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Unmanned Aircraft System (UAS)

Risk Assessment and Safety Manual

2025

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**Appendix 1: Risk Assessment Matrix**

# **Introduction**

### A good safety risk management process describes the systematic application of management policies, procedures and practices to the activities of communicating, consulting, establishing the context, and assessing, evaluating, treating, monitoring and reviewing risk of a program’s activities. This process is undertaken to provide assurances that the risks associated with the operation, in this case of unmanned aircraft systems (UAS), have been managed to acceptable levels. The risk management process and its outcomes form part of the documented safety that is necessary to obtain approvals for UAS operations while mitigating unnecessary risk to the operations. It also helps guide the development of an approved flight operations manual (FOM) and is a key component of the training program. The scope of this manual is limited to safety risks associated with the operation of UAS in the civil airspace system and over inhabited areas. There are many unique aspects associated with the application of the safety risk management process to UAS compared to that of conventionally piloted aircraft. Theis manual examines some solutions to these challenges, including those currently in practice.

# **Objective**

### The general overarching objective of this manual and the risk management process is to provide assurances that the safety of all UAS operations is of utmost consideration. One of the first steps is to define the particular risks associated with UAS applications. At the end of this manual many of the potential risks to UAS operations are detailed. These risks also need to be defined in relation to the expected benefits of the operation to the different stakeholders involved. For UAS operations, these risks can often be derived from the strategic objectives of the mission. As such, in addition to operating a UAS in the civil airspace, each primary operations should have a completed risk assessment matrix completed. A generic Risk Matrix is included here as a separate appendix. All risks should be clearly defined to ensure transparency in decision making to help identify potential risks and conflicts for any planned UAS operation.

# **Safety Assurance**

The Program’s dedication to safety should identified in the FOM, however further safety policies and principles are identified below to explain the responsibilities and authorities for operational safety.

* Safety is a vital duty and responsibility for every job function relating to operation.
* Even personnel without direct flight operations involvement contribute to hazard identifications at all levels of an organization and every person can have a positive impact on safety.
* Safety is always given the top priority, even above mission success.
* Every individual within the program’s operations will perform with concern for safety at all times.
* The PIC has exclusive and final authority for proceeding with any flight operation or test. The PIC may delegate some safety responsibility for flight termination to the accompanying VO or other crew members, however the PIC is ultimately responsible for the outcome of each mission.
* All PICs should understand the importance of listening to their other crew members and be encouraged to heed safety concerns from their crew.

Overall performance of the safety risk management program will have a direct result on the safety, efficiency, and performance of programmatic operations. The end result of the safety program will be to track the overall safety performance of UAS operations and encourage confidence in the way all UAS operations are being run.

To ensure that the program is functioning appropriately, hazards will be identified before they become incidents, and the operation will continue to focus on safety development rather than safety results. The following four major components exist to collect data beyond Flight Data Analytics.

**Inspections –** The program should conduct internal inspections to establish if the program is continuing to meet the needs of the organization and overall safety goals. At least once per year, the UAS Coordinator will conduct internal review of operational processes to include the following:

* Maintenance and inspections processes, checklists, airframe and component lists, ground control condition, parts and material control, documentation, and technical data management.
* Certification and qualification systems
* Training requirements and performance records
* Flight Operations data and documentation

**Audits –** Verifying compliance with the operations manual, standard operating procedures, and policies is vital to ensuring that the SMS program is functioning effectively. Audits are an integral component to the risk management program and must cover all aspects of operations, support, and infrastructure to ensure completeness.

The UAS Coordinator will ensure regularly scheduled audits will be performed at a minimum annually to examine the performance and effectiveness of risk mitigation strategies and controls. All audits must be conducted in an objective and unprejudiced manner, with auditors who are not assessing their own work, and with findings that are well documented, communicated, and archived for a minimum of five (5) years.

**Investigations –** Mishaps, incidents, accidents, and other events will be investigated as required in cooperation with authorities and in alignment with the program’s broader safety policies. Information gathered in the course of the investigation will populate briefings to further the interests of safety for all UAS operations.

Each safety investigation will be led by the UAS Coordinator and will include the following elements:

* Analysis focused on determining the “root cause” of the event
* An understanding that “human error” is not a root cause but reflects latent conditions that lead to an active error.
* An analytical and systematic approach to accident causation
* A detailed report of all findings that includes specific recommendations for reducing the effects or probability of the event occurring in the future

**Performance Monitoring, Data Analysis, Change Management** – Understanding safety impacts through monitored change, and data that reflects a need for change, is only helpful in an environment in which change can be managed**.** With any organizational, operational or procedural change, new hazards may arise and therefore a process for addressing those is extremely important.

