Chapter 2 Aeronautical Decision-Making

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.

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Margin of Safety

Takeoff

Time Cruise

Approach & landing

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). [*Figure 2-1*]

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.

This chapter focuses on helping the pilot improve his or her ADM skills with the goal of mitigating the risk factors associated with flight. Advisory Circular (AC) 60-22, "Aeronautical Decision-Making," provides background references, definitions, and other pertinent information about ADM training in the general aviation (GA) environment. [Figure 2-2]

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. 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 in-flight errors than those who had



Figure 2-1. The percentage of aviation accidents as they relate to the different phases of flight. Note that the greatest percentage of accidents take place during a minor percentage of the total flight.



Figure 2-2. Advisory Circular (AC) 60-22, "Aeronautical Decision Making," carries a wealth of information for the pilot to learn.

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 in the flight deck 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 2-3*.

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.



Figure 2-3. Risk management decision-making process.

- 1. Accept no unnecessary risk. Flying is not possible without risk, but unnecessary risk comes without a corresponding return. If you are flying a new airplane for the first time, you might determine that the risk of making that flight in low visibility conditions is unnecessary.
- 2. Make risk decisions at the appropriate level. Risk decisions should be made by the person who can develop and implement risk controls. Remember that you are pilot-in-command, so never let anyone else—not ATC and not your passengers—make risk decisions for you.
- 3. Accept risk when benefits outweigh dangers (costs). In any flying activity, it is necessary to accept some degree of risk. A day with good weather, for example, is a much better time to fly an unfamiliar airplane for the first time than a day with low IFR conditions.
- 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 (both on-board the aircraft and from outside sources) 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. Although the flight is coordinated by a single person and not an onboard flight crew, the use of available resources such as auto-pilot and air traffic control (ATC) replicates the principles of CRM.

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. For example, the pilot arrives to preflight and discovers a small, blunt type nick in the leading edge at the middle of the aircraft's prop. Since the aircraft is parked on the tarmac, the nick was probably caused by another aircraft's prop wash blowing some type of debris into the propeller. The nick is the hazard (a present condition). The risk is prop fracture if the engine is operated with damage to a prop blade.

The seasoned pilot may see the nick as a low risk. He realizes this type of nick diffuses stress over a large area, is located in the strongest portion of the propeller, and based on experience; he does not expect it to propagate a crack that can lead to high risk problems. He does not cancel his flight.

The inexperienced pilot may see the nick as a high risk factor because he is unsure of the affect the nick will have on the operation of the prop, and he has been told that damage to a prop could cause a catastrophic failure. This assessment leads him to cancel his flight.

Therefore, elements or factors affecting individuals are different and profoundly impact decision-making. These are called human factors and can transcend education, experience, health, physiological aspects, etc.

Another example of risk assessment was the flight of a Beechcraft King Air equipped with deicing and anti-icing. The pilot deliberately flew into moderate to severe icing conditions while ducking under cloud cover. A prudent pilot would assess the risk as high and beyond the capabilities of the aircraft, yet this pilot did the opposite. Why did the pilot take this action?

Past experience prompted the action. The pilot had successfully flown into these conditions repeatedly although the icing conditions were previously forecast 2,000 feet above the surface. This time, the conditions were forecast from the surface. Since the pilot was in a hurry and failed to factor

in the difference between the forecast altitudes, he assigned a low risk to the hazard and took a chance. He and the passengers died from a poor risk assessment of the situation.

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 2-4*]

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 2-4. *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.

Examining National Transportation Safety Board (NTSB) reports and other accident research can help a pilot learn to assess risk more effectively. For example, the accident rate during night visual flight rules (VFR) decreases by nearly 50 percent once a pilot obtains 100 hours and continues to decrease until the 1,000 hour level. The data suggest that for the first 500 hours, pilots flying VFR at night might want to establish higher personal limitations than are required by the regulations and, if applicable, apply instrument flying skills in this environment.

