather	Winds aloft < 12 m/s	
3	Payload	Attachments secure, 3 points of attachment for items > 5 lbs	
		RF link active (if applicable)	
4	Winch	DC voltmeter for batteries on winch displays > 26 V	
		No visible leaks, wear/damage; no unusual sounds	
E. Upon retrieval			
No.	**Item**	**Acceptable Condition**	**Sat.**
1	GPS EDD	Unplug from battery before leaving launch site	
2	Handling Lines	Secured on trailer	
3	Generator	Powered off and circuit breakers switched off	

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