A safe UAS program recognizes the need for positive change management and should create an outline with the following requirements:

* Identify any new hazards that may arise from any change, and assess that hazard for new risk to the operation
* Identify any need for new procedure, process, or checklist item that may mitigate that risk if the risk is deemed unacceptable
* Follow the FOM revision process in order to update the document with changes as needed
* Communicate all changes to program personnel to whom it may affect and provide listing of all changes in a regular safety briefing.

# **Accident/Incident Reporting**

The safety of those involved in any suspected incident or accident is the first priority. Response to any such incident or accident will include the coordination of emergency response and medical care if necessary. All members of the UAS team involved in flight operations should be familiar with the flight operations manual.

# **Aeronautical Decision Making**

Traditionally, the belief was that good decision making in aircraft flight operations came from experience rather than training and cannot be taught, however recent studies have shown that by using checklists and understanding how to interpret signals, better decisions can be made without long careers in aviation. This is vital knowledge for new and old pilots alike. Aeronautical decision making is a grounded in the following 6 steps identified by FAA the in Advisory Circular (AC) 60-22, re-iterated in the qualification for 14 C.F.R. 107 certification.

* Identifying personal attitudes hazardous to safe flight
* Learning behavior modification techniques
* Learning how to recognize and cope with stress
* Developing risk assessment skills
* Using all resources
* Evaluating the effectiveness of one’s skills

# **Crew Safety**

All personnel who regularly interact with the UAS during their work will complete a Safety Training class. Alternatively, on a case-by-case basis, the PIC or their designee can provide on-site safety training prior to any UAS operation(s) as needed. Employees are expected to question any unsafe condition or activity in and around the operating environment and will not initiate launch procedures for the UAS if they have any question or concerns about the safety of the crew, public, or the planned operation.

# **Crew Resource Management**

Crew Resource Management is fundamental to safe and effective flight in all aviation operations. It is the key to understanding the “total crew concept” underlying the core of all safety operations. Each crew member is trained to do their job, to demand that other crew members do theirs, with each monitoring the other, and giving assistance on demand or soliciting assistance, as necessary.

Any person can make a mistake or error, and no one is to be considered the master of all emergencies. Each crew member must continuously monitor all that goes on in relation to the aircraft; they must speak up when discomforted and advise when advice is needed regardless of title, experience, or seniority. Leaders understand that crew communication is what makes the mission success.

All crew members operate as a team, with the PIC responsible for team management. Crew members are not, however, required to comply with any procedure, technique, or other action that they believe is unauthorized or unsafe. If a crew member is uncomfortable with any directive, they must speak up in an effort to alleviate the discomfort for the sake of safety.

Studies have shown that a well-defined role structure reduces ambiguity and enhances each crew member’s performance. Each PIC must find and practice a balance between a command role that is too overbearing and one that is too passive. Balancing leadership and direction with acceptance and understanding is extremely difficult yet provides a crew the requisite elements for success.

# **Safety Risk Assessment**

When conducting a risk assessment, identify the present risks and look for ways to mitigate the hazards they create. Pre-flight familiarizations, inspections, and actions can be accomplished as part of an overall safety risk assessment. FAA encourages the PIC to complete the overall safety risk assessment as a method of compliance with the prohibition on operations over certain persons and the requirements to remain clear of other aircraft. Flight operations should be conducted at least 30 ft. from all nonparticipating persons, structures, vehicles, and vessels unless:

* Barriers, structures or setbacks are present that sufficiently protect nonparticipating persons from the UAS and/or debris in the event of a mishap. If a situation arises where nonparticipating persons leave such protection and are within 30 ft. of the aircraft, flight operations must be terminated immediately in a manner ensuring the safety of nonparticipating persons.
* The owner/controller of any structures, vehicles, and/or vessels has granted permission for operating closer to 30 ft. of those objects, and the operator has made a safety assessment of the risk of operating closer to those objects and determined that is does not present an undue hazard.

###

# **Risks Specific to UAS Operations**

### **Risk: Knowledge of the UAS Mission Parameters**

All phases of flight should be trained to, and all PICs will be considered current and “flight ready” for the following phases of flight according to the policies and procedures of the FOM. The specifics of these flight phases will be outlined and approved per the UAS being certified to and derived largely from manufacturer user manuals:

* On-Site Pre-Flight
* Launch of UAS
* Landing of UAS
* Post-Flight

### **Risk: Pre-Flight Planning & Authorizations**

The UAS Coordinator will receive all UAS operational requests via the service request form developed and maintained by management staff. They will then conduct an initial assessment to ensure the location and time requested complies with regulatory and airspace restrictions in accordance with the training manual.

The UAS Coordinator will assign the flight operation to an approved, current, and available pilot for the operation and notify them of any safety concerns identified in the assessment.

