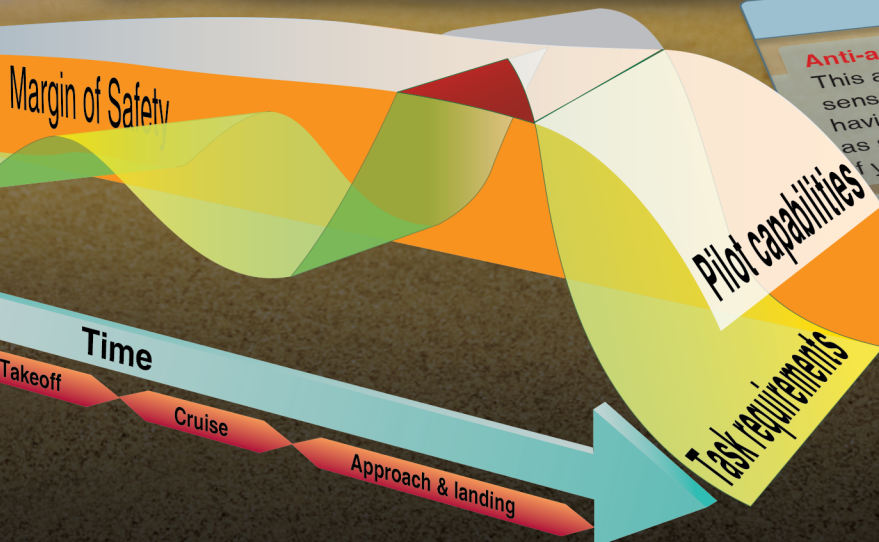
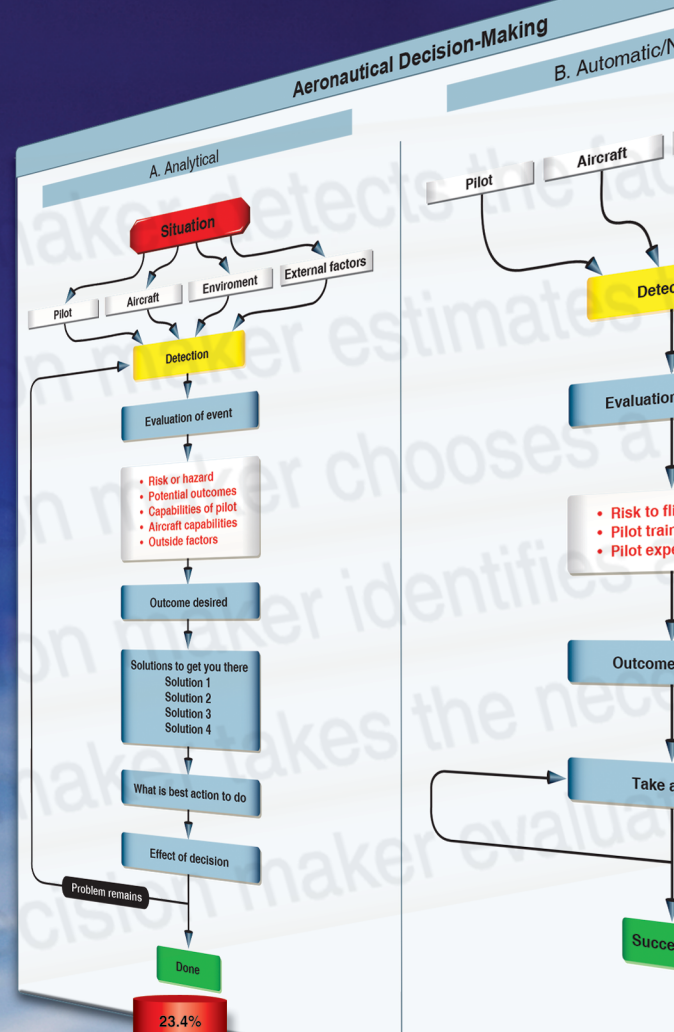


Aeronautical Decision-Making

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.



Biases

Cognitive Biases

Anti-authority: "Don't tell me."
This attitude is found in people who do not like anyone telling them sense, they are saying, "No one can tell me what to do." They may be 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 if you feel it is in error.

Impulsivity: "Do it quickly."
This is the attitude of people who frequently feel the need to do something immediately. They do not stop to think about what they are about to do, select the best alternative, and they do the first thing that comes to mind.

Invulnerability: "It won't happen to me."
Many people falsely believe that accidents happen to others, but they know accidents can happen, and they know that anyone can be hurt. They never really feel or believe that they will be personally involved. This way are more likely to take chances and increase risk.

Macho: "I can do it."
Pilots who are always trying to prove that they are better than others do it—I'll show them." Pilots with this type of attitude will be taking risks in order to impress others. While this pattern is characteristic, women are equally susceptible.

Question: "What's the use?"
What's the use? do not see the value in what happens to them. Things go bad...

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

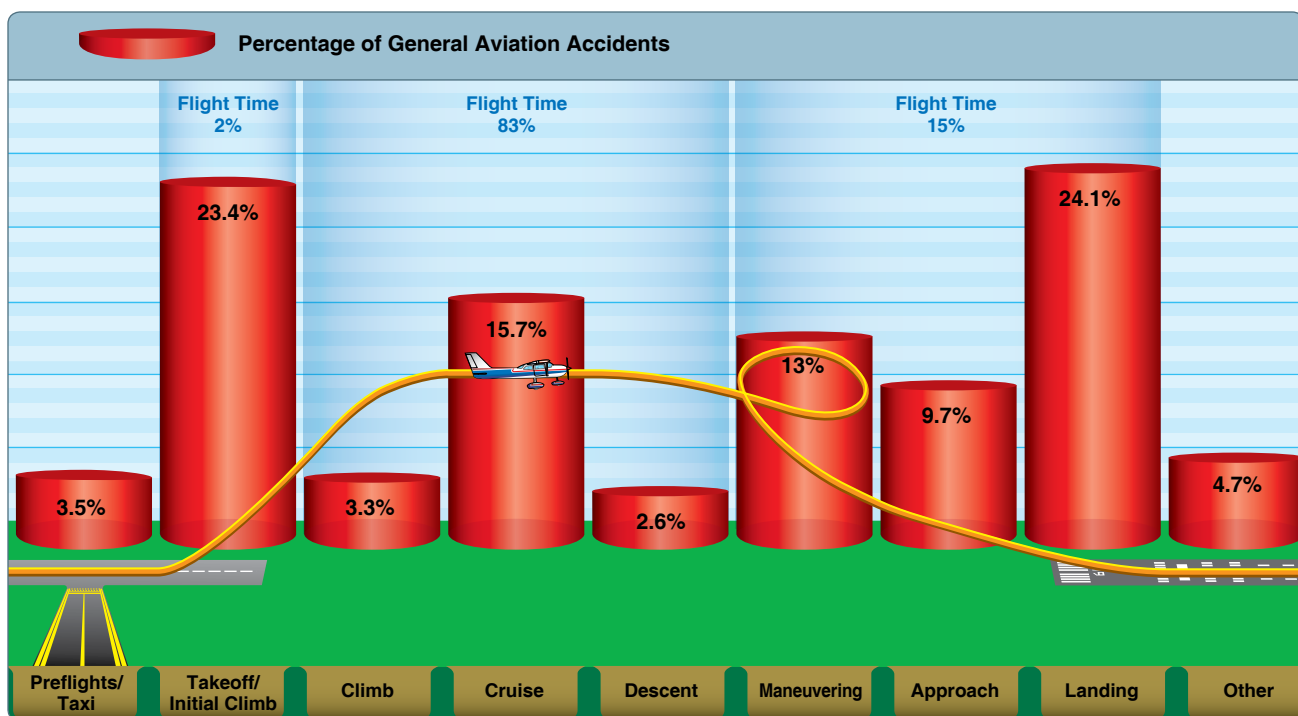


Figure 2-1. The percentage of aviation accidents as they relate to the different phases of flight. Note that the greatest percentage of accidents take place during a minor percentage of the total flight.

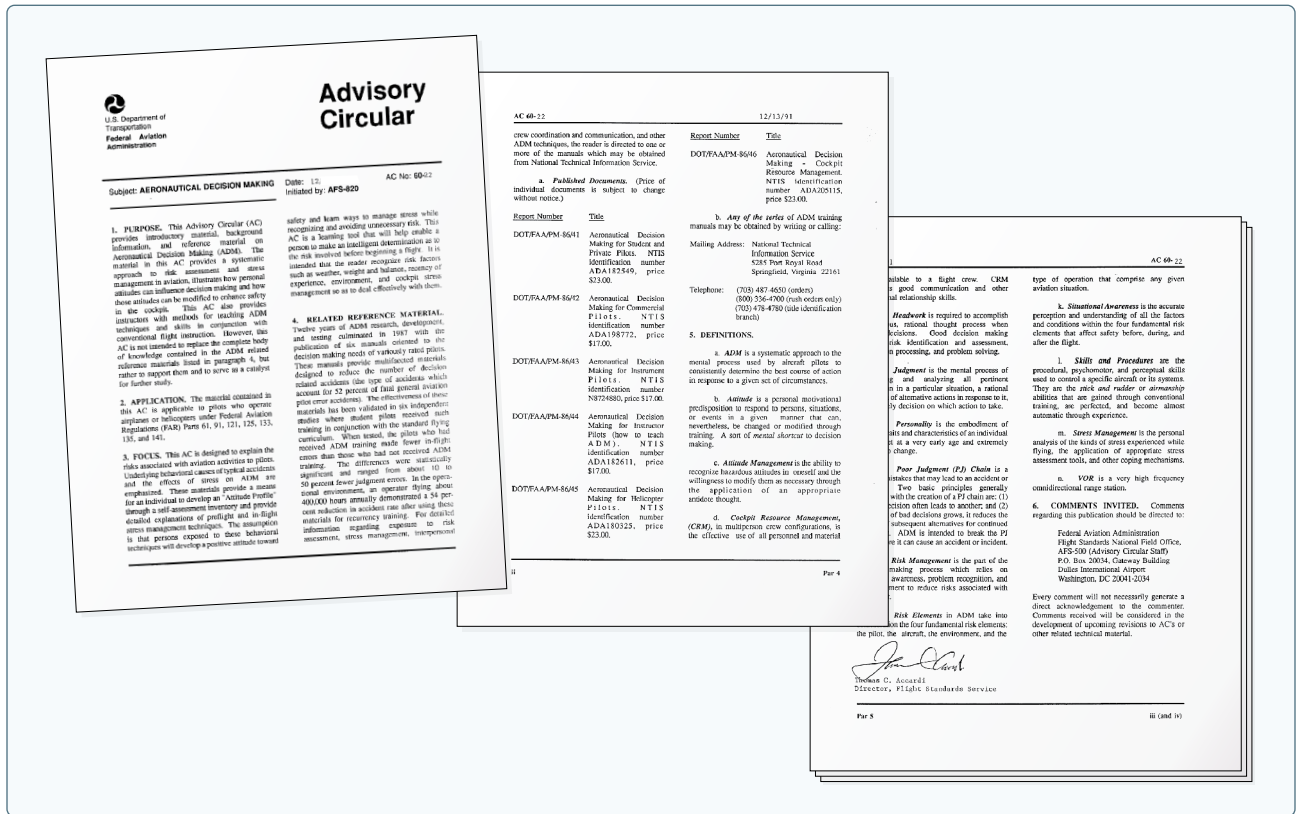


Figure 2-2. Advisory Circular (AC) 60-22, “Aeronautical Decision Making,” carries a wealth of information for the pilot to learn.

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

Risk Assessment Matrix				
Likelihood	Severity			
	Catastrophic	Critical	Marginal	Negligible
Probable	High	High	Serious	
Occasional	High	Serious		
Remote	Serious	Medium		Low
Improbable				

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,

RISK ASSESSMENT	
Pilot's Name <input style="width: 90%;" type="text"/>	Flight From <input style="width: 40%;" type="text"/> To <input style="width: 40%;" type="text"/>
SLEEP <ul style="list-style-type: none"> 1. Did not sleep well or less than 8 hours 2 <input type="radio"/> 2. Slept well 0 <input type="radio"/> 	HOW IS THE DAY GOING? <ul style="list-style-type: none"> 1. Seems like one thing after another (late, making errors, out of step) 3 <input type="radio"/> 2. Great day 0 <input type="radio"/>
HOW DO YOU FEEL? <ul style="list-style-type: none"> 1. Have a cold or ill 4 <input type="radio"/> 2. Feel great 0 <input type="radio"/> 3. Feel a bit off 2 <input type="radio"/> 	IS THE FLIGHT <ul style="list-style-type: none"> 1. Day? 1 <input type="radio"/> 2. Night? 3 <input type="radio"/>
WEATHER AT TERMINATION <ul style="list-style-type: none"> 1. Greater than 5 miles visibility and 3,000 feet ceilings 1 <input type="radio"/> 2. At least 3 miles visibility and 1,000 feet ceilings, but less than 3,000 feet ceilings and 5 miles visibility 3 <input type="radio"/> 3. IMC conditions 4 <input type="radio"/> 	PLANNING <ul style="list-style-type: none"> 1. Rush to get off ground 3 <input type="radio"/> 2. No hurry 1 <input type="radio"/> 3. Used charts and computer to assist 0 <input type="radio"/> 4. Used computer program for all planning Yes 3 <input type="radio"/> No 0 <input type="radio"/> 5. Did you verify weight and balance? Yes 0 <input type="radio"/> No 3 <input type="radio"/> 6. Did you evaluate performance? Yes 0 <input type="radio"/> No 3 <input type="radio"/> 7. Do you brief your passengers on the ground and in flight? Yes 0 <input type="radio"/> No 2 <input type="radio"/>
Column total <input style="width: 50px;" type="text"/>	Column total <input style="width: 50px;" type="text"/>
TOTAL SCORE <input style="width: 150px;" type="text"/>	

0
Not complex flight

10
Exercise caution

20
Area of concern

30
Endangerment

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?
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: Pilot-in-command (PIC), Aircraft, Environment, and External 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.

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 ("get-home-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

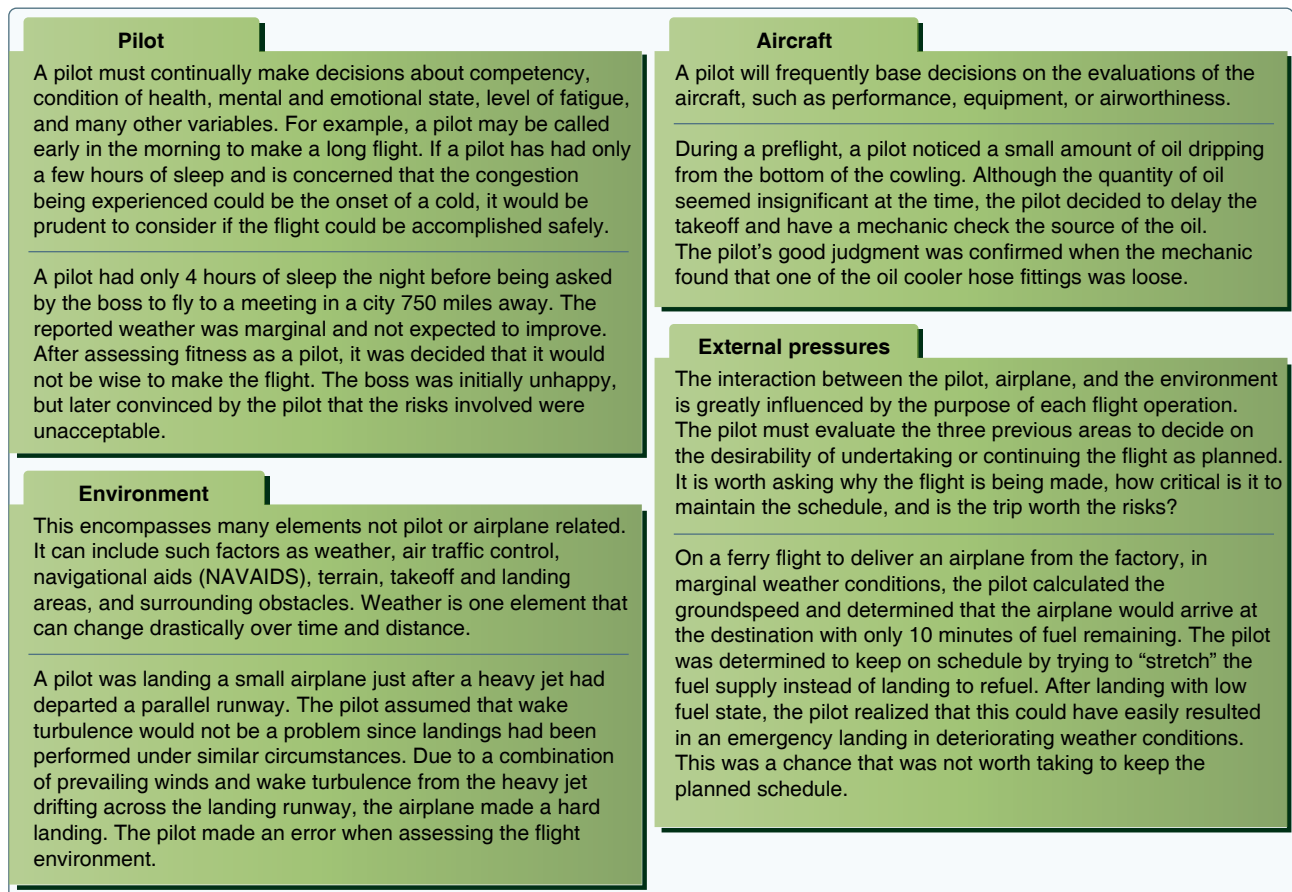


Figure 2-7. The PAVE checklist.

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 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.

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

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

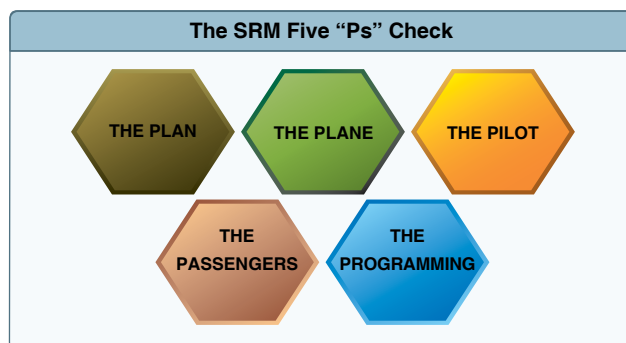


Figure 2-9. The Five Ps checklist.

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 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.

list hazards associated with all aspects of the flight: **P**ilot, **A**ircraft, **e**n**V**ironment, and **E**xternal pressures, which makes up the PAVE checklist. [Figure 2-11] For each element, ask “what could hurt me, my passengers, or my aircraft?” 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 a 1970s-model aircraft with no weather avoidance gear. On the other hand, you may have a new technically advanced aircraft with moving map GPS, weather datalink, and autopilot—but if you do not have much weather flying experience or practice in using this kind of equipment, you cannot rely on the airplane’s capability to compensate for your own lack of experience.

CARE Checklist: Review Hazards and Evaluate Risks

In the second step, the goal is to process this information to determine whether the identified hazards constitute risk, which is defined as the future impact of a hazard that is not controlled or eliminated. The degree of risk posed by a given hazard can be measured in terms of exposure (number of people or resources affected), severity (extent of possible loss), and probability (the likelihood that a hazard will cause a loss). The goal is to evaluate their impact on the safety of your flight, and consider “why must I CARE about these circumstances?”

For each hazard that you perceived in step one, process by using the CARE checklist of: **C**onsequences, **A**lternatives, **R**eality, **E**xternal factors. [Figure 2-12] For example, let’s evaluate a night flight to attend a business meeting:

Consequences—departing after a full workday creates fatigue and pressure

Alternatives—delay until morning; reschedule meeting; drive

Reality —dangers and distractions of fatigue could lead to an accident

External pressures—business meeting at destination might influence me

A good rule of thumb for the processing phase: if you find yourself saying that it will “probably” be okay, it is definitely time for a solid reality check. If you are worried about missing a meeting, be realistic about how that pressure will affect not just your initial go/no-go decision, but also your inflight decisions to continue the flight or divert.

TEAM Checklist: Choose and Implement Risk Controls

Once you have perceived a hazard (step one) and processed its impact on flight safety (step two), it is time to move to the third step, perform. Perform risk management by using the TEAM checklist of: **T**ransfer, **E**liminate, **A**ccept, **M**itigate to deal with each factor. [Figure 2-13]

Transfer—Should this risk decision be transferred to someone else (e.g., do you need to consult the chief flight instructor?)

Eliminate—Is there a way to eliminate the hazard?

Accept—Do the benefits of accepting risk outweigh the costs?

Mitigate—What can you do to mitigate the risk?

The goal is to perform by taking action to eliminate hazards or mitigate risk, and then continuously evaluate the outcome of this action. With the example of low ceilings at destination, for instance, the pilot can perform good ADM by selecting a suitable alternate, knowing where to find good weather,

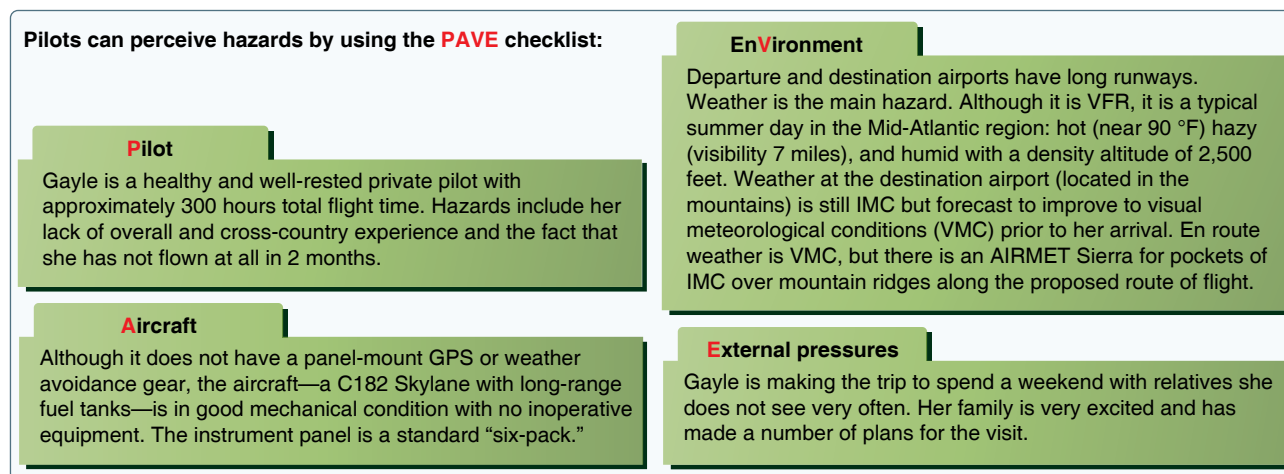


Figure 2-11. A real-world example of how the 3P model guides decisions on a cross-country trip using the PAVE checklist.

Pilots can perceive hazards by using the CARE checklist:

Pilot

- **C**onsequences: Gayle's inexperience and lack of recent flight time create some risks for an accident, primarily because she plans to travel over mountains on a hazy day and land at an unfamiliar mountain airport that is still in IMC conditions.
- **A**lternatives: Gayle might mitigate the pilot-related risk by hiring a CFI to accompany her and provide dual cross-country instruction. An added benefit is the opportunity to broaden her flying experience in safe conditions.
- **R**eality: Accepting the reality that limited experience can create additional risks is a key part of sound risk management and mitigation.
- **E**xternal Factors: Like many pilots, Gayle must contend with the emotional pressure associated with acknowledging that her skill and experience levels may be lower than she would like them to be. Pride can be a powerful external factor!

Environment

- **C**onsequences: For a pilot whose experience consists mostly of local flights in good VMC, launching a long cross-country flight over mountainous terrain in hazy conditions could lead to pilot disorientation and increase the risk of an accident.
- **A**lternatives: Options include postponing the trip until the visibility improves, or modifying the route to avoid extended periods of time over the mountains.
- **R**eality: Hazy conditions and mountainous terrain clearly create risks for an inexperienced VFR-only pilot.
- **E**xternal Factors: Few pilots are immune to the pressure of "get-there-itis," which can sometimes induce a decision to launch or continue in less than ideal weather conditions.

Aircraft

- **C**onsequences: This area presents low risk because the aircraft is in excellent mechanical condition and Gayle is familiar with its avionics.
- **A**lternatives: Had there been a problem with her aircraft, Gayle might have considered renting another plane from her flight school. Bear in mind, however, that alternatives sometimes create new hazards. In this instance, there may be hazards associated with flying an unfamiliar aircraft with different avionics.
- **R**eality: It is important to recognize the reality of an aircraft's mechanical condition. If you find a maintenance discrepancy and then find yourself saying that it is "probably" okay to fly with it anyway, you need to revisit the consequences part of this checklist.
- **E**xternal Factors: Pilot decision-making can sometimes be influenced by the external pressure of needing to return the airplane to the FBO by a certain date and time. Because Gayle owns the airplane, there was no such pressure in this case.

External pressures

- **C**onsequences: Any number of factors can create the risk of emotional pressure from a "get-there" mentality. In Gayle's case, the consequences of her strong desire to visit family, her family's expectations, and personal pride could induce her to accept unnecessary risks.
- **A**lternatives: Gayle clearly needs to develop a mitigating strategy for each of the external factors associated with this trip.
- **R**eality: Pilots sometimes tend to discount or ignore the potential impact of these external factors. Gayle's open acknowledgement of these factors (e.g., "I might be pressured into pressing on so my mother won't have to worry about our late arrival.") is a critical element of effective risk management.
- **E**xternal Factors: (see above)

Figure 2-12. A real-world examples of how the 3P model guides decisions on a cross-country trip using the CARE checklist.

and carrying sufficient fuel to reach it. This course of action would mitigate the risk. The pilot also has the option to eliminate it entirely by waiting for better weather.

Once the pilot has completed the 3P decision process and selected a course of action, the process begins anew because now the set of circumstances brought about by the course of action requires analysis. The decision-making process is a continuous loop of perceiving, processing, and performing. With practice and consistent use, running through the 3P cycle can become a habit that is as smooth, continuous, and automatic as a well-honed instrument scan. This basic set of practical risk management tools can be used to improve risk management.

Your mental willingness to follow through on safe decisions, especially those that require delay or diversion is critical. You can bulk up your mental muscles by:

- Using personal minimums checklist to make some decisions in advance of the flight. To develop a good personal minimums checklist, you need to assess your abilities and capabilities in a non-flying environment, when there is no pressure to make a specific trip. Once developed, a personal minimums checklist will give you a clear and concise reference point for making your go/no-go or continue/discontinue decisions.
- In addition to having personal minimums, some pilots also like to use a preflight risk assessment checklist to help with the ADM and risk management processes. This kind of form assigns numbers to certain risks and situations, which can make it easier to see when a particular flight involves a higher level of risk
- Develop a list of good alternatives during your processing phase. In marginal weather, for instance, you might mitigate the risk by identifying a reasonable

Pilots can perform risk management by using the **TEAM** checklist:

Pilot

To manage the risk associated with her inexperience and lack of recent flight time, Gayle can:

- **T**ransfer the risk entirely by having another pilot act as PIC.
- **E**liminate the risk by canceling the trip.
- **A**ccept the risk and fly anyway.
- **M**itigate the risk by flying with another pilot.

Gayle chooses to mitigate the major risk by hiring a CFI to accompany her and provide dual cross-country instruction. An added benefit is the opportunity to broaden her flying experience.

Aircraft

To manage risk associated with any doubts about the aircraft's mechanical condition, Gayle can:

- **T**ransfer the risk by using a different airplane.
- **E**liminate the risk by canceling the trip.
- **A**ccept the risk.
- **M**itigate the remaining (residual) risk through review of aircraft performance and careful preflight inspection.

Since she finds no problems with the aircraft's mechanical condition, Gayle chooses to mitigate any remaining risk through careful preflight inspection of the aircraft.

Environment

To manage the risk associated with hazy conditions and mountainous terrain, Gayle can:

- **T**ransfer the risk of VFR in these conditions by asking an instrument-rated pilot to fly the trip under IFR.
- **E**liminate the risk by canceling the trip.
- **A**ccept the risk.
- **M**itigate the risk by careful preflight planning, filing a VFR flight plan, requesting VFR flight following, and using resources such as Flight Watch.

Detailed preflight planning must be a vital part of Gayle's weather risk mitigation strategy. The most direct route would put her over mountains for most of the trip. Because of the thick haze and pockets of IMC over mountains, Gayle might mitigate the risk by modifying the route to fly over valleys. This change will add 30 minutes to her estimated time of arrival (ETA), but the extra time is a small price to pay for avoiding possible IMC over mountains. Because her destination airport is IMC at the time of departure, Gayle needs to establish that VFR conditions exist at other airports within easy driving distance of her original destination. In addition, Gayle should review basic information (e.g., traffic pattern altitude, runway layout, frequencies) for these alternate airports. To further mitigate risk and practice good cockpit resource management, Gayle should file a VFR flight plan, use VFR flight following, and call Flight Watch to get weather updates en route. Finally, basic functions on her handheld GPS should also be practiced.

External pressures

To mitigate the risk of emotional pressure from family expectations that can drive a "get-there" mentality, Gayle can:

- **T**ransfer the risk by having her co-pilot act as PIC and make the continue/divert decision.
- **E**liminate the risk by canceling the trip.
- **A**ccept the risk.
- **M**itigate the risk by managing family expectations and making alternative arrangements in the event of diversion to another airport.

Gayle and her co-pilot choose to address this risk by agreeing that each pilot has a veto on continuing the flight, and that they will divert if either becomes uncomfortable with flight conditions. Because the destination airport is still IMC at the time of departure, Gayle establishes a specific point in the trip—an en route VORTAC located between the destination airport and the two alternates—as the logical place for her "final" continue/divert decision. Rather than give her family a specific ETA that might make Gayle feel pressured to meet the schedule, she manages her family's expectations by advising them that she will call when she arrives.

Figure 2-13. A real-world example of how the 3P model guides decisions on a cross-country trip using the TEAM checklist.

alternative airport for every 25–30 nautical mile segment of your route.

- Preflight your passengers by preparing them for the possibility of delay and diversion, and involve them in your evaluation process.
- Another important tool—overlooked by many pilots—is a good post-flight analysis. When you have safely secured the airplane, take the time to review and analyze the flight as objectively as you can. Mistakes and judgment errors are inevitable; the most important thing is for you to recognize, analyze, and learn from them before your next flight.

The DECIDE Model

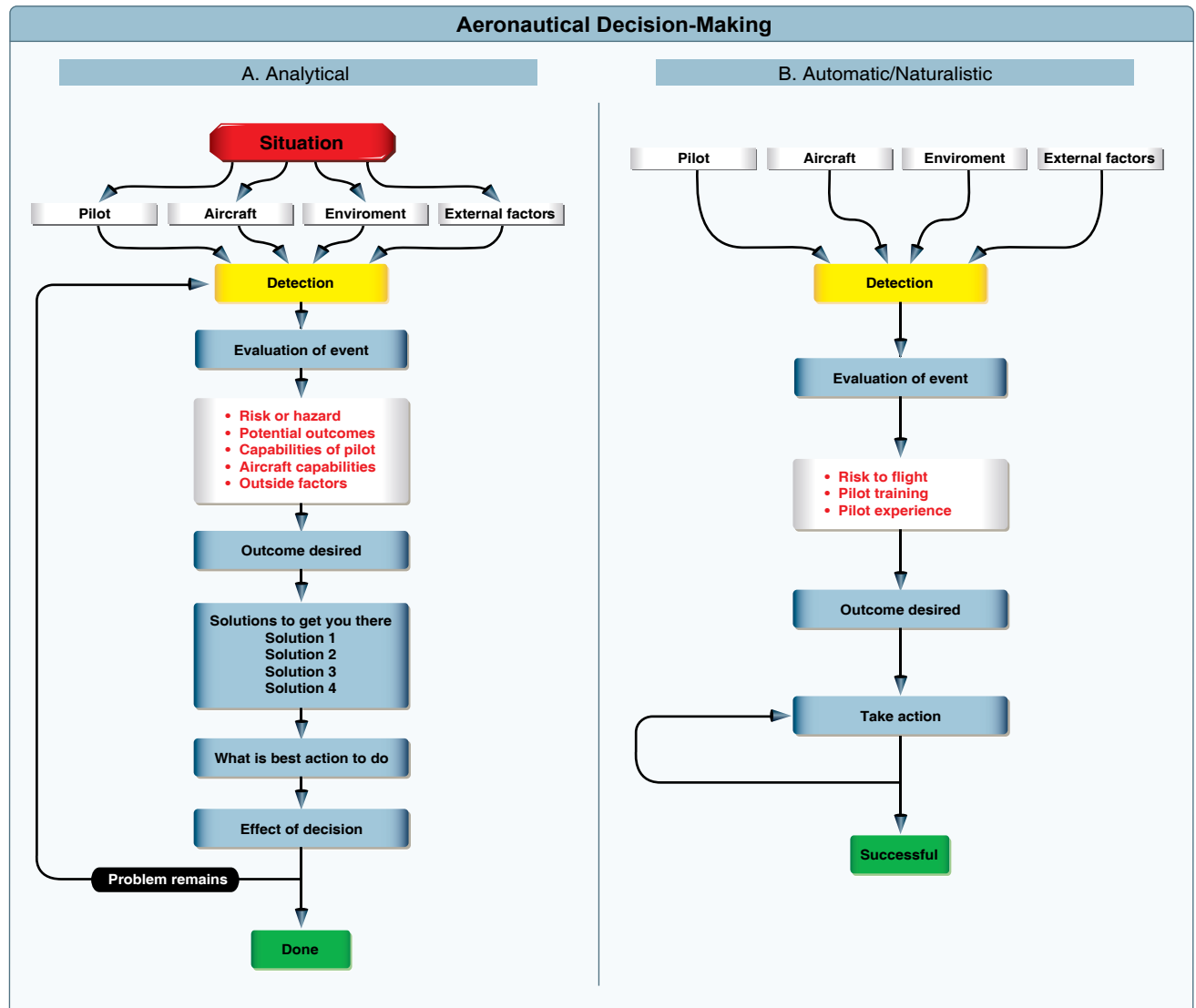
Using the acronym "DECIDE," the six-step process DECIDE Model is another continuous loop process that provides the pilot with a logical way of making decisions. [Figure 2-14] DECIDE means to Detect, Estimate, Choose a course of action, Identify solutions, Do the necessary actions, and Evaluate the effects of the actions.

First, consider a recent accident involving a Piper Apache (PA-23). The aircraft was substantially damaged during impact with terrain at a local airport in Alabama. The certificated airline transport pilot (ATP) received minor injuries and the certificated private pilot was not injured. The private pilot

was receiving a checkride from the ATP (who was also a designated examiner) for a commercial pilot certificate with a multi-engine rating. After performing airwork at altitude, they returned to the airport and the private pilot performed a single-engine approach to a full stop landing. He then taxied back for takeoff, performed a short field takeoff, and then joined the traffic pattern to return for another landing. During the approach for the second landing, the ATP simulated a right

engine failure by reducing power on the right engine to zero thrust. This caused the aircraft to yaw right.

The procedure to identify the failed engine is a two-step process. First, adjust the power to the maximum controllable level on both engines. Because the left engine is the only engine delivering thrust, the yaw increases to the right, which necessitates application of additional left rudder application.



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 2-14. The DECIDE model has been recognized worldwide. Its application is illustrated in column A while automatic/naturalistic decision-making is shown in column B.

The failed engine is the side that requires no rudder pressure, in this case the right engine. Second, having identified the failed right engine, the procedure is to feather the right engine and adjust power to maintain descent angle to a landing.

However, in this case the pilot feathered the left engine because he assumed the engine failure was a left engine failure. During twin-engine training, the left engine out is emphasized more than the right engine because the left engine on most light twins is the critical engine. This is due to multiengine airplanes being subject to P-factor, as are single-engine airplanes. The descending propeller blade of each engine will produce greater thrust than the ascending blade when the airplane is operated under power and at positive angles of attack. The descending propeller blade of the right engine is also a greater distance from the center of gravity, and therefore has a longer moment arm than the descending propeller blade of the left engine. As a result, failure of the left engine will result in the most asymmetrical thrust (adverse yaw) because the right engine will be providing the remaining thrust. Many twins are designed with a counter-rotating right engine. With this design, the degree of asymmetrical thrust is the same with either engine inoperative. Neither engine is more critical than the other.

Since the pilot never executed the first step of identifying which engine failed, he feathered the left engine and set the right engine at zero thrust. This essentially restricted the aircraft to a controlled glide. Upon realizing that he was not going to make the runway, the pilot increased power to both engines causing an enormous yaw to the left (the left propeller was feathered) whereupon the aircraft started to turn left. In desperation, the instructor closed both throttles and the aircraft hit the ground and was substantially damaged.

This case is interesting because it highlights two particular issues. First, taking action without forethought can be just as dangerous as taking no action at all. In this case, the pilot's actions were incorrect; yet, there was sufficient time to take the necessary steps to analyze the simulated emergency. The second and more subtle issue is that decisions made under pressure are sometimes executed based upon limited experience and the actions taken may be incorrect, incomplete, or insufficient to handle the situation.

Detect (the Problem)

Problem detection is the first step in the decision-making process. It begins with recognizing a change occurred or an expected change did not occur. A problem is perceived first by the senses and then it is distinguished through insight and experience. These same abilities, as well as an objective analysis of all available information, are used to determine the nature and severity of the problem. One critical error made during the decision-making process is incorrectly

detecting the problem. In the previous example, the change that occurred was a yaw.

Estimate (the Need To React)

In the engine-out example, the aircraft yawed right, the pilot was on final approach, and the problem warranted a prompt solution. In many cases, overreaction and fixation excludes a safe outcome. For example, what if the cabin door of a Mooney suddenly opened in flight while the aircraft climbed through 1,500 feet on a clear sunny day? The sudden opening would be alarming, but the perceived hazard the open door presents is quickly and effectively assessed as minor. In fact, the door's opening would not impact safe flight and can almost be disregarded. Most likely, a pilot would return to the airport to secure the door after landing.

The pilot flying on a clear day faced with this minor problem may rank the open cabin door as a low risk. What about the pilot on an IFR climb out in IMC conditions with light intermittent turbulence in rain who is receiving an amended clearance from ATC? The open cabin door now becomes a higher risk factor. The problem has not changed, but the perception of risk a pilot assigns it changes because of the multitude of ongoing tasks and the environment. Experience, discipline, awareness, and knowledge influences how a pilot ranks a problem.

Choose (a Course of Action)

After the problem has been identified and its impact estimated, the pilot must determine the desirable outcome and choose a course of action. In the case of the multiengine pilot given the simulated failed engine, the desired objective is to safely land the airplane.

Identify (Solutions)

The pilot formulates a plan that will take him or her to the objective. Sometimes, there may be only one course of action available. In the case of the engine failure already at 500 feet or below, the pilot solves the problem by identifying one or more solutions that lead to a successful outcome. It is important for the pilot not to become fixated on the process to the exclusion of making a decision.

Do (the Necessary Actions)

Once pathways to resolution are identified, the pilot selects the most suitable one for the situation. The multiengine pilot given the simulated failed engine must now safely land the aircraft.

Evaluate (the Effect of the Action)

Finally, after implementing a solution, evaluate the decision to see if it was correct. If the action taken does not provide the desired results, the process may have to be repeated.

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 2-14B]

Automatic Decision-Making

In an emergency situation, a pilot might not survive if he or she rigorously applies analytical models to every decision made as there is not enough time to go through all the options. Under these circumstances he or she should attempt to find the best possible solution to every problem.

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, please passengers, and meet schedules. The desire to meet these goals can have an adverse effect on safety and contribute to an unrealistic assessment of piloting skills. All experienced pilots have fallen prey to, or have been tempted by, one or more of these tendencies in their flying careers. These dangerous tendencies or behavior patterns, which must be identified and eliminated, include the operational pitfalls shown in *Figure 2-15*.

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 17, “Aeromedical Factors.”

Factors referred to as stressors can increase a pilot’s risk of error in the flight deck. [Figure 2-16] Remember the cabin door that suddenly opened in flight on the Mooney climbing through 1,500 feet on a clear sunny day? It may startle the pilot, but the stress would wane when it became apparent the situation was not a serious hazard. Yet, if the cabin door opened in IMC conditions, the stress level makes significant impact on the pilot’s ability to cope with simple tasks. The key to stress management is to stop, think, and analyze before jumping to a conclusion. There is usually time to think before drawing unnecessary conclusions.

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 resources found inside and outside the flight deck. 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

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 2-15. Typical operational pitfalls requiring pilot awareness.

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 2-16. 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.

time to use a particular resource and the impact its use will have upon the safety of flight. For example, the assistance of ATC may be very useful if a pilot becomes lost, but in an emergency situation, there may be no time available to contact ATC.

Internal Resources

One of the most underutilized resources may be the person in the right seat, even if the passenger has no flying experience. When appropriate, the PIC can ask passengers to assist with certain tasks, such as watching for traffic or reading checklist items. The following are some other ways a passenger can assist:

- Provide information in an irregular situation, especially if familiar with flying. A strange smell or sound may alert a passenger to a potential problem.
- Confirm after the pilot that the landing gear is down.
- Learn to look at the altimeter for a given altitude in a descent.
- Listen to logic or lack of logic.

Also, the process of a verbal briefing (which can happen whether or not passengers are aboard) can help the PIC in the decision-making process. For example, assume a pilot provides a lone passenger a briefing of the forecast landing weather before departure. When the Automatic Terminal Information Service (ATIS) is picked up, the weather has significantly changed. The discussion of this forecast change can lead the pilot to reexamine his or her activities and decision-making. [Figure 2-17] Other valuable internal resources include ingenuity, aviation knowledge, and flying skill. Pilots can increase flight deck resources by improving these characteristics.

When flying alone, another internal resource is verbal communication. It has been established that verbal communication reinforces an activity; touching an object while communicating further enhances the probability an activity has been accomplished. For this reason, many solo pilots read the checklist out loud; when they reach critical items, they touch the switch or control. For example, to ascertain the landing gear is down, the pilot can read the checklist. But, if he or she touches the gear handle during the process, a safe extension of the landing gear is confirmed.

It is necessary for a pilot to have a thorough understanding of all the equipment and systems in the aircraft being flown. Lack of knowledge, such as knowing if the oil pressure gauge is direct reading or uses a sensor, is the difference between making a wise decision or poor one that leads to a tragic error.



Figure 2-17. When possible, have a passenger reconfirm that critical tasks are completed.

Checklists are essential flight deck internal resources. They are used to verify the aircraft instruments and systems are checked, set, and operating properly, as well as ensuring the proper procedures are performed if there is a system malfunction or in-flight emergency. Students reluctant to use checklists can be reminded that pilots at all levels of experience refer to checklists, and that the more advanced the aircraft is, the more crucial checklists become. In addition, the pilot's operating handbook (POH) is required to be carried on board the aircraft and is essential for accurate flight planning and resolving in-flight equipment malfunctions. However, the most valuable resource a pilot has is the ability to manage workload whether alone or with others.

External Resources

ATC and flight service specialists are the best external resources during flight. In order to promote the safe, orderly flow of air traffic around airports and, along flight routes, the ATC provides pilots with traffic advisories, radar vectors, and assistance in emergency situations. Although it is the PIC's responsibility to make the flight as safe as possible, a pilot with a problem can request assistance from ATC. [Figure 2-18] For example, if a pilot needs to level off, be

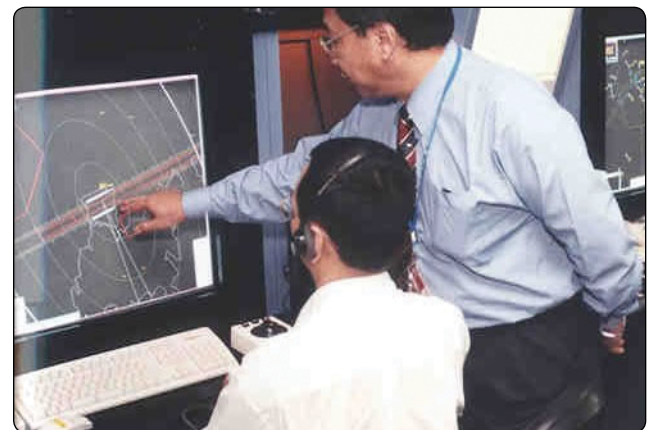


Figure 2-18. Controllers work to make flights as safe as possible.

given a vector, or decrease speed, ATC assists and becomes integrated as part of the crew. The services provided by ATC can not only decrease pilot workload, but also help pilots make informed in-flight decisions.

The Flight Service Stations (FSSs) are air traffic facilities that provide pilot briefing, en route communications, VFR search and rescue services, assist lost aircraft and aircraft in emergency situations, relay ATC clearances, originate Notices to Airmen (NOTAM), broadcast aviation weather and National Airspace System (NAS) information, receive and process IFR flight plans, and monitor navigational aids (NAVAIDs). In addition, at selected locations, FSSs provide En Route Flight Advisory Service (Flight Watch), issue airport advisories, and advise Customs and Immigration of transborder flights. Selected FSSs in Alaska also provide TWEB recordings and take weather observations.

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. Monitoring radio communications for traffic, weather discussion, and ATC communication can enhance situational awareness by helping the pilot develop a mental picture of what is happening.

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. For instance, while flying above Richmond, Virginia, toward Dulles Airport or Leesburg, the pilot should know why he or she is being vectored and be able to anticipate spatial location. A pilot who is simply making turns without understanding why has added an additional burden to his or her management in the event of an emergency. To maintain situational awareness, all of the skills involved in ADM are used.

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 instruments or scanning outside the aircraft. Many flight deck distractions begin as a minor problem, such as a gauge that is not reading correctly,

but result in accidents as the pilot diverts attention to the perceived problem and neglects proper control of the aircraft.

Workload Management

Effective workload management ensures essential operations are accomplished by planning, prioritizing, and sequencing tasks to avoid work overload. [Figure 2-19] As experience is gained, a pilot learns to recognize future workload requirements and can prepare for high workload periods during times of low workload. Reviewing the appropriate chart and setting radio frequencies well in advance of when they are needed helps reduce workload as the flight nears the airport. 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. Checklists should be performed well in advance so there is time to focus on traffic and ATC instructions. These procedures are especially important prior to entering a high-density traffic area, such as Class B airspace.

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. [Figure 2-20]

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. For example, in the case of the cabin door that opened in VFR flight, the impact on workload should be insignificant. If the cabin door opens under IFR different conditions, its impact on workload changes. Therefore, placing a situation in the proper perspective,



Figure 2-19. Balancing workloads can be a difficult task.

remaining calm, and thinking rationally are key elements in reducing stress and increasing the capacity to fly safely. This ability depends upon experience, discipline, and training.

Managing Risks

The ability to manage risks begins with preparation. Here are some things a pilot can do to manage risks:

- Assess the flight's risk based upon experience. Use some form of risk assessment. For example, if the weather is marginal and the pilot has little IMC training, it is probably a good idea to cancel the flight.
- Brief passengers using the SAFETY list:
 - S** Seat belts fastened for taxi, takeoff, landing
Shoulder harness fastened for takeoff, landing
Seat position adjusted and locked in place
 - A** Air vents (location and operation)
All environmental controls (discussed)
Action in case of any passenger discomfort
 - F** Fire extinguisher (location and operation)
 - E** Exit doors (how to secure; how to open)
Emergency evacuation plan
Emergency/survival kit (location and contents)
 - T** Traffic (scanning, spotting, notifying pilot)
Talking, ("sterile flight deck" expectations)
 - Y** Your questions? (Speak up!)

- In addition to the SAFETY list, discuss with passengers whether or not smoking is permitted, flight route altitudes, time en route, destination, weather during flight, expected weather at the destination, controls and what they do, and the general capabilities and limitations of the aircraft.
- Use a sterile flight deck (one that is completely silent with no pilot communication with passengers or by passengers) from the time of departure to the first intermediate altitude and clearance from the local airspace.
- Use a sterile flight deck during arrival from the first radar vector for approach or descent for the approach.
- Keep the passengers informed during times when the workload is low.
- Consider using the passenger in the right seat for simple tasks, such as holding the chart. This relieves the pilot of a task.

Automation

In the GA community, an automated aircraft is generally comprised of an integrated advanced avionics system consisting of a primary flight display (PFD), a multifunction flight display (MFD) including an instrument-certified global positioning system (GPS) with traffic and terrain graphics, and a fully integrated autopilot. This type of aircraft is commonly known as a technically advanced aircraft (TAA). In a TAA aircraft, there are typically two display (computer) screens: PFD (left display screen) and MFD.

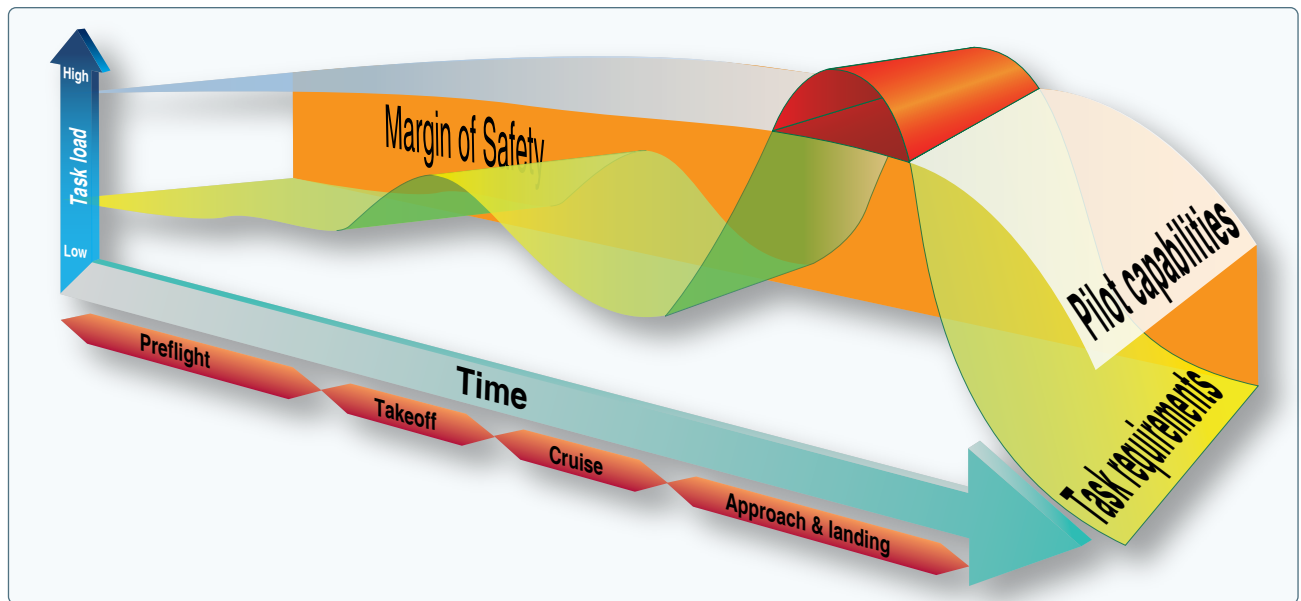


Figure 2-20. The pilot has a certain capacity of doing work and handling tasks. However, there is a point where the tasking exceeds the pilot's capability. When this happens, tasks are either not performed properly or some are not performed at all.

Automation is the single most important advance in aviation technologies. Electronic flight displays (EFDs) have made vast improvements in how information is displayed and what information is available to the pilot. Pilots can access electronic databases that contain all of the information traditionally contained in multiple handbooks, reducing clutter in the flight deck. [Figure 2-21]

MFDs are capable of displaying moving maps that mirror sectional charts. These detailed displays depict all airspace, including Temporary Flight Restrictions (TFRs). MFDs are so descriptive that many pilots fall into the trap of relying solely on the moving maps for navigation. Pilots also draw upon the database to familiarize themselves with departure and destination airport information.

More pilots now rely on electronic databases for flight planning and use automated flight planning tools rather than planning the flight by the traditional methods of laying out charts, drawing the course, identifying navigation points (assuming a VFR flight), and using the POH to figure out the weight and balance and performance charts. Whichever method a pilot chooses to plan a flight, it is

important to remember to check and confirm calculations. Always remember that it is up to the pilot to maintain basic airmanship skills and use those skills often to maintain proficiency in all tasks.

Although automation has made flying safer, automated systems can make some errors more evident and sometimes hide other errors or make them less evident. There are concerns about the effect of automation on pilots. In a study published in 1995, the British Airline Pilots Association officially voiced its concern that “Airline pilots increasingly lack ‘basic flying skills’ as a result of reliance on automation.”

This reliance on automation translates into a lack of basic flying skills that may affect the pilot’s ability to cope with an in-flight emergency, such as sudden mechanical failure. The worry that pilots are becoming too reliant on automated systems and are not being encouraged or trained to fly manually has grown with the increase in the number of MFD flight decks.

As automated flight decks began entering everyday line operations, instructors and check airmen grew concerned about some of the unanticipated side effects. Despite the promise of reducing human mistakes, the flight managers reported the automation actually created much larger errors at times. In the terminal environment, the workload in an automated flight deck actually seemed higher than in the older analog flight decks. At other times, the automation seemed to lull the flight crews into complacency. Over time, concern surfaced that the manual flying skills of the automated flight crews deteriorated due to over-reliance on computers. The flight crew managers said they worried that pilots would have less “stick-and-rudder” proficiency when those skills were needed to manually resume direct control of the aircraft.

A major study was conducted to evaluate the performance of two groups of pilots. The control group was composed of pilots who flew an older version of a common twin-jet airliner equipped with analog instrumentation and the experimental group was composed of pilots who flew the same aircraft, but newer models equipped with an electronic flight instrument system (EFIS) and a flight management system (FMS). The pilots were evaluated in maintaining aircraft parameters, such as heading, altitude, airspeed, glideslope, and localizer deviations, as well as pilot control inputs. These were recorded during a variety of normal, abnormal, and emergency maneuvers during 4 hours of simulator sessions.



Figure 2-21. Electronic flight instrumentation comes in many systems and provides a myriad of information to the pilot.

Results of the Study

When pilots who had flown EFIS for several years were required to fly various maneuvers manually, the aircraft parameters and flight control inputs clearly showed some erosion of flying skills. During normal maneuvers, such as turns to headings without a flight director, the EFIS group exhibited somewhat greater deviations than the analog group. Most of the time, the deviations were within the practical test standards (PTS), but the pilots definitely did not keep on the localizer and glideslope as smoothly as the analog group.

The differences in hand-flying skills between the two groups became more significant during abnormal maneuvers, such as accelerated descent profiles known as “slam-dunks.” When given close crossing restrictions, the analog crews were more adept at the mental math and usually maneuvered the aircraft in a smoother manner to make the restriction. On the other hand, the EFIS crews tended to go “heads down” and tried to solve the crossing restriction on the FMS. [Figure 2-22]

Another situation used in the simulator experiment reflected real world changes in approach that are common and can be assigned on short notice. Once again, the analog crews transitioned more easily to the parallel runway’s localizer, whereas the EFIS crews had a much more difficult time with the pilot going head down for a significant amount of time trying to program the new approach into the FMS.

While a pilot’s lack of familiarity with the EFIS is often an issue, the approach would have been made easier by disengaging the automated system and manually flying the approach. At the time of this study, the general guidelines in the industry were to let the automated system do as much of the flying as possible. That view has since changed and it is recommended that pilots use their best judgment when choosing which level of automation will most efficiently do the task considering the workload and situational awareness.

Emergency maneuvers clearly broadened the difference in manual flying skills between the two groups. In general, the analog pilots tended to fly raw data, so when they were given an emergency, such as an engine failure, and were instructed to fly the maneuver without a flight director, they performed it expertly. By contrast, SOP for EFIS operations at the time was to use the flight director. When EFIS crews had their flight directors disabled, their eye scan again began a more erratic searching pattