Chapter 9: Physiological Factors (Including Drugs and Alcohol) Affecting Pilot Performance

Introduction

14 CFR part 107 does not allow operation of small UA if the remote PIC, the person manipulating the controls, or Visual Observer (VO) is unable to safely carry out his or her responsibilities. It is the remote PIC's responsibility to ensure all crewmembers are not participating in the operation while impaired. While drug and alcohol use are known to impair judgment, certain over-the-counter (OTC) medications and medical conditions could also affect the ability to safely operate a small UA. For example, certain antihistamines and decongestants may cause drowsiness. We also emphasize that part 107 prohibits a person from serving as a remote PIC, person manipulating the controls, VO, or other crewmember if he or she:

- Has consumed any alcoholic beverage within the preceding 8 hours
- Is under the influence of alcohol
- Has a blood alcohol concentration of .04 percent or greater
- Is using a drug that affects the person's mental or physical capabilities.

There are certain medical conditions, such as epilepsy, may also create a risk to operations. It is the remote PIC's responsibility to determine that their medical condition is under control and they can safely conduct a small UA operation.

Physiological/Medical Factors that Affect Pilot Performance

Important medical factors that a pilot should be aware of include the following:

- hyperventilation
- stress
- fatigue
- dehydration
- heatstroke
- the effects of alcohol and drugs

Hyperventilation

Hyperventilation is the excessive rate and depth of respiration leading to abnormal loss of carbon dioxide from the blood. This condition occurs more often among pilots than is generally recognized. It seldom incapacitates completely, but it causes disturbing symptoms that can alarm the uninformed pilot. In such cases, increased breathing rate and anxiety further aggravate the problem. Hyperventilation can lead to unconsciousness due to the respiratory system's overriding mechanism to regain control of breathing. Pilots encountering an unexpected stressful situation may subconsciously increase their breathing rate.

Common symptoms of hyperventilation include:

- Visual impairment
- Unconsciousness
- Lightheaded or dizzy sensation
- Tingling sensations

- Hot and cold sensations
- 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

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 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 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.

Like stress, fatigue falls into two broad categories: acute and chronic. Acute fatigue is short term and is a normal occurrence in everyday living. It is the kind of tiredness people feel after a period of strenuous effort, excitement, or lack of sleep. Rest after exertion and 8 hours of sound sleep ordinarily cures this condition.

A special type of acute fatigue is skill fatigue. This type of fatigue 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.

Acute fatigue has many causes, but the following are among the most important for the pilot:

- Mild hypoxia (oxygen deficiency)
- Physical stress
- Psychological stress
- Depletion of physical energy resulting from psychological stress
- Sustained psychological stress

Acute fatigue can be prevented by proper diet and adequate rest and sleep. A well-balanced diet prevents the body from needing to consume its own tissues as an energy source. Adequate rest maintains the body's store of vital energy.

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.

If suffering from acute fatigue, a remote pilot should not operate a small UA. If fatigue occurs during the operation of a small UA, no amount of training or experience can overcome the detrimental effects. Getting adequate rest is the only way to prevent fatigue from occurring. Avoid flying a small UA without a full night's rest, after working excessive hours, or after an especially exhausting or stressful day. Remote pilots who suspect they are suffering from chronic fatigue should consult a physician.

Dehydration

Dehydration is the term given to a critical loss of water from the body. Causes of dehydration are hot temperatures, wind, humidity, and diuretic drinks—coffee, tea, alcohol, and caffeinated soft drinks. Some common signs of dehydration are headache, fatigue, cramps, sleepiness, and dizziness.

The first noticeable effect of dehydration is fatigue, which in turn makes top physical and mental performance difficult, if not impossible. Flying a small UA for long periods in hot summer temperatures or at high altitudes increases the susceptibility to dehydration because these conditions tend to increase the rate of water loss from the body.

To help prevent dehydration, drink two to four quarts of water every 24 hours. Since each person is physiologically different, this is only a guide. Most people are aware of the eight-glasses-a-day guide: If each glass of water is eight ounces, this equates to 64 ounces, which is two quarts. If this fluid is not replaced, fatigue progresses to dizziness, weakness, nausea, tingling of hands and feet, abdominal cramps, and extreme thirst.

The key for pilots is to be continually aware of their condition. Most people become thirsty with a 1.5 quart deficit or a loss of 2 percent of total body weight. This level of dehydration triggers the "thirst mechanism." The problem is that the thirst mechanism arrives too late and is turned off too easily. A small amount of fluid in the mouth turns this mechanism off and the replacement of needed body fluid is delayed.

Other steps to prevent dehydration include:

- Carrying a container in order to measure daily water intake.
- Staying ahead—not relying on the thirst sensation as an alarm. If plain water is not preferred, add some sport drink flavoring to make it more acceptable.
- Limiting daily intake of caffeine and alcohol (both are diuretics and stimulate increased production of urine).

Heatstroke

Heatstroke is a condition caused by any inability of the body to control its temperature. Onset of this condition may be recognized by the symptoms of dehydration, but also has been known to be recognized only upon complete collapse.

To prevent these symptoms, it is recommended that an ample supply of water be carried and used at frequent intervals, whether thirsty or not. The body normally absorbs water at a rate of 1.2 to 1.5 quarts per hour. Individuals should drink one quart per hour for severe heat stress conditions or one pint per hour for moderate stress conditions. For more information on water consumption, refer to the “Dehydration” section of this chapter.

Drugs

The Federal Aviation Regulations include no specific references to medication usage. Title 14 of the CFR prohibits acting as PIC or in any other capacity as a required pilot flight crewmember, while that person:

1. Knows or has reason to know of any medical condition that would make the person unable to meet the requirement for the medical certificate necessary for the pilot operation, or
2. Is taking medication or receiving other treatment for a medical condition that results in the person being unable to meet the requirements for the medical certificate necessary for the pilot operation.

Further, 14 CFR part 107 and 14 CFR part 91, sections 91.17 and 91.19 prohibit the use of any drug that affects the person’s faculties in any way contrary to safety.

There are several thousand medications currently approved by the U.S. Food and Drug Administration (FDA), not including OTC drugs. Virtually all medications have the potential for adverse side effects in some people. Additionally, herbal and dietary supplements, sport and energy boosters, and some other “natural” products are derived from substances often found in medications that could also have adverse side effects. While some individuals experience no side effects with a particular drug or product, others may be noticeably affected. The FAA regularly reviews FDA and other data to assure that medications found acceptable for aviation duties do not pose an adverse safety risk.

Some of the most commonly used OTC drugs, antihistamines and decongestants, have the potential to cause noticeable adverse side effects, including drowsiness and cognitive deficits. The symptoms associated with common upper respiratory infections, including the common cold, often suppress a pilot’s desire to fly, and treating symptoms with a drug that causes adverse side effects only compounds the problem. Particularly, medications containing diphenhydramine (e.g., Benadryl) are known to cause drowsiness and have a prolonged half-life, meaning the drugs stay in one's system for an extended time, which lengthens the time that side effects are present.

Prior to each and every flight, all pilots must do a proper physical self-assessment to ensure safety. A great mnemonic is IMSAFE, which stands for Illness, Medication, Stress, Alcohol, Fatigue, and Emotion.

For the medication component of IMSAFE, pilots need to ask themselves, "Am I taking any medicines that might affect my judgment or make me drowsy? For any new medication, OTC or prescribed, you should wait at least 48 hours after the first dose before flying to determine you do not have any adverse side effects that would make it unsafe to operate an aircraft. In addition to medication questions, pilots should also consider the following:

- Do not take any unnecessary or elective medications.
- Make sure you eat regular balanced meals.
- Bring a snack.
- Maintain good hydration - bring plenty of water.
- Ensure adequate sleep the night prior to the flight.
- Stay physically fit.

Alcohol

Alcohol impairs the efficiency of the human body. *[Figure 9-1]* Studies have shown that consuming alcohol is closely linked to performance deterioration. Pilots must make hundreds of decisions, some of them time-critical, during the course of a flight. The safe outcome of any flight depends on the ability to make the correct decisions and take the appropriate actions during routine occurrences, as well as abnormal situations. The influence of alcohol drastically reduces the chances of completing a flight without incident. Even in small amounts, alcohol can impair judgment, decrease sense of responsibility, affect coordination, constrict visual field, diminish memory, reduce reasoning ability, and lower attention span. As little as one ounce of alcohol can decrease the speed and strength of muscular reflexes, lessen the efficiency of eye movements while reading, and increase the frequency at which errors are committed. Impairments in vision and hearing can occur from consuming as little as one drink.

Type Beverage	Typical Serving (oz)	Pure Alcohol Content (oz)
Table wine	4.0	.48
Light beer	12.0	.48
Aperitif liquor	1.5	.38
Champagne	4.0	.48
Vodka	1.0	.50
Whiskey	1.25	.50

0.01–0.05% (10–50 mg)	average individual appears normal
0.03–0.12%* (30–120 mg)	mild euphoria, talkativeness, decreased inhibitions, decreased attention, impaired judgment, increased reaction time
0.09–0.25% (90–250 mg)	emotional instability, loss of critical judgment, impairment of memory and comprehension, decreased sensory response, mild muscular incoordination
0.18–0.30% (180–300 mg)	confusion, dizziness, exaggerated emotions (anger, fear, grief), impaired visual perception, decreased pain sensation, impaired balance, staggering gait, slurred speech, moderate muscular incoordination
0.27–0.40% (270–400 mg)	apathy, impaired consciousness, stupor, significantly decreased response to stimulation, severe muscular incoordination, inability to stand or walk, vomiting, incontinence of urine and feces
0.35–0.50% (350–500 mg)	unconsciousness, depressed or abolished re exes, abnormal body temperature, coma, possible death from respiratory paralysis (450 mg or above)

* Legal limit for motor vehicle operation in most states is 0.08 or 0.10% (80–100 mg of alcohol per dL of blood).

Figure 9-1. *Impairment scale with alcohol use.*

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. 14 CFR part 91 requires that blood alcohol level be less than .04 percent and that 8 hours pass between drinking alcohol and piloting an aircraft. A pilot with a blood alcohol level of .04 percent or greater after 8 hours cannot fly 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.

Vision and Flight

The more a pilot understands about the eyes and how they function, the easier it is to use vision effectively and compensate for potential problems.

Scanning Techniques

To scan effectively, pilots must look from right to left or left to right. They should begin scanning at the greatest distance an object can be perceived (top) and move inward toward the position of the aircraft (bottom). For each stop, an area approximately 30° wide should be scanned. The duration of each stop is based on the degree of detail that is required, but no stop should last longer than 2 to 3 seconds. When moving from one viewing point to the next, pilots should overlap the previous field of view by 10°. *[Figure 9-2]*

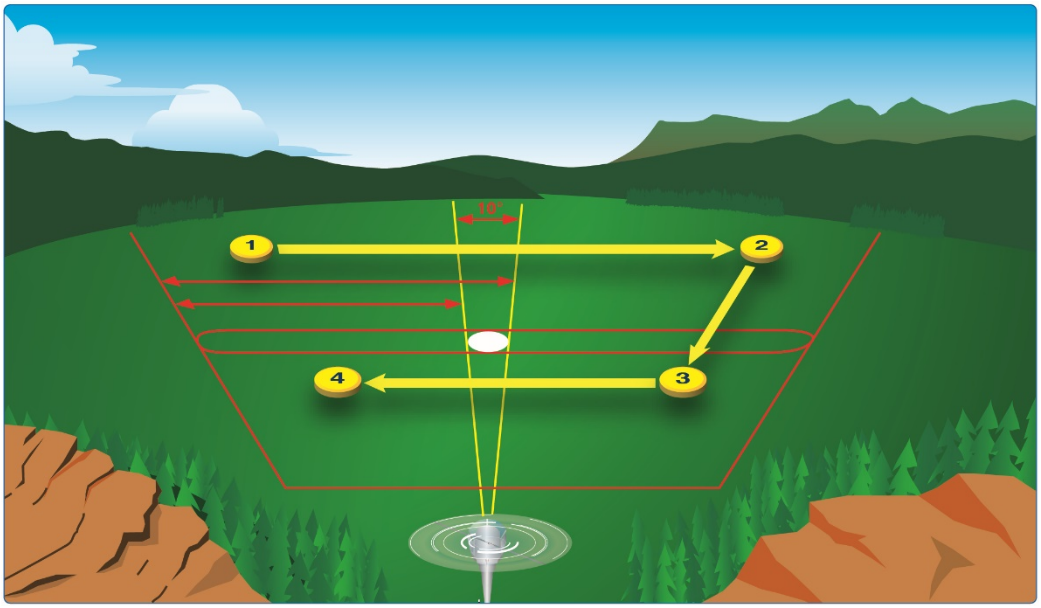


Figure 9-2. *Scanning techniques.*

Chapter 10:
Aeronautical Decision-Making and Judgment

Introduction

Aeronautical decision-making (ADM) is decision-making in a unique environment—aviation. It is a systematic approach to the mental process used by pilots to consistently determine the best course of action in response to a given set of circumstances. It is what a pilot intends to do based on the latest information he or she has.

The importance of learning and understanding effective ADM skills cannot be overemphasized. While progress is continually being made in the advancement of pilot training methods, aircraft equipment and systems, and services for pilots, accidents still occur. Despite all the changes in technology to improve flight safety, one factor remains the same: the human factor which leads to errors. It is estimated that approximately 80 percent of all aviation accidents are related to human factors and the vast majority of these accidents occur during landing (24.1 percent) and takeoff (23.4 percent).

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 operation of a small UA. 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.

History of ADM

For over 25 years, the importance of good pilot judgment, or aeronautical decision-making (ADM), has been recognized as critical to the safe operation of aircraft, as well as accident avoidance. The airline industry, motivated by the need to reduce accidents caused by human factors, developed the first training programs based on improving ADM. 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.

Research in this area prompted the Federal Aviation Administration (FAA) to produce training directed at improving the decision-making of pilots and led to current FAA regulations that require that decision-making be taught as part of the pilot training curriculum. Aeronautical Decision Making and Risk Management are topics that the FAA is required to test an applicant about for the issuance of an sUAS certificate. ADM research, development, and testing culminated in 1987 with the publication of six manuals oriented to the decision-making needs of variously rated pilots. These manuals provided multifaceted materials designed to reduce the number of decision-related accidents. The effectiveness of these materials was validated in independent studies where student pilots received such training in conjunction with the standard flying curriculum. When tested, the pilots who had received ADM-training made fewer inflight errors than those who had not received ADM training. The differences were statistically significant and ranged from about 10 to 50 percent fewer judgment errors. In the operational environment, an operator flying about 400,000 hours annually demonstrated a 54 percent reduction in accident rate after using these materials for recurrency training.

Contrary to popular opinion, good judgment can be taught. Tradition held that good judgment was a natural by-product of experience, but as pilots continued to log accident-free flight hours, a corresponding increase of good judgment was assumed. Building upon the foundation of conventional decision-making, ADM enhances the process to decrease the probability of human error and increase the probability of a safe flight. ADM provides a structured, systematic approach to analyzing changes that occur during a flight and how these changes might affect the safe outcome of a flight. The ADM process addresses all aspects of decision-making and identifies the steps involved in good decision-making.

Steps for good decision-making are:

1. Identifying personal attitudes hazardous to safe flight.
2. Learning behavior modification techniques.
3. Learning how to recognize and cope with stress.
4. Developing risk assessment skills.
5. Using all resources.
6. Evaluating the effectiveness of one's ADM skills.

