DRONE LAUNCH academy

DRONE PILOT EXAM

STUDY GUIDE

Everything you need to know to pass the FAA's Unmanned Aircraft Knowledge Exam & receive your Remote Pilot Airman Certificate.

BY

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REMOTE PILOT CERTIFICATE

FAA Knowledge Exam Study Guide

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TERMS TO BE FAMILIAR WITH

Before we get started, there are a few terms that the reader needs to be familiar with in order to fully understand the material in this study guide. A selection of terms and acronyms are listed in layman's terms below for quick reference. These aren't intended to be the strict, textbook definitions. Just here for help and reference.

If you come across something in the material that you don't recognize, come back to this section and see if its listed here. If you think it would be helpful to add anything to this initial list, feel free to email me directly at david.young@dronelaunch.co. Thanks!

- **UA: Unmanned Aircraft**
    - An unmanned aircraft is exactly as it sounds – an aircraft that can fly without carrying any people on board, including the pilot. This generally encompasses all types of unmanned aircraft.
- **UAS: Unmanned Aircraft System**
    - Another name for UA. Although, this may mean the entire "system", to include all sensors and other systems aboard the aircraft.
- **sUAS: Small Unmanned Aircraft System**
    - Generally, this is a UAS that is larger than 0.55 lbs but is less than 55.00 lbs.
- **UAV: Unmanned Aerial Vehicle**
    - Another term for UAS
- **Drone**
    - Another term for UAS, although some consider this to be the less official "street" term for UAS.
- **VFR: Visual Flight Rules**
    - VFR is generally used in manned aircraft aviation to describe the type of operations or set of "rules" that a pilot is flying under. Visual flight rules mean that the pilot is primarily looking outside of the aircraft to avoid other aircraft and navigate the sky. He is flying "visually".
- **IFR: Instrument Flight Rules**
    - IFR, like VFR, is a set of rules that a pilot is operating the aircraft under. Under IFR, the pilot is flying primarily using his or her instruments, not by looking outside the aircraft. Under these instances, the aircraft must be on a pre-determined IFR flight plan with the FAA. The air traffic controllers are responsible for telling the pilot how high, how fast, and which direction to fly in order to not hit other aircraft.
- **FAA: Federal Aviation Administration**
    - The FAA is the government agency that regulates the airspace over the United States.
- **VLOS: Visual Line of Sight**
    - VLOS refers to being able to see something with your own eyes. This is generally in reference to being able to see your drone and its position at all times.
- **PIC: Pilot in Command**
    - The PIC is the final say and bears the final responsibility for safe flight operations.
- **NAS: National Airspace System**
    - The NAS generally refers to the airspace over the United States
- **VO: Visual Observer**
    - The VO assists the pilot of a drone in avoiding obstacles and other aircraft.

SECTION 1: REGULATIONS – GENERAL

Applicability of 14 CFR part 107 to sUAS Operations

- Part 107 applies to all civil small, unmanned aircraft in the National Air Space (NAS). However, Part 107 does NOT apply to the following:
  - Model Aircraft covered under part 191, subpart E
  - Operations outside of the United States
  - Amateur rockets
  - Moored balloons
  - Unmanned free balloons
  - Kites
  - Public aircraft operations
  - Air carrier operations

Falsification, Reproduction, or Alterations

The FAA doesn't like it when you lie and make stuff up on official requests and documents – bad idea. Part 107 states that the FAA can seek civil sanctions (aka – fine you and make you pay money) and/or suspend or revoke your license. None of these are good scenarios. From Advisory Circular 107:

> *"The FAA relies on information provided by owners and remote pilots of sUAS when it authorizes operations or when it has to make a compliance determination. Accordingly, the FAA may take appropriate action against an sUAS owner, operator, remote PIC, or anyone else who fraudulently or knowingly provides false records or reports, or otherwise reproduces or alters any records, reports, or other information for fraudulent purposes. Such action could include civil sanctions and the suspension or revocation of a certificate or waiver."*

Accident Reporting

Which Accidents Require a Report

- If you have the unfortunate experience of crashing your drone, you MAY have to report it to the FAA. If you crash your drone and the only damage is to your drone or associated equipment, you don't need to report anything. However, you DO need to report the accident in the following instances:
  - If the sUAS causes a **serious injury** or any **loss of consciousness**.
    - A serious injury is defined as a Level 3 or higher on the Abbreviated Injury Scale (AIS), which essentially means any injury that results in someone being hospitalized.
    - Any loss of consciousness must be reported regardless of hospitalization.
  - If the sUAS causes damage to property (NOT INCLUDING THE COST OF DAMAGE TO THE DRONE) that costs **at least $500 to either repair or replace**, whichever is lower.
    - Advisory Circular 107 gave this example:

> *A small UA damages a property whose fair market value is $200, and it would cost $600 to repair the damage. Because the fair market value is below $500, this accident is not required to be reported. Similarly, if the aircraft causes $200 worth of damage to property whose fair market value is $600, that accident is also not required to be reported because the repair cost is below $500.*

Timeline and Content Requirements for Report Filing

- Any reportable accident (as defined in the previous section) is required to be reported to the FAA within **10 calendar days** of the accident. Reports can be made to FAA Regional Operations Centers or local Flight Standards District Offices. Reports can also be made online at www.faa.gov/uas.
- The report must include the following information:
  1. UAS remote PIC's name and contact information;
  2. sUAS remote PIC's FAA airman certificate number;
  3. sUAS registration number issued to the aircraft, if required (FAA registration number);
  4. Location of the accident;
  5. Date of the accident;
  6. Time of the accident;
  7. Person(s) injured and extent of injury, if any or known;
  8. Property damaged and extent of damage, if any or known; and
  9. Description of what happened.

Inspection, Testing, and Demonstration of Compliance

- As a Remote PIC, owner, or person manipulating the flight controls, part 107.7 requires you to make the following items available for inspection at the request of the "Administrator":
  1. A remote pilot certificate with sUAS rating;
  2. Any other document, record, or report required to be kept by part 107 (e.g., sUAS registration information, etc.).
- Flight operation crewmembers must also allow the Administrator to conduct any test or inspection of the sUAS or flight crewmembers.

SECTION 2: REGULATIONS – OPERATING RULES

Registration Requirements for Small Unmanned Aircraft Systems

- All sUAS operated in the National Air Space are required to be registered with the FAA. The registration number must be affixed to the sUAS or may be stored within the sUAS, as long as no tools are required to retrieve the registration number upon inspection.

Operating Rules

- For the remote pilot knowledge exam, the FAA wants you to show competence in knowledge and risk management associated with the operating rules of 14 CFR Part 107. The following sections of Part 107 will likely come up in the test questions.

Conditions for Safe Operations

- Part 107 simply states that the **Remote PIC** must perform a preflight inspection to determine that the sUAS is safe for operation.
- If an unsafe condition arises during flight, the person operating the sUAS may not continue the flight. Hazardous conditions are explored further in the "Hazardous Conditions" section later in this study guide.

Medical Condition(s) That Would Interfere With Safe Operation

- No one is allowed to act as a flight crewmember (remote PIC, person manipulating the controls, or visual observer) if they know they have a physical or mental condition that would interfere with the safe operation of the sUAS.

Alcohol or Drugs

- You are not allowed to operate an sUAS or act as a crewmember under the following conditions (see 14 CFR Part 91.17):
  - You have consumed ANY alcohol within the last 8 hours;
  - You are under the influence of alcohol;
  - You are using any drug that affects you in a manner that would cause you to be unsafe in the operation of the sUAS; and/or
  - You have a blood alcohol level of 0.04 or greater.
- You are also generally not allowed to transport any type of drugs on the sUAS.

Responsibility and Authority of the Remote Pilot in Command

- The Remote PIC must be designated before the flight operation begins.
- The Remote PIC has the ultimate authority for the flight operations – to decide if the flight should be cancelled due to weather or other human factors such as fatigue or lack of fitness for flight operations.
  - The Remote PIC is responsible for making sure the sUAS will not pose an undue hazard to people, aircraft, or property in the event that there is a loss of control of the aircraft.
- The Remote PIC is responsible for maintaining compliance with all rules in part 107.
- If the Remote PIC is supervising another person who is manipulating the controls (i.e., flying the sUAS), the Remote PIC must be able to intervene immediately – either by being close by to take the controls or by having an additional set of controls that manipulate the UAV.

Regulatory Deviation and Reporting Requirements of In-flight Emergencies

Part 107.21:

- If you experience an in-flight emergency, you are allowed to deviate from the rules of Part 107 to ensure the safety of people and property.
- The regulations state that if you deviate from any of the Part 107 operating rules you MAY (upon request) have to send a written report to the FAA explaining what happened.

Hazardous Operations

Part 107.23:

- The FAA does not want you operating your sUAS in a "careless or reckless" manner. Part 107 specifically says that sUAS pilots are prohibited from doing so. The rules applying to sUAS (as opposed to manned aircraft) may be interpreted more strictly since sUAS operate in unique situations – often close to property or other people.
- The FAA guidance says, for example, that failing to consider unfavorable weather conditions in densely populated areas could be considered reckless operation.
- Dropping anything from an sUAS that would cause a hazard to those on the ground is also prohibited. Even if the item is soft, like a t-shirt, it is usually considered to cause a hazard if dropping it from the air into a crowd of people.

Operating from a moving aircraft or moving land- or water-borne vehicle

Part 107.25

- You are **only** allowed to operate your sUAS from a moving vehicle if you are flying it in a **sparsely** populated area.
  - Side note: you are not allowed to be the one driving the car if you are also the one flying the sUAS. This seems obvious, but stupid people are everywhere these days – so they wrote it down.
- You are **not** allowed to operate your sUAS from a moving vehicle if you are **transporting property for compensation**. I guess the FAA doesn't want you delivering a package by flying the sUAS in front of your

car all the way to the person's house. Although that sounds fun, it's not allowed. Also, this provision is **not** allowed to be waived.

- Under no circumstance are you allowed to operate your sUAS from another aircraft.

Daylight Operations

Part 107.29

- Under Part 107, UAS operations are only allowed during daylight hours. The FAA classifies "daylight hours" as morning civil twilight to evening civil twilight, which, said more simply just means daylight is 30 minutes before official sunrise to 30 minutes after official sunset.
    - For example, if the official sunrise time in your area is 7:30 am and the official sunset time is 8:00 pm, you would be allowed to operate your UAS from 7:00 am to 8:30 pm. Anything else would be considered outside of daylight hours.
- There is an important requirement to be aware of. If you are operating during either the morning or evening civil twilight times (in our example above, civil twilight would be 7:00 am to 7:30 am and 8:00 pm to 8:30 pm), your sUAS is required to be equipped with anti-collision lighting that is visible for 3 statute miles.

Visual Line of Sight

Part 107.31

- Part 107 requires that Visual Line of Sight (VLOS) must be maintained (with unaided vision) by the PIC or whoever is manipulating the controls at all times during flight operations. Plainly said, you must always be able to see your UAS with your own eyes. However, the rule does say that you are allowed to periodically and briefly break VLOS for operational necessities such as looking down at your control station to check battery power, scanning the airspace, and other situations deemed necessary by the Remote PIC.
- Also, the rule makes allowance for the UAS briefly going out of sight during the operation (other than the pilot "looking away", as in our examples above). The FAA gives examples such as if the UAS briefly goes behind a column of dense smoke during emergency response efforts or if the UAS briefly goes out of sight at the far end of a roof during an inspection. However, if the UAS DOES go out of sight, the Remote PIC must ensure that VLOS is reestablished **as soon as practicable** (a fancy way of saying, as soon as realistic/possible/feasible).
- The FAA wants you to know that even though the regulation allows for temporary gaps in VLOS, these gaps do **not** excuse the Remote PIC from his/her see-and-avoid responsibilities. So, even if you are temporarily behind a plume of smoke, you are still responsible to make sure that you do not collide with other aircraft or property.

Note on Unaided Vision

- Crewmembers are allowed to use eyeglasses or contact lenses when maintaining VLOS.
- Crewmembers are NOT allowed to meet the VLOS criteria by using binoculars, telescopes, etc. Crewmembers are allowed to use binoculars and other tools to help them avoid obstacles and other

aircraft, but if you can't see the sUAS with your naked eye (plus glasses/contacts), you aren't meeting the VLOS requirement.

Visual Observer

Part 107.33

- A visual observer (VO)may be used to enhance VLOS and help situational awareness during the flight operation. Please note that the use of VO does not relieve the Remote PIC, or person manipulating the controls, of the VLOS requirement. If a Remote PIC chooses to use a VO, the VO must be able to effectively communicate the following three things:
    1. The sUAS location, attitude, altitude, and direction of flight;
    2. The position of other aircraft or hazards in the airspace; and
    3. The determination that the sUAS does not endanger the life or property of another.
- Essentially, if you are a VO, you need to be able to tell whoever is flying the sUAS if they are about to crash into something.
- The FAA also notes that the person flying the sUAS and the VO have to work out a method of effective communication, such as radios or other device that allows them to communicate in a way that is not distracting to the operation of the sUAS.

Operating Multiple Unmanned Aircraft

Part 107.35

- You are not allowed to fly more than one sUAS at a time. Part 107.35 says this:

> *"A person may not operate or act as a remote pilot in command or visual observer in the operation of more than one unmanned aircraft at the same time."*

Carrying Hazardous Materials

Part 107.36:

- You are not allowed to carry any "hazardous materials" on or within your sUAS, as this is seen as high risk. Hazardous materials are further defined in 40 CFR Part 171.8

Right-of-Way and See-and-Avoid

Part 107.37

- The RPIC has the responsibility to give the right of way to ALL other aircraft and to see and avoid other aircraft as to prevent a collision. Unmanned Systems are at the bottom of the totem pole in the National Airspace System. If another aircraft is headed toward your sUAS, you are required to move your sUAS out of the way.

Operation Over People

- Part 107 prohibits flying an unmanned aircraft over people unless those people are **directly involved** in the operation of the aircraft, such as the Remote PIC, the visual observer, or the person manipulating the controls.
- However, you **are** allowed to fly directly over a person if they are under a structure that would protect them if the sUAS fell from the sky, such as a car or some other structure with a protective roof.

Airspace Authorization and Restrictions

- All unmanned aircraft are required to receive **prior** authorization before flying in controlled airspace (Class A, B, C, D, and E airspace – discussed later in the course). No notice or authorization is required to fly in uncontrolled airspace (Class G airspace).

Prohibited or Restricted Areas

- Prohibited and restricted areas are areas where flight operations are generally not allowed without prior consent of the agency controlling the airspace.
    - For instance, military bases and other sensitive areas may be considered prohibited or restricted, and thus unmanned aircraft would not be allowed to fly there without prior permission.

Flight Restrictions – Notices to Airmen (NOTAMs)

- Remote pilots are required to be familiar with Notices to Airmen (NOTAMs) and Temporary Flight Restrictions (TFRs).
- NOTAMs and TFRs warn pilots of potential hazards and notify pilots of sections of the airspace where flight operations are temporarily prohibited. Remote pilots should check all NOTAMs and TFRs for their planned flight area before each operation. These items are discussed in more detail later in the course.

Preflight Requirements and Procedures

- Before conducting each flight, the RPIC is responsible for conducting preflight procedures such as inspection of the aircraft, briefing of crewmembers, assessment of the operating environment, and other actions necessary for operations.

Assessment of Operating Environment

- Prior to each flight the Remote PIC must conduct an assessment of the operating environment. This assessment should include, but is not limited to:
    - Local weather conditions where the operations will be taking place;
    - Local airspace and any flight restrictions (including NOTAMs and TFRs);
    - The location of persons and property on the surface; and
    - Other ground hazards.

Crewmember Briefing

- Prior to each flight, the Remote PIC must brief all crewmembers aiding in the operation of the unmanned aircraft. Crewmembers should be briefed on at least the following items:
    - Operating conditions;
    - Emergency procedures;
    - Contingency procedures;
    - Roles and responsibilities of each person involved in the operation; and
    - Potential hazards.

Inspection of Equipment

- The RPIC is required to make the following assessments before flight:
    - Ensure that all control links between the unmanned aircraft and the ground station are functioning and working properly;
    - Ensure that there is enough power to fly the aircraft for the intended operational time; and
    - Ensure that any object attached to or carried by the unmanned aircraft does not negatively affect the flight characteristics or controllability of the aircraft.

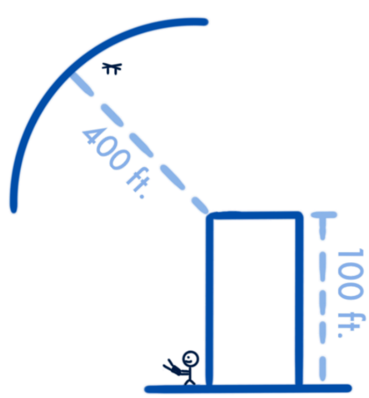
Operating Limitations

Speed Limit

- Unmanned aircraft are limited to 87 knots (roughly 100 mph), measured in ground speed.

Altitude Limit

- Unmanned aircraft are limited to a maximum of 400 feet AGL. However, if you are flying next to a building or structure, you can fly the sUAS within a 400 ft. radius of the structure.
- In the figure below, you will see that the building is 100 ft high, and the sUAS is flying within a 400 ft radius of the structure.



Visibility

- The visibility at the location of the control station must be at least 3 statute miles. To determine this, the Remote PIC should check local weather reporting stations and information sources (covered later in the course) and use the station or reporting location that is closest to the control station location.

Cloud Clearance

- Unmanned aircraft are not allowed to fly closer than 2,000 ft to the side of a cloud or 500 ft below a cloud.
    - [Note: pilots of manned VFR aircraft are also required not to fly closer than 500 *above* clouds, but since the remote pilot is required to maintain VLOS with the sUAS, and the altitude limit is 400 ft AGL, this rule isn't relevant.]
- These distance minimums are to help avoid collisions with other aircraft flying through clouds on IFR flight plans or approaches.

Model Aircraft Operations

- Model aircraft are covered under 14 CFR Part 101, and are not covered under part 107. Model aircraft are defined as unmanned aircraft that:
    1. Fly through the air;
    2. Are operated within visual line of site of the operator; and
    3. Are flown for recreational or hobby use only.

Public Aircraft Operations

- Part 107 does NOT apply to public aircraft operations.
- Public aircraft operations are generally defined as any flights by an aircraft owned by a governmental entity that is not for a commercial purpose.
    - For instance, emergency responders conducting search and rescue with an unmanned aircraft would be considered a public aircraft operation.

Requirements for Remote Pilot with sUAS Rating

Drug and Alcohol Offenses

- If a pilot or candidate violates any of the drug or alcohol policies described previously or if the pilot or candidate is convicted of any drug offensive, the FAA can (and likely will):
    - Deny any application for a remote pilot certificate for up to one year from the offense date; or
    - Suspend or revoke any currently existing remote pilot certificate.

Eligibility

- To be eligible to receive a remote pilots license, an applicant must:
    - Be 16 years old;

- Be able to read, write, and speak the English language (certain exceptions made for medical issues);
- Be in a physical and mental condition that will not interfere with the safe operation of an unmanned aircraft; and
- Pass the FAA knowledge exam for remote pilots (current Part 61 pilots need only to complete the online FAA Part 107 training course).

Temporary Certificate

- Upon successful completion of the FAA knowledge exam, and meeting the additional requirements above, a temporary remote pilot certificate will be issued and will be valid for **120 calendar days**. The candidate should receive a permanent certificate in the mail within the 120-day window.

Knowledge Recency

- To ensure that remote pilots don't lose the knowledge they gained while preparing for and taking the initial remote pilot knowledge exam, the FAA has required that remote pilots pass a recurrent knowledge exam that must be taken and passed every 24 months.
- The 24-month window begins immediately after each exam you pass (initial exam and subsequent recurrent exams).
    - For instance, if you take and pass your initial exam on April 1, 2017, you have until March 31, 2019 to take and pass the recurrent knowledge exam. If you decide to take (and pass) the exam on February 1, 2019, you have until January 31, 2021 to pass your next recurrent exam.