Several risk assessment models are available to assist in the process of assessing risk. The models, all taking slightly different approaches, seek a common goal of assessing risk in an objective manner. The most basic tool is the risk matrix. *[Figure 2-5]* It assesses two items: the likelihood of an event occurring and the consequence of that event.

Likelihood of an Event

Likelihood is nothing more than taking a situation and determining the probability of its occurrence. It is rated as probable, occasional, remote, or improbable. For example, a pilot is flying from point A to point B (50 miles) in marginal visual flight rules (MVFR) conditions. The likelihood of encountering potential instrument meteorological conditions (IMC) is the first question the pilot needs to answer. The experiences of other pilots, coupled with the forecast, might



Figure 2-5. This risk matrix can be used for almost any operation by assigning likelihood and consequence. In the case presented, the pilot assigned a likelihood of occasional and the severity as catastrophic. As one can see, this falls in the high risk area.

cause the pilot to assign "occasional" to determine the probability of encountering IMC.

The following are guidelines for making assignments.

- Probable—an event will occur several times
- Occasional-an event will probably occur sometime
- Remote—an event is unlikely to occur, but is possible
- Improbable—an event is highly unlikely to occur

Severity of an Event

The next element is the severity or consequence of a pilot's action(s). It can relate to injury and/or damage. If the individual in the example above is not an instrument rated pilot, what are the consequences of him or her encountering inadvertent IMC conditions? In this case, because the pilot is not IFR rated, the consequences are catastrophic. The following are guidelines for this assignment.

- Catastrophic—results in fatalities, total loss
- Critical—severe injury, major damage
- Marginal—minor injury, minor damage
- Negligible—less than minor injury, less than minor system damage

Simply connecting the two factors as shown in *Figure 2-5* indicates the risk is high and the pilot must either not fly or fly only after finding ways to mitigate, eliminate, or control the risk.

Although the matrix in *Figure 2-5* provides a general viewpoint of a generic situation, a more comprehensive program can be made that is tailored to a pilot's flying. *[Figure 2-6]* This program includes a wide array of aviation-related activities specific to the pilot and assesses health, fatigue, weather,



Figure 2-6. Example of a more comprehensive risk assessment program.

capabilities, etc. The scores are added and the overall score falls into various ranges, with the range representative of actions that a pilot imposes upon himself or herself.

Mitigating Risk

Risk assessment is only part of the equation. After determining the level of risk, the pilot needs to mitigate the risk. For example, the pilot flying from point A to point B (50 miles) in MVFR conditions has several ways to reduce risk:

- Wait for the weather to improve to good visual flight rules (VFR) conditions.
- Take an instrument-rated pilot.
- Delay the flight.
- Cancel the flight.
- Drive.

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?
- 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**ilotin-command (PIC), **A**ircraft, en**V**ironment, and **E**xternal pressures (PAVE) which form part of a pilot's decisionmaking 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.

For example, the aircraft may have a maximum crosswind component of 15 knots listed in the aircraft flight manual (AFM), and the pilot has experience with 10 knots of direct crosswind. It could be unsafe to exceed a 10 knot crosswind component without additional training. Therefore, the 10 knot crosswind experience level is that pilot's personal limitation until additional training with a certificated flight instructor (CFI) provides the pilot with additional experience for flying in crosswinds that exceed 10 knots.

One of the most important concepts that safe pilots understand is the difference between what is "legal" in terms of the regulations, and what is "smart" or "safe" in terms of pilot 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 trip?" 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? Aircraft performance figures and the AFM are based on a brand new aircraft flown by a professional test pilot. Keep that in mind while assessing personal and aircraft performance.
- Is this aircraft equipped for the flight? Instruments? Lights? Navigation and communication equipment adequate?
- Can this aircraft use the runways available for the trip with an adequate margin of safety under the conditions to be flown?
- Can this aircraft carry the planned load?
- Can this aircraft operate at the altitudes needed for the trip?
- Does this aircraft have sufficient fuel capacity, with reserves, for trip legs planned?

