

**Drone Flight
Operations
& CRM**

5.1 Aeronautical Decision Making

5.2 Hazardous Attitudes

5.3 Crew Roles

FAA Requirements

- According to the FAA's UAS Airman Certification Standards, a Remote PIC should be able to demonstrate knowledge of:
- Aeronautical Decision-Making (ADM):
 - Effective team communication.
 - Task management.
- Hazard identification and risk assessment.
- Hazardous attitudes.
- Crew Resource Management (CRM).
Situational awareness.

Good Aeronautical Judgment

- Estimates suggest that about 80% of all aviation accidents are related to human factors.
- “Error Chain” Describes a series of judgmental errors leading to a human factors-related accident.
- Your job as the RPIC is to do everything possible to prevent Error Chain accidents.

5.1 Aeronautical Decision- Making

A systematic mental approach to consistently determine the best course of action in a given situation.

As the RPIC you will use a number of resources to safely operate your UAS: e.g. human resources (visual observers or other the person manipulating the controls), hardware, flight software, and other information.

RPIC uses ADM to mitigate risk factors associated with flight operations.

ADM Reduces Risk

- ADM provides a framework with the purpose of:
 1. Identifying Hazards
 2. Classifying the potential threat from those hazards.

What does AMD Involve and what are ADM Best Practices?

1. Conducting an attitude assessment before flight to identify where/when a hazardous attitudes might be present.
2. Learning to recognize and cope with stress.
 - Situations likely to increase stress include:
 - inexperienced crewmember(s)
 - interacting with the public officials
 - understanding new regulatory requirements
3. Using visual observers (VO), who are trained crewmembers in visual line-of-sight of the UAS and who assists the remote PIC with collision avoidance and complying with the rules of flight.
4. Completing a thorough preflight inspection,
5. Planning for weather
6. Familiarity with the airspace & project area
7. Proper aircraft loading,
8. Performance planning to mitigate identified risks.

Examples of ADM Best Practices

- Schedule flights to avoid possible conflict/overflights of people on the ground. e.g. around school schedules or other activities that take place on a regular schedule.
- Restrict people from area where the flight is to take place. e.g. Cordon off the project area and/or post VOs or other crew members at likely access points.
- Identify alternative landing sites in the event of an emergency or airspace conflict with other aircraft. There are times when it might be necessary to sacrifice your UAV to avoid endangering others. You need to be aware of this possibility and plan accordingly.

Assessing Risk

Risk mitigation involves:

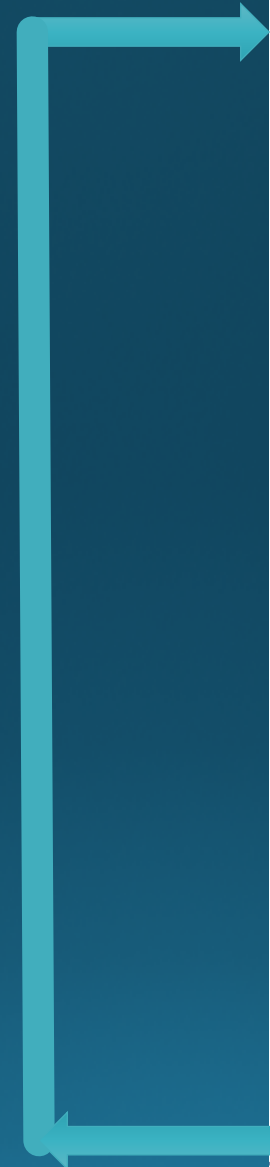
1. Considering the hazards of a given operation
2. Determining the risk severity, and
3. Developing a plan to lessen (or to mitigate) the risk to an acceptable level.

Risk Assessment involves considering **both**

1. The likelihood of an event happening
and
2. The severity of the situation

It may not be possible to eliminate all risk so it is necessary to assess what is "Acceptable Risk?"

Risk Assessment Workflow



Hazard Identification



Determine the Severity and Likelihood of the Hazard on the operation



Develop mitigations to reduce the risk identified.



Verify mitigations do not create new hazards to the operation

Acceptability of Risk

- The acceptability of risk can be evaluated using a risk matrix, that shows three levels of risk acceptability.

Risk Likelihood	Risk Severity				
	High				Low
More Less	Unacceptable	Unacceptable	Unacceptable	Acceptable with Mitigation	Acceptable
	Unacceptable	Unacceptable	Acceptable with Mitigation	Acceptable with Mitigation	Acceptable
	Unacceptable	Acceptable with Mitigation	Acceptable with Mitigation	Acceptable	Acceptable
	Acceptable with Mitigation	Acceptable with Mitigation	Acceptable	Acceptable	Acceptable
	Acceptable	Acceptable	Acceptable	Acceptable	Acceptable

Sample Severity & Likelihood Criteria

You may want to
revise this table
to better suit
your operations.

Severity of Consequences			Likelihood of Occurrence		
Severity Level	Definition	Value	Likelihood Level	Definition	Value
Catastrophic	Equipment destroyed, multiple deaths.	5	Frequent	Likely to occur many times	5
Hazardous	Large reduction in safety margins, physical distress, or a workload such that crewmembers cannot be relied upon to perform their tasks accurately or completely. Serious injury or death. Major equipment damage.	4	Occasional	Likely to occur sometimes	4
Major	Significant reduction in safety margins, reduction in the ability of crewmembers to cope with adverse operating conditions as a result of an increase in workload, or as result of conditions impairing their efficiency. Serious incident. Injury to persons.	3	Remote	Unlikely, but possible to occur	3
Minor	Nuisance. Operating limitations. Use of emergency procedures. Minor incident.	2	Improbable	Very unlikely to occur	2
Negligible	Little consequence.	1	Extremely Improbable	Almost inconceivable that the event will occur	1

Risk Acceptance

Risk Acceptance. In the development of risk assessment criteria, sUAS remote PICs are expected to:

- Develop risk acceptance procedures, including acceptance criteria and designation of authority and responsibility for risk management decision making.