### The PIC will confirm that appropriate ATC airspace approval is obtained and a Drone Notice to Air Men (DNOTAM) is filed not later than 24 hours prior to the operation if deemed necessary (not required under 14 C.F.R. 107 regulations, but may be for higher risk environments and provide any other guidance to the assignment for the situation in the area (potential aircraft, ground traffic, site-hazards previously mentioned, monthly safety items that may be relevant).

# **Risk: Lost Link**

Any aircraft that fails to respond to positive control, due to any assumed condition, and does not respond within 30 seconds will be considered “Lost Link” and directed to land as soon as is safe. The direction to land will take place even if control is regained after that 30 seconds.

Lost Link can indicate high electromagnetic interference in the area and therefore must be well documented during flight debrief. While it alone is not an emergency condition, it often indicates the potential for signal degradation and should not be taken lightly. The Lost Link event should be documented and reported to the UAS Coordinator after the flight but does not need to be broadcasted on the local area frequency unless it becomes a Fly-Away event.

 The PIC may choose to land immediately at the UAS current position or return to the takeoff/landing position at their discretion and in the interest of safety. The PIC should consider all crew member communications in the decision to land or continue. All flight decisions should be made with safety as the main priority.

## **Risk: Unauthorized Airspace**

Basic aeronautical knowledge, as it pertains to all aviation, should be known including all airspace classifications. This knowledge will be acquired through the 14 C.F.R. 107 UAS Pilot Licensing Exam and preparation.

PICs should be able to explain what airspace they are permitted to operate in, under what regulation, exemption, or authorization and what may happen if they enter other types of airspace



### **Risk: Flight Restrictions**

Flights are restricted to Visual Line of Sight Operations only.

**Risk: Inclement Weather and the Environment**

It is important to consider the risk associated through the interaction of the UAS and its operational environment. Many of the hazards to aviation activities arising from the natural environment are common well known. For example, storms and bird strikes. The VO should be continuously looking for birds and other environmental factors that could impede the path of the UAS. In addition, if lightning is detected within 5 miles of the area of operation, the UAS should return to home and/or remain on the ground until at least 30 minutes after the last lightning strike. Similarly, the local weather should be monitored and any impending rainstorm or high winds within 5 miles of the area of operation shall cause the PIC to initiate a return to home or prevent take off.

### **Risk: Battery Loss of Life**

Lithium-ion (Li-ion) batteries are common in UASs. A lithium polymer battery, or more correctly lithium-ion polymer battery (abbreviated variously as LiPo, LIP, Li-poly, and others), is a rechargeable battery of lithium-ion technology in a pouch format. Unlike cylindrical and prismatic cells, LiPos come in a soft package or pouch, which makes them lighter but also less rigid. The difference between a lithium battery and a Li-ion battery is that most Li-ion batteries are rechargeable. Li-ion batteries can be dangerous under some conditions and can pose a safety hazard because they, unlike other rechargeable batteries, contain a flammable electrolyte and are kept pressurized. In 2013, at least four aircraft suffered electrical system problems stemming from Li-ion battery use, and in at least two instances the batteries started fires. Therefore, it is extremely important that all Li-ion batteries be handled in accordance with the manufacturer’s recommendations. Even when fires have not resulted from Li-ion battery use, Li-ion batteries have been known to show signs of battery fatigue, including overheating and bloating of the battery cells. Misused or faulty batteries can lead to inconsistent power supply to the system. The aircraft may also experience erratic flight, loss of control authority, or premature landing due to improper amperage or low voltage spikes.

A battery log will be maintained and enable the PIC to keep track of battery parameters to include voltage before and after the mission. All batteries should be maintained by following guidelines in the UAS operator’s manual. If a bad cell is detected, the battery will be replaced immediately.

### **Risk: Battery Transportation**

Most people are unaware that Li-ion batteries are dangerous goods that can pose a safety risk. Concerns are so great that there are in fact regulations for their safe transport, and the International Civil Aviation Organization (ICAO) Council Air Navigation Commission has even taken the extreme step of prohibiting Li-ion batteries as cargo on passenger aircraft. However, for the purposes of field use, Li-ion batteries can be transported in stainless steel or plastic battery boxes capable of containing any free liquid. The battery holder should be securely fastened, and the battery protected in such a manner as to prevent damage and short circuits. If possible, tape over the battery terminals and cables before transport.

# **Risk: Fly A Way**

This failure condition occurs when the UAS fails to respond to any control system commands and proceeds on a route unknown to the pilot. This failure condition creates significant risk to other aircraft and persons and is therefore considered a reportable event to all air traffic in the area and the UAS Coordinator. If VLOS is compromised during a Fly-Away condition (the UAS position is lost and cannot be reasonably deduced based on current flight conditions or dependable software) an emergency call will be given on the local FX broadcast.

In the event of a Fly-Away the following procedure should be followed:

* Switch to Direct Control or ATTI Mode.
* Check for control response and return to the recovery/landing area.
* Initiate Return to Land or Return to Home Function if control is not established.

The PIC is responsible for calling the control tower of any affected airport if control is not regained or if the flight is not terminated.

# **Risk: Loss of Payload**

Loss of payload control is not an emergency condition, but often indicates interference with signal from an unknown source. Loss of payload control can indicate signal degradation and the PIC should be notified by the VO and MPO (if one is in use) as control is degraded, latency between input and execution of commands increases, or otherwise the payload acts strangely. As the flight is focused on mission completion, the inability for payload operation negates the need for the mission to continue.

If at any point the payload becomes inoperable or difficult to control, the VO or MPO should communicate that loss to the PIC. The PIC should consider the mission unable to complete and begin return to launch/landing procedures. If payload control is regained, the mission may continue but the loss or degradation should be documented during the post-flight debrief.

**Risk: Tank Puncture or Leak**

The UAS operated typically consists of composite tanks made of polyethylene plastic. The structural properties of the tank(s) allow for a sturdy holding container and minimize the risk to punctures and chemical spillage resulting from regular operations. All chemical tanks, when not in use, should be triple rinsed and secured safely within the UAS support trailer for transportation

The use of a small UAS with a small capacity tank (3 gallons liquid and 30 pounds of dry product) reduces the risk created by a complete tank failure as compared to the failure of a large tank on a larger manned aircraft. The MPO should always carefully weigh/measure the amount of product being mixed/used and never over fill the tank beyond the “max fill” line.

**Risk: Malfunction of spraying equipment (nozzles, pumps, tubing) causes off target applications**

Teejet spray nozzles are a common and standard nozzle for agricultural spraying operations. Teejet manufactures nozzles for precision applications, irrigation lines, backpack sprayers, and other ground-based pesticide and fertilizer applications. The UAS will use multiple, flat fan pattern nozzles that produce a straight twelve foot wide swath when sprayed above a target area. TeeJet markets these nozzles for irrigation booms that are usually vehicle/tractor mounted. These nozzles have the capabilities to work with their precision spray systems which identify and spray targets as the vehicle moves along the ground. The quick-change nozzle set-up allows us to swap nozzles if the chemical mix, target composition, or environmental conditions dictates using different nozzles. Spill pads, clean up kits and all appropriate PPE, as identified, on the label should always be present should a hoe or nozzle leak occur.

# **Risk: Unexpected People in Flight Area**

All persons within 500’ radially from the operating environment will be appropriately identified and warned prior to the first flight in which they are present to develop their understanding of potential hazards with UAS operations. The warning will include operational information, privacy concerns, emergency procedures, smoking and cell phone policies, the use of fire extinguishers, communication procedures for interacting with the flight crew, safety protocols, and headset usage as is reasonable in the environment of operation.

Persons in the area do not need to receive a full briefing on subsequent flights during the day, but the Visual Observer or other non-PIC crew member will ensure that these persons understand and comply with all briefing directives.

The PIC will not take off until they have received verbal or visual confirmation that all persons in the operational environment are not at risk from launching the UAS. Likewise, the PIC will not land until they have received verbal or visual confirmation that all persons are not at risk from landing the UAS.

If unexpected people or vehicles on the ground enter the area of operation, all efforts will be made to avoid flying directly over or near those vehicles and/or people. If traffic increases to an unsafe level, the PIC will land the UAS as soon as it is considered safe and shall not launch again until the unexpected people leave the area. If they do not leave, the VO has the responsibility to engage with the community to ask them to move to a different location in the interest of safety. If they will not move, operations should be halted until alternate mission parameters can be determined.

## **Risk: Effects of Drugs and Alcohol on Crew Members**

It is extremely important that all persons involved in aviation activities, including all crew members regardless of their flight role, not be impaired in any manner. Therefore, no personnel shall not at any time be under the influence of any psychoactive substance that might in any way limit their ability to perform their duties in a safe and effective manner.

Flight performance can be seriously hampered by prescription and over the counter medication. The UAS Coordinator and all members of the flight team will be advised anytime such drugs are being taken. If it is determined that the medication being taken could hamper an operator, that member shall be prohibited from undertaking the mission until such time that the risk is no longer a factor.

Any member of the flight team who voluntary reports being unable to perform flight duties due to medication or illness will not be punished.

# **Risk: Public Awareness**

UAS crew members are ambassadors for their program, and the crew’s actions will affect other pilots and the industry in general. It is expected that all UAS crew members will always be courteous and polite. In addition, all staff will at all times conduct themselves in a professional manner, and wear approved uniform attire. If the flight plan requires the UAS to hover over or adjacent to private property, staff shall always attempt to notify and inform the nearby residents of the mission intent, duration, and scope.

**Appendix 1: Risk Assessment Matrix**