• Does the fuel quantity delivered match the fuel quantity ordered?

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? In mountainous terrain, consider having higher minimums for ceiling and visibility, particularly if the terrain is unfamiliar.
- Consider the possibility that the weather may be different than forecast. Have alternative plans and be ready and willing to divert, should an unexpected change occur.
- Consider the winds at the airports being used and the strength of the crosswind component.
- If flying in mountainous terrain, consider whether there are strong winds aloft. Strong winds in mountainous terrain can cause severe turbulence and downdrafts and be very hazardous for aircraft even when there is no other significant weather.
- 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? Can descent be made safely all along the route?
- If icing conditions are encountered, is the pilot experienced at operating the aircraft's deicing or anti-icing equipment? Is this equipment in good condition and functional? For what icing conditions is the aircraft rated, if any?

Terrain

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

- To avoid terrain and obstacles, especially at night or in low visibility, determine safe altitudes in advance by using the altitudes shown on VFR and IFR charts during preflight planning.
- Use maximum elevation figures (MEFs) and other easily obtainable data to minimize chances of an inflight collision with terrain or obstacles.

Airport

• What lights are available at the destination and alternate airports? VASI/PAPI or ILS glideslope

guidance? Is the terminal airport equipped with them? Are they working? Will the pilot need to use the radio to activate the airport lights?

- Check the Notices to Airmen (NOTAM) for closed runways or airports. Look for runway or beacon lights out, nearby towers, etc.
- Choose the flight route wisely. An engine failure gives the nearby airports supreme importance.
- Are there shorter or obstructed fields at the destination and/or alternate airports?

Airspace

- If the trip is over remote areas, is there appropriate clothing, water, and survival gear onboard in the event of a forced landing?
- If the trip includes flying over water or unpopulated areas with the chance of losing visual reference to the horizon, the pilot must be prepared to fly IFR.
- Check the airspace and any temporary flight restriction (TFRs) along the route of flight.

Nighttime

Night flying requires special consideration.

- If the trip includes flying at night over water or unpopulated areas with the chance of losing visual reference to the horizon, the pilot must be prepared to fly IFR.
- Will the flight conditions allow a safe emergency landing at night?
- Perform preflight check of all aircraft lights, interior and exterior, for a night flight. Carry at least two flashlights—one for exterior preflight and a smaller one that can be dimmed and kept nearby.

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:

- Someone waiting at the airport for the flight's arrival
- A passenger the pilot does not want to disappoint
- The desire to demonstrate pilot qualifications
- The desire to impress someone (Probably the two most dangerous words in aviation are "Watch this!")
- The desire to satisfy a specific personal goal ("gethome-itis," "get-there-itis," and "let's-go-itis")
- 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. External pressures put time-related pressure on the pilot and figure into a majority of accidents.

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. These procedures include but are not limited to:

- Allow time on a trip for an extra fuel stop or to make an unexpected landing because of weather.
- Have alternate plans for a late arrival or make backup airline reservations for must-be-there trips.
- For really important trips, plan to leave early enough so that there would still be time to drive to the destination, if necessary.

- Advise those who are waiting at the destination that the arrival may be delayed. Know how to notify them when delays are encountered.
- Manage passengers' expectations. Make sure passengers know that they might not arrive on a firm schedule, and if they must arrive by a certain time, they should make alternative plans.
- Eliminate pressure to return home, even on a casual day flight, by carrying a small overnight kit containing prescriptions, contact lens solutions, toiletries, or other necessities on every flight.

The key to managing external pressure is to be ready for and accept delays. Remember that people get delayed when traveling on airlines, driving a car, or taking a bus. The pilot's goal is to manage risk, not create hazards. *[Figure 2-7]*

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

Pilot

A pilot must continually make decisions about competency, condition of health, mental and emotional state, level of fatigue, and many other variables. For example, a pilot may be called early in the morning to make a long flight. If a pilot has had only a few hours of sleep and is concerned that the congestion being experienced could be the onset of a cold, it would be prudent to consider if the flight could be accomplished safely.

A pilot had only 4 hours of sleep the night before being asked by the boss to fly to a meeting in a city 750 miles away. The reported weather was marginal and not expected to improve. After assessing fitness as a pilot, it was decided that it would not be wise to make the flight. The boss was initially unhappy, but later convinced by the pilot that the risks involved were unacceptable.

Environment

This encompasses many elements not pilot or airplane related. It can include such factors as weather, air traffic control, navigational aids (NAVAIDS), terrain, takeoff and landing areas, and surrounding obstacles. Weather is one element that can change drastically over time and distance.

A pilot was landing a small airplane just after a heavy jet had departed a parallel runway. The pilot assumed that wake turbulence would not be a problem since landings had been performed under similar circumstances. Due to a combination of prevailing winds and wake turbulence from the heavy jet drifting across the landing runway, the airplane made a hard landing. The pilot made an error when assessing the flight environment.

Aircraft

A pilot will frequently base decisions on the evaluations of the aircraft, such as performance, equipment, or airworthiness.

During a preflight, a pilot noticed a small amount of oil dripping from the bottom of the cowling. Although the quantity of oil seemed insignificant at the time, the pilot decided to delay the takeoff and have a mechanic check the source of the oil. The pilot's good judgment was confirmed when the mechanic found that one of the oil cooler hose fittings was loose.

External pressures

The interaction between the pilot, airplane, and the environment is greatly influenced by the purpose of each flight operation. The pilot must evaluate the three previous areas to decide on the desirability of undertaking or continuing the flight as planned. It is worth asking why the flight is being made, how critical is it to maintain the schedule, and is the trip worth the risks?

On a ferry flight to deliver an airplane from the factory, in marginal weather conditions, the pilot calculated the groundspeed and determined that the airplane would arrive at the destination with only 10 minutes of fuel remaining. The pilot was determined to keep on schedule by trying to "stretch" the fuel supply instead of landing to refuel. After landing with low fuel state, the pilot realized that this could have easily resulted in an emergency landing in deteriorating weather conditions. This was a chance that was not worth taking to keep the planned schedule.

Figure 2-7. The PAVE checklist.

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. [Figure 2-8] 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.

Human Behavior

Studies of human behavior have tried to determine an individual's predisposition to taking risks and the level of an individual's involvement in accidents. In 1951, a study regarding injury-prone children was published by Elizabeth Mechem Fuller and Helen B. Baune, of the University of Minnesota. The study was comprised of two separate groups of second grade students. Fifty-five students were considered accident repeaters and 48 students had no accidents. Both groups were from the same school of 600 and their family demographics were similar.

The accident-free group showed a superior knowledge of safety, was considered industrious and cooperative



Figure 2-8. Human factors effects pilots, aviation maintenance technicians (AMTs) and air traffic control (ATC).

with others, but were not considered physically inclined. The accident-repeater group had better gymnastic skills, was considered aggressive and impulsive, demonstrated rebellious behavior when under stress, were poor losers, and liked to be the center of attention. One interpretation of this data—an adult predisposition to injury stems from childhood behavior and environment—leads to the conclusion that any pilot group should be comprised only of pilots who are safety-conscious, industrious, and cooperative.

Clearly, this is not only an inaccurate inference, it is impossible. Pilots are drawn from the general population and exhibit all types of personality traits. Thus, it is important that good decision-making skills be taught to all pilots.

Historically, the term "pilot error" has been used to describe an accident in which an action or decision made by the pilot was the cause or a contributing factor that led to the accident. This definition also includes the pilot's failure to make a correct decision or take proper action. From a broader perspective, the phrase "human factors related" more aptly describes these accidents. A single decision or event does not lead to an accident, but a series of events and the resultant decisions together form a chain of events leading to an outcome.

In his article "Accident-Prone Pilots," Dr. Patrick R. Veillette uses the history of "Captain Everyman" to demonstrate how aircraft accidents are caused more by a chain of poor choices rather than one single poor choice. In the case of Captain Everyman, after a gear-up landing accident, he became involved in another accident while taxiing a Beech 58P Baron out of the ramp. Interrupted by a radio call from the dispatcher, Everyman neglected to complete the fuel cross-feed check before taking off. Everyman, who was flying solo, left the right-fuel selector in the cross-feed position. Once aloft and cruising, he noticed a right roll tendency and corrected with aileron trim. He did not realize that both engines were feeding off the left wing's tank, making the wing lighter.

After two hours of flight, the right engine quit when Everyman was flying along a deep canyon gorge. While he was trying to troubleshoot the cause of the right engine's failure, the left engine quit. Everyman landed the aircraft on a river sand bar but it sank into ten feet of water.

Several years later Everyman flew a de Havilland Twin Otter to deliver supplies to a remote location. When he returned to home base and landed, the aircraft veered sharply to the left, departed the runway, and ran into a marsh 375 feet from the runway. The airframe and engines sustained considerable damage. Upon inspecting the wreck, accident investigators found the nose wheel steering tiller in the fully deflected position. Both the after takeoff and before landing checklists require the tiller to be placed in the neutral position. Everyman had overlooked this item.

Now, is Everyman accident prone or just unlucky? Skipping details on a checklist appears to be a common theme in the preceding accidents. While most pilots have made similar mistakes, these errors were probably caught prior to a mishap due to extra margin, good warning systems, a sharp copilot, or just good luck. What makes a pilot less prone to accidents?

The successful pilot possesses the ability to concentrate, manage workloads, and monitor and perform several simultaneous tasks. Some of the latest psychological screenings used in aviation test applicants for their ability to multitask, measuring both accuracy, as well as the individual's ability to focus attention on several subjects simultaneously. The FAA oversaw an extensive research study on the similarities and dissimilarities of accident-free pilots and those who were not. The project surveyed over 4,000 pilots, half of whom had "clean" records while the other half had been involved in an accident.

Five traits were discovered in pilots prone to having accidents. These pilots:

- Have disdain toward rules
- Have very high correlation between accidents on their flying records and safety violations on their driving records
- Frequently fall into the "thrill and adventure seeking" personality category
- Are impulsive rather than methodical and disciplined, both in their information gathering and in the speed and selection of actions to be taken
- Have a disregard for or tend to under utilize outside sources of information, including copilots, flight attendants, flight service personnel, flight instructors, and ATC

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 decisionmaking 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.

The 5 Ps Check

SRM sounds good on paper, but it requires a way for pilots to understand and use it in their daily flights. One practical application is called the "Five Ps (5 Ps)." *[Figure 2-9]* The 5 Ps consist of "the Plan, the Plane, the Pilot, the Passengers, and the Programming." Each of these areas consists of a set of challenges and opportunities that every pilot encounters. Each challenge and opportunity can substantially increase or decrease the risk of successfully completing the flight based on the pilot's ability to make informed and timely decisions. The 5 Ps are used to evaluate the pilot's current situation at key decision points during the flight or when an emergency



Figure 2-9. The Five Ps checklist.

arises. These decision points include preflight, pretakeoff, hourly or at the midpoint of the flight, pre-descent, and just prior to the final approach fix or for VFR operations, just prior to entering the traffic pattern.

The 5 Ps are based on the idea that pilots have essentially five variables that impact his or her environment and forcing him or her to make a single critical decision, or several less critical decisions, that when added together can create a critical outcome. These variables are the Plan, the Plane, the Pilot, the Passengers, and the Programming. This concept stems from the belief that current decision-making models tended to be reactionary in nature. A change has to occur and be detected to drive a risk management decision by the pilot. For instance, many pilots complete risk management sheets prior to takeoff. These form a catalog of risks that may be encountered that day. Each of these risks is assigned a numerical value. If the total of these numerical values exceeds a predetermined level, the flight is altered or cancelled. Informal research shows that while these are useful documents for teaching risk factors, they are almost never used outside of formal training programs. The 5P concept is an attempt to take the information contained in those sheets and in the other available models and use it.

The 5P concept relies on the pilot to adopt a "scheduled" review of the critical variables at points in the flight where decisions are most likely to be effective. For instance, the easiest point to cancel a flight due to bad weather is before the pilot and passengers walk out the door and load the aircraft. So the first decision point is preflight in the flight planning room, where all the information is readily available to make a sound decision, and where communication and Fixed Base Operator (FBO) services are readily available to make alternate travel plans.

The second easiest point in the flight to make a critical safety decision is just prior to takeoff. Few pilots have ever had to make an "emergency takeoff." While the point of the 5P check is to help the pilot fly, the correct application of the 5 P before takeoff is to assist in making a reasoned go/no-go decision based on all the information available. That decision will usually be to "go," with certain restrictions and changes, but may also be a "no-go." The key idea is that these two points in the process of flying are critical go/no-go points on each and every flight.

The third place to review the 5 Ps is at the midpoint of the flight. Often, pilots may wait until the Automated Terminal information Service (ATIS) is in range to check weather, yet, at this point in the flight, many good options have already passed behind the aircraft and pilot. Additionally, fatigue

and low-altitude hypoxia serve to rob the pilot of much of his or her energy by the end of a long and tiring flight day. This leads to a transition from a decision-making mode to an acceptance mode on the part of the pilot. If the flight is longer than 2 hours, the 5 P check should be conducted hourly.

The last two decision points are just prior to descent into the terminal area and just prior to the final approach fix, or if VFR, just prior to entering the traffic pattern as preparations for landing commence. Most pilots execute approaches with the expectation that they will land out of the approach every time. A healthier approach requires the pilot to assume that changing conditions (the 5 Ps again) will cause the pilot to divert or execute the missed approach on every approach. This keeps the pilot alert to all manner of conditions that may increase risk and threaten the safe conduct of the flight. Diverting from cruise altitude saves fuel, allows unhurried use of the autopilot and is less reactive in nature. Diverting from the final approach fix, while more difficult, still allows the pilot to plan and coordinate better, rather than executing a futile missed approach. Let's look at a detailed discussion of each of the Five Ps.

The Plan

The "Plan" can also be called the mission or the task. It contains the basic elements of cross-country planning, weather, route, fuel, publications currency, etc. The "Plan" should be reviewed and updated several times during the course of the flight. A delayed takeoff due to maintenance, fast moving weather, and a short notice TFR may all radically alter the plan. The "plan" is not only about the flight plan, but also all the events that surround the flight and allow the pilot to accomplish the mission. The plan is always being updated and modified and is especially responsive to changes in the other four remaining Ps. If for no other reason, the 5 P check reminds the pilot that the day's flight plan is real life and subject to change at any time.

Obviously, weather is a huge part of any plan. The addition of datalink weather information gives the advanced avionics pilot a real advantage in inclement weather, but only if the pilot is trained to retrieve and evaluate the weather in real time without sacrificing situational awareness. And of course, weather information should drive a decision, even if that decision is to continue on the current plan. Pilots of aircraft without datalink weather should get updated weather in flight through an FSS and/or Flight Watch.

The Plane

Both the "plan" and the "plane" are fairly familiar to most pilots. The "plane" consists of the usual array of mechanical and cosmetic issues that every aircraft pilot, owner, or operator can identify. With the advent of advanced avionics, the "plane" has expanded to include database currency, automation status, and emergency backup systems that were unknown a few years ago. Much has been written about single pilot IFR flight, both with and without an autopilot. While this is a personal decision, it is just that—a decision. Low IFR in a non-autopilot equipped aircraft may depend on several of the other Ps to be discussed. Pilot proficiency, currency, and fatigue are among them.