Waivers

- Remote pilots and organization may request a waiver from certain sections of Part 107. The waivable portions are:
    - Section 107.25: Operation from a moving vehicle or aircraft. However, no waiver of this provision will be issued to allow the carriage of property of another by aircraft for compensation or hire.
    - Section 107.29: Daylight operation.
    - Section 107.31: Visual line of sight aircraft operation. However, no waiver of this provision will be issued to allow the carriage of property of another by aircraft for compensation or hire.
    - Section 107.33: Visual observer.
    - Section 107.35: Operation of multiple small unmanned aircraft systems.
    - Section 107.37(a): Yielding the right of way.
    - Section 107.39: Operation over people.
    - Section 107.41: Operation in certain airspace.
    - Section 107.51: Operating limitations for small unmanned aircraft.

Considerations

- When submitting a waiver for consideration, you must show how you will be able to show the FAA how you can deviate from the regulations and still operate the unmanned aircraft in a safe manner. The complexity and risk level of the request should match the amount of supplemental information submitted.
    - For example, if you are asking the FAA to let you fly your unmanned aircraft at night going 200 mph through the streets of New York City, they are likely going to require much more documentation than if you were asking to fly multiple unmanned aircraft in the desert of Arizona.

SECTION 3: AIRSPACE CLASSIFICATION

General Airspace

- Controlled airspace generally refers to any airspace where Air Traffic Control (ATC) services are provided. The different types of controlled airspace are Class A, B, C, D, and E. Class G airspace is considered to be uncontrolled airspace, thus no ATC services are available in this airspace.
- Although traditional aircraft are only required to provide notice when flying into certain controlled airspaces (prior permission required for class B), UAS operators are required to obtain permission BEFORE operating in any controlled airspace (except for Class E).

Class A Airspace

- Class A Airspace is generally the airspace from 18,000 feet MSL up to and including 60,000 feet MSL (also referred to as "Flight Level" – or FL – 600). All flights in this airspace must be conducted under instrument flight rules.
- This area also extends out 12 NM from the coast of the contiguous 48 states and Alaska.

Class B Airspace

- Class B airspace is for BIG airports (think B for Big). This is the airspace around the busiest airports in the United States. The airspace is made up of several layers that get wider and wider as you get up in altitude. Generally, it is recommended to think of Class B airspace as an upside-down wedding cake (graphic below), although Class B airspace is generally customized for each airport to account for the flow of aircraft landing and taking off at the airport.
- Before entering Class B airspace, aircraft MUST receive prior ATC authorization. Manned aircraft are typically required to be equipped with a Mode-C (altitude reporting) transponder.
- **The typical ceiling for Class B airspace is 10,000 feet MSL (mean sea level, not above ground level) – remember this for the exam!**

Class C Airspace

- Class C airspace is for airports smaller than Class B but bigger than Class D, in terms of passenger air traffic. Class C airspace usually consists of two rings: a surface area and a shelf area. The center ring (or the surface area) usually extends from the surface to 4,000 feet above the airport and usually has a diameter of about 5 NM. The outer ring (or shelf area) usually starts at 1,200 feet AGL and goes up to 4,000 AGL. The shelf area usually has a diameter of 10 NM.
- Traditional manned aircraft are required to establish radio contact with the ATC tower before entering the airspace. UAS remote pilots are required to obtain a clearance before entering Class B airspace. Instructions for this process are consistently being updated and can be found on the FAA's website, faa.gov.
- **The typical ceiling for Class C airspace is 4,000 feet AGL (above ground level, not mean sea level) – remember this for the exam!**

- **Note: On a SECTIONAL chart, Class C airspace will be displayed in MSL (Not AGL). For example, If an airport was Class C at an elevation of 2000 feet MSL, the ceiling would be at 6000 feet MSL (4000 feet + 2000 feet). This would appear as 60 on the sectional chart.**

Class D Airspace

- Class D airspace is for airports smaller than Class B or C that still have a control tower. There is usually only one ring for this airspace, which extends up to 2,500 feet above the airport.
- As with Class B and C airspace, prior authorization is required before flying in class D airspace. Traditional aircraft are simply required to establish two-way radio communication with the tower before entering the airspace.
- **The typical ceiling for Class D airspace is 2,500 feet AGL (above ground level, not mean sea level) – remember this for the exam!**

Class E Airspace

- Class E Airspace is ANY controlled airspace that is NOT Class A, B, C, or D airspace. Class E airspace is frequently adjacent to other controlled airspace to allow for instrument procedures (IFR flights) in and out of airports.
    - Surrounding airports with instrument procedures, you will typically see Class E airspace either starting at 700 feet AGL or at the surface.
- The airspace from 14,500 feet MSL up to but not including 18,000 feet MSL is generally considered to be class E airspace (unless Class E begins at a lower altitude).
- In most cases, it is NOT required to obtain prior authorization before operating a UAS in Class E airspace.

Class G Airspace

- Class G airspace is uncontrolled, meaning that the FAA does not provide services in this airspace, nor do they provide any aircraft tracking or redirection. This is a free zone. As such, UAS operations are unrestricted.
- Prior authorization is NOT required before operating in Class G airspace.

Special Use Airspace

- Special Use Airspace is airspace where certain activates must be contained and/or areas where flight is not allowed. Special Use Airspace consists of:
    - Prohibited Areas;
    - Restricted Areas;
    - Warning Areas;
    - Military Operation Areas;
    - Alert Areas; and
    - Controlled Firing Areas (CFA).

Prohibited Areas

- Prohibited areas are areas where flying is not allowed. Think: over the White House and other sensitive areas. Prohibited areas on charts are marked by a "P" and number, such as P-41.

Restricted Areas

- Restricted areas are not entirely prohibited from the flight. However, generally only IFR flights are allowed in these areas and only during times when the restricted area is not in use by the controlling agency (generally this is referred to as the controlling agency "releasing" the airspace to the FAA). For instance, many restricted areas are controlled by the military and have artillery fire in the area.
- In short, only the FAA or the controlling agency can authorize flights through restricted areas, and generally flights are only authorized for IFR activities.
- A restricted area is noted on a sectional chart by an R and then a number, such as "R-4451."

Warning Areas

- Warning areas are similar to restricted areas in that it alerts pilots to potential in-flight hazards. However, the US government does not have sole jurisdiction over warning areas.
- Warning areas can begin as close as 12 NM from the US coastline and go outward. Warning areas are depicted by a W followed by numbers, such as "W–4153."

Military Operation Areas

- Military Operation Areas (MOAs) are just like the name says: areas where the military operates, such as a military training flight activity.
- The purpose of specially designating these areas is so that the FAA can keep civilian air traffic out of the way of military training activities. Civilian flight activities are not specifically prohibited in these areas, but since the kinds of operations being conducted in MOAs can cause serious hazards, it is advised to exercise extreme caution.
- MOAs are marked on sectional charts by name (e.g., Pine Crest MOA). More information such as specific altitudes of the areas and contact information of the controlling agency can usually be found on the back of the corresponding sectional chart.

Alert Areas

- Alert Areas are areas where unusual aerial activity is taking place, such as dense flight training activities, parachute jumping, and glider towing, among others.
- Alert Areas will be marked with an A followed by numbers, such as "A-65", and will usually describe the unusual activity to be aware of.

Controlled Firing Areas (CFA)

- Controlled Firing Areas (CFA) are areas that would normally pose a threat to aircraft entering the area during active operations. However, CFAs have radar or spotter aircraft that send alerts when it is detected that aircraft are approaching the area, and the dangerous activity is suspended until the area is again clear.

- Since air traffic does not have to be rerouted (due to the hazardous activity being temporarily suspended), these areas are not charted on sectional charts.

Other Airspace Areas

- Other Airspace Areas is the term used to describe most of the other remaining airspace. It includes:
    - Airport Advisory Services;
    - Military Training Routes (MTRs);
    - Temporary Flight Restrictions (TFRs);
    - Parachute Jump Operations;
    - Terminal Radar Service Areas (TRSAs);
    - National Security Areas (NSA); and
    - Federal Airways.

Airport Advisory Services

- Airport Advisory Services are generally available at airports that have a Flight Service Station (FSS) and are active when the tower to the airport is closed (or when at an airport with no tower). These services normally provide weather updates and airport information over a recorded broadcast on a specific frequency.

Military Training Routes (MTRs)

- Military Training Routes (MTRs) are routes established by the military for tactical flight training. Military aircraft are flown along these routes at speeds in excess of 250 kts.
- The important thing to remember here is that:
    - **Routes where ALL of the segments are below 1,500 feet AGL are designated by 4 numbers** (e.g., IR8376 and VR9371) - so there will be a lot of fast, low-altitude flying here.
    - **Routes with at least one segment ABOVE 1,500 feet AGL will have only 3 numbers** (e.g., VR392 and IR849).

Temporary Flight Restrictions (TFRs)

- A Temporary Flight Restriction (TFR) is, as it sounds, a temporary restriction of flight activity in a particular portion of airspace. TFRs are issued through Notices To Airmen (NOTAMs) and begin with the phrase "FLIGHT RESTRICTION."
- TFRs are issued in a variety of situations, to include: if the President or Vice President is in a particular area, if there is an event or incident that would cause air congestion due to "sight-seeing" air traffic, over disaster relief areas, and other instances where flight operations need to be restricted to protect those in the air and on the ground.
- To check to see if there are TFRs applicable to your proposed flight area, visit www.tfr.faa.gov.

Parachute Jump Operations

- Parachute jump aircraft operations are published in the Airport/Facility Directory (A/FD) – recently renamed as the Chart Supplements (CS). Sites that are used frequently are depicted on sectional charts.
- UAS pilots should be particularly cautious in these areas, as parachute operations involve persons being fully exposed in the air. If a parachute jumper collided with a UAS, it could cause serious injury or death to the jumper. Extra vigilance is required in these areas.

Terminal Radar Service Areas (TRSAs)

- Terminal Radar Service Areas (TRSAs) are extra radar services that can be found around some Class D airports. The purpose of TRSAs is to provide separation of IFR and VFR air traffic (i.e., make sure they don't hit each other). Participating in the TRSA service is not required for pilots of traditional aircraft, but is recommended. The portion of TRSAs that are not contained within Class D airspace generally fall within Class E airspace.
- As of this writing, TRSAs have no direct impact on UAS operations, as prior authorization is already required to operate within controlled Class D or E airspace.

National Security Areas (NSA)

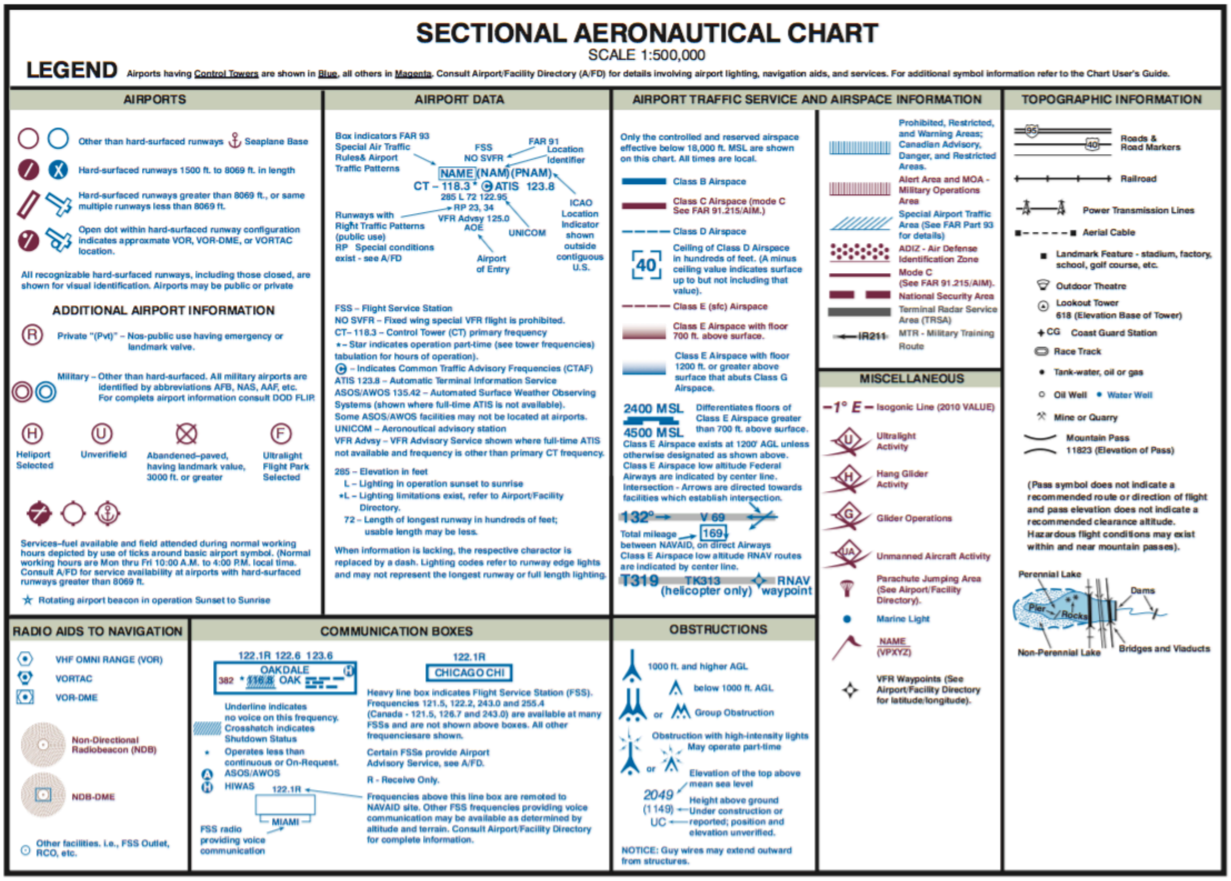
- National Security Areas (NSAs) are designated in areas where increased security is required to protect ground facilities. Pilots are requested not to fly in NSAs, although compliance is voluntary. Occasionally, NSAs will temporarily become Prohibited Areas (remember – this means you CANNOT fly in the area). If an NSA becomes a Prohibited Area, it will be issued via a NOTAM.

Federal Airways

- Federal Airways (sometimes referred to as "Victor Airways") are marked on the sectional charts by faded blue lines. You can think of Federal Airways as highways in the sky. These airways connect various navigation points.
- **Federal Airways begin at 1,200 feet AGL (remember for exam)** and extend up to 18,000 feet MSL. These are considered to be Class E airspace.
- UAS pilots should exercise caution when flying UASs around Federal Airways, since there will be an increased level of air traffic in these areas.

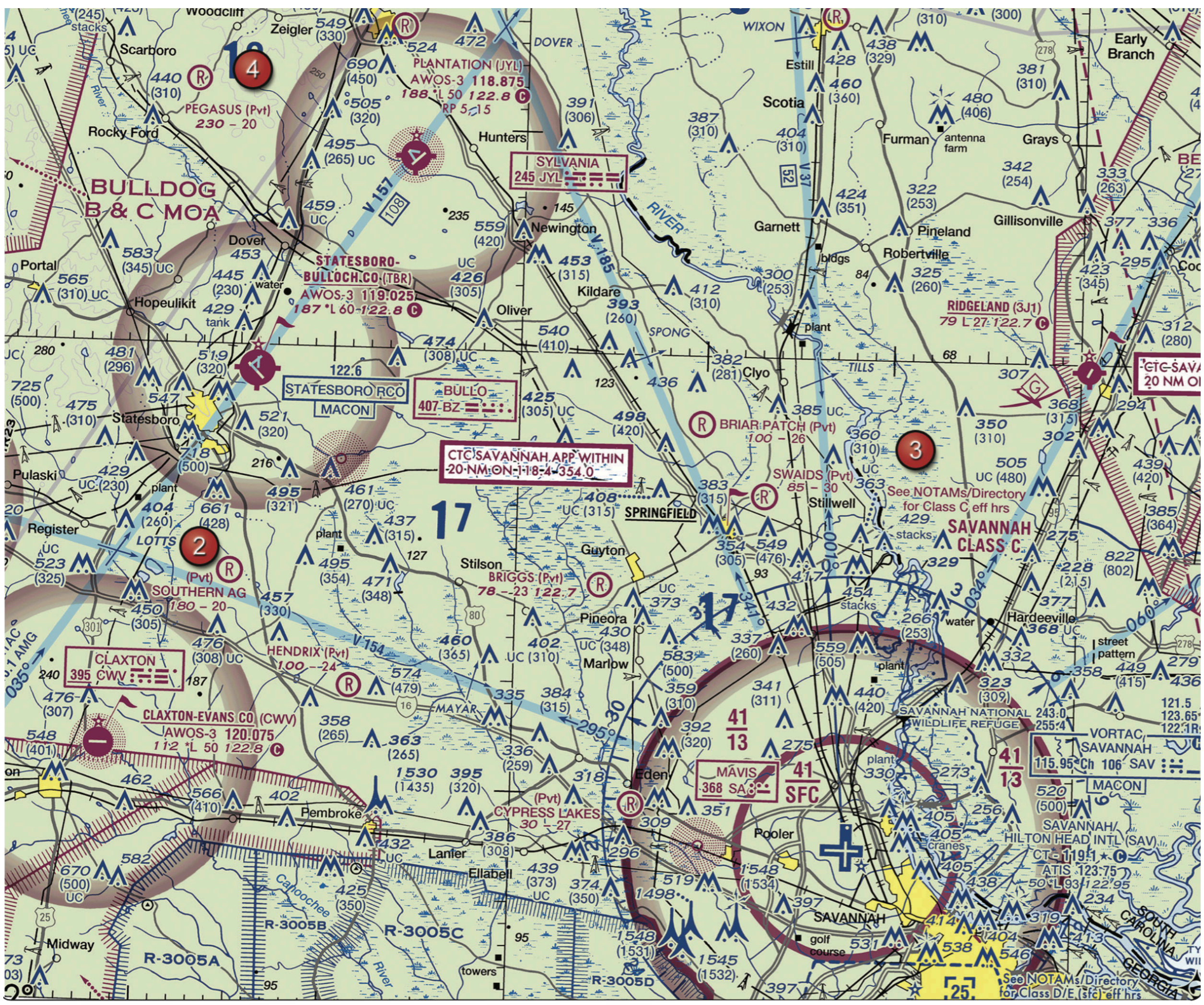
Reading Sectional Charts

- One of the key skills of operating an aircraft safely in the National Airspace System is being able to read and interpret a sectional chart.
- The charts explained below are taken directly from the FAA's supplemental testing materials.
- Within your supplemental testing materials, you should receive a legend to the sectional charts. This will help you interpret symbols and other markings on the chart. A copy of the legend is below.



- The obstructions section is very important to note for sUAS operations (see the center of the bottom of the legend above). Due to low altitude operations, these noted obstructions will often pose one of the biggest hazards to safe flight operations of the sUAS.
- Obstructions are noted in several ways depending on the height and lighting of the obstruction.
  - A single triangle (looks like a mountain peak) means there is an obstruction with a maximum altitude of 1,000 feet AGL.
  - Multiple triangles (or mountain peaks) are used to denote groups of obstruction with maximum altitudes of less than 1,000 feet AGL.
  - Obstructions with maximum altitudes of 1,000 feet or higher are marked with a three-pronged symbol that resembles the Eiffel Tower.
  - If the upward-facing prong is doubled, that means there are a group of obstructions that are above 1,000 feet AGL.
  - If any of the obstructions have lighting, the symbols will have small electrical bolts circling the top of the symbol.
- The altitude of the associated obstruction will be reported in mean sea level next to the obstruction on the sectional chart.
  - The above ground level altitude will be in parentheses directly below the mean sea level altitude.

- The chart below is one of the samples found on the FAA exam. Let's walk through a few pertinent items on this chart.
- Class C Airspace
    - At the bottom right corner of the chart (close to area 3), we can find the Savannah Class C airspace. This is evidenced by the SOLID MAROON LINES around the airfield. The runways are depicted by blue rectangles.
    - We see that the inner ring of the Class C airspace begins at the surface and goes up to 4,100 feet. The outer ring of the airspace begins at 1,300 feet AGL and extends up to 4,100 feet AGL.
    - Another item to note: just above the Savannah Class C label, we see a note that says to see the NOTAMS/Directory for Class C eff hours. This likely means that the tower is only open for a specified period during the day. When the tower is closed, the area defaults to Class E airspace (as indicated by the SHADDED MARRON ring, just inside the bold Class C outer ring).
    - The communication information for the Class C airspace can be found in blue text, just to the east of the airport symbol.
- Also note the restricted areas to the west of the airport (blue solid line with dashed blue inner spokes) and the military operations areas (maroon solid line with dashed maroon inner spokes) at the top left, top right, and bottom left of the chart.



- The chart below depicts Dallas/Ft Worth Intl airport (DFW), another excerpt from the supplemental materials that will be utilized during the actual exam.
- Class B Airspace
    - The airspace surrounding DFW is primarily Class B airspace, as evidenced by the solid blue lines extending out around the perimeter. We can see that the inner ring goes from the surface up to 11,000 feet. The areas extending out from there all start and stop at different levels that should be carefully noted within each section (remember, the altitude start and stop looks like a fraction).
- Class D Airspace
    - Underneath the DFW Class B airspace, we can find several Class D airports. Area 2 on the chart depicts Addison airport (ADS), which is a Class D airport, evidenced by the dashed blue line surrounding the airfield. The ceiling of the Class D airspace is noted by a dashed blue box containing the number "-30", which means up to but not including 3,000 feet. The Class D airspace does not include 3,000 feet because if we look directly to the east of the airport, we can see that the DFW Class B airspace BEGINS at 3,000 feet and extends up to 11,000 feet.

SECTION 4: AIRSPACE AND OPERATING REQUIREMENTS

Basic Weather Minimiums

- The FAA requires that the weather be at least a certain quality in order to conduct drone operations.
  - Visibility: you must be able to see at least 3 statute miles in a horizontal distance from the control station.
  - Distance from clouds: you must stay at least 500 feet below any cloud and at least 2,000 feet to the side of any cloud. For instance,
    - If the cloud ceiling is at 700 feet above ground level, you would not be able to fly your drone higher than 200 feet above ground level; and
    - If there are scattered low clouds in the area, you would not be allowed to fly an unmanned aircraft within 2,000 feet of the side of the cloud.

Concepts Relating to ATC Clearances and Permissions

- Operations within Class B, C, D airspace, or within the lateral boundaries of the surface area of Class E airspace designated for an airport are NOT allowed unless that person has prior authorization from ATC.
- Authorization must be requested through the FAA's website at faa.gov/uas.
- The sUAS Remote PIC must understand airspace classifications and requirements.
- The FAA has authority to approve or deny aircraft operations based on traffic density, controller workload, communications issues, or any other type of operations that could potentially impact the safe flow of air traffic in the airspace.

Operations Near Airports

- When operating in the vicinity of an airport, the Remote PIC must be aware of all traffic patterns and approach corridors to runways and landing areas.
- The remote PIC must avoid operating anywhere that the presence of the sUAS may interfere with operations at the airport, such as approach corridors, taxiways, runways, or helipads. The Remote PIC must also yield right-of-way to all other aircraft, including aircraft operating on the surface of the airport.
- Remote PICs should avoid operating in the traffic pattern or published approach corridors used by manned aircraft. When operational necessity requires the Remote PIC to operate at an airport in uncontrolled airspace, the Remote PIC should operate the sUAS in such a way that the manned aircraft pilot does not need to alter his or her flight path in the traffic pattern or on a published instrument approach in order to avoid a potential collision.

Potential Flight Hazards

Common Aircraft Accident Causal Factors

- The most frequent cause factors for aircraft accidents that involve the Remote PIC are:
  1. Inadequate preflight preparation and/or planning;
  2. Failure to obtain and/or maintain flying speed;
  3. Failure to maintain direction control;

4. Improper level-off;
5. Failure to see and avoid objects or obstructions;
6. Mismanagement of fuel;
7. Improper inflight decisions or planning;
8. Misjudgment of distance and speed;
9. Selection of unsuitable terrain; and/or
10. Improper operation of flight controls.

Flight Beneath Unmanned Balloons

- Most unmanned free balloons have a suspension device, a wire or something similar, to which payload or equipment is attached. This wire is often invisible or very difficult to see.
- Avoiding flight underneath an unmanned balloon will ensure that the unmanned aircraft will not become entangled in any wire or other hazard.
- Pilots are urged to report any unmanned balloon sightings to the nearest FAA ground facility.

Emergency Airborne Inspection of Other Aircraft

- An unmanned aircraft may occasionally be called upon to inspect other aircraft while both are in flight, particularly during an in-flight emergency. This is likely to result in the unmanned aircraft and manned (or other unmanned) aircraft being in close proximity while in flight.
- Some of the safety considerations during these situations are:
    - Area, direction, and speed of the intercept (intercept relating to the aircraft coming together for inspection);
    - Aerodynamic effects (i.e., rotorcraft downwash);
    - Minimum safe separation distances;
    - Communications requirements, lost communications procedures, coordination with ATC;
    - Suitability of diverting the distressed aircraft to the nearest safe airport; and

  - Emergency actions to terminate the intercept.
- The pilot in command of the aircraft experiencing the problem/emergency must not relinquish control of the situation or jeopardize the safety of their aircraft.

Precipitation Static

- Precipitation static (P-static) is frequently encountered when any solid or liquid particles, such as rain, snow, fog, sleet, hail, ash, etc., comes into contact with the aircraft. If these particles are uncharged, the negative portion of the particle can adhere to the skin of the aircraft and cause issues with communications and instrument function.
- Common symptoms of P-static include:
  - Complete loss of VHF communications;
  - Erroneous magnetic compass readings (30% in error);
  - High pitched squeal on radio;
  - Motor boat sound on radio;
  - Loss of all avionics when in clouds;
  - Navigation system inoperative;
  - Erratic instrument readouts; and
  - Weak transmissions and poor receptivity of radios.
- The solution to this problem is to have adequate static dischargers equipped on the aircraft. These dischargers take the negative charge from the skin of the aircraft and effectively discharge the current into the atmosphere.

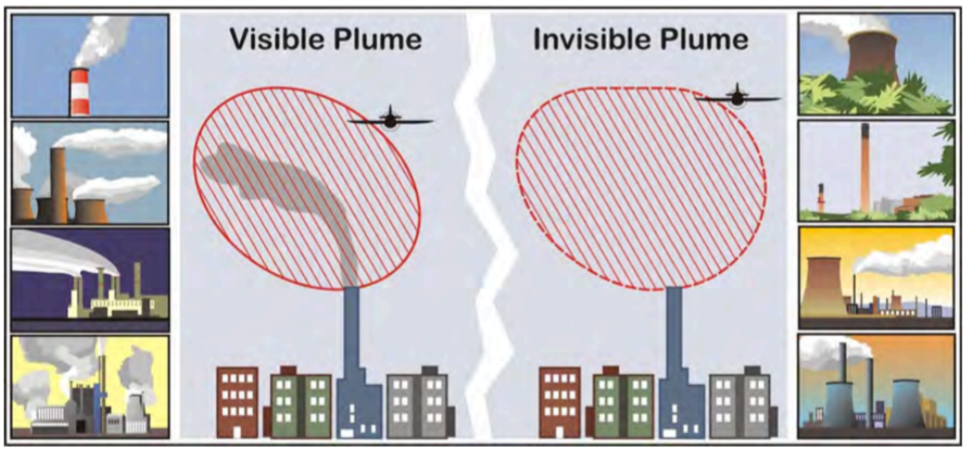
Laser Operations and Reporting Illumination of Aircraft

- Lasers (in the form of outdoor laser shows for special events or even an individual with a single laser) may negatively impact aviation operations. FAA regulations prohibit the disruption of aviation activity by any person on the ground or in the air, to include disruptions from lasers.
- Lasers are able to create temporary vision impairment miles from the actual location and can cause permanent eye damage.
- Pilots should avoid areas where lasers demonstrations or activities are taking place
- Pilots should report laser illumination activity to the FAA with the following information:
  - Date and time of event;
  - Aircraft registration number;
  - Type of aircraft;
  - Nearest major city;
  - Altitude;
  - Location of laser event; and
  - Brief description of event.
- When the FAA is notified about laser events, NOTAMs are issued. Pilots should consult NOTAMs to receive updated information about possible laser activities.

Thermal Plumes

- Thermal plumes are visible or invisible emissions from power plants, industrial production facilities, or other industrial systems that release large amounts of vertically directed unstable gases. High temperature exhaust plumes may cause significant air disturbances such as turbulence and vertical shear.
- Potential hazards with flying in and around thermal plumes include:
  - Reduced visibility;
  - Engine contamination;
  - Exposure to gaseous oxides; and
  - Icing.
- Given that a plume can be both visible and invisible, it is advised to always treat exhaust stacks as if a thermal plume is present and to remain clear of the area around the exhaust stack.
- Try to fly upwind of the possible thermal plume in order to avoid any contact with the exhaust.

Plumes



Flying in the Wire Environment

- The wire environment refers to the low altitudes at which sUAS, helicopters, and other aircraft, such as cropdusters, fly, named after the many types of wires that present a hazard at this altitude range: powerlines, guy wires extending from radio towers, wires extending from construction sites, among others.
- Unmanned aircraft pilots should be particularly vigilant in respects to flying in the wire environment, as flying into wires and similar obstacles is a leading cause in sUAS accidents.
- Pilots should be sure to consult sectional charts, TFRs, and NOTAMs to locate and be aware of any wire-related hazards in their proposed area of operation.

Temporary Flight Restrictions (TFRs) Airspace and NOTAMs System

- Certain temporary flight restrictions (http://tfr.faa.gov/tfr2/list.html) may be imposed by way of a NOTAM (https://pilotweb.nas.faa.gov/PilotWeb/). Therefore, it is necessary for the sUAS Remote PIC to check for NOTAMs before each flight to determine if there are any applicable airspace restrictions.

SECTION 5: WEATHER – SOURCES OF WEATHER

Internet Weather Briefing and Available Sources

- Obtaining a weather briefing prior to flight is essential to conduction safe flight operations. There are a number of resources online that provide relevant weather data to pilots.
- One source of internet weather that the FAA frequently references is www.1800wxbrief.com. This website contains many if not all of the reports described further in this section.
- Other internet sources of weather that may be useful are:
  - www.aviaitonweather.gov
  - www.wunderground.com/Aviation/
  - www.weather.com

Aviation Routine Weather Reports (METAR)

- A METAR is a standard weather report that tells the pilot about the conditions observed from the ground from a particular area. Typically, these weather observation stations are located at airfields. METAR reports come in a standard text format that can be read (or decoded) to determine the current weather conditions.
- A standard METAR report looks like this:

> *METAR KGGG 161753Z AUTO 14021G26 3/4SM +TSRA BR BKN008 OVC012CB 18/17 A2970 RMK PRESFR*

- Each group of text means something different. METAR reports can be read as follows:
  1. Report Type: The first group of text tells you what the type of report is. There are two types of METARs, routine and special. Routine METAR reports are issued every hour and begin with "METAR". Special METAR reports are issued as needed for rapidly changing weather and begin with "SPECI".
  2. Station Identifier: Next is the station identifier – where the report is coming from. In this case it is "KGGG," which represents Gregg County Airport. In the United States, station identifiers always begin with the letter "K" (except for Alaska – "PA" – and Hawaii – "PH").
  3. Date and Time of Report: The next character grouping represents the date and time of the report. METARs are always reported in Zulu time. The first two digits, "16," indicate that this report was issued on the 16^{th} day of the month. The next four digits, "1753," indicate that this report was issued at 17:53 (or 5:53 pm) Zulu.
  4. Modifier: The next section lists a modifier. This will often say "AUTO," representing that the report came from an automated source. If this section has "COR," this means the report is a corrected report.
  5. Wind: The next section gives information about the wind. The first three digits, "140," indicate that the wind is blowing from a heading of 140 degrees (southwest). The next two digits, "21," indicate the wind speed is 21 knots. If there are gusts, a "G" will be listed, with the gust speed following. In this instance the station is reporting gusts of 26 knots. If the wind is variable, the wind section will read "VRB."

6. Visibility: The next section indicates the visibility at the station, measured in statute miles. In this instance, visibility of ¾ of a mile is being reported.
7. Weather: The following section reports the status of weather phenomena in the area. The section can be made up of five pieces (a-e below). See the table below for the full set of abbreviations.
    a. Intensity/Proximity (light, heavy, in the vicinity, etc.);
    b. Descriptor (freezing, blowing, showers, etc.);
    c. Precipitation (rain, snow, etc.);
    d. Obscuration (fog, smoke, mist, etc.); and
    e. Other (dust storm, tornado, etc.).
8. Sky conditions: The following section shows the sky conditions directly over the reporting facility. Each layer of cloud cover will be listed in amount, height (always add two zeros to the end), and type (if applicable). So the above example would read: a broken layer of clouds at 800 ft. AGL and an overcast layer of cumulonimbus clouds at 1,200 ft. AGL. [Note: "ceilings" are considered to be anything broken or above, and are measured at AGL altitude.] See chart below for full abbreviation list.
9. Temperature and Dew Point: The next section indicates a surface temperature of 18 degrees Celsius and a dew point of 17 degrees Celsius. Temperatures are always given in Celsius. If a temperature is negative, it will be noted with an "M" before it.
10. Altimeter setting: The next set of characters reports the altimeter setting at the airport. This is typically for manned aircraft that have altimeters that function by reading the pressure of the atmosphere. As you climb in altitude, the pressure tends to decrease. Altimeter settings are measured in inches of mercury. The altimeter setting in the example above is 29.70 inches of mercury, or an altimeter setting of 2970.
11. Remarks: The last section lists anything that does not fit into the other categories. In the above example, PRESFR indicates that the pressure is falling rapidly. Another example of remarks would be OCNL LTGICCG, which means occasional lighting inter-cloud and from cloud to ground.

Qualifier		Weather Phenomena		
Intensity or Proximity 1	Descriptor 2	Precipitation 3	Obscuration 4	Other 5
– Light	**MI** Shallow	**DZ** Drizzle	**BR** Mist	**PO** Dust/sand whirls
Moderate (no qualifier)	**BC** Patches	**RA** Rain	**FG** Fog	**SQ** Squalls
+ Heavy	**DR** Low drifting	**SN** Snow	**FU** Smoke	**FC** Funnel cloud
VC in the vicinity	**BL** Blowing	**SG** Snow grains	**DU** Dust	**+FC** Tornado or waterspout
	SH Showers	**IC** Ice crystals (diamond dust)	**SA** Sand	**SS** Sandstorm
	TS Thunderstorms	**PL** Ice pellets	**HZ** Haze	**DS** Dust storm
	FZ Freezing	**GR** Hail	**PY** Spray	
	PR Partial	**GS** Small hail or snow pellets	**VA** Volcanic ash	
		UP *Unknown precipitation		

The weather groups are constructed by considering columns 1–5 in this table in sequence:
intensity, followed by descriptor, followed by weather phenomena (e.g., heavy rain showers(s) is coded as +SHRA).
* Automated stations only

Sky Cover	Contraction
Less than ⅛ (Clear)	SKC, CLR, FEW
⅛-²⁄₈ (Few)	FEW
⅜-⁴⁄₈ (Scattered)	SCT
⅝-⅞ (Broken)	BKN
⁸⁄₈ or (Overcast)	OVC

Terminal Aerodrome Forecasts

- Think of Terminal Aerodrome Forecasts (TAFs) as the forecasted version of a METAR. TAFs are meant to be a forecast for the area within a 5 statute mile radius of the airport.
- The abbreviations are the same as the METAR report in the last section. TAFs are issued every 6 hours (4 times per day), and valid for up to 30 hours.
- Here are two TAF examples that come from the FAA exam supplements:

TAF	
KMEM	121720Z 1218/1324 20012KT 5SM HZ BKN030 PROB40 2022 1SM TSRA OVC008CB FM2200 33015G20KT P6SM BKN015 OVC025 PROB40 2202 3SM SHRA FM0200 35012KT OVC008 PROB40 0205 2SM-RASN BECMG 0608 02008KT BKN012 BECMG 1310/1312 00000KT 3SM BR SKC TEMPO 1212/1214 1/2SM FG FM131600 VRB06KT P6SM SKC=
KOKC	051130Z 0512/0618 14008KT 5SM BR BKN030 TEMPO 0513/0516 1 1/2SM BR FM051600 18010KT P6SM SKC BECMG 0522/0524 20013G20KT 4SM SHRA OVC020 PROB40 0600/0606 2SM TSRA OVC008CB BECMG 0606/0608 21015KT P6SM SCT040=

- TAFs can be read in the following sequential order:

1. Type of Report: Routine TAFs will simply say "TAF". Amended TAFs will say "TAF AMD."
2. Station Identifier: This is the same as the METAR report. This tells you which airport/station the report is for. The examples above list KMEM – Memphis Intl Airport and KOKC – Will Rogers World Airport in Oklahoma City.
3. Date and Time of Origin: The next section, and first section of the text block above, give the date and time the report was issued. The first two numbers indicate the day of the month the report was issued, and the next four digits indicate the time in Zulu time.
4. Valid Period Date and Time: The next set of numbers indicate the time that the TAF is valid for. The first hour digits indicate the day of the month and hour the report window starts at (example above = 12th day of month, 18:00 Zulu), and the numbers after the "/" indicate when the report window ends.
5. Forecast Wind: The forecasted wind is reported in the same manner as the METAR. The above forecast for KMEM states that the winds will be from a heading of 200 degrees at 12 knots.
6. Forecast Visibility: The forecasted visibility is reported in the same manner as the METAR. The above forecast for KMEM states that the visibility is 5 statute miles.
7. Forecast Significant Weather: The forecasted significant weather is reported in the same manner as the METAR. In the above forecast for KMEM, haze (HZ) is reported.
8. Forecast Sky Conditions: The forecasted sky conditions are reported in the same manner as the METAR. In the above forecast for KMEM, clouds are reported to be broken at 3,000 feet AGL.
9. Forecast Change Group: A forecast change group indicates how the weather will change over the course of the forecast. These sections begin with abbreviations such as FM, BECMG, PROB, and TEMPO.
    a. FM means "From". This indicates that the weather will change rapidly, usually within one hour. In the KMEM example above, the first FM indicates that beginning at 22:00 Zulu, and within about one hour, the weather will change into conditions described immediately afterwards. In this case the conditions read: winds from 330 degrees at 15 knots, gusting up to 20 knots… better than 6 statute miles of visibility… clouds broken at 1,500 feet and overcast at 2,500 feet.
    b. BECMG means "Becoming". This indicates that the weather will change gradually over the course of no more than two hours into the conditions described immediately after the abbreviation.
    c. PROB means "Probability". This indicates that there is a probability of the weather turning into a certain condition within a specific time period. For instance, the KMEM example above states "PROB40 2022 1 SM TSRA OVC008CB", which reads: there is a 40% probability that between 20:00 and 22:00 Zulu that the weather conditions will be 1 statute mile visibility… thunderstorms with rain… clouds overcast at 800 feet AGL (remember, 008 means 800 feet – always add two zeros at the end) with cumulonimbus.
    d. TEMPO means "Temporary". This indicates that there is forecasted to be temporary fluctuations in the weather, expected to last less than one hour.

Weather Charts

- Weather charts give you an overall picture of the weather around the United States. Surface analysis charts, weather depiction charts, and radar summary charts give you a picture of the current weather conditions, while the significant weather prognostic chart gives you forecasted conditions.

Surface Analysis Chart

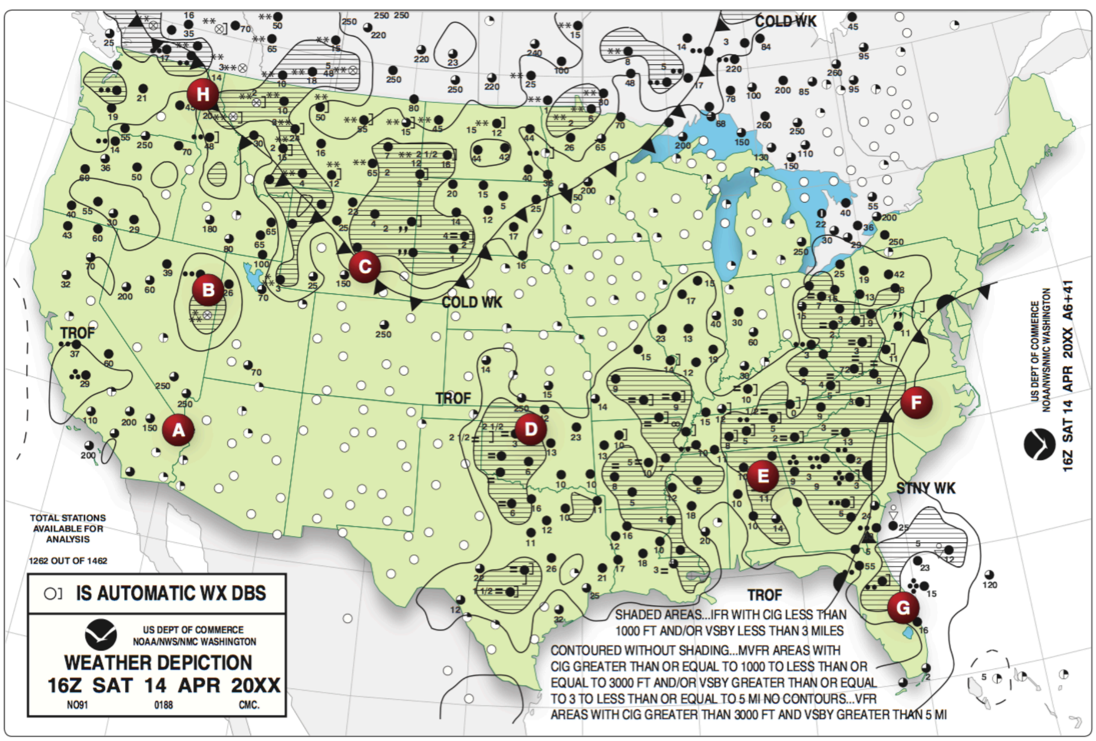
- The surface analysis charts are issued every three hours and give information on areas of high and low pressure, fronts, temperatures, dew points, wind directions and speeds, local weather, and visual obstructions.

Weather Depiction Chart

- A weather depiction chart is a graphical representation of METAR readings and other surface observations. These reports are issued every three hours. This chart will give you information on areas of high or low pressure, major fronts, and areas indicating VFR, MVFR, or IFR flight conditions.

Conditions: Not outlined (view area A as an example)

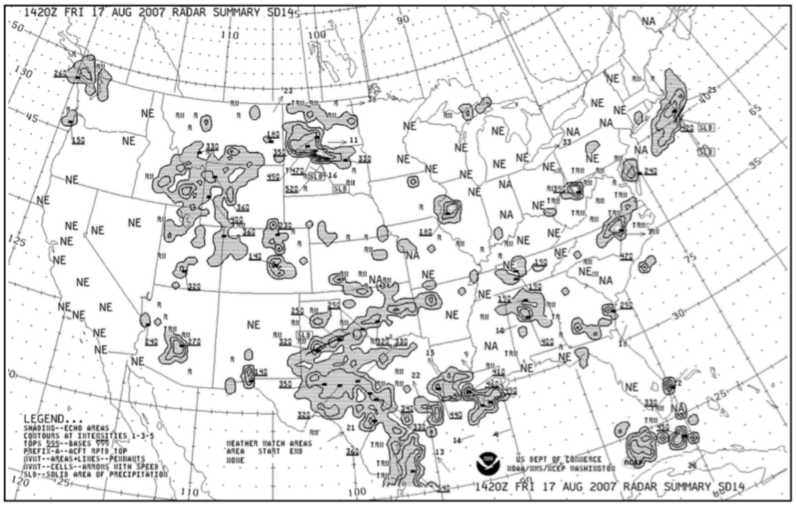
- Marginal VFR Conditions: Outlined but not shaded (view the outer ring of area B as an example)
- IRF Conditions: Outlined and shaded (view the inner ring of area B as an example)



Radar Summary Chart

Radar summary charts give information about radar cells, precipitation, and the characteristics of the precipitation. These reports are generated every hour at 35 minutes past the hour.

Weather cells are indicated by outlines and shaded areas. An outlined area within an outlined area indicates more severe weather. A number next to the shaded areas indicates the tops of the cells, reported in AGL (add two zeros to the end). The type of precipitation and movement of the cells are indicated according to the legend below.



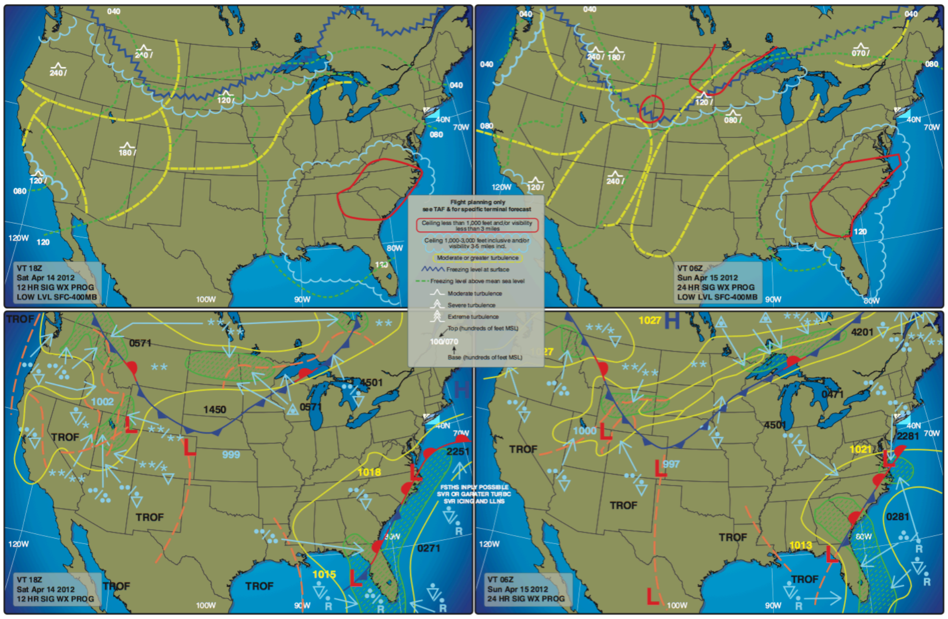
Symbol	Meaning
R	Rain
RW	Rain shower
S	Snow
SW	Snow shower
T	Thunderstorm
NA	Not available
NE	No echoes
OM	Out for maintenance
↗ 35	Cell movement to the northeast at 35 knots
LM	Little movement
WS999	Severe thunderstorm watch number 999
WT210	Tornado watch number 210
SLD	8/10 or greater coverage in a line
	Line of echoes

Significant Weather Prognostic Chart

Significant weather prognostic charts provide forecasts of flight conditions (VFR, MVFR, and IFR, freezing level, and turbulence) and other significant weather developments over a 12- and 24-hour period. The chart blow is an example of a low-level significant weather depiction chart.

The top two squares give a 12- (left) and 24-hour (right) snapshot of the flight conditions over the United States. VFR areas are not outlines, whereas MVFR and IFR conditions are outlined by light blue and red lines, respectively. Refer to the legend in the middle of the chart for more information.

The bottom two squares (12-hour on the left, 24-hour on the right) give information about pressure centers, fronts, types of precipitation, and weather movement.



ASOS and AWOS

ASOS and AWOS are automated weather reporting stations that are typically broadcast over certain frequencies that pilots can monitor, as well as by phone. These stations typically give the pilot the same information received from a text METAR report.

SECTION 6: WEATHER – EFFECTS OF WEATHER ON PERFORMANCE

Overview

- Weather plays a large role in the safe operation of an sUAS. Winds and other low-level weather has the potential to cause the sUAS to collide into obstacles, have systems malfunctions, or other experience other negative factors.
- The areas listed below show how weather impacts the performance of drones and what the pilot should be aware of when encountering different types of weather phenomena.

Density Altitude and Pressure

- The pressure and density of the air tends to decrease as altitude increases.
- Cool air is denser than warm air.
- These factors have an impact on aircraft performance
    - The denser the air is, the more air molecules are going over and under the wing to create more lift (for fixed wing aircraft) and the more air there is for the propeller to take a "bite" out of.
- Air pressure in the atmosphere is typically measured in inches or millibars of mercury (Hg). Standard pressure at sea level is 29.92" or 1013.2 millibars Hg.
- When you hear the term "pressure altitude", that is referring to altitude that is measured based on the pressure of the atmosphere at a standard pressure of **29.92**" Hg and a standard temperature of 15 degrees Celsius.
- **Pressure typically decreases by an average of 1" Hg for every 1,000' increase in altitude**.
- If you correct for non-standard temperature, you get the density altitude. Let's say the actual temperature is 10 degrees C, the air at that temperature would be denser than at normal standard temperature of 15 degrees C. Thus, the density altitude would be lower than the pressure altitude. From a performance perspective, the aircraft will act like it is flying at a lower altitude – the air is denser, there is more air for the propeller to take a bite out of and more air to flow over the wings.

Wind and Currents

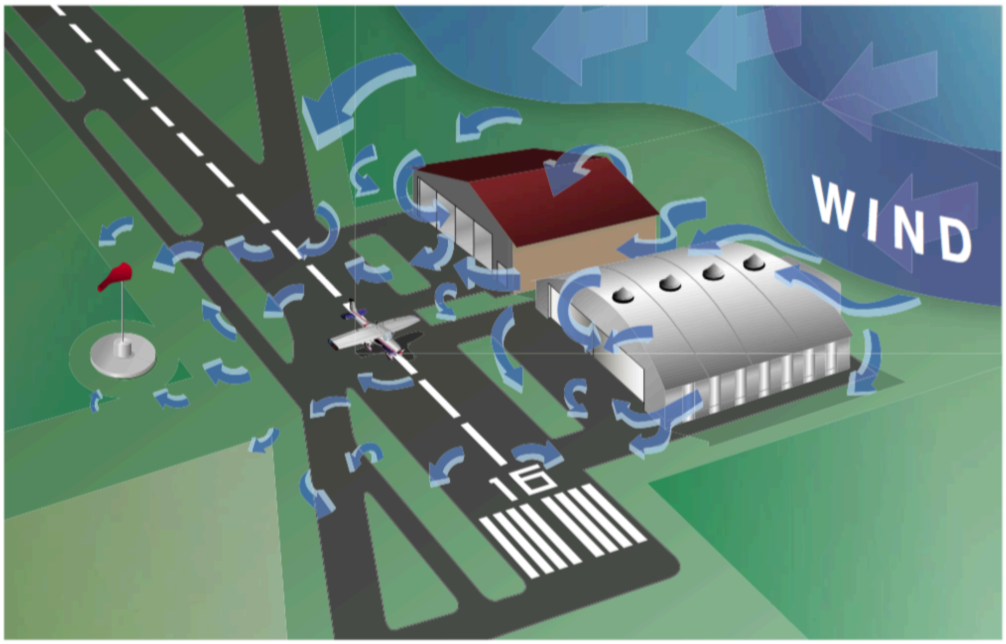
- Wind is caused by uneven heating of the earth's surface. Varying temperatures create different pressure zones within the earth's atmosphere. Air flows from areas of high pressure to low pressure, which creates the movement of air and thus, wind.
- Due to the spinning of the earth, known as the Coriolis effect, air flows in a clockwise direction around a high pressure system and counterclockwise around a low pressure system, in the northern hemisphere.

Convective Currents

- Convective currents are pockets of local updrafts and downdrafts caused by the differences in how geographical features (water, pavement, trees, grass, etc.) absorb or reflect heat. Water tends to heat up and cool down more slowly than land, thus creating different sections of rising and sinking air that can cause sudden updrafts, downdrafts, and general low-level turbulence.
- The lightweight profile of most unmanned aircraft makes them especially susceptible to performance issues caused by low-level turbulence, updrafts, and downdrafts.

Effects of Obstructions on Wind

- Manmade structures can create significant turbulent air. As the wind hits the man-made structure, it tends to flow over and around the structure, and as the air "falls off" the other end, significant turbulence is created as the air spins and bounces around.
- The windward side (side the wind is coming from) usually has low turbulence, although some turbulence could be experienced at the lower end of the structure, while the leeward side (opposite of windward side) will be characterized by heavy turbulence and "eddies" (swirling air).
- See the figures below to see possible ways that wind could flow around a building.



Atmospheric Stability and Temperature

Stability

- The stability of the atmosphere is its ability to resist the vertical movement of air. When the atmosphere is unstable, generally it allows for large cloud formations, bad weather, and turbulence.
- When air rises, it starts to expand due to the decrease in pressure. This expansion causes the temperature to decrease. The opposite is also true: descending air compresses as it falls, causing an increase in temperature. The change in temperate as altitude increases or decreases is referred to as the "lapse rate." **The average lapse rate is about 2 degrees C per 1,000 feet.**
- As a general rule, cool and dry conditions lead to stable air and clear conditions. Warm air with lots of water vapor tends to lead to unstable air with adverse weather conditions.

Temperature Inversion

- A temperature inversion is when the lapse rate is backwards – the air temperature actually gets warmer as altitude increases. This generally only happens at low altitudes. Above the layer with the inversion, the traditional lapse rate often takes effect again as altitude increases.
- This often causes moisture and pollutants to be trapped in the inversion layer, resulting in reduced visibility – fog, smog, etc.
- Temperature inversions can form in the following situations:
    - Clear, cool nights where the air close to the ground is cooled by the lowering temperature of the ground. The air close to the ground becomes cooler than the air above it.
    - A warm front spreads warm air over a layer of cooler air.

Humidity, Dew Point, and Convergence Rate

- Relative humidity is the amount of water vapor present in the atmosphere at a given time compared to the amount of water vapor that can be held by the air at a given temperature. If the current relative humidity is 70%, that means that the air is holding 70% of the maximum water vapor capacity at that temperature and pressure.
- The dew point is the temperature at which the air can hold no more water. As the temperature decreases, the air becomes denser and thus can hold less and less water vapor. Once the temperature decreases to a certain point (the dew point), the air will not be able to hold any more water vapor, and the water will start to come out of the air to form clouds and condensation.
- As altitude increases, the air generally becomes cooler and denser, thus driving the air temperature and the dew point closer together. The rate at which these two numbers come together is called the convergence rate. The average convergence rate is 2.5 degrees C for every 1,000 ft.
    - Bases of clouds are said to begin at the point where the dew point and the temperature meet.
    - For example, if the outside air temperature at sea level was 25 degrees C and the dew point was 13 degrees C, the temperature dew point spread would be 12 (25 – 13 = 12). If the spread narrows by 2.5 degrees for every thousand feet, we can determine the beginning of the base of clouds by taking the spread (12), dividing by 2.5, and multiplying by 1,000 feet. In this instance that would be 12.0/2.5 = 4.8 … 4.8 * 1,000 = 4,800 feet.

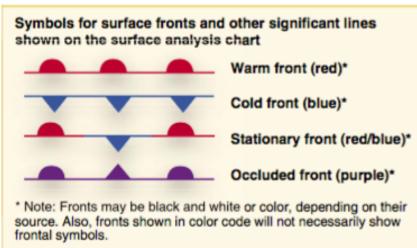
Air Masses and Fronts

Air Masses

- Air masses are named and categorized according to the regions where they originate. For instance, a continental polar air mass forms over a polar region and brings cool, dry air. Likewise, a maritime tropical air mass forms over waters like the Caribbean Sea and brings warm, moist air.
- When air masses move and pass over surfaces with different temperatures and characteristics, it can affect the nature of the air mass.
    - When a cool air mass passes over a warm surface, the air is warmed from below causing convective currents (think rising air, unstable atmosphere).
    - When warm air passes over a cooler surface, no convective currents form. This generally leads to stable air and possible temperature inversions, leading to smooth air and poor visibility (remember the discussion on stable air mentioned above).

Fronts

- When one type of air mass collides with another type of air mass, it is generally referred to as a "front".
- The front is usually described by the temperature and characteristics of the front that is advancing. For instance, if warm air is overtaking cool air, this would be a warm front.
- There are four types of fronts:
  - Warm front
  - Cold front
  - Stationary front
  - Occluded front



Warm Front

- Move slowly – generally 10 to 25 mph
- The warm air moves over the cool air that it is replacing.
- Prior to passage of warm front
  - Cirriform or stratiform clouds, along with fog
  - Thunderstorms likely
  - Light to moderate precipitation
  - Poor visibility
- During passage of warm front
  - Stratiform clouds
  - Drizzle
  - Visibility poor but improving
  - Steadily rising temperature
  - Dew point steady
- After passage of warm front
  - Stratocumulous clouds
  - Rain showers
  - Improving visibility
  - Rising dew point

Cold Front

- Faster than warm fronts – generally 25 to 30 mph
- Works like a snow plow and pushes underneath the warm air it is replacing

- Prior to passage of cold front
    - Cirriform or towering cumulus clouds
    - Rain showers and haze possible
    - High dew point, falling pressure
- During passage of cold front
    - Towering cumulus or cumulonimbus clouds
    - Heavy rain showers possible, accompanied by lighting, thunder, and/or hail
    - Poor visibility
    - Temperature and dew point drop rapidly
- After cold front passes
    - Clouds dissipate
    - Precipitation decreases
    - Improving visibility
    - Temperature remains cooler
    - Pressure rises

Stationary Front

- When the forces from both masses of air are relatively equal, the boundary line is generally referred to as a stationary front. Weather from a stationary front is typically a mixture of the weather that can be found in both warm and cold fronts.

Occluded Front

- An occluded front occurs when a fast-moving cold front catches up to a slower-moving warm front.
- There are two types of occluded fronts:
    - Cold front occlusion
        - Fast-moving cold front air is colder than the cool air that the warm front is overtaking
    - Warm front occlusion
        - Fast-moving cold front air is not as cold as the air that the warm front is overtaking
- Cold front occlusions are generally characterized by a mixture of warm and cold front weather conditions
- Warm front occlusions generally bring more severe weather than cold front occlusions. Thunderstorms, rain, and fog are likely.

Thunderstorms and Microbursts

Thunderstorms

- Thunderstorms are usually associated with weather that is severe and potentially hazardous to unmanned aircraft.
- Thunderstorms generally need three ingredients to form:
    - Sufficient water vapor;
    - Unstable lapse rate; and
    - Lifting action.

- Thunderstorms have three phases:
    - Cumulus Stage
    - Mature Stage
    - Dissipating stage

Cumulus stage

- Lifting action of the air begins
- Clouds increasing in vertical height, moisture prohibited from falling due to updrafts
- Lasts approximately 15 minutes

Mature Stage

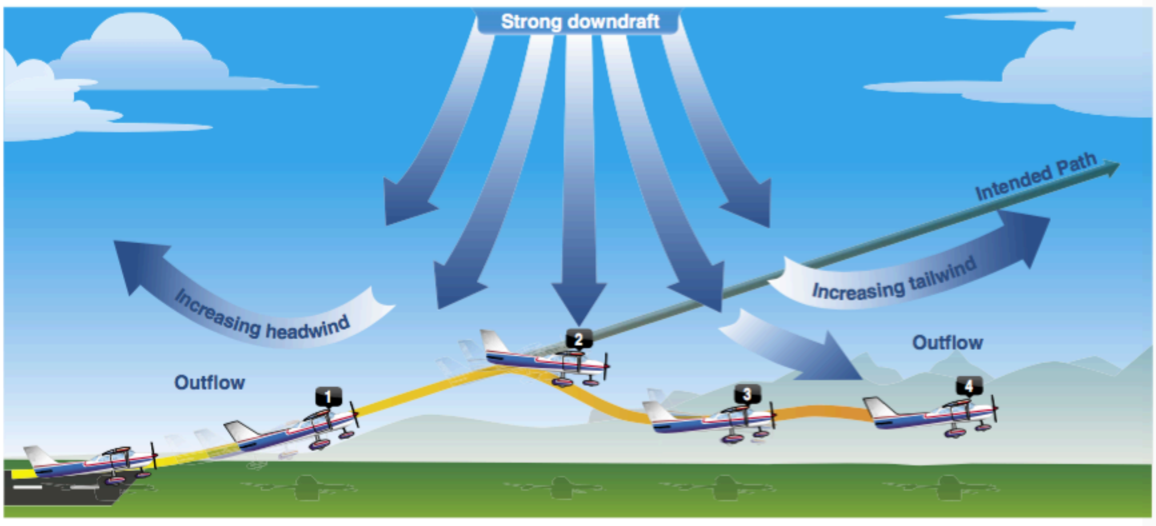
- Most violent part of thunderstorm's life
- Moisture too heavy to stay in clouds – begin falling to the surface as rain or hail
- Strong downdrafts at the bottom of the cloud
- Top of the cloud spreads out and forms the "anvil" shape

Dissipating stage

- Downdrafts spread out and replace the updrafts needed to sustain the storm.
- Cloud height decreases.

Microbursts

- Microbursts are strong downdrafts that normally occur over horizontal distances of 1 NM or less and vertical distances of less than 1,000 feet.
- An intense microburst could induce wind speeds of over 100 kts.
- Microbursts are known to frequently coincide with thunderstorms.
- Usually last about 15 minutes.
- Can cause a change in wind direction of 45 degrees or more.
- The conditions caused by microbursts would make it extremely difficult to fly or maintain positive control of a small unmanned aircraft.
- Below is a depiction of how microbursts affect a fixed wing aircraft:



Tornados

- One of the hazards that can be associated with thunderstorms is tornados.
- Thunderstorms are characterized by rapidly rising air (aka convective activity). If the storm is severe enough and the rising air that is being sucked in has any rotating movement, a tornado can form.
- Any aircraft entering a tornado vortex is almost sure to suffer structural damage and be destroyed.

Icing

- Another hazard associated with a thunderstorm is icing (although icing is not exclusively seen with thunderstorms)
- Icing occurs when water is carried upward above the freezing level and is supercooled to below freezing level. The supercooled water will instantly turn to ice upon impact with the aircraft.
- Ice build-up on the surface of the aircraft can cause serious issues with the aircraft's instruments (if a pilot static system is being used) or impact the ability of the wings to create lift.

Hail

- A hazard frequently associated with thunderstorms is hail.
- Hail forms by supercooled water freezing into a small piece of ice. Other supercooled water freezes to the piece of ice and forms a larger piece, until a ball of ice is formed – called a hailstone.
- Hail typical exits out of the anvil portion of the thunderstorm cloud. Hailstones can be encountered in clear air several miles from the actual thunderstorm clouds
- The more updrafts and taller the thunderstorm clouds are, the larger the hailstones are likely to be.

Fog

- Fog is a cloud that begins within 50 feet of the surface of the earth. Fog occurs when the temperature drops below the dew point, causing the water vapor to condense out of the air.
- There are several types of fog:
    - Radiation Fog;
    - Advection Fog;
    - Upslope Fog;
    - Steam Fog; and
    - Ice Fog.

Radiation Fog

- Forms in low-lying areas like mountain valleys when there is little to no wind.
- Occurs when the ground cools rapidly and the temperature reaches its dew point.
- As the sun rises and the temperature increases (thus allowing the air to hold more water vapor), the fog dissipates.

Advection Fog

- Formed when a layer of warm, moist air moves over a cold surface – wind needed to move the air layer.
- Common in coastal areas where sea breezes blow air over cooler landmasses.

Upslope Fog

- Occurs when moist, stable air is forced up a slope, such as a mountain – wind needed to move the moist air.
- As the moist air is pushed up the slope, the temperature decreases and meets the dew point, causing fog.

Steam Fog

- Forms when cold, dry air moves over warm water – as the water evaporates, it turns to fog.
- Common over bodies of water during the coldest times of the year.
- Low-level turbulence and icing are common with steam fog.

Ice fog

- Occurs in cold weather when the temperature is much below freezing and water vapor forms directly into ice crystals
- Same conditions as radiation fog, except colder temperature – typically negative 25 degrees F.
- Occurs mostly in arctic regions.

Ceiling and Visibility

Ceilings

- For aviation purposes, a ceiling is generally the lowest layer of clouds reported as being broken or overcast. A ceiling can also be the farthest you can see upwards (or "vertical visibility") into fog or haze.
- "Broken" conditions are when 5/8 to 7/8 of the sky is covered with clouds.
- "Overcast" conditions are when the entire sky is covered with clouds.
- Ceilings are reported on METARs in feet AGL.

Visibility

- Visibility refers to the greatest horizontal distance at which prominent objects can be viewed with the naked eye.
- Visibility is reported on METARs, generally in statute miles.

Lightning

- Lightning strikes (directly to the aircraft or even nearby) can cause many problems for the unmanned aircraft and related systems.
- Direct lightning strikes can puncture the hull of an aircraft and can cause serious electrical issues.
- Nearby lightning can:
    - Temporarily blind the pilot, leaving him/her unable to operate the controls effectively;
    - Induce permanent errors in a magnetic compass; and
    - Disrupt radio communications between the control station and the unmanned aircraft.

SECTION 7: LOADING AND PERFORMANCE

General Loading and Performance

- Before any flight, the Remote PIC should verify the aircraft is correctly loaded by determining the weight and balance (W&B) condition of the aircraft.
- An aircraft's W&B restrictions established by the manufacturer or the builder should be closely followed. Compliance with the manufacturer's W&B limits is critical to flight safety. The remote PIC must consider the consequences of an overweight aircraft if an emergency condition arises.

Effects of Loading Changes

- Weight changes during flight also have a direct effect on aircraft performance. Fuel burn is the most common weight change that takes place during flight. As fuel is used, the aircraft becomes lighter and performance is improved, but this could have a negative effect on balance.
- In sUAS operations, weight change during flight may occur when expendable items are used on board (e.g., a jettisonable load).

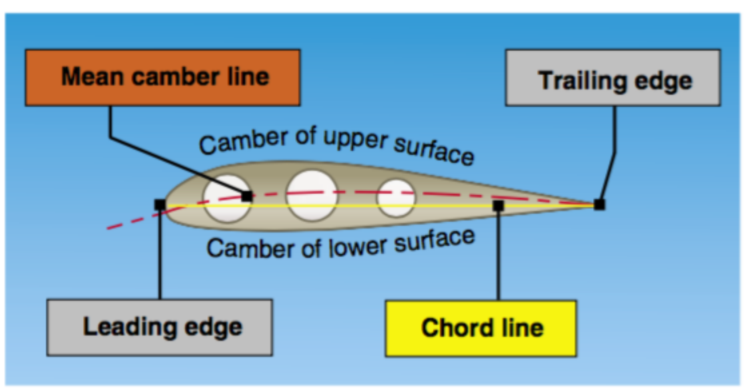
Balance, Stability, and Center of Gravity

- Adverse balance conditions (i.e., weight distribution) may affect flight characteristics in much the same manner as those mentioned for an excess weight condition.
- Limits for the location of the CG may be established by the manufacturer. The CG is not a fixed point marked on the aircraft; its location depends on the distribution of aircraft weight. As variable load items are shifted or expended, there may be a resultant shift in CG location.
- The Remote PIC should determine how the CG will shift and the resultant effects on the aircraft. If the CG is not within the allowable limits after loading or does not remain within the allowable limits for safe flight, it will be necessary to relocate or shed some weight before flight is attempted.

Determining Performance

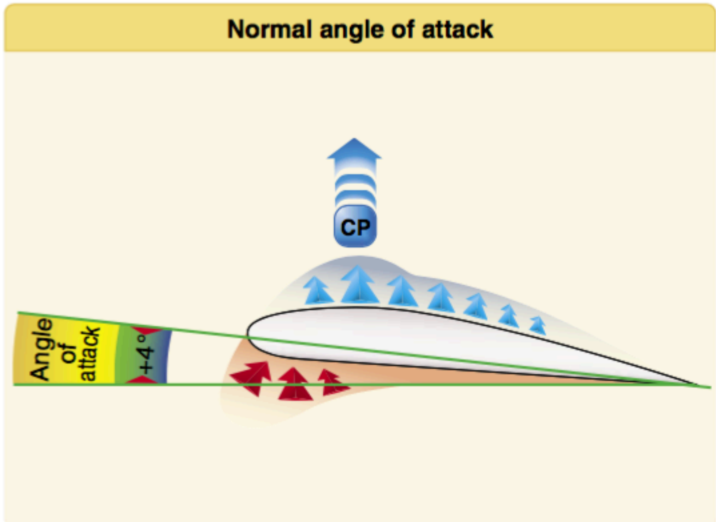
Lift and Stalls

- With fixed-wing unmanned aircraft, two important flight factors to understand are lift (what makes the aircraft fly) and stalls (when the wings don't create lift).
- The general principle with lift has to do with high and low pressure areas.
  - Due to the shape of the wing (referred to as an "airfoil"), the air flows FASTER over the top of the wing than the bottom of the wing. This creates a LOW-pressure area above the wing and a HIGH-pressure area below the wing, thus pushing the wings up into the air.
  - To create lift, the air needs to be flowing smoothly over the wing, coming back together after the trailing edge.
- To fully understand the components of lift and stalls, you need to know the terms associated with a wing
  - Leading edge = forward-most point of the wing
  - Trailing edge = rearward-most point of the wing
  - Chord line = an imaginary straight line drawn from the trailing edge to the leading edge
  - Mean camber line = a line drawn from the trailing edge to the leading edge that stays exactly between the top and bottom edges of the wing

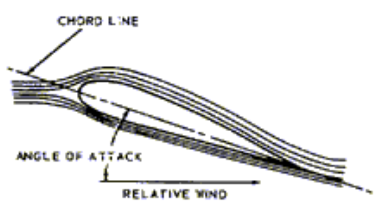


- The **angle of attack** describes the angle between the relative wind and the chord line of the wing. You can almost think of this as how much wind is hitting the top of the wing vs. the bottom of the wing.
  - If you were to stick your hand out the window of a moving car, and your hand was perfectly parallel to the ground, your hand's angle of attack would be 0°. If you suddenly angled the

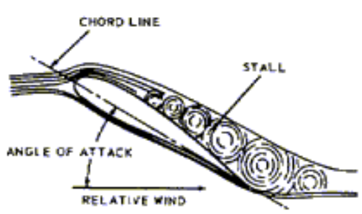
forward portion of your hand to the sky, your hand and arm would instantly be pulled upwards due to the high angle of attack. Remember – the angle between the wind and the chord line of the wing (aka the direction the wing – or your hand – is pointing).



- **A stall occurs when the wing exceeds its CRTICAL angle of attack**. The critical angle of attack is the point at which the air can no longer flow smoothly over the wing, and eddies and buffets after going over the leading edge of the wing. This hampers the speed at which the air can flow over the wing, thus the LOW pressure above the wing disappears. No low pressure above the wing = no lift.
- The following figure illustrates the stalled and non-stalled conditions of a wing:



ANGLE OF ATTACK



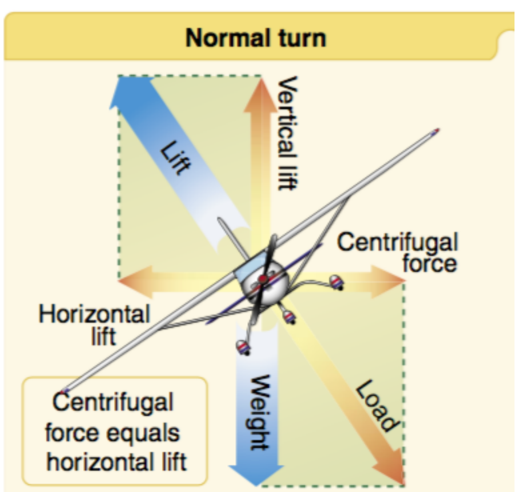
AIRFOIL ANGLES OF ATTACK VS LIFT

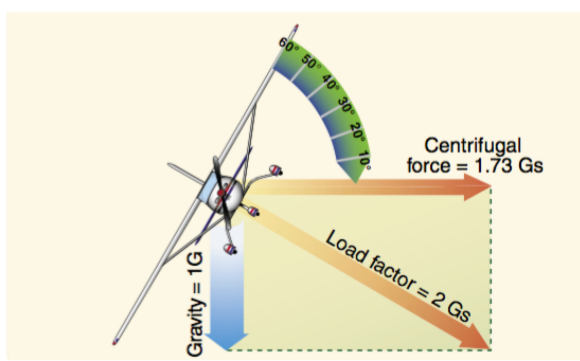
SCHEMATIC DIAGRAM ILLUSTRATING STALL

- When a stall occurs, the nose of the airplane will typically fall (unless the controls hold the nose back, which further exacerbates the stall condition). When the nose falls, airspeed increases and the angle of attack decreases, thus remedying the stall condition and restoring normal flight.
- The problems arise when stall occurs too close to the ground. The aircraft does not have enough available altitude to build up speed and recover before colliding with the ground or a ground structure.

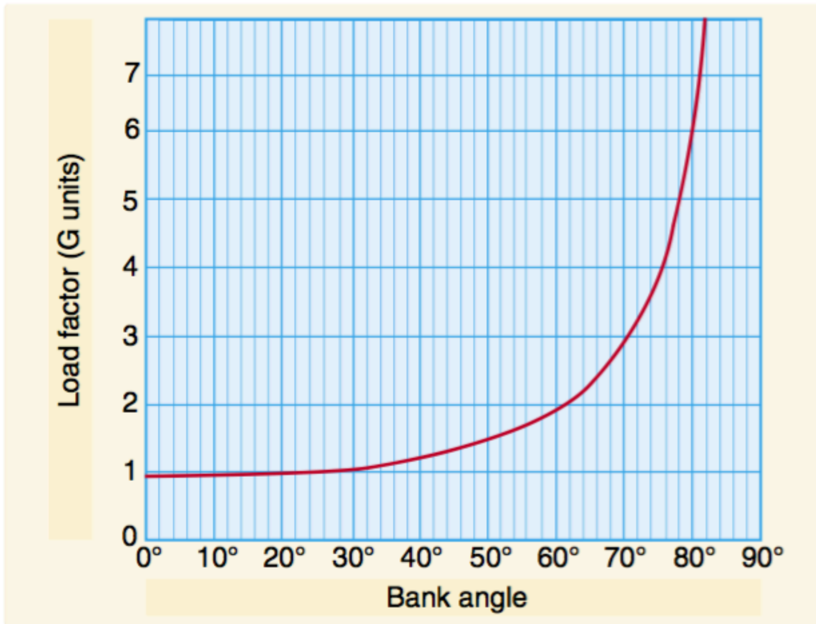
Load Factor

- The "load factor" placed on an aircraft is how much weight the aircraft *feels*.
    - Let's say you're on a rollercoaster; when you're cruising in a straight line, you don't feel extra heavy or extra light. You are at 1G (1G is the normal force of gravity).
    - However, when you get to the top and go over the first big drop, you feel that rush in your stomach and you feel weightless. For a moment, you are likely at 0Gs – weightlessness (feeling of no gravity).
    - Then, as you come to the first turn, the rollercoaster turns on its side and you feel as if you are being sucked straight down into the seat as the coaster proceeds through the turn. You are likely experiencing strong positive G forces – maybe 2Gs.
    - The same forces that act on your body when on a rollercoaster are the same forces acting on an aircraft when it's in flight.
- A key point to keep in mind when talking about load factor is the principle that as the aircraft begins to turn, the lift isn't pulling the aircraft directly upwards; it's pulling the aircraft some upwards and some to the side, thus reducing the overall amount of lift keeping the aircraft in the air.
    - To compensate for this, the pilot needs to pull the nose of the aircraft up, creating a tighter turn and resulting in a higher load factor.
    - The steeper the turn, the more required backpressure, which means more load factor.
    - The following graphics illustrates this:





- One thing the FAA may want you to calculate is the load factor at a given angle of a turn. To do this, use the following chart to look up the bank angle along the bottom and follow the chart up until you hit the red line. Then follow the chart to the left and read what load factor corresponds with that bank angle.
    - For instance, in the example below, a 60° bank angle would result in a load factor of 2. Which means that you would feel twice as heavy in an aircraft that's holding a 60° turn.



Using Performance Data

- In the event that the sUAS manufacturer does not provide performance data about the unmanned aircraft and how its flight characteristics are affected by various factors such as weight, balance, temperature, and altitude, it is important that the operator of an unmanned aircraft keep a log of the aircraft's performance to aid future planning for flight operations.

SECTION 8: RADIO COMMUNICATION

Airport Ops – With and Without Control Tower

- Some airports have full time towers, some have part-time towers, and some have no tower at all.
  - Airports with full-time towers will be staffed with an air traffic controller at all times, who will handle takeoff and landing clearances along with other general air traffic management.
  - Airports with part-time towers will frequently be open during the daytime and other times where flights in and out of the airport are more frequent, but will be closed at night or at non-busy traffic times. While the air traffic control tower is closed, the airport is treated as if it had no tower at all.
  - Airports with no towers rely on pilot self-reporting for air traffic management. Pilots will either report their position to a Flight Service Station, a UNICOM monitor, or will announce their position to whomever may be listening to the designated CTAF frequency. More on these in the next few sections.
- To find out the tower status and hours of operation at a given airfield, consult the Airport and Facilities Directory, also known as the Chart Supplements. A sample airport directory page is shown for Witham Field in Stuart, FL. The tower hours can generally be found next to the tower frequency. As you can see below, the tower hours for Witham Field are 1200 to 0300 Zulu. An online version of the Chart

Supplements can be found online at https://www.faa.gov/air_traffic/flight_info/aeronav/digital_products/dafd/search/.

STUART

WITHAM FLD (SUA)(KSUA) 1 SE UTC–5(–4DT) N27°10.90´ W80°13.28´ **MIAMI**

16 B NOTAM FILE MIA **H–8I, L–23C**

RWY 12–30: H5828X100 (ASPH–GRVD) S–65, D–105, 2D–190 MIRL **IAP, AD**

RWY 12: REIL. PAPI(P4L)—GA 3.0° TCH 35´. Thld dsplcd 460´. Tree.

RWY 30: REIL. PAPI(P4L)—GA 3.0° TCH 28´. Tree.

RWY 16–34: H4998X100 (ASPH) S–55, D–90, 2D–160

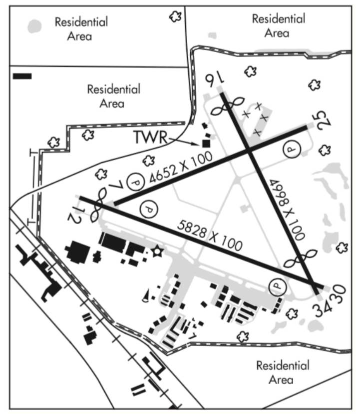
RWY 16: Thld dsplcd 336´. Tree.

RWY 34: Thld dsplcd 880´. Tree.

RWY 07–25: H4652X100 (ASPH–GRVD) S–58, D–95, 2D–170 MIRL

RWY 07: PAPI(P4L)—GA 3.0° TCH 42´. Tree.

RWY 25: PAPI(P4L)—GA 3.0° TCH 44´. Trees.



ARRESTING GEAR/SYSTEM

RWY 12: EMAS

RWY 30: EMAS

SERVICE: S4 **FUEL** 100LL, JET A **LGT** ACTIVATE REIL Rwy 12, Rwy 30 after 0300Z‡, ACTIVATE MIRL Rwy 12–30 and Rwy 07–25 from 0300Z‡—CTAF. PAPI Rwys 07, 12, 25 and 30 opr continuously.

AIRPORT REMARKS: Attended 1200–0100Z‡. Birds on and invof arpt. Acft with wingspans exceeding 79´ are prohibited from opr on Twy A btn Twy C and AER 12 when acft with wingspan exceeding 79´ is on apch to ldg or tkf Rwy 12–30. PPR for acft exceeding rwy wt capacity. Touch and Go ops permitted Mon–Sat (exc New Years, Christmas and Thanksgiving) 1400Z‡ until 2 hrs past SS and are ltd to 3 ops per pilot per day. Stop and Go ops and int tkfs strongly discouraged at all times. Stage 1 and 2 jet ops strongly discouraged 0300–1200Z‡. Noise sensitive areas all quadrants. NS ABTMT procedures call arpt mgr 772–221–2374. PAPI rstd to 7.5 NM west of Rwy 25 due to 1548´ MSL twrs within 10° of extended centerline.

AIRPORT MANAGER: 772-221-2374

WEATHER DATA SOURCES: AWOS–3 (772) 692–7399

COMMUNICATIONS: CTAF 126.6 **ATIS** 134.475

®**PALM BEACH APP/DEP CON** 128.3

STUART TOWER 126.6 (1200–0300Z‡) **GND CON** 121.7

AIRSPACE: CLASS D svc 1200–0300Z‡ other times CLASS G.

RADIO AIDS TO NAVIGATION: NOTAM FILE VRB.

TREASURE (H) VORTAC 117.3 TRV Chan 120 N27°40.70´ W80°29.38´ 161° 33.0 NM to fld. 19/7W. **HIWAS.**

Common Traffic Advisory Frequency (CTAF)

- At airports that do not have a control tower (or when the tower is closed), pilots will report their aircraft position and intentions (landing, takeoff, etc.), on a radio frequency that is monitored by all participants at the airport. This frequency is called the Common Traffic Advisory Frequency (CTAF).
- The designated CTAF frequency will be published in the Airport/Facilities Directory.

Traffic Advisory Procedures Used by Manned Aircraft Pilots

- Typically, aircraft will give the following advisories, indicating the position and intentions of their aircraft:
  - Oubound:
    - Before taxiing; and
    - Before entering the runway for departure.
  - Inbound:
    - 10 miles out;
    - Entering downwind leg;
    - Entering base leg;
    - Entering final approach; and

- Exiting the runway.

UNICOM

- UNICOM stations are non-government ground stations, generally found at low-traffic general aviation airports, which provide various information and advisories to users of the airport.
- Information provided can include weather information, wind direction, recommended runway, and any previously reported traffic. Pilots will self-report position information to UNICOM as appropriate.
- The UNICOM and CTAF frequencies are generally one and the same. When no one is staffed at the UNICOM station, the pilot will obviously not receive a response; rather, the pilot will report his or her position and intentions to any other pilots monitoring the UNICOM frequency.

Automatic Terminal Information Service (ATIS)

- Automatic Terminal Information Service (ATIS) is the continuous broadcast of recorded information relevant to a certain station – usually an airport. The ATIS generally contains information about the weather conditions at the airport as well as other airport information such as active runways, navigation equipment outages, and potential hazards. Much of the information that is contained within a METAR is transmitted over the ATIS frequency.
  - A sample ATIS would sound like this:

> *Dulles International information Sierra. 1300 zulu weather. Measured ceiling three thousand overcast. Visibility three, smoke. Temperature six eight. Wind three five zero at eight. Altimeter two niner niner two. ILS runway one right approach in use. Landing runway one right and left. Departure runway three zero. Armel VORTAC out of service. Advise you have Sierra.*

- The information is updated every hour and is associated with a certain letter of the phonetic alphabet (i.e., Alpha, Bravo, etc.). When pilots contact ATC for takeoff/landing clearance, or other requests, they will generally be required to confirm with the tower that they have listened to the most recent ATIS report, and will indicate so by giving the phonetic alphabet letter corresponding with the report they listened to
  - For instance, a pilot might say:

> *Lakeland tower, this is November three three five niner Mike, with information Seirra. We are 10 miles south of the airport – inbound requesting permission for full stop landing.*

- Note: if the ceiling is higher than 5,000 feet and/or visibility is 5 miles or more, the information will be omitted from the ATIS report.
- If operating in or around an airport, it is recommended that sUAS pilots monitor the ATIS frequency to determine the active traffic patterns and conditions at the airfield.

Aircraft Call Signs and Registration Numbers

- Traditional manned aircraft have registration and identification markings that consist of numbers and letters. Typically, in the United States the first letter of the registration number is the letter N.
- When communicating with air traffic control, a pilot will refer to his or her aircraft by the registration number. After initial contact with ATC, the pilot may refer to his or her aircraft by a call sign. This is often the manufacturer of the aircraft with the following registration marking (without the N at the beginning).
    - For instance, if your aircraft was a Cessna and the registration number was N508Q, after initial contact you could refer to your aircraft as "Cessna Five Zero Eight Quebec."
- The call sign MEDEVAC (followed by the relevant registration numbers) is used for air ambulance flights and other special medical emergency transportation.

Phonetic Alphabet

- The FAA, specifically ATC, uses what is called the "phonetic alphabet" during radio communications in order to more easily understand which letters of the alphabet are being said. Many letters, especially when radio communication signals are weak, can sound the same – such as letters that end with an "ee" sound (e.g., B, D, G, T).
- The table below identifies the words that are associated with certain letters of the alphabet. For instance, if you were trying to communicate the tail number: N34TF to ATC, you would say, "November Three Four Tango Foxtrot."

Character	Phonetic Word
A	Alpha
B	Bravo
C	Charlie
D	Delta
E	Echo
F	Foxtrot
G	Golf
H	Hotel
I	India
J	Juliette
K	Kilo
L	Lima
M	Mike

Character	Phonetic Word
N	November
O	Oscar
P	Papa
Q	Quebec
R	Romeo
S	Sierra
T	Tango
U	Uniform
V	Victor
W	Whiskey
X	Xray
Y	Yankee
Z	Zulu

Phraseology

Proper phraseology is essential when communicating with air traffic control or understanding communications of other pilots when monitoring various tower, ground, and other frequencies. Phraseology consists of how certain numbers, letters, words, and other figures are communicated over the radio to ensure clarity and understanding between speaker and listener.

Figures

- Figures indicating hundreds and thousands in round number, as for ceiling heights, and upper wind levels up to 9,900 must be spoken in accordance with the following examples:
    - 500 = five hundred

    - 4,500 = four thousand five hundred
- Numbers above 9,900 must be spoken by separating the digits preceding the word "thousand", as in the following examples:
    - 10,000 = one zero thousand
    - 13,500 = one three thousand five hundred
- All other numbers must be transmitted by pronouncing each digit. For example:
    - 10 = one zero
- When a radio frequency contains a decimal point, the decimal point is spoken as "POINT." For example:
    - 122.1 = one two two point one

Altitudes

- Up to but not including 18,000 feet MSL, state the separate digits of the thousands plus the hundreds if appropriate. For example:
    - 12,000 = one two thousand
    - 12,500 = one two thousand five hundred
- At and above 18,000 feet MSL (FL 180), state the words "flight level" followed by the separate digits of the flight level. For example:
    - 190 = Flight Level One Niner Zero
    - 275 = Flight Level Two Seven Five

Directions

- The three digits of bearing, course, heading, or wind direction should always be magnetic. The word "true" must be added when it applies. For example:
    - (Magnetic course) 005 = zero zero five
    - (True course) 050 = zero five zero true
    - (Magnetic bearing) 360 = three six zero
    - (Magnetic heading) 100 = heading one zero zero
    - (Wind direction) 220 = wind two two zero

Speed

- The separate digits of the speed should be followed by the word "KNOTS." Controllers may omit the word "KNOTS" when using speed adjustment procedures; e.g., "REDUCE/INCREASE SPEED TO TWO FIVE ZERO." For example:
    - (Speed) 250 = two five zero knots
    - (Speed) 190 = one niner zero knots
- The separate digits of the Mach Number preceded by "Mach."
    - (Mach number) 1.5 = Mach one point five
    - (Mach number) 0.64 = Mach point six four
    - (Mach number) 0.7 = Mach point seven

Time

- FAA uses Coordinated Universal Time (UTC) for all operations. The word "local" or the time zone equivalent must be used to denote local when local time is given during radio and telephone communications. The term "Zulu" may be used to denote UTC. For example:
    - 0920 UTC =
        - zero niner two zero,
        - zero one two zero pacific (or local), or
        - one twenty AM
- To convert from Standard Time to Coordinated Universal Time, use the following table (note: for Daylight Savings Time, subtract 1 hour):

Standard Time to Coordinated Universal Time

Eastern Standard Time	Add 5 hours
Central Standard Time	Add 6 hours
Mountain Standard Time	Add 7 hours
Pacific Standard Time	Add 8 hours
Alaska Standard Time	Add 9 hours
Hawaii Standard Time	Add 10 hours

- A reference may be made to local daylight or standard time utilizing the 24–hour clock system. The hour is indicated by the first two figures, and the minutes by the last two figures. For example:
    - 0000 = zero zero zero zero
    - 0920 = zero niner two zero

SECTION 9: AIRPORT OPERATIONS

Types of Airports

Towered

- A towered airport has an operating control tower. Air traffic control (ATC) is responsible for providing the safe, orderly, and expeditious flow of air traffic at airports where the type of operations and/or volume of traffic requires such a service.
- Manned aircraft pilots operating from a towered airport are required to maintain two-way radio communication with air traffic controllers, and to acknowledge and comply with their instructions.
- ATC towers are found in Class B, C, and D airports/airspaces.

Uncontrolled Towered

- Certain towered airports, particularly in Class D airspace, are only staffed during the day or portions of the day. When the tower is CLOSED, the airport is treated as if it is a non-towered airport.

Non-Towered

- A non-towered airport does not have an operating control tower. Two-way radio communications are not required, although it is a good operating practice for pilots to transmit their intentions on the specified frequency for the benefit of other traffic in the area.
- Communication procedures at non-towered airports are covered in more depth in the Radio Communications section of the course.

Heliport

- A heliport is a small airport that is only used by helicopters. Generally, the heliport consists of one or more helipads, lighting, fuel services, and. occasionally, hangars.
- There is not as much standardization on air traffic flow with heliports as there is with traditional airports.

Seaplane Bases

- Seaplane bases typically offer areas to park and other services to seaplanes and amphibious aircraft.
- Bodies of water with seaplane bases will typically have increased air traffic activity as compared to bodies of water without a seaplane bases. If operating a small unmanned aircraft near a body of water, the Remote PIC should first consult sectional charts and chart supplements to determine if there is a seaplane base in the vicinity.

Monitoring ATC Communications

- As a remote pilot, being able to understand and interpret ATC communications between controllers and other manned aircraft is critically important to the safety of flight operations. Knowing where other aircraft are and where they are going to be will allow the remote pilot to avoid these areas, reducing the likelihood of a mid-air collision.
- Phraseology and other ATC communication procedures are discussed in more detail in the Airspace and Radio Communications section of this course.
- In regards to operating an sUAS in and around airports, there are a few phrases and communication procedures that unmanned aircraft pilots need to keep in mind:
    - Example:
        - ATC Tower - "N1234AL [said: November one two three four Alpha Lima] cleared for takeoff, runway 35."
            - This means an aircraft is about to takeoff from runway 35, which has a magnetic heading of 350. If you are operating an sUAS to the north of the airport, you should watch out for this air traffic.
    - Example:
        - After requesting landing and being instructed to enter the traffic pattern, an aircraft is turning onto the base leg of the pattern.
        - Aircraft – "Melbourne Tower, N1234AL is turning base for runway 35."
        - ATC Tower – "N1234AL, cleared to land, runway 35."
            - This means an aircraft is turning onto the base leg, which is perpendicular to runway 35. Since the aircraft will be landing in a northerly direction, this means they will be landing from the south end of the runway. If you are operating an sUAS south of the airport, you should watch out for this air traffic.
    - Example:

- Aircraft – "Melbourne Tower, N1234AL is 10 miles west of the airport, inbound for full stop landing."
- ATC Tower – "N1234AL, enter the pattern on downwind for runway 35, left traffic. You are number 3 for landing."
    - This means that an aircraft is coming in from the west of the airport and will be entering the traffic pattern on the downwind leg (which, in this instance would also be to the west of the runway). If you are west or south of the airport (since base and final will be south), you should watch out for this traffic.
    - We also know from the controller that this aircraft was number 3 for landing. That tells us that there are two aircraft that are ahead if it for landing that are likely also in the pattern. The remote pilot should be mindful of these aircraft as well.

Runway Markings and Signage

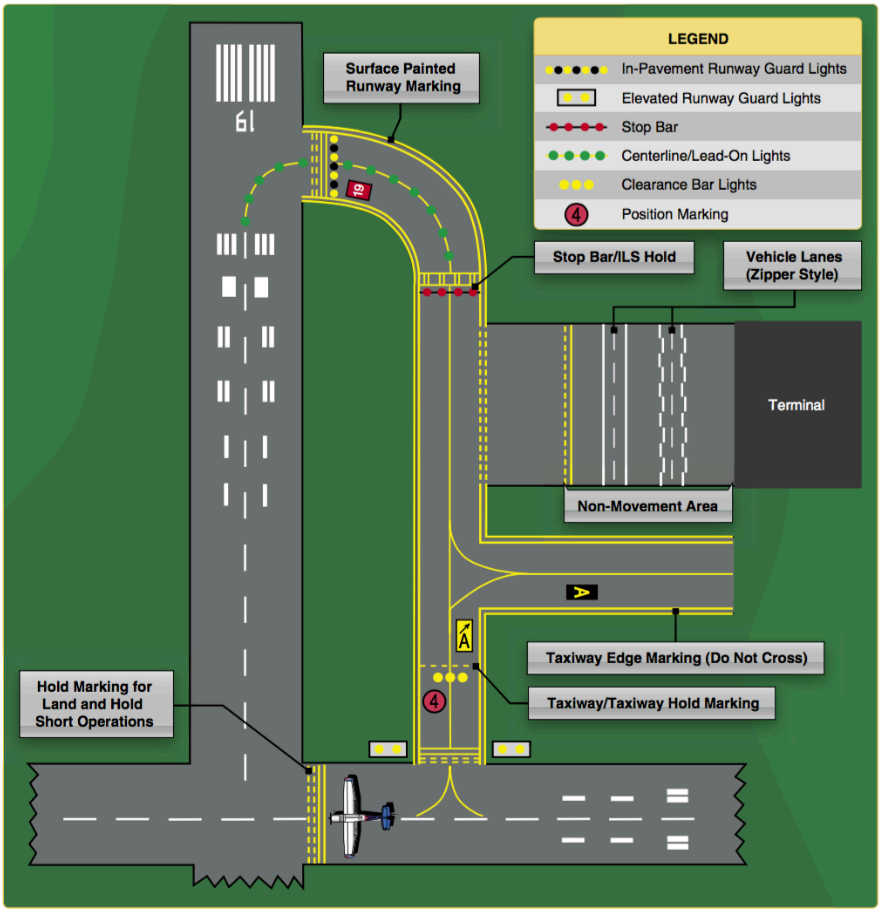
- There are markings and signs used at airports that provide directions and assist pilots in airport operations. Some of the most common markings and signs are discussed below.

Runways

- When airports are being constructed, the direction/heading of the runways are determined by the direction of the prevailing winds in that location. Traditionally, aircraft like to land INTO the wind. This provides the most airflow over the wings at the slowest ground speed.
- The numbers on runways are given in MAGNETIC heading, by the first two numbers of the heading.
    - For example, a runway facing directly west (270 degrees) would be "Runway 27."
    - If there are two runways with the same heading, they will be designated by an "L" or "R" after the heading (i.e., "27R" or "27L").
- Runways generally have a white dashed line to indicate the centerline of the runway. You will also occasionally find thick white lines that indicate the optimal "touchdown" point at the beginning of the runway for aircraft landing on that particular runway.

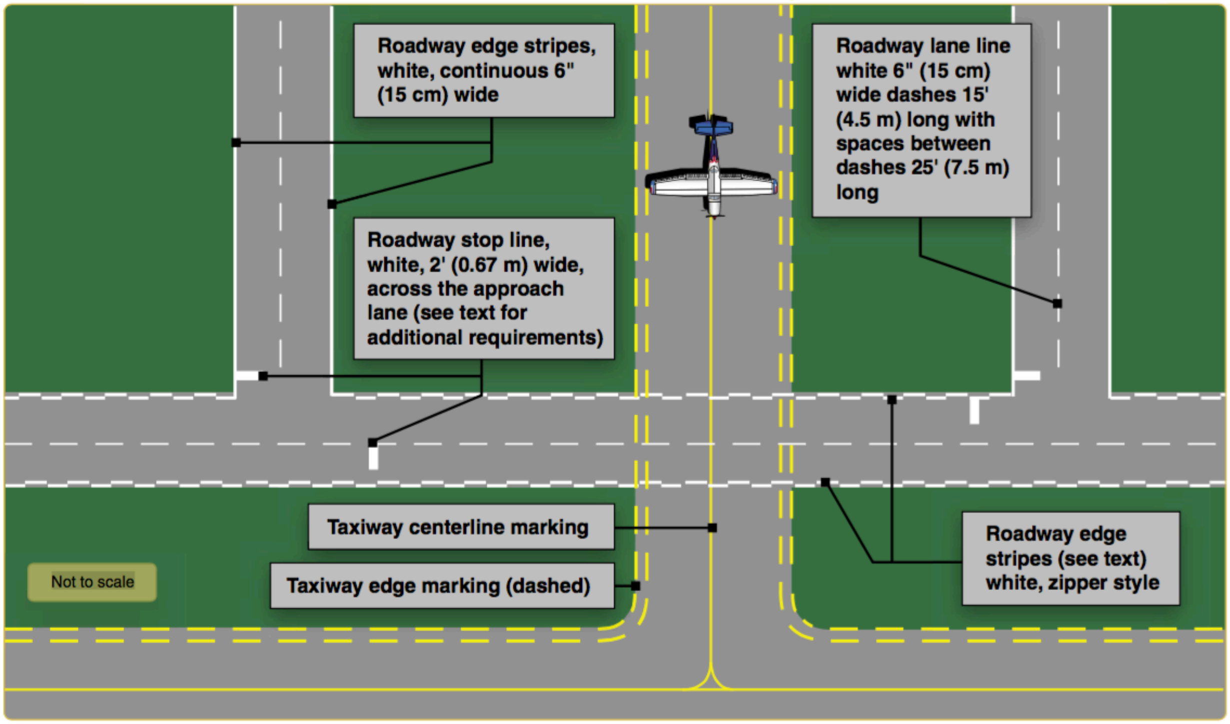
Taxiways

- Aircraft use taxiways to transition from parking areas to the runway. Taxiways are identified by a continuous yellow centerline stripe and may include edge markings to define the edge of the taxiway. This is usually done when the taxiway edge does not correspond with the edge of the pavement.
- If an edge marking is a continuous line, the paved shoulder is not intended to be used by an aircraft. If it is a dashed marking, an aircraft may use that portion of the pavement.
- Where a taxiway approaches a runway, there may be a holding position marker. These consist of four yellow lines (two solid and two dashed). The solid lines are where the aircraft is to hold. At some towered airports, holding position markings may be found on a runway. They are used when there are intersecting runways, and ATC issues instructions such as "cleared to land—hold short of runway 30."



Vehicle Roadways

- Vehicle roadway markings are used when necessary to define a pathway for vehicle crossing areas that are also intended for aircraft. These markings usually consist of a solid white line to delineate each edge of the roadway and a dashed line to separate lanes within the edges of the roadway. In lieu of the solid lines, zipper markings may be used to delineate the edges of the vehicle roadway.



Airport Signs

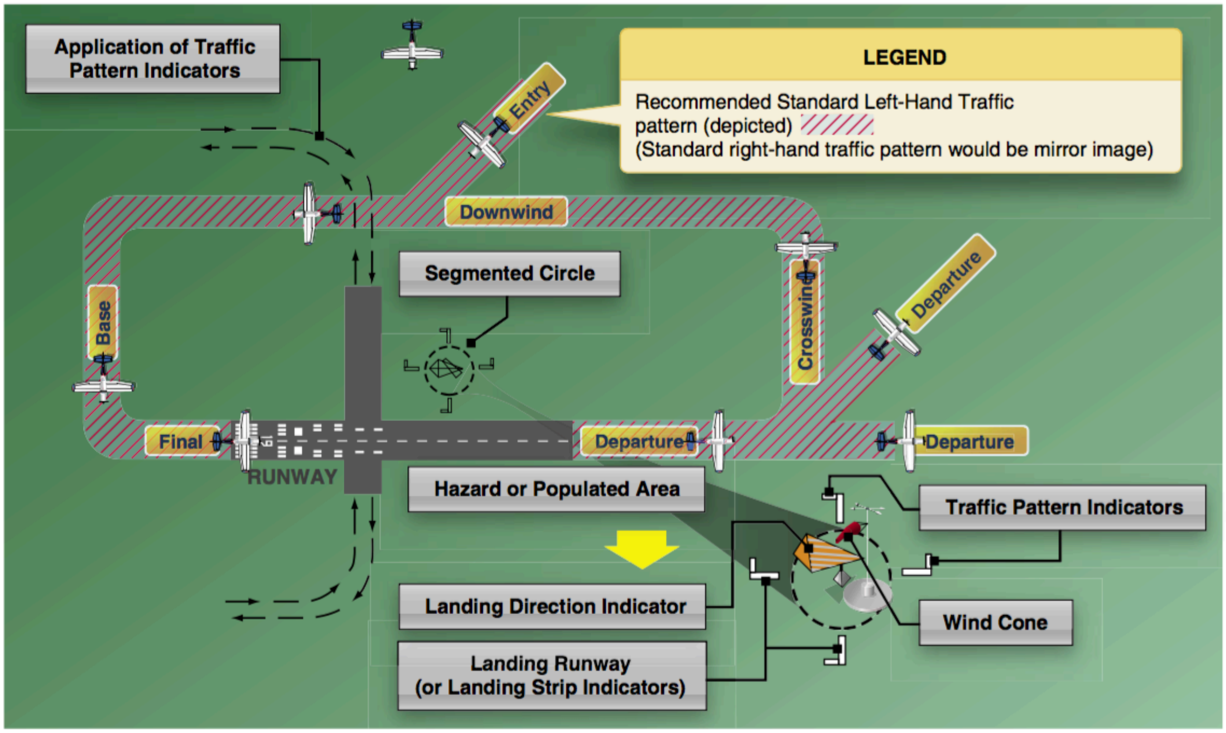
- There are six types of signs that may be found at airports. The more complex the layout of an airport, the more important the signs become to pilots. The figure below shows examples of signs, their purpose, and appropriate pilot action. The six types of signs are:
  - Mandatory instruction signs
    - Red background with white inscription. These signs denote an entrance to a runway, critical area, or prohibited area.
  - Location signs
    - Black with yellow inscription and a yellow border, no arrows. They are used to identify a taxiway or runway location, to identify the boundary of the runway, or identify an instrument landing system (ILS) critical area.
  - Direction signs
    - Yellow background with black inscription. The inscription identifies the designation of the intersecting taxiway(s) leading out of an intersection.
  - Destination signs
    - Yellow background with black inscription and also contain arrows. These signs provide information on locating things, such as runways, terminals, cargo areas, and civil aviation areas.
  - Information signs
    - Yellow background with black inscription. These signs are used to provide the pilot with information on such things as areas that cannot be seen from the control tower, applicable radio frequencies, and noise abatement procedures. The airport operator determines the need, size, and location of these signs.
  - Runway distance remaining signs

- Black background with white numbers. The numbers indicate the distance of the remaining runway in thousands of feet.

Type of Sign	Action or Purpose	Type of Sign	Action or Purpose
4-22	**Taxiway/Runway Hold Position:** Hold short of runway on taxiway		**Runway Safety Area/Obstacle Free Zone Boundary:** Exit boundary of runway protected areas
26-8	**Runway/Runway Hold Position:** Hold short of intersecting runway		**ILS Critical Area Boundary:** Exit boundary of ILS critical area
8-APCH	**Runway Approach Hold Position:** Hold short of aircraft on approach	J →	**Taxiway Direction:** Defines direction & designation of intersecting taxiway(s)
ILS	**ILS Critical Area Hold Position:** Hold short of ILS approach critical area	↙ L	**Runway Exit:** Defines direction & designation of exit taxiway from runway
⊖	**No Entry:** Identifies paved areas where aircraft entry is prohibited	22 ↑	**Outbound Destination:** Defines directions to takeoff runways
B	**Taxiway Location:** Identifies taxiway on which aircraft is located	↖ MIL	**Inbound Destination:** Defines directions for arriving aircraft
22	**Runway Location:** Identifies runway on which aircraft is located		**Taxiway Ending Marker:** Indicates taxiway does not continue
4	**Runway Distance Remaining:** Provides remaining runway length in 1,000 feet increments	↙A G L →	**Direction Sign Array:** Identifies location in conjunction with multiple intersecting taxiways

Traffic Patterns Used by Manned Aircraft

- To facilitate the safe and orderly flow of traffic into and out of the airport, certain traffic patterns are followed by manned aircraft on takeoff and landing. This pattern consists of several parts or "legs:"
  - Crosswind Leg;
  - Downwind Leg;
  - Base Leg; and
  - Final Approach.
- Traffic patterns are shaped in a rectangle around the runway. Patterns where the aircraft is continuously making left turns is referred to "left traffic" and patterns with right turns are referred to as "right traffic."



- As previously stated, aircraft generally land INTO the wind, as this provides the most airflow over the wings (generating lift) and allows the aircraft to land at the slowest ground speed. Thus, the direction of the wind will usually dictate which runway (or runways) is the one being utilized for takeoffs and landings at a given point in time.
- It is standard practice for aircraft to enter the traffic pattern at a 45-degree angle on the DOWNWIND leg of the traffic pattern. However, if an aircraft is approaching the airfield from a location that wouldn't be conducive to a downwind entry, the ATC operator may direct the pilot to enter at a different point in the pattern.
    - For instance, if a pilot is already flying the same heading as active runway 19, and there is no other air traffic at the airport, ATC may instruct the pilot as follows: "Approved for landing, straight in, Runway 19." In this example, the pilot would enter the pattern on final approach.
- Generally, aircraft fly in and around the pattern at 1,000 feet AGL. If different, the pattern altitude should be located in the Chart Supplements.

Security Identification Display Areas (SIDA)

- Security Identification Display Areas (SIDA) are limited-access areas at an airport or other aviation center that require a badge. Movement through or into these areas is prohibited without proper identification being displayed. If you are unsure of the location of a SIDA, contact the airport authority for additional information. Airports that have a SIDA must have the following information available:
    - A description and map detailing boundaries and pertinent features;
    - Measures used to perform the access control functions;
    - Procedures to control movement within the secured area, including identification media; and
    - A description of the notification signs.

- Pilots or passengers without proper identification that are observed entering a SIDA (ramp area) may be reported to TSA or airport security. Pilots are advised to brief passengers accordingly.

Sources for Airport Data

- When an sUAS pilot flies in or around an airport, it is important to review the current data for that airport. This data provides the pilot with information, such as communication frequencies, flow of air traffic, and other hazards and information to aid safe operation. Two important sources of information are:
    - Aeronautical Charts
    - Chart Supplements (formerly Airport/Facility Directory)

Aeronautical Charts

- An aeronautical chart is the typical road map for a manned aircraft pilot flying under visual flight rules (VFR),. The chart provides information that allows pilots to track their position and provides available information, which enhances safety. The three aeronautical charts used by VFR pilots are:
    - Sectional Chart
    - VFR Terminal Area Chart
    - World Aeronautical Chart
- Unmanned aircraft pilots can and should use aeronautical charts, such as a sectional chart, to determine the type of airspace that proposed flight operations will be conducted in. Additionally, aeronautical charts provide the remote pilot with helpful information on where to expect other manned aircraft, frequencies for monitoring air traffic in specific airspaces, and information on other potential hazards and safety items.

Chart Supplements

- The Chart Supplements (CS) provide the most comprehensive information on a given airport. They contain information on airports, heliports, and seaplane bases that are open to the public. The CS are published in seven books, which are organized by regions and are revised every 56 days. The CS are also available digitally at www.naco.faa.gov.
- In addition to airport information, each CS contains information such as special notices, Federal Aviation Administration (FAA) and National Weather Service (NWS) telephone numbers, preferred instrument flight rules (IFR) routing, visual flight rules (VFR) waypoints, a listing of very high frequency (VHF) omnidirectional range (VOR) receiver checkpoints, aeronautical chart bulletins, land and hold short operations (LAHSO) for selected airports, airport diagrams for selected towered airports, en route flight advisory service (EFAS) outlets, parachute jumping areas, and facility telephone numbers.

Bird and Wildlife Hazards and Reporting

Bird Strike Risks and Mitigation

- Birds present one of the greatest hazards to aircraft operations, given their size, abundance, and habit of flying in dense flocks.
- 90% of reported bird strikes occur at or below 3,000 feet.

- Given the relatively small size of sUAS, a bird strike could cause serious structural damage or lead to a crash of the sUAS.
- To mitigate the risk of bird strikes, pilots should avoid flying over areas known to have high concentrations of birds, such as wildlife refuges and should exercise caution when operating within bird flyways such as the:
    - Atlantic Flyway, parallel to the Atlantic coast;
    - Mississippi Flyway, stretching from Canada through the great lakes, along the Mississippi River;
    - Central Flyway, stretching from Canada through Central America, along the Rocky Mountains; and
    - Pacific Flyway, following the west coast over Washington, Oregon, and California.

Reporting Bird Strikes and Other Wildlife Activities

- Pilots are urged to report any bird or other wildlife strike using FAA Form 5200–7, Bird/Other Wildlife Strike Report, which can be found at http://wildlife–mitigation.tc.faa.gov. The data derived from these reports are used to develop standards to cope with this potential hazard to aircraft and for documentation of necessary habitat control on airports.
- If you observe a large flock of birds or other animals on or near the runway at an airport, contact the nearest Flight Service Station or tower (including non–Federal towers) regarding large flocks of birds and report the:
    - Geographic location;
    - Bird type (geese, ducks, gulls, etc.);
    - Approximate numbers;
    - Altitude; and
    - Direction of bird flight path.

SECTION 10: EMERGENCY PROCEDURES

Emergency Planning and Communication

- There are a number of risks that are inherent to sUAS operations.
    - Lithium batteries, while excellent at providing power to unmanned aircraft in a small size profile, can be quite dangerous when not used properly or are exposed to overheating.
    - Furthermore, the communication link between the control station and the unmanned aircraft may be interrupted, causing potential fly-aways and other undesirable flight characteristics.
- Proper planning can help mitigate these risks and minimize potential hazards to people and property in the flight operations area.

Lithium Batteries

Safe Transportation

- Given that lithium batteries are at risk of combustion and ignition, special care must be taken when these batteries are transported.

- Batteries being transported that are not currently installed in the unmanned aircraft should be individually protected so as to prevent short circuits. This may be accomplished by placing the battery in the original retail packaging, insulating terminals by placing electrical tape over them, or placing each battery in a separate plastic bag or protective pouch.
- Lithium batteries should be inspected before and after transportation, as well as before being installed into the unmanned aircraft. The user should check for any external damage or any other condition that may cause the battery to malfunction.

Safe Charging

- As previously stated, lithium batteries at risk of combustion when they are exposed to overheating, overcharging, or are otherwise defective.
- To mitigate these risks, the user should follow all manufacturer guidelines and instructions for charging and handling lithium batteries.

Safe Usage

- Lithium-based batteries are highly flammable and capable of ignition. A battery fire could cause an in-flight emergency by causing a loss of control of the sUAS. In addition to the risks previously stated, Lithium battery fires can be caused if the lithium battery is damaged as a result of a crash, mishandled, or simply defective. The Remote PIC should consider following the manufacturer's recommendations, when available, to help ensure safe battery handling and usage.

Loss of Control Link and Fly-Aways

- Loss of control (LOC) link and fly-aways are instances where the communication link between the unmanned aircraft and the control station is severed, causing the sUAS to act unpredictably and often "fly away" from the pilot, potentially crashing into and harming people or property.
- To help prevent LOC and fly-away events, the Remote PIC should be sure to inspect the unmanned aircraft before each flight. This includes:
  - Ensuring that all control links between the control station and the sUAS are working properly; and
  - Ensuring there is sufficient power to continue controlled flight operation into a normal landing.
- Regarding the preflight inspection of control links, one of the ways the Remote PIC may test this is by checking to see that the control surfaces (ailerons, elevator, propellers, or rotors) are operating appropriately when the control station inputs (joystick, thumb sticks, or other control mechanisms) are manipulated.
  - Simply put, if you do something to the controls (push forward, back, etc.), does the unmanned aircraft respond appropriately?

Loss of GPS During Flight

- If GPS is lost during flight, this may impact a number of unmanned aircraft functionalities such as speed, location/position, and altitude reporting to the pilot.
- Additionally, since many sUAS flight computers are aided by GPS, the flight characteristics of the unmanned aircraft may also change. For instance, with a loss of GPS, the sUAS may not automatically

hold its altitude, correct for wind, or brake when forward control is released. This may cause an increased risk that the unmanned aircraft will collide with an obstacle during flight.

- To mitigate this risk, GPS signal should be inspected and performing at an appropriate level before flight, if being relied upon for flight operations.
    - Advisory circular 107-2 advises that the Remote PIC should confirm that the sUAS has acquired at least **four** satellites before takeoff.

Frequency Spectrums

- Unmanned aircraft typically use radio frequencies (RF) for the communication link between the control station and the sUAS.

Frequency Spectrum Basics

- The 2.4 GHz and 5.8 GHz systems are the unlicensed band RFs that most sUAS use for the connection between the control station and the small UA.
    - Note the frequencies are also used for computer wireless networks and the interference can cause problems when operating an sUAS in an area (e.g., dense housing and office buildings) that has many wireless signals. LOC and fly-aways are some of the reported problems with sUAS frequency implications.
- To avoid frequency interference, many modern sUAS operate using a 5.8 GHz system to control the sUAS and a 2.4 GHz system to transmit video and photos to the ground. Consult the sUAS operating manual and manufacturer's recommended procedures before conducting sUAS operations.
- It should be noted that both RF bands (2.4 GHz and 5.8 GHz) are considered line of sight and the command and control link between the control station and the sUAS will not work properly when barriers are between the control station and the sUAS. Part 107 requires the Remote PIC or person manipulating the controls to be able to see the sUAS at all times, which should also help prevent obstructions from interfering with the line of sight frequency spectrum.

Spectrum Authorization

- Frequency spectrum used for sUAS operations are regulated by the Federal Communications Commission (FCC).
- Radio transmissions, such as those used to control an sUAS and to downlink real-time video, must use frequency bands that are approved for use by the operating agency.
- The FCC authorizes civil operations. Some operating frequencies are unlicensed and can be used freely (e.g., 900 MHz, 2.4 GHz, and 5.8 GHz) without FCC approval. All other frequencies require a user-specific license for all civil users, except federal agencies, to be obtained from the FCC. For further information, visit https://www.fcc.gov/licensing-databases/licensing.

SECTION 11: AERONAUTICAL DECISION-MAKING

Aeronautical Decision-Making (ADM)

- ADM is a systematic approach to risk assessment and stress management. To understand ADM is to also understand how personal attitudes can influence decision-making and how those attitudes can be modified to enhance safety in the flight deck. It is important to understand the factors that cause humans to make decisions and how the decision-making process not only works, but can be improved.
- A Remote PIC uses many different resources to safely operate an sUAS and needs to be able to manage these resources effectively.
- The ADM process addresses all aspects of decision-making in a solo or crew environment and identifies the steps involved in good decision-making. These steps for good decision-making are as follows:
    - 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 Available Resources with More Than One Crewmember (CRM).

Effective Team Communication

- A Remote PIC must be able to function in a team environment and maximize team performance. This skill set includes situational awareness, proper allocation of tasks to individuals, avoidance of work overloads in self and in others, and effectively communicating with other members of the crew, such as VOs and persons manipulating the controls of an sUAS.

Task Management

- Tasks vary depending on the complexity of the operation. Depending upon the area of the operations, additional crewmembers may be needed to safely operate the aircraft.
- Enough crewmembers should be utilized to ensure no one on the team becomes overloaded. Once a member of the team becomes overworked, there's a greater possibility of an incident/accident.

Crew Resource Management (CRM)

- Crew resource management (CRM) training for flight crews is focused on the effective use of all available resources: human resources, hardware, and information supporting ADM to facilitate crew cooperation and improve decision-making. The goal of all flight crews is good ADM and the use of CRM is one way to make good decisions.
- While CRM focuses on pilots operating in crew environments, many of the concepts apply to single-pilot operations. Many CRM principles have been successfully applied to single-pilot aircraft, and led to the development of Single-Pilot Resource Management (SRM).
- A characteristic of CRM is creating an environment where open communication is encouraged and expected, and involves the entire crew to maximize team performance.

Situational Awareness

- Situational awareness is the accurate perception and understanding of all the factors and conditions within the five fundamental risk elements (flight, pilot, aircraft, environment, and type of operation that comprise any given aviation situation) that affect safety before, during, and after the flight.

- When a pilot understands what is going on and has an overview of the total operation, he or she is not fixated on one perceived significant factor.
- Maintaining situational awareness requires an understanding of the relative significance of all flight related factors and their future impact on the flight.
- To maintain situational awareness, all of the skills involved in ADM are used.

Hazardous Attitudes

The attitude of a pilot is a key factor in a safe flying practice. Knowing and identifying hazardous attitudes is important and should be easily identified by the pilot.

- **Anti-Authority: "Don't tell me."**
  - This attitude is found in people who do not like anyone telling them what to do. In a sense, they are saying, "No one can tell me what to do." The may be resentful of having someone tell them what to do or may regard rules, regulations and procedures as silly or unnecessary. However, it is always your prerogative to question authority if you feel it is in error.
- **Impulsivity: "Do it quickly."**
  - This is the attitude of people who frequently feel the need to do something, anything immediately. They do not stop to think about what they are about to do; they do not select the best alternative, but instead they do the first thing that comes to mind.
- **Invulnerability: "It won't happen to me."**
  - Many people falsely believe that accidents happen to others but never to them. They know accidents can happen and they know that anyone can be affected. However, they never really feel or believe that they will be personally involved. Pilots who think this way are more likely to take chances and increase risk.
- **Macho: "I can do it."**
  - Pilots who are always trying to prove that they are better than anyone else think, "I can do it. I'll show them." Pilots with this type of attitude will try to prove themselves by taking risks in order to impress others. While this pattern is thought to be a male characteristic, women are equally susceptible.
- **Resignation: "What's the use?"**
  - Pilots who think, "What's the use?" do not see themselves as being able to make a great deal of difference in what happens to them. When things go well, the pilot is apt to think that it is good luck. When things go badly, the pilot may feel that someone is out to get him or her or attribute it to bad luck. The pilot will leave the action to others for better or worse. Sometimes such pilots will even go along with unreasonable requests just to be a 'nice guy.'

SECTION 12: PHYSIOLOGY

Physiological Considerations

- There are a number of physiological factors to consider when planning for safe unmanned aircraft operations. Given the considerable amount of time that sUAS pilots may spend outdoors, two major factors to consider are dehydration and heatstroke.

Dehydration

- Dehydration is the critical loss of water from the body. Symptoms may include:
  - Headache;
  - Fatigue;
  - Cramps;
  - Sleepiness; and
  - Dizziness.
- Common causes of dehydration are prolonged exposure to asphalt areas (where heat may be more intense), wind, humidity, and diuretic drinks such as coffee, tea, alcohol, and caffeinated soft drinks.
- To prevent dehydration, drink two to four quarts of water every 24 hours.

Heatstroke

- Heatstroke is a condition cause be an inability of the body to control its temperature.
- The onset of heatstroke has similar symptoms to that of dehydration, but the final symptom is full collapse.
- To prevent heatstroke, similar steps should be taken as to prevent dehydration: drink ample water.
  - In intense heat, individuals should drink one quart per hour.
  - In moderate heat, individuals should drink one pint per hour.

Alcohol Use

- The safe operation of unmanned aircraft requires careful attention, coordination, and communication with one's own self and others.
- Alcohol has been proven to greatly reduce the efficiency and coordination of the human body, while also having impacts on the speed and quality of decision making. Even in small amounts, alcohol can:
  - Impair judgment;
  - Decrease sense of responsibility;
  - Affect coordination;
  - Constrict visual field;
  - Diminish memory;
  - Reduce reasoning power; and
  - Lower attention span.
- Impairments to vision and hearing occur at alcohol blood levels due to as little as one drink.
- The bloodstream absorbs about 80 to 90 percent of the alcohol in a drink within 30 minutes when ingested on an empty stomach.
- While experiencing a hangover, a pilot is still under the influence of alcohol. Although a pilot may think he or she is functioning normally, motor and mental response impairment is still present. Considerable amounts of alcohol can remain in the body for over 16 hours, so pilots should be cautious about flying too soon after drinking.
- Intoxication is determined by the amount of alcohol in the bloodstream. This is usually measured as a percentage by weight in the blood. **Regulations require that blood alcohol level be less than .04 percent and that 8 hours pass between drinking alcohol and piloting an unmanned aircraft.** A remote pilot with a blood alcohol level of .04 percent or greater after 8 hours cannot operate an sUAS until the blood alcohol falls below that amount. Even though blood alcohol may be well below .04 percent, a pilot

cannot fly sooner than 8 hours after drinking alcohol. Although the regulations are quite specific, it is a good idea to be more conservative than the regulations require.

Prescription and Over-The-Counter (OTC) Medication

- Pilot performance can be seriously degraded by both prescription and over-the-counter medications, as well as by the medical conditions for which they are taken.
- **Regulations prohibit remote pilots from performing as a crewmember to any unmanned aircraft operation while using medication that affects the body in any way contrary to safety.**
- Many medications, such as tranquilizers, sedatives, strong pain relievers, and cough suppressants have primary effects that may impair judgment, memory, alertness, coordination, vision, and the ability to make calculations.
- Others, such as antihistamines, blood pressure drugs, muscle relaxants, and agents to control diarrhea and motion sickness have side effects that may impair the same critical functions.
- There are several other types and categories of OTC medications that may impact the safety of sUAS operations:
    - Analgesics
        - These are typically made up of OTC painkillers such as Aspirin, Tylenol, Advil, Aleve, and other prescription strength drugs such as Darvon, Oxycodone, Demerol, and Codeine.
        - The OTC analgesics generally do not impact flight operations unless the individual is allergic to such medications.
        - Prescription analgesics are known to cause side effects such as mental confusion, dizziness, headaches, nausea, and vision problems. These medications should be avoided while operating sUAS.
    - Anesthetics
        - Anesthetic drugs are commonly used for dental and surgical procedures. Most local anesthetics used for minor dental and outpatient procedures wear off within a relatively short period of time. The anesthetic itself may not limit safe flight operations as much as the actual procedure and subsequent pain.
    - Stimulants
        - Stimulants are drugs that excite the central nervous system and produce an increase in alertness and activity.
        - Amphetamines, caffeine, and nicotine are all forms of stimulants. Common uses of these drugs include appetite suppression, fatigue reduction, and mood elevation. Some of these drugs may cause a stimulant reaction, even though this reaction is not their primary function.
        - In some cases, stimulants can produce anxiety and mood swings, both of which are dangerous when flying.
    - Depressants
        - Depressants are drugs that reduce the body's functioning in many areas. These drugs lower blood pressure, reduce mental processing, and slow motor and reaction responses.
        - There are several types of drugs that can cause a depressing effect on the body, including tranquilizers, motion sickness medication, some types of stomach

medication, decongestants, and antihistamines. The most common depressant is alcohol.

- Crewmembers should not take more than one drug or medication at a time unless specifically prescribed by a physician. And never mix drugs with alcohol, because the effects are often unpredictable.

Hyperventilation

- Hyperventilation is the excessive rate and depth of respiration leading to abnormal loss of carbon dioxide from the blood.
- Hyperventilation seldom incapacitates a person completely, but it can cause disturbing symptoms that can alarm the uninformed crewmember. In such cases, increased breathing rate and anxiety further aggravate the problem.
- Common symptoms of hyperventilation are:
  - Visual impairment;
  - Unconsciousness;
  - Lightheaded or dizzy sensation;
  - Tingling sensations;
  - Hot and cold sensations; and
  - Muscle spasms.
- The treatment for hyperventilation involves restoring the proper carbon dioxide level in the body. Breathing normally is both the best prevention and the best cure for hyperventilation.
- In addition to slowing the breathing rate, breathing into a paper bag or talking aloud helps to overcome hyperventilation. Recovery is usually rapid once the breathing rate is returned to normal.

Stress and Fatigue

Stress

- Stress is the body's response to physical and psychological demands placed upon it. The body's reaction to stress includes releasing chemical hormones (such as adrenaline) into the blood, and increasing metabolism to provide more energy to the muscles. Blood sugar, heart rate, respiration, blood pressure, and perspiration all increase. The term "stressor" is used to describe an element that causes an individual to experience stress. Examples of stressors include:
  - Physical stress (noise or vibration),
  - Physiological stress (fatigue), and
  - Psychological stress (difficult work or personal situations).
- Stress falls into two broad categories: acute (short term) and chronic (long term).

Acute Stress

- Acute stress involves an immediate threat that is perceived as danger. This is the type of stress that triggers a "fight or flight" response in an individual, whether the threat is real or imagined.
- Normally, a healthy person can cope with acute stress and prevent stress overload. However, ongoing acute stress can develop into chronic stress.

Chronic Stress

- Chronic stress can be defined as a level of stress that presents an intolerable burden, exceeds the ability of an individual to cope, and causes individual performance to fall sharply.
- Unrelenting psychological pressures, such as loneliness, financial worries, and relationship or work problems can produce a cumulative level of stress that exceeds a person's ability to cope with the situation.
- When stress reaches these levels, performance falls off rapidly. Pilots experiencing this level of stress are not safe and should not exercise their airman privileges. Pilots who suspect they are suffering from chronic stress should consult a physician.

Fatigue

- Fatigue is frequently associated with pilot error. Some of the effects of fatigue include:
  - Degradation of attention and concentration;
  - Impaired coordination; and
  - Decreased ability to communicate.
- These factors seriously influence the ability to make effective decisions. Physical fatigue results from sleep loss, exercise, or physical work. Factors such as stress and prolonged performance of cognitive work result in mental fatigue.
- There are two types of fatigue: acute and chronic.

Acute Fatigue

- Acute Fatigue is typically short term and is a normal occurrence in everyday life. This can typically be mitigated by a night of restful sleep.
  - Skill Fatigue: A special type of acute fatigue, which has two main effects on performance:
    - **Timing Disruption** - Appearing to perform a task as usual, but the timing of each component is slightly off. This makes the pattern of the operation less smooth, because the pilot performs each component as though it were separate, instead of part of an integrated activity.
    - **Disruption of the Perceptual Field**—Concentrating attention upon movements or objects in the center of vision and neglecting those in the periphery. This is accompanied by loss of accuracy and smoothness in control movements.
- The following factors are common causes of acute fatigue:
  - Physical stress;
  - Psychological stress;
  - Depletion of physical energy resulting from psychological stress; and
  - Sustained psychological stress.

Chronic Fatigue

- Chronic fatigue, extending over a long period of time, usually has psychological roots, although an underlying disease is sometimes responsible.
- Continuous high stress levels produce chronic fatigue. Chronic fatigue is not relieved by proper diet and adequate rest and sleep, and usually requires treatment by a physician.

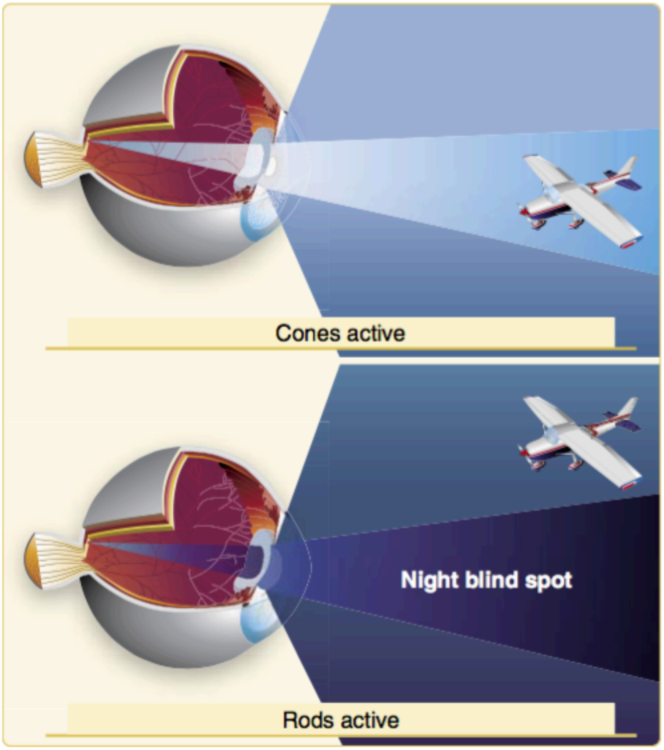
- An individual may experience this condition in the form of:
    - Weakness;
    - Tiredness;
    - Palpitations of the heart;
    - Breathlessness;
    - Headaches; or
    - Irritability.
- Sometimes chronic fatigue even creates stomach or intestinal problems and generalized aches and pains throughout the body. When the condition becomes serious enough, it leads to emotional illness.

Factors Effecting Vision

- Of all the senses, vision is the most important for safe flight operations. As remarkable and vital as it is, vision is subject to limitations, such as illusions and blind spots. The more a remote pilot understands about the eyes and how they function, the easier it is to use vision effectively and compensate for potential problems.
- The eye functions much like a camera and has two categories of light-sensitive cells: rods and cones.
    - Cones – responsible for color vision. Good at detecting detail in environments with high light levels.
    - Rods – able to detect movement. Provide vision in dim light environments. "Night vision." Downside is a "blind spot" in the center of field of vision.

Night Vision

- It is estimated that once fully adapted to darkness, the rods are 10,000 times more sensitive to light than the cones, making them the primary receptors for night vision.
- The location of rods and cones within the eye can make a night blind spot in the center of the field of vision. To see an object clearly at night, the remote pilot must expose the rods to the image. This can be done by looking 5° to 10° off center of the object to be seen.
    - This can be tried in a dim light in a darkened room. When looking directly at the light, it dims or disappears altogether. When looking slightly off center, it becomes clearer and brighter.

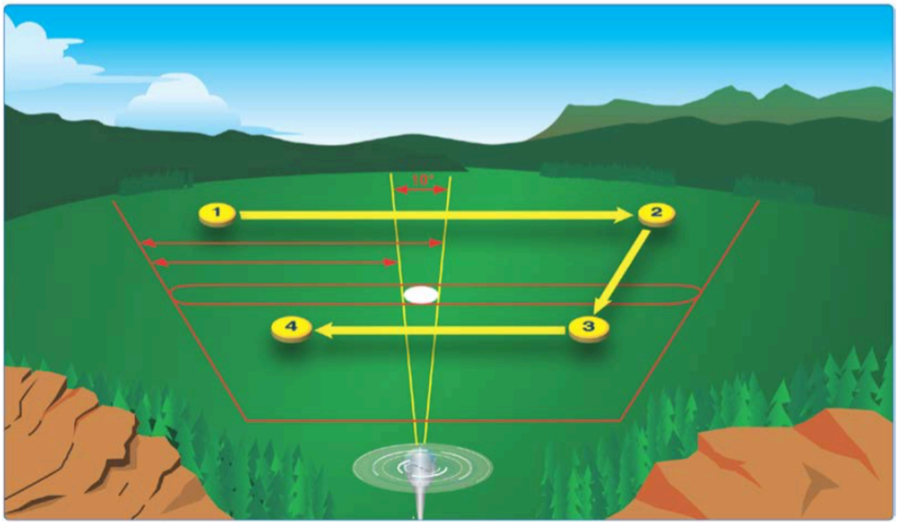


- While the cones adapt rapidly to changes in light intensities, the rods take much longer. Walking from bright sunlight into a dark movie theater is an example of this dark adaptation period experience.
  - The rods can take approximately 30 minutes to fully adapt to darkness. A bright light, however, can completely destroy night adaptation, leaving night vision severely compromised while the adaptation process is repeated.
- Several things can be done to keep the eyes adapted to darkness. The first is obvious: avoid bright lights before and during flight.
  - For 30 minutes before a night flight, avoid any bright light sources, such as headlights, landing lights, strobe lights, or flashlights. If a bright light is encountered, close one eye to keep it light sensitive. This allows the use of that eye to see again when the light is gone.
  - Dim red light is also recognized as being able to provide illumination while still preserving night vision.
- Diet and general physical health have an impact on how well a pilot can see in the dark. Deficiencies in vitamins A and C have been shown to reduce night acuity. Other factors, such as CO poisoning, smoking, alcohol, certain drugs, and a lack of oxygen also can greatly decrease night vision.

Scanning

- One method that a remote pilot should use to avoid other air traffic is scanning. Scanning involves "scanning" your eyes across certain sections of the sky and area around your unmanned aircraft, looking for other air traffic and potential hazards.
- This should be a methodical movement of the eyes from side to side, starting at the greatest distance that an object can be perceived, then moving back towards your aircraft.

- What you need to know for the exam: **When scanning, remote pilots should look at an area that is approximately 30-degrees wide for no longer than 2 to 3 seconds. The next 30-degree area that's scanned should overlap with the previous area by 10-degrees.**



- While Part 107 requires remote pilots to maintain visual line of sight of their aircraft at all times, scanning is a task that is likely most easily accomplished by a visual observer. The remote pilot has a number of duties: observing the aircraft, checking the controls, looking out for other aircraft and obstacles (including scanning), and piloting the aircraft safely. If the visual observer is the primary "scanner", this eases some of the task load on the remote pilot, who can now focus his or her attention to maintaining visual contact with the unmanned aircraft they are piloting.

Fitness for Flight

- The factors mentioned in this section, as well as others the remote pilot may encounter, may impact an individual's fitness for conduction of sUAS flight operations.
- Remote pilots and other crewmembers should complete a self-assessment before conducting flight operations to ensure that they are mentally and physically fit for operations.

SECTION 13: MAINTENANCE AND INSPECTION PROCEDURES

- According to 14 CFR Part 107.15, the Remote PIC MUST perform checks of the sUAS prior to each flight to determine if the aircraft is in a condition for safe operation.

Basic Maintenance

- Maintenance includes scheduled and unscheduled overhaul, repair, inspection, modification, replacement, and system software upgrades of the sUAS and its components necessary for flight.

- Whenever possible, the operator should maintain the sUAS and its components in accordance with manufacturer's instructions. The aircraft manufacturer may provide the maintenance program, or, if one is not provided, the applicant may choose to develop one.

Scheduled Maintenance

- The aircraft manufacturer may provide documentation for scheduled maintenance of the entire unmanned aircraft and associated system equipment. There may be components of the sUAS that are identified by the manufacturer to undergo scheduled periodic maintenance or replacement based on time-in-service limits (such as flight hours, cycles, and/or the calendar days). All manufacturer-scheduled maintenance instructions should be followed in the interest of achieving the longest and safest service life of the sUAS.
- **If there are no scheduled maintenance instructions provided by the sUAS manufacturer or component manufacturer, the operator should establish a scheduled maintenance protocol**.
    - This could be done by documenting any repair, modification, overhaul, or replacement of a system component resulting from normal flight operations, and recording the time-in-service for that component at the time of the maintenance procedure. Over time, the operator should then be able to establish a reliable maintenance schedule for the sUAS and its components.

Unscheduled Maintenance

- During the course of a preflight inspection, the Remote PIC may discover that an sUAS component is in need of servicing, repair, modification, overhaul, or replacement outside of the scheduled maintenance period as a result of normal flight operations or resulting from a mishap.
- In addition, the sUAS manufacturer or component manufacture may require an unscheduled system software update to correct a problem.
    - In the event such a condition is found, the Remote PIC should not conduct flight operations until the discrepancy is corrected.

Preflight Inspection

- Preflight inspections should be conducted in accordance with the unmanned aircraft manufacturer's inspection procedures when available (usually found in the manufacturer's owner or maintenance manual) and/or an inspection procedure developed by the sUAS owner or operator.

Creating an Inspection Program

- As an option, the sUAS owner or operator may wish to create an inspection program for their sUAS. The person creating an inspection program for a specific sUAS may find sufficient details to assist in the development of a suitable inspection program tailored to a specific sUAS in a variety of industry programs.

Scalable Preflight Inspection

- The preflight check as part of the inspection program should include an appropriate sUAS preflight inspection that is scalable to the sUAS, program, and operation to be performed prior to each flight.

- An appropriate preflight inspection should encompass the entire system in order to determine a continued condition for safe operation prior to flight.

Preflight Inspection Items

- Even if the sUAS manufacturer has a written preflight inspection procedure, it is recommended by Advisory Circular 107 that the Remote PIC ensure that the following inspection items are incorporated into the preflight inspection procedure required by part 107 to help the Remote PIC determine that the sUAS is in a condition for safe operation. The preflight inspection should include a visual or functional check of the following items:
    - Visual condition inspection of the sUAS components;
    - Airframe structure (including undercarriage), all flight control surfaces, and linkages;
    - Registration markings, for proper display and legibility;
    - Moveable control surface(s), including airframe attachment point(s);
    - Servo motor(s), including attachment point(s);
    - Propulsion system, including powerplant(s), propeller(s), rotor(s), ducted fan(s), etc.;
    - Verify all systems (e.g., aircraft and control unit) have an adequate energy supply for the intended operation and are functioning properly;
    - Avionics, including control link transceiver, communication/navigation equipment, and antenna(s);
    - Calibrate sUAS compass prior to any flight;
    - Control link transceiver, communication/navigation data link transceiver, and antenna(s);
    - Display panel, if used, is functioning properly;
    - Check ground support equipment, including takeoff and landing systems, for proper operation;
    - Check that control link correct functionality is established between the aircraft and the CS;
    - Check for correct movement of control surfaces using the CS;
    - Check onboard navigation and communication data links;
    - Check flight termination system, if installed;
    - Check fuel for correct type and quantity;
    - Check battery levels for the aircraft and CS;
    - Check that any equipment, such as a camera, is securely attached;
    - Verify communication with sUAS and that the sUAS has acquired GPS location from at least four satellites;
    - Start the sUAS propellers to inspect for any imbalance or irregular operation;
    - Verify all controller operations for heading and altitude;
    - If required by flight path walk through, verify any noted obstructions that may interfere with the sUAS; and
    - At a controlled low altitude, fly within range of any interference and recheck all controls and stability.

Appropriate Record Keeping

- sUAS owners and operators may find recordkeeping to be beneficial. This could be done by documenting any repair, modification, overhaul, or replacement of a system component resulting from normal flight operations, and recording the time-in-service for that component at the time of the maintenance procedure.

- Over time, the operator should then be able to establish a reliable maintenance schedule for the sUAS and its components. Recordkeeping that includes a record of all periodic inspections, maintenance, preventative maintenance, repairs, and alterations performed on the sUAS could be retrievable from either hardcopy and/or electronic logbook format for future reference. This includes all components of the sUAS, including: sUAS, CS, launch, and recovery equipment; C2 link equipment; payload; and any other components required to safely operate the sUAS.
- Recordkeeping of documented maintenance and inspection events reinforces owner/operator responsibilities for airworthiness through systematic inspection of the sUAS to ensure its condition for safe flight determinations. Maintenance and inspection recordkeeping provides retrievable empirical evidence of vital safety assessment data defining the condition of safety-critical systems and components supporting the decision to launch.
- Recordkeeping of an sUAS may provide essential safety support for commercial operators that may experience rapidly accumulated flight operational hours/cycles. Methodical maintenance and inspection data collection can prove to be very helpful in the tracking of sUAS component service life, as well as systemic component, equipage, and structural failure events.

Persons That May Perform Maintenance on an sUAS

- In some instances, the sUAS or component manufacturer may require certain maintenance tasks be performed by the manufacturer or by a person or facility (personnel) specified by the manufacturer. It is highly recommended that the maintenance be performed in accordance with the manufacturer's instructions.
- However, if the operator decides not to use the manufacturer or personnel recommended by the manufacturer and is unable to perform the required maintenance, the operator should consider the expertise of maintenance personnel familiar with the specific sUAS and its components. In addition, though not required, the use of certificated maintenance providers is encouraged, which may include repair stations, holders of mechanic and repairman certificates, and persons working under the supervision of these mechanics and repairman.
- If the operator or other maintenance personnel are unable to repair, modify, or overhaul an sUAS or component back to its safe operational specification, then it is advisable to replace the sUAS or component with one that is in a condition for safe operation.
- It is important that all required maintenance be completed before each flight, and preferably in accordance with the manufacturer's instructions or, in lieu of that, within known industry best practices.