Risk Management

The goal of risk management is to proactively identify safety-related hazards and mitigate the associated risks. Risk management is an important component of ADM. When a pilot follows good decision-making practices, the inherent risk in a flight is reduced or even eliminated. The ability to make good decisions is based upon direct or indirect experience and education. The formal risk management decision-making process involves six steps as shown in *Figure 10-1.*

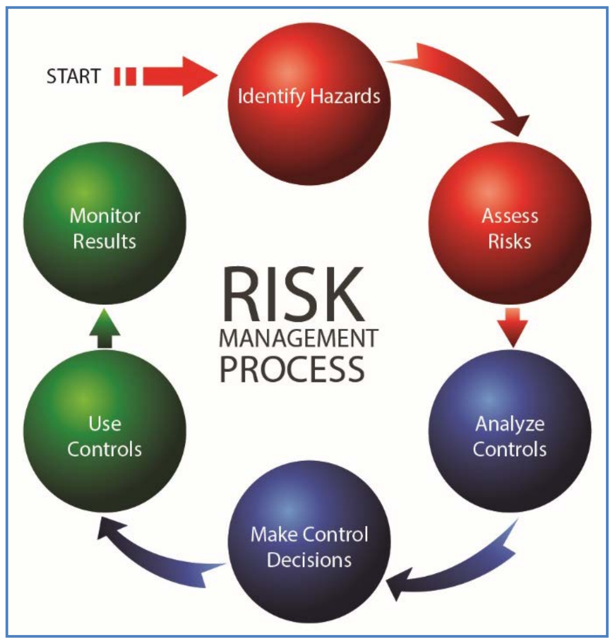


Figure 10-1. *Risk management decision-making process.*

Consider automotive seat belt use. In just two decades, seat belt use has become the norm, placing those who do not wear seat belts outside the norm, but this group may learn to wear a seat belt by either direct or indirect experience. For example, a driver learns through direct experience about the value of wearing a seat belt when he or she is involved in a car accident that leads to a personal injury. An indirect learning experience occurs when a loved one is injured during a car accident because he or she failed to wear a seat belt.

As you work through the ADM cycle, it is important to remember the four fundamental principles of risk management.

1. Accept no unnecessary risk. Flying is not possible without risk, but unnecessary risk comes without a corresponding return.
2. Make risk decisions at the appropriate level. Risk decisions should be made by the person who can develop and implement risk controls.
3. Accept risk when benefits outweigh dangers (costs).

4. Integrate risk management into planning at all levels. Because risk is an unavoidable part of every flight, safety requires the use of appropriate and effective risk management not just in the preflight planning stage, but in all stages of the flight.

While poor decision-making in everyday life does not always lead to tragedy, the margin for error in aviation is thin. Since ADM enhances management of an aeronautical environment, all pilots should become familiar with and employ ADM.

Crew Resource Management (CRM) and Single-Pilot Resource Management

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). SRM is defined as the art and science of managing all the resources available to a single pilot (prior to and during flight) to ensure the successful outcome of the flight. SRM includes the concepts of ADM, risk management (RM), task management (TM), automation management (AM), controlled flight into terrain (CFIT) awareness, and situational awareness (SA). SRM training helps the pilot maintain situational awareness by managing the automation and associated aircraft control and navigation tasks. This enables the pilot to accurately assess and manage risk and make accurate and timely decisions.

SRM is all about helping pilots learn how to gather information, analyze it, and make decisions.

Hazard and Risk

Two defining elements of ADM are hazard and risk. Hazard is a real or perceived condition, event, or circumstance that a pilot encounters. When faced with a hazard, the pilot makes an assessment of that hazard based upon various factors. The pilot assigns a value to the potential impact of the hazard, which qualifies the pilot's assessment of the hazard—risk.

Therefore, risk is an assessment of the single or cumulative hazard facing a pilot; however, different pilots see hazards differently.

Hazardous Attitudes and Antidotes

Being fit to fly depends on more than just a pilot's physical condition and recent experience. For example, attitude affects the quality of decisions. Attitude is a motivational predisposition to respond to people, situations, or events in a given manner. Studies have identified five hazardous attitudes that can interfere with the ability to make sound decisions and exercise authority properly: anti-authority, impulsivity, invulnerability, macho, and resignation. *[Figure 10-2]*

Hazardous attitudes contribute to poor pilot judgment but can be effectively counteracted by redirecting the hazardous attitude so that correct action can be taken. Recognition of hazardous thoughts is the first step toward neutralizing them. After recognizing a thought as hazardous, the pilot should label it as hazardous, then state the corresponding antidote. Antidotes should be memorized for each of the hazardous attitudes so they automatically come to mind when needed.

The Five Hazardous Attitudes	Antidote
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." They 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.	**Follow the rules. They are usually right.**
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, and they do the first thing that comes to mind.	**Not so fast. Think first.**
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.	**It could happen to me.**
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.	**Taking chances is foolish.**
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 them 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."	**I'm not helpless. I can make a difference.**

Figure 10-2. *The five hazardous attitudes identified through past and contemporary study.*

Risk

During each flight, the single pilot makes many decisions under hazardous conditions. To fly safely, the pilot needs to assess the degree of risk and determine the best course of action to mitigate the risk.

Assessing Risk

For the single pilot, assessing risk is not as simple as it sounds. For example, the pilot acts as his or her own quality control in making decisions. If a fatigued pilot who has flown 16 hours is asked if he or she is too tired to continue flying, the answer may be "no." Most pilots are goal oriented and when asked to accept a flight, there is a tendency to deny personal limitations while adding weight to issues not germane to the mission. For example, pilots of helicopter emergency services (EMS) have been known (more than other groups) to make flight decisions that add significant weight to the patient's welfare. These pilots add weight to intangible factors (the patient in this case) and fail to appropriately quantify actual hazards, such as fatigue or weather, when making flight decisions. The single pilot who has no other crew member for consultation must wrestle with the intangible factors that draw one into a hazardous position. Therefore, he or she has a greater vulnerability than a full crew.

Mitigating Risk

Risk assessment is only part of the equation.

One of the best ways single pilots can mitigate risk is to use the IMSAFE checklist to determine physical and mental readiness for flying:

1. Illness—Am I sick? Illness is an obvious pilot risk.
2. Medication—Am I taking any medicines that might affect my judgment or make me drowsy?
3. Stress—Am I under psychological pressure from the job? Do I have money, health, or family problems? Stress causes concentration and performance problems. While the regulations list medical conditions that require grounding, stress is not among them. The pilot should consider the effects of stress on performance.
4. Alcohol—Have I been drinking within 8 hours? Within 24 hours? As little as one ounce of liquor, one bottle of beer, or four ounces of wine can impair flying skills. Alcohol also renders a pilot more susceptible to disorientation and hypoxia.
5. Fatigue—Am I tired and not adequately rested? Fatigue continues to be one of the most insidious hazards to flight safety, as it may not be apparent to a pilot until serious errors are made.
6. Emotion—Am I emotionally upset?

The PAVE Checklist

Another way to mitigate risk is to perceive hazards. By incorporating the PAVE checklist into preflight planning, the pilot divides the risks of flight into four categories: **P**ilot-in-command (PIC), **A**ircraft, en**V**ironment, and **E**xternal pressures (PAVE) which form part of a pilot's decision-making process.

With the PAVE checklist, pilots have a simple way to remember each category to examine for risk prior to each flight.

Once a pilot identifies the risks of a flight, he or she needs to decide whether the risk, or combination of risks, can be managed safely and successfully. If not, make the decision to cancel the flight. If the pilot decides to continue with the flight, he or she should develop strategies to mitigate the risks. One way a pilot can control the risks is to set personal minimums for items in each risk category. These are limits unique to that individual pilot's current level of experience and proficiency.

P = Pilot-in-Command (PIC)

The pilot is one of the risk factors in a flight. The pilot must ask, "Am I ready for this flight?" in terms of experience, recency, currency, physical, and emotional condition. The IMSAFE checklist provides the answers.

A = Aircraft

What limitations will the aircraft impose upon the trip? Ask the following questions:

- Is this the right aircraft for the flight?
- Am I familiar with and current in this aircraft?
- Can this aircraft carry the planned load?

V = EnVironment

Weather

Weather is a major environmental consideration. Earlier it was suggested pilots set their own personal minimums, especially when it comes to weather. As pilots evaluate the weather for a particular flight, they should consider the following:

- What is the current ceiling and visibility?
- Consider the possibility that the weather may be different than forecast.
- Are there any thunderstorms present or forecast?
- If there are clouds, is there any icing, current or forecast? What is the temperature/dew point spread and the current temperature at altitude?

Terrain

Evaluation of terrain is another important component of analyzing the flight environment.

Airspace

Check the airspace and any temporary flight restriction (TFRs).

E = External Pressures

External pressures are influences external to the flight that create a sense of pressure to complete a flight—often at the expense of safety. Factors that can be external pressures include the following:

- The desire to demonstrate pilot qualifications
- The desire to impress someone (Probably the two most dangerous words in aviation are “Watch this!”)
- The pilot’s general goal-completion orientation
- Emotional pressure associated with acknowledging that skill and experience levels may be lower than a pilot would like them to be. Pride can be a powerful external factor!

Managing External Pressures

Management of external pressure is the single most important key to risk management because it is the one risk factor category that can cause a pilot to ignore all the other risk factors.

The use of personal standard operating procedures (SOPs) is one way to manage external pressures. The goal is to supply a release for the external pressures of a flight.

Human Factors

Why are human conditions, such as fatigue, complacency and stress, so important in aviation? These conditions, along with many others, are called human factors. Human factors directly cause or contribute to many aviation accidents and have been documented as a primary contributor to more than 70 percent of aircraft accidents.

Typically, human factor incidents/accidents are associated with flight operations but recently have also become a major concern in aviation maintenance and air traffic management as well. Over the past several years, the FAA has made the study and research of human factors a top priority by working closely with engineers, pilots, mechanics, and ATC to apply the latest knowledge about human factors in an effort to help operators and maintainers improve safety and efficiency in their daily operations.

Human factors science, or human factors technologies, is a multidisciplinary field incorporating contributions from psychology, engineering, industrial design, statistics, operations research, and anthropometry. It is a term that covers the science of understanding the properties of human capability, the application of this understanding to the design, development and deployment of systems and services, and the art of ensuring successful application of human factor principles into all aspects of aviation to include pilots, ATC, and aviation maintenance. Human factors is often considered synonymous with CRM or maintenance resource management (MRM) but is really much broader in both its knowledge base and scope. Human factors involves gathering research specific to certain situations (i.e., flight, maintenance, stress levels, knowledge) about human abilities, limitations, and other characteristics and applying it to tool design, machines, systems, tasks, jobs, and environments to produce safe, comfortable, and effective human use. The entire aviation community benefits greatly from human factors research and development as it helps better understand how humans can most safely and efficiently perform their jobs and improve the tools and systems in which they interact.

The Decision-Making Process

An understanding of the decision-making process provides the pilot with a foundation for developing ADM and SRM skills. While some situations, such as engine failure, require an immediate pilot response using established procedures, there is usually time during a flight to analyze any changes that occur, gather information, and assess risks before reaching a decision.

Risk management and risk intervention is much more than the simple definitions of the terms might suggest. Risk management and risk intervention are decision-making processes designed to systematically identify hazards, assess the degree of risk, and determine the best course of action. These processes involve the identification of hazards, followed by assessments of the risks, analysis of the controls, making control decisions, using the controls, and monitoring the results.

The steps leading to this decision constitute a decision-making process. Three models of a structured framework for problem-solving and decision-making are the 5P, the 3P using PAVE, CARE and TEAM, and the DECIDE models. They provide assistance in organizing the decision process. All these models have been identified as helpful to the single pilot in organizing critical decisions.

Single-Pilot Resource Management (SRM)

Single-Pilot Resource Management (SRM) is about how to gather information, analyze it, and make decisions. Learning how to identify problems, analyze the information, and make informed and timely decisions is not as straightforward as the training involved in learning specific maneuvers. Learning how to judge a situation and “how to think” in the endless variety of situations encountered while flying out in the “real world” is more difficult.

There is no one right answer in ADM, rather each pilot is expected to analyze each situation in light of experience level, personal minimums, and current physical and mental readiness level, and make his or her own decision.

Perceive, Process, Perform (3P) Model

The Perceive, Process, Perform (3P) model for ADM offers a simple, practical, and systematic approach that can be used during all phases of flight. To use it, the pilot will:

- Perceive the given set of circumstances for a flight
- Process by evaluating their impact on flight safety
- Perform by implementing the best course of action

Use the Perceive, Process, Perform, and Evaluate method as a continuous model for every aeronautical decision that you make. Although human beings will inevitably make mistakes, anything that you can do to recognize and minimize potential threats to your safety will make you a better pilot.

Depending upon the nature of the activity and the time available, risk management processing can take place in any of three timeframes. *[Figure 10-3]* Most flight training activities take place in the "time-critical" timeframe for risk management. The six steps of risk management can be combined into an easy-to-remember 3P model for practical risk management: Perceive, Process, Perform with the PAVE, CARE and TEAM checklists. Pilots can help perceive hazards by using the PAVE checklist of: Pilot, Aircraft, enVironment, and External pressures. They can process hazards by using the CARE checklist of: Consequences, Alternatives, Reality, External factors. Finally, pilots can perform risk management by using the TEAM choice list of: Transfer, Eliminate, Accept, or Mitigate.

	Strategic	Deliberate	Time-Critical
Purpose	Used in a complex operation (e.g., introduction of new equipment); involves research, use of analysis tools, formal testing, or long term tracking of risks.	Uses experience and brainstorming to identify hazards, assess risks, and develop controls for planning operations, review of standard operating or training procedures, etc.	"On the fly" mental or verbal review using the basic risk management process during the execution phase of an activity.

Figure 10-3. *Risk management processing can take place in any of three timeframes.*

PAVE Checklist: Identify Hazards and Personal Minimums

In the first step, the goal is to develop situational awareness by perceiving hazards, which are present events, objects, or circumstances that could contribute to an undesired future event. In this step, the pilot will systematically identify and list hazards associated with all aspects of the flight: **P**ilot, **A**ircraft, en**V**ironment, and **E**xternal pressures, which makes up the PAVE checklist. *[Figure 10-4]* All four elements combine and interact to create a unique situation for any flight. Pay special attention to the pilot-aircraft combination, and consider whether the combined "pilot-aircraft team" is capable of the mission you want to fly. For example, you may be a very experienced and proficient pilot, but your weather flying ability is still limited if you are flying an unfamiliar aircraft. On the other hand, you may have a new technically advanced aircraft that you have flown for a considerable amount of time.

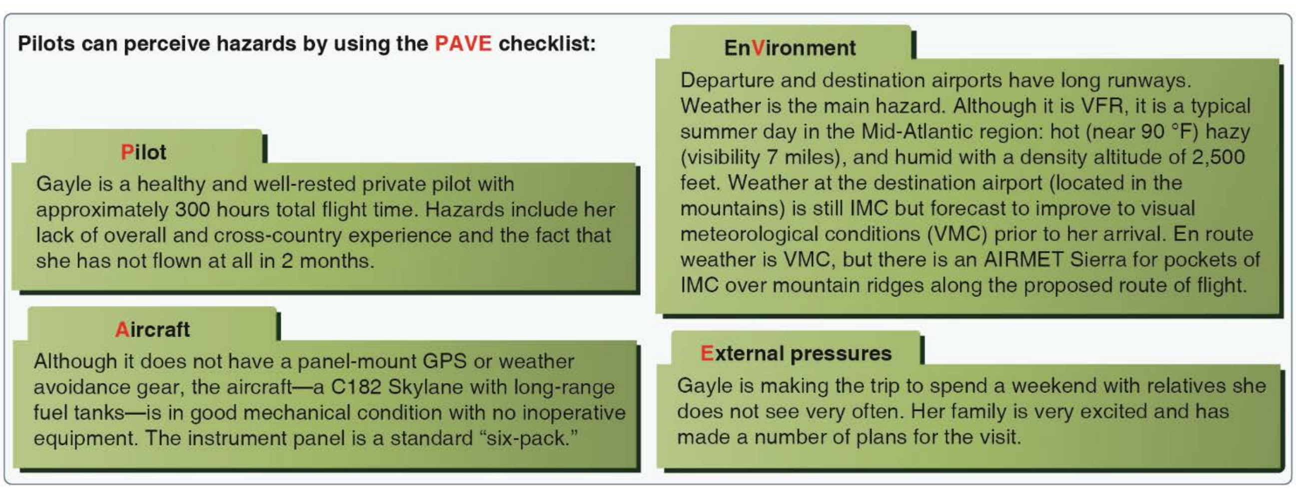
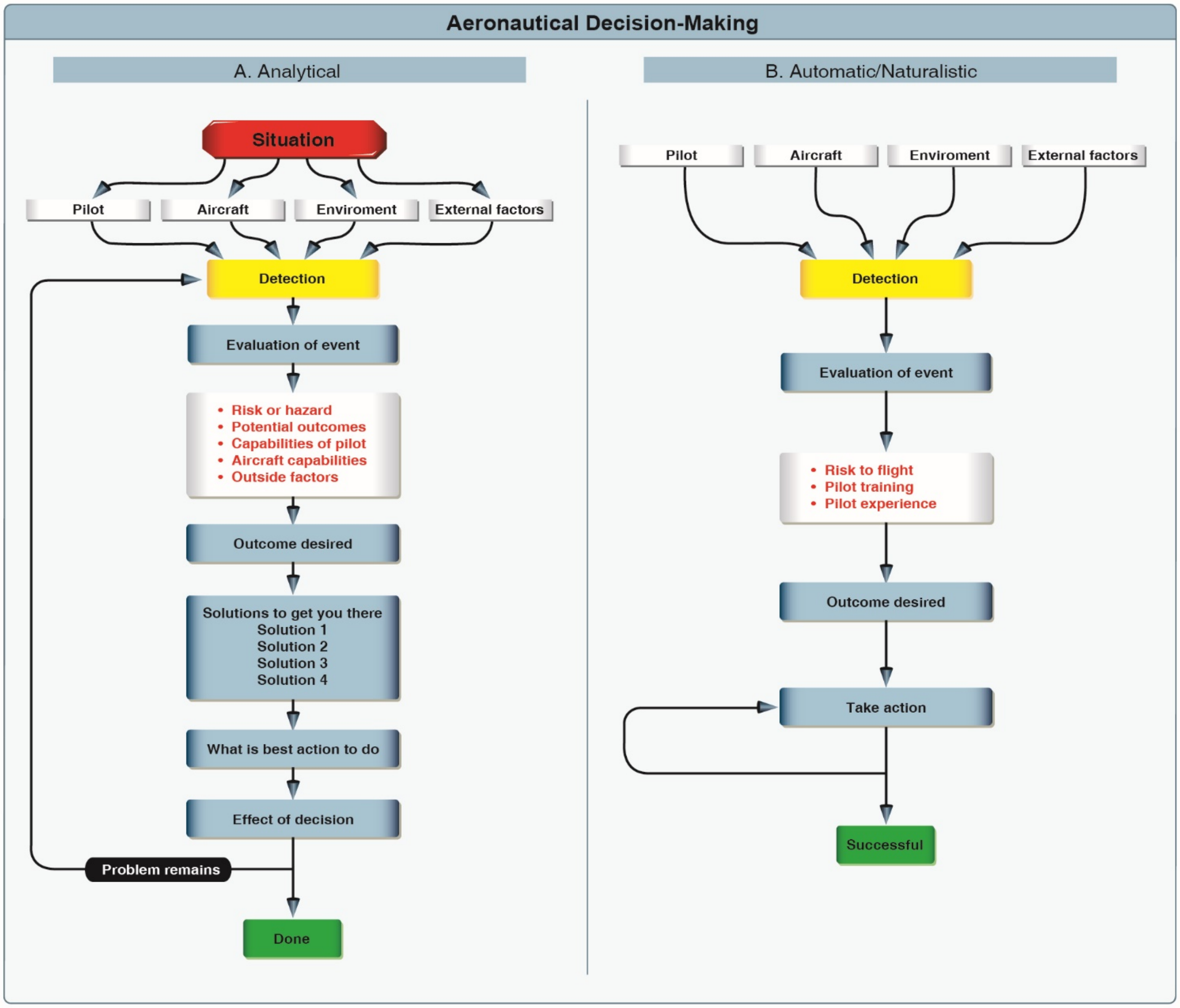


Figure 10-4. *A real-world example of how the 3P model guides decisions on a cross-country trip using the PAVE checklist.*

Decision-Making in a Dynamic Environment

A solid approach to decision-making is through the use of analytical models, such as the 5 Ps, 3P, and DECIDE. Good decisions result when pilots gather all available information, review it, analyze the options, rate the options, select a course of action, and evaluate that course of action for correctness.

In some situations, there is not always time to make decisions based on analytical decision-making skills. A good example is a quarterback whose actions are based upon a highly fluid and changing situation. He intends to execute a plan, but new circumstances dictate decision-making on the fly. This type of decision-making is called automatic decision-making or naturalized decision-making.
[Figure 10-5B]



The DECIDE model

1. **Detect.** The decision maker detects the fact that change has occurred.
2. **Estimate.** The decision maker estimates the need to counter or react to the change.
3. **Choose.** The decision maker chooses a desirable outcome (in terms of success) for the flight.
4 **Identify.** The decision maker identifies actions which could successfully control the change.
5. **Do.** The decision maker takes the necessary action.
6. **Evaluate.** The decision maker evaluates the effect(s) of his/her action countering the change.

Figure 10-5. *The DECIDE model has been recognized worldwide. Its application is illustrated in column A while automatic/naturalistic decision-making is shown in column B.*

Automatic Decision-Making

For the past several decades, research into how people actually make decisions has revealed that when pressed for time, experts faced with a task loaded with uncertainty first assess whether the situation strikes them as familiar. Rather than comparing the pros and cons of different approaches, they quickly imagine how one or a few possible courses of action in such situations will play out.

Experts take the first workable option they can find. While it may not be the best of all possible choices, it often yields remarkably good results.

The terms “naturalistic” and “automatic decision-making” have been coined to describe this type of decision-making. The ability to make automatic decisions holds true for a range of experts from firefighters to chess players. It appears the expert’s ability hinges on the recognition of patterns and consistencies that clarify options in complex situations. Experts appear to make provisional sense of a situation, without actually reaching a decision, by launching experience-based actions that in turn trigger creative revisions.

This is a reflexive type of decision-making anchored in training and experience and is most often used in times of emergencies when there is no time to practice analytical decision-making. Naturalistic or automatic decision-making improves with training and experience, and a pilot will find himself or herself using a combination of decision-making tools that correlate with individual experience and training.

Operational Pitfalls

Although more experienced pilots are likely to make more automatic decisions, there are tendencies or operational pitfalls that come with the development of pilot experience. These are classic behavioral traps into which pilots have been known to fall. More experienced pilots, as a rule, try to complete a flight as planned. The desire to meet these goals can have an adverse effect on safety and contribute to an unrealistic assessment of piloting skills. These dangerous tendencies or behavior patterns, which must be identified and eliminated, include the operational pitfalls shown in *Figure 10-6.*

Operational Pitfalls

Peer pressure
Poor decision-making may be based upon an emotional response to peers, rather than evaluating a situation objectively.

Mindset
A pilot displays mind set through an inability to recognize and cope with changes in a given situation.

Get-there-itis
This disposition impairs pilot judgment through a fixation on the original goal or destination, combined with a disregard for any alternative course of action.

Duck-under syndrome
A pilot may be tempted to make it into an airport by descending below minimums during an approach. There may be a belief that there is a built-in margin of error in every approach procedure, or a pilot may want to admit that the landing cannot be completed and a missed approach must be initiated.

Scud running
This occurs when a pilot tries to maintain visual contact with the terrain at low altitudes while instrument conditions exist.

Continuing visual flight rules (VFR) into instrument conditions
Spatial disorientation or collision with ground/obstacles may occur when a pilot continues VFR into instrument conditions. This can be even more dangerous if the pilot is not instrument rated or current.

Getting behind the aircraft
This pitfall can be caused by allowing events or the situation to control pilot actions. A constant state of surprise at what happens next may be exhibited when the pilot is getting behind the aircraft.