The Pilot

Flying, especially when business transportation is involved, can expose a pilot to risks such as high altitudes, long trips requiring significant endurance, and challenging weather. Advanced avionics, when installed, can expose a pilot to high stresses because of the inherent additional capabilities which are available. When dealing with pilot risk, it is always best to consult the "IMSAFE" checklist (see page 2-6).

The combination of late nights, pilot fatigue, and the effects of sustained flight above 5,000 feet may cause pilots to become less discerning, less critical of information, less decisive, and more compliant and accepting. Just as the most critical portion of the flight approaches (for instance a night instrument approach, in the weather, after a 4-hour flight), the pilot's guard is down the most. The 5 P process helps a pilot recognize the physiological challenges that they may face towards the end of the flight prior to takeoff and allows them to update personal conditions as the flight progresses. Once risks are identified, the pilot is in a better place to make alternate plans that lessen the effect of these factors and provide a safer solution.

The Passengers

One of the key differences between CRM and SRM is the way passengers interact with the pilot. The pilot of a highly capable single-engine aircraft maintains a much more personal relationship with the passengers as he/she is positioned within an arm's reach of them throughout the flight.

The necessity of the passengers to make airline connections or important business meetings in a timely manner enters into this pilot's decision-making loop. Consider a flight to Dulles Airport in which and the passengers, both close friends and business partners, need to get to Washington, D.C. for an important meeting. The weather is VFR all the way to southern Virginia, then turns to low IFR as the pilot approaches Dulles. A pilot employing the 5 P approach might consider reserving a rental car at an airport in northern North Carolina or southern Virginia to coincide with a refueling stop. Thus, the passengers have a way to get to Washington, and the pilot has an out to avoid being pressured into continuing the flight if the conditions do not improve. Passengers can also be pilots. If no one is designated as pilot in command (PIC) and unplanned circumstances arise, the decision-making styles of several self-confident pilots may come into conflict.

Pilots also need to understand that non-pilots may not understand the level of risk involved in flight. There is an element of risk in every flight. That is why SRM calls it risk management, not risk elimination. While a pilot may feel comfortable with the risk present in a night IFR flight, the passengers may not. A pilot employing SRM should ensure the passengers are involved in the decision-making and given tasks and duties to keep them busy and involved. If, upon a factual description of the risks present, the passengers decide to buy an airline ticket or rent a car, then a good decision has generally been made. This discussion also allows the pilot to move past what he or she thinks the passengers want to do and find out what they actually want to do. This removes self-induced pressure from the pilot.

The Programming

The advanced avionics aircraft adds an entirely new dimension to the way GA aircraft are flown. The electronic instrument displays, GPS, and autopilot reduce pilot workload and increase pilot situational awareness. While programming and operation of these devices are fairly simple and straightforward, unlike the analog instruments they replace, they tend to capture the pilot's attention and hold it for long periods of time. To avoid this phenomenon, the pilot should plan in advance when and where the programming for approaches, route changes, and airport information gathering should be accomplished, as well as times it should not. Pilot familiarity with the equipment, the route, the local ATC environment, and personal capabilities vis-à-vis the automation should drive when, where, and how the automation is programmed and used.

The pilot should also consider what his or her capabilities are in response to last minute changes of the approach (and the reprogramming required) and ability to make large-scale changes (a reroute for instance) while hand flying the aircraft. Since formats are not standardized, simply moving from one manufacturer's equipment to another should give the pilot pause and require more conservative planning and decisions. The SRM process is simple. At least five times before and during the flight, the pilot should review and consider the "Plan, the Plane, the Pilot, the Passengers, and the Programming" and make the appropriate decision required by the current situation. It is often said that failure to make a decision is a decision. Under SRM and the 5 Ps, even the decision to make no changes to the current plan is made through a careful consideration of all the risk factors present.

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 2-10]* 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.

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

	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 2-10. Risk management processing can take place in any of three timeframes.