Example Risk Matrix

Risk Likelihood		Risk Severity				
		Catastrophic A	Hazardous B	Major C	Minor D	Negligible E
Frequent	5	5A	5B	5C	5D	5E
Occasional	4	4A	4B	4C	4D	4E
Remote	3	3A	3B	3C	3D	3E
Improbable	2	2A	2B	2C	2D	2E
Extremely Improbable	1	1A	2B	2C	2D	2E

RED – Unacceptable Risk

YELLOW – Acceptable Risk with Appropriate Mitigation

GREEN – Acceptable Risk

Source: FAA AC 107-2 (Table A-2 - Example)

Mitigating Levels of Risk – Unacceptable Risk

- **Unacceptable (Red).** When the severity and the likelihood are both high, you fall into the red area.
- The risk should be assessed as **unacceptable**.
- In this situation, you should design an intervention to eliminate that associated hazard or to control the factors that lead to higher risk likelihood or severity.

Mitigating Levels of Risk – Acceptable Risk with Mitigation

- **Acceptable with Mitigation (Yellow).** Where the risk assessment falls into the yellow area, the risk may be accepted if you identify ways to mitigate, or lower, the risk.
- Example of this situation - Operations near school.
 - Scheduling the operation to take place when school is not in session to mitigate the likelihood of students being in the area of the project.
 - Another mitigation could be restricting people from the area of operations by placing cones or security personnel to prevent unauthorized access during the flight operation.

Mitigating Levels of Risk – Acceptable Risk

- **Acceptable (Green).** When the severity and the likelihood are both low, you fall into the green area.
- The objective in risk management should always be to reduce risk to as low as practicable regardless of whether or not the assessment indicates that it is already an acceptable level of risk.
- Anytime the RPIC becomes apprehensive for the safety of the operations, for any reason, they should request immediate assistance.

Reducing Risk - *root cause analysis*

- Risk analyses should concentrate not only on assigning levels of severity and likelihood, but on determining why these particular levels were selected.
- The first step in developing effective controls is to reduce risk to lower levels.
 - In many cases, simple brainstorming sessions among crewmembers is the most effective and affordable method of finding ways to reduce risk. This also has the advantage of involving people who will ultimately be required to implement the controls developed.

Procedure for Hazard ID and Risk Assessment

- Consider the hazards presented during the operation.
- Determine the risk severity.
- Develop a plan to lessen (or mitigate) the risk to an acceptable level.

Responsibility

- It is the responsibility of the RPIC, **and** all participating Crew Members to identify all potential hazards and risks **and** that you take all appropriate actions to reduce the risk to people and property.

Risk Management

- As noted above, it is not realistically possible to identify every possible risk.
- Therefore the Risk Assessment should focus on the hazards that pose the greatest risks.
- Once appropriate risk controls are developed and implemented, the operation can begin.

Crew Resource Management (CRM)

- CRM – is the process of managing all the resources that are available to the remote pilot-in-command (PIC) prior to, and during, flight. That includes resources both on board the aircraft and from outside sources.

Components of CRM

- **Communication Procedures.** One way to accomplish this is to have the VO maintain visual contact with the small UA and maintain awareness of the surrounding airspace, and then communicate flight status and any hazards to the remote PIC and the person manipulating the controls so that appropriate action can be taken. Then, as conditions change, the remote PIC should brief the crew on the changes and any needed adjustments to ensure a safe outcome of the operation.
- **Communication Methods.** The remote PIC, person manipulating the controls, and VO must work out a method of communication, such as hand-held radio, that would not create a distraction and allows them to understand each other. The remote PIC should evaluate which method is most appropriate for the operation and decide on it prior to flight.

Components of CRM

- **Task Management.** Task management is the process pilots use to manage the many concurrent tasks involved in safely flying an aircraft. Tasks vary depending on the complexity of the operation. Depending upon the area of the operations, additional crewmembers may be needed to safely operate. Enough crewmembers should be utilized to ensure no one on the team becomes overloaded. Once a member of the team becomes over-worked, there's a greater possibility of an incident/accident.
- **Other Resources.** Take advantage of information from a weather briefing, air traffic control (ATC), the FAA, local pilots, and landowners. Technology can aid in decision-making and improve situational awareness. Being able to collect the information from these resources and manage the information is key to situational awareness and could have a positive effect on your decision-making.

Situational Awareness

- Situational awareness describes the accurate perception and understanding of all the factors and conditions that affect safety before, during, and after flight.
- An extreme case of a pilot being over taxed, or “getting behind the aircraft” can lead to the operational pitfall of loss of situational awareness.

Sources for Hazards Identification, Risk Assessment & Hazardous Attitudes

- Additional Information is available from these documents.
- AC-107-2 small Unmanned Aircraft Systems (sUAS) Circular
- Pilot's Handbook of Aeronautical Knowledge

All of these documents are available for download on the course website.