Loss of positional or situational awareness
In extreme cases, when a pilot gets behind the aircraft, a loss of positional or situational awareness may result. The pilot may not know the aircraft's geographical location or may be unable to recognize deteriorating circumstances.

Operating without adequate fuel reserves
Ignoring minimum fuel reserve requirements is generally the result of overconfidence, lack of flight planning, or disregarding applicable regulations.

Descent below the minimum en route altitude
The duck-under syndrome, as mentioned above, can also occur during the en route portion of an IFR flight.

Flying outside the envelope
The assumed high performance capability of a particular aircraft may cause a mistaken belief that it can meet the demands imposed by a pilot's overestimated flying skills.

Neglect of flight planning, preflight inspections, and checklists
A pilot may rely on short- and long-term memory, regular flying skills, and familiar routes instead of established procedures and published checklists. This can be particularly true of experienced pilots.

Figure 10-6. *Typical operational pitfalls requiring pilot awareness.*

Stress Management

Everyone is stressed to some degree almost all of the time. A certain amount of stress is good since it keeps a person alert and prevents complacency. Effects of stress are cumulative and, if the pilot does not cope with them in an appropriate way, they can eventually add up to an intolerable burden. Performance generally increases with the onset of stress, peaks, and then begins to fall off rapidly as stress levels exceed a person's ability to cope. The ability to make effective decisions during flight can be impaired by stress. There are two categories of stress—acute and chronic. These are both explained in Chapter 9, "Physiological Factors (Including Drugs and Alcohol) Affecting Pilot Performance," of this study guide.

There are several techniques to help manage the accumulation of life stresses and prevent stress overload. For example, to help reduce stress levels, set aside time for relaxation each day or maintain a program of physical fitness. To prevent stress overload, learn to manage time more effectively to avoid pressures imposed by getting behind schedule and not meeting deadlines.

Use of Resources

To make informed decisions during flight operations, a pilot must also become aware of the available resources. Since useful tools and sources of information may not always be readily apparent, learning to recognize these resources is an essential part of ADM training. Resources must not only be identified, but a pilot must also develop the skills to evaluate whether there is time to use a particular resource and the impact its use will have upon the safety of flight.

Stressors
Environmental Conditions associated with the environment, such as temperature and humidity extremes, noise, vibration, and lack of oxygen.
Physiological stress Physical conditions, such as fatigue, lack of physical fitness, sleep loss, missed meals (leading to low blood sugar levels), and illness.
Psychological stress Social or emotional factors, such as a death in the family, a divorce, a sick child, or a demotion at work. This type of stress may also be related to mental workload, such as analyzing a problem, navigating an aircraft, or making decisions.

Figure 10-7. *System stressors. Environmental, physiological, and psychological stress are factors that affect decision-making skills. These stressors have a profound impact especially during periods of high workload.*

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.

Maintaining situational awareness requires an understanding of the relative significance of all flight related factors and their future impact on 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. Not only is it important for a pilot to know the aircraft’s geographical location, it is also important he or she understand what is happening.

Obstacles to Maintaining Situational Awareness

Fatigue, stress, and work overload can cause a pilot to fixate on a single perceived important item and reduce an overall situational awareness of the flight. A contributing factor in many accidents is a distraction that diverts the pilot’s attention from monitoring the aircraft.

Workload Management

Effective workload management ensures essential operations are accomplished by planning, prioritizing, and sequencing tasks to avoid work overload. As experience is gained, a pilot learns to recognize future workload requirements and can prepare for high workload periods during times of low workload.

In addition, a pilot should listen to ATIS, Automated Surface Observing System (ASOS), or Automated Weather Observing System (AWOS), if available, and then monitor the tower frequency or Common Traffic Advisory Frequency (CTAF) to get a good idea of what traffic conditions to expect.

Recognizing a work overload situation is also an important component of managing workload. The first effect of high workload is that the pilot may be working harder but accomplishing less. As workload increases, attention cannot be devoted to several tasks at one time, and the pilot may begin to focus on one item. When a pilot becomes task saturated, there is no awareness of input from various sources, so decisions may be made on incomplete information and the possibility of error increases.

When a work overload situation exists, a pilot needs to stop, think, slow down, and prioritize. It is important to understand how to decrease workload.

Chapter 11:
Airport Operations

Introduction

The definition for airports refers to any area of land or water used or intended for landing or takeoff of aircraft. This includes, within the five categories of airports listed below, special types of facilities including seaplane bases, heliports, and facilities to accommodate tilt rotor aircraft. An airport includes an area used or intended for airport buildings, facilities, as well as rights of way together with the buildings and facilities.

Types of Airports

There are two types of airports—towered and non-towered. These types can be further subdivided to:

- Civil Airports—airports that are open to the general public.
- Military/Federal Government airports—airports operated by the military, National Aeronautics and Space Administration (NASA), or other agencies of the Federal Government.
- Private Airports—airports designated for private or restricted use only, not open to the general public.

Towered Airport

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.

Non-towered Airport

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 monitor other aircraft on the specified frequency for the benefit of other traffic in the area. The key to monitoring traffic at an airport without an operating control tower is selection of the correct common frequency. The acronym CTAF, which stands for Common Traffic Advisory Frequency, is synonymous with this program. A CTAF is a frequency designated for the purpose of carrying out airport advisory practices while operating to or from an airport without an operating control tower. The CTAF may be a Universal Integrated Community (UNICOM), MULTICOM, FSS, or tower frequency and is identified in appropriate aeronautical publications. UNICOM is a nongovernment air/ground radio communication station that may provide airport information at public use airports where there is no tower or FSS.

Non-towered airport traffic patterns are always entered at pattern altitude. How you enter the pattern depends upon the direction of arrival. The preferred method for entering from the downwind side of the pattern is to approach the pattern on a course 45 degrees to the downwind leg and join the pattern at midfield.

Sources for Airport Data

When a remote pilot operates in the vicinity of an airport, it is important to review the current data for that airport. This data provides the pilot with information, such as communication frequencies, services available, closed runways, or airport construction. Three common sources of information are:

- Aeronautical Charts

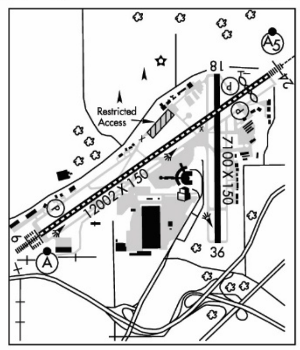
- Chart Supplement U.S. (formerly Airport/Facility Directory)
- Notices to Airmen (NOTAMs)
- Automated Terminal Information Service (ATIS)

Chart Supplement U.S. (formerly Airport/Facility Directory)

The Chart Supplement U.S. (formerly Airport/Facility Directory) provides the most comprehensive information on a given airport. It contains information on airports, heliports, and seaplane bases that are open to the public. The Chart Supplement U.S. is published in seven books, which are organized by regions and are revised every 56 days. The Chart Supplement U.S. is also available digitally at www.faa.gov/air_traffic/flight_info/aeronav. *Figure 11-1* contains an excerpt from a directory. For a complete listing of information provided in a Chart Supplement U.S. and how the information may be decoded, refer to the "Legend Sample" located in the front of each Chart Supplement U.S.

26 ALABAMA

BIRMINGHAM INTL (BHM) 4 NE UTC–6(–5DT) N33°33.83′ W86°45.14′ **ATLANTA**
650 B S4 **FUEL** 100LL, JET A OX 1, 2 LRA ARFF Index C **H–6K, 9A, L–14H**
RWY 06–24: H12002X150 (ASPH–GRVD) S–175, D–205, DT–350 HIRL CL **IAP, AD**
RWY 06: ALSF2. TDZL. PAPI(P4L)—GA 2.8° TCH 39′.
RWY 24: MALSR. PAPI(P4L)—GA 3.0° TCH 50′. Thld dsplcd 1200′. Tree. 0.5% down.
RWY 18–36: H7100X150 (ASPH–GRVD) S–75, D–170, DT–240 MIRL
RWY 18: PAPI(P4L)—GA 3.2° TCH 52′. Ground.
RWY 36: REIL. Trees.
AIRPORT REMARKS: Attended continuously. Bird activity invof all rwys. Normal dep point for Rwy 24 at numbers located at Twy A6. Twy F between twys G and B restricted to acft weighing 100,000 pounds or less. Twy N restricted to acft weighing 204,000 lbs or less. Twy M restricted to acft 75,000 lbs or less. Twy G restricted to acft 65,000 lbs or less. MALSR Rwy 24 controlled by twr but ops unmonitored. South ramp clsd to transient tfc permanently. Flight Notification Service (ADCUS) avbl. NOTE: See Land and Hold Short Operations Section.



WEATHER DATA SOURCES: ASOS (205) 591–6172. WSP.
COMMUNICATIONS: ATIS 119.4 **UNICOM** 122.95
ANNISTON FSS (ANB) TF 1–800–WX–BRIEF. NOTAM FILE BHM.
RCO 122.2 123.65 (ANNISTON FSS)
Ⓡ **APP/DEP CON** 127.675 (231°–049°) 123.8 (050°–230°)
TOWER 119.9 118.25 **GND CON** 121.7 **CLNC DEL** 125.675 **PRE–TAXI CLNC** 125.675
AIRSPACE: CLASS C svc continuous ctc **APP CON**
RADIO AIDS TO NAVIGATION: NOTAM FILE ANB.
VULCAN (H) VORTAC 114.4 VUZ Chan 91 N33°40.21′ W86°53.99′ 129° 9.8 NM to fld. 750/02E. **HIWAS.**
MC DEN NDB (HW/LOM) 224 BH N33°30.68′ W86°50.74′ 057° 5.6 NM to fld. NOTAM FILE BHM.
ROEBY NDB (LOM) 394 RO N33°36.46′ W86°40.73′ 235° 4.6 NM to fld. NOTAM FILE BHM.
ILS 110.3 I–BHM Rwy 06. CLASS IIE. LOM MC DEN NDB.
ILS/DME 109.5 I–ROE Chan 32 Rwy 24. CLASS IE. LOM ROEBY NDB.
ILS/DME 111.3 I–BXO Chan 50 Rwy 18. (LOC only).
ASR

BLACKWELL FLD (See OZARK)

BLOOD N31°49.82′ W86°06.33′ NOTAM FILE TOI. **NEW ORLEANS**
NDB (MHW/LOM) 365 TO 070° 5.1 NM to Troy Muni. **L–18F**

BOGGA N33°32.06′ W85°55.88′ NOTAM FILE ANB. **ATLANTA**
NDB (LOM) 211 AN 050° 4.9 to Anniston Metropolitan.

BOLL WEEVIL N31°20.21′ W85°59.00′ NOTAM FILE ANB. **NEW ORLEANS**
NDB (MHW) 352 BVG 121° 4.8 NM to Enterprise Muni. Unmonitored Sun and Mon 0500–1200Z‡. **L–18F, 19A**
Unusable byd 20 NM.

BRANTLEY N31°33.71′ W86°17.58′ NOTAM FILE ANB. **NEW ORLEANS**
NDB (MHW) 410 XBR 120° 34.4 NM to Cairns AAF. NDB unmonitored Sun and Mon 0500–1200Z‡. **L–18F, 19A**

Figure 11-1. *Chart Supplement U.S. (formerly Airport/Facility Directory excerpt.*

Notices to Airmen (NOTAM)

Time-critical aeronautical information, which is of a temporary nature or not sufficiently known in advance to permit publication, on aeronautical charts or in other operational publications, that receives immediate dissemination by the NOTAM system. The NOTAM information could affect your decision to make the flight. Although NOTAMs contain information such as taxiway and runway closures, construction, communications, changes in status of navigational aids, and other information essential to planned en route, terminal, or landing operations, a remote pilot can use this information to help them make an informed decision about where and when to operate their small UA. Exercise good judgment and common sense by carefully regarding the information readily available in NOTAMs.

Prior to any flight, pilots should check for any NOTAMs that could affect their intended flight. For more information on NOTAMs, refer back to Chapter 2, “Airspace Classification, Operating Requirements, and Flight Restrictions,” of this study guide.

Automated Terminal Information Service (ATIS)

The Automated Terminal Information Service (ATIS) is a recording of the local weather conditions and other pertinent non-control information broadcast on a local frequency in a looped format. It is normally updated once per hour but is updated more often when changing local conditions warrant. Important information is broadcast on ATIS including weather, runways in use, specific ATC procedures, and any airport construction activity that could affect taxi planning.

When the ATIS is recorded, it is given a code. This code is changed with every ATIS update. For example, ATIS Alpha is replaced by ATIS Bravo. The next hour, ATIS Charlie is recorded, followed by ATIS Delta and progresses down the alphabet.

Aeronautical Charts

An aeronautical chart is the road map for a pilot. The chart provides information that allows remote pilots to obtain information about the areas where they intend to operate. The two aeronautical charts used by VFR pilots are:

- Sectional
- VFR Terminal Area

A free catalog listing aeronautical charts and related publications including prices and instructions for ordering is available at the Aeronautical Navigation Products website: www.aeronav.faa.gov.

Sectional Charts

Sectional charts are the most common charts used by pilots today. The charts have a scale of 1:500,000 (1 inch = 6.86 nautical miles (NM) or approximately 8 statute miles (SM)), which allows for more detailed information to be included on the chart.

The charts provide an abundance of information, including airport data, navigational aids, airspace, and topography. *Figure 11-2* is an excerpt from the legend of a sectional chart. By referring to the chart legend, a pilot can interpret most of the information on the chart. A pilot should also check the chart for other legend information, which includes air traffic control (ATC) frequencies and information on airspace. These charts are revised semiannually except for some areas outside the conterminous United States where they are revised annually.

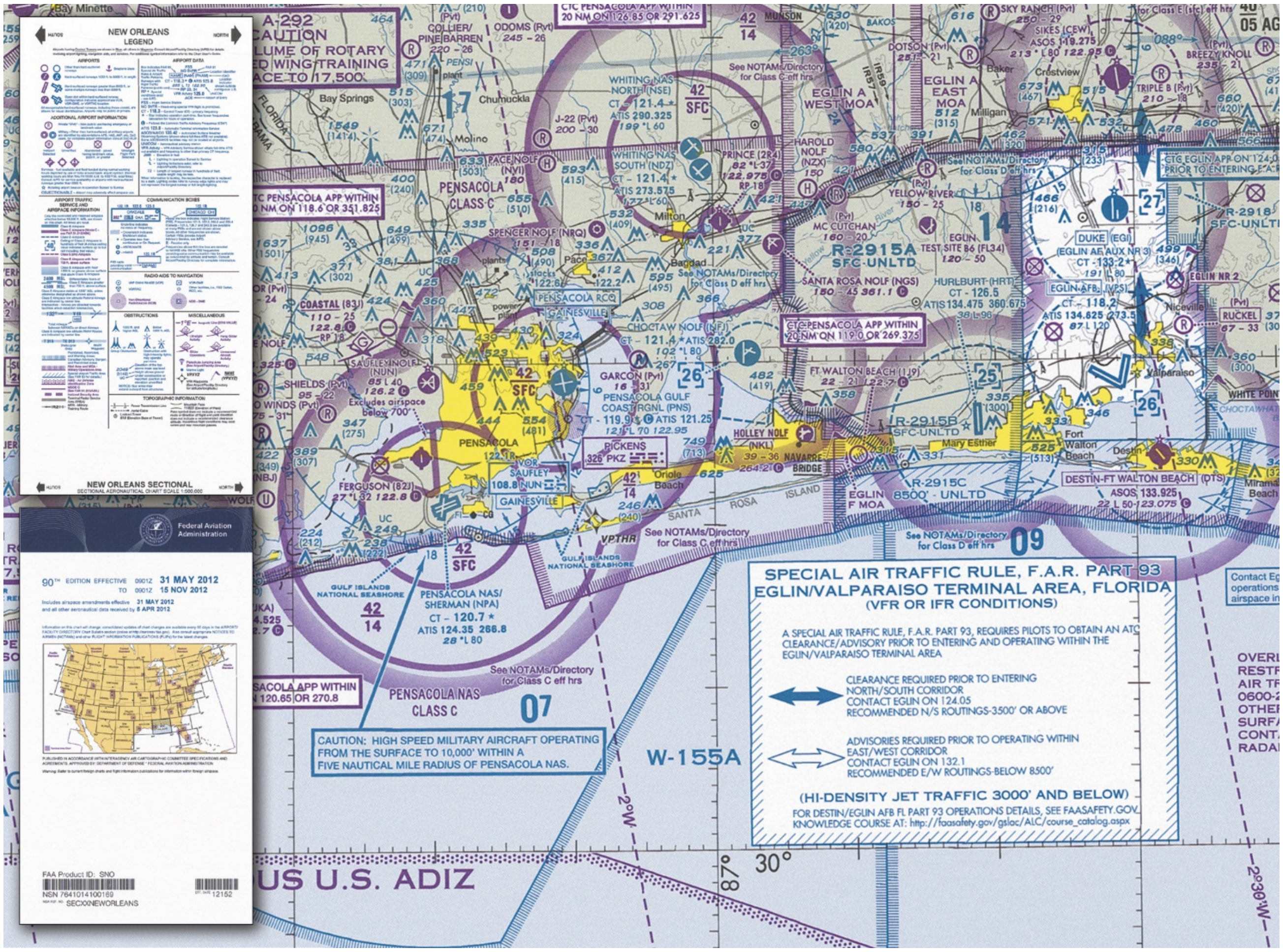


Figure 11-2. *Sectional chart and legend.*

Latitude and Longitude (Meridians and Parallels)

The equator is an imaginary circle equidistant from the poles of the Earth. Circles parallel to the equator (lines running east and west) are parallels of latitude. They are used to measure degrees of latitude north (N) or south (S) of the equator. The angular distance from the equator to the pole is one-fourth of a circle or 90°. The 48 conterminous states of the United States are located between 25° and 49° N latitude. The arrows in *Figure 11-3* labeled "Latitude" point to lines of latitude. Meridians of longitude are drawn from the North Pole to the South Pole and are at right angles to the Equator. The "Prime Meridian," which passes through Greenwich, England, is used as the zero line from which measurements are made in degrees east (E) and west (W) to 180°. The 48 conterminous states of the United

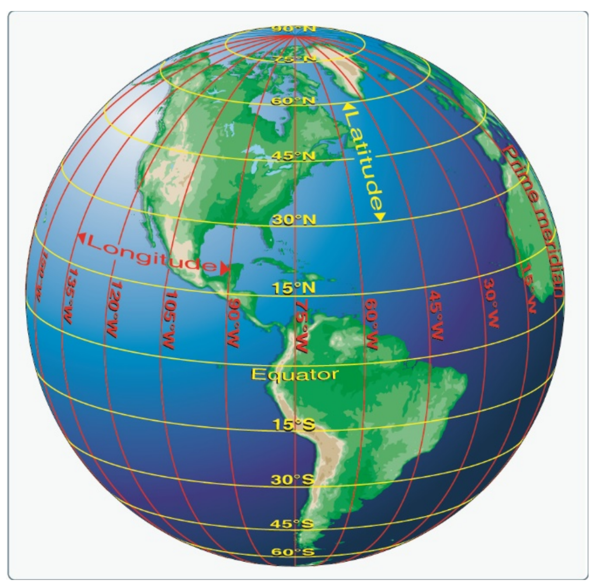


Figure 11-3. *Meridians and parallels—the basis of measuring time, distance, and direction.*

States are between 67° and 125° W longitude. The arrows in *Figure 11-3* labeled "Longitude" point to lines of longitude.

Any specific geographical point can be located by reference to its longitude and latitude. Washington, D.C., for example, is approximately 39° N latitude, 77° W longitude. Chicago is approximately 42° N latitude, 88° W longitude.

Variation

Variation is the angle between true north (TN) and magnetic north (MN). It is expressed as east variation or west variation depending upon whether MN is to the east or west of TN.

The north magnetic pole is located close to 71° N latitude, 96° W longitude and is about 1,300 miles from the geographic or true north pole, as indicated in *Figure 11-4.* If the Earth were uniformly magnetized, the compass needle would point toward the magnetic pole, in which case the variation between TN (as shown by the geographical meridians) and MN (as shown by the magnetic meridians) could be measured at any intersection of the meridians.

Actually, the Earth is not uniformly magnetized. In the United States, the needle usually points in the general direction of the magnetic pole, but it may vary in certain geographical localities by many degrees. Consequently, the exact amount of variation at thousands of selected locations in the United States has been carefully determined. The amount and the direction of variation, which change slightly from time to time, are shown on most aeronautical charts as broken magenta lines called isogonic lines that connect points of equal magnetic variation. (The line connecting points at which there is no variation between TN and MN is the agonic line.) An isogonic chart is shown in *Figure 11-5*. Minor bends and turns in the isogonic and agonic lines are caused by unusual geological conditions affecting magnetic forces in these areas.

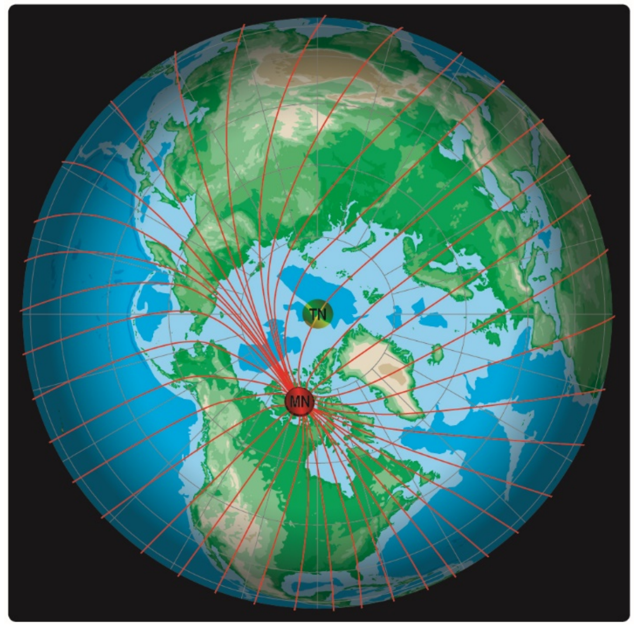


Figure 11-4. *Magnetic meridians are in red while the lines of longitude and latitude are in blue. From these lines of variation (magnetic meridians), on can determine the effect of local magnetic variations on a magnetic compass.*

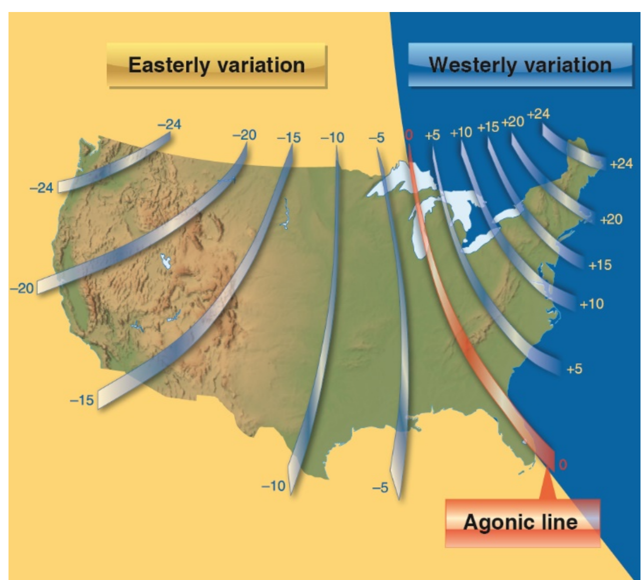


Figure 11-5. *Note the agonic line where magnetic variation is zero.*

Antenna Towers

Extreme caution should be exercised when flying less than 2,000 feet AGL because of numerous skeletal structures, such as radio and television antenna towers, that exceed 1,000 feet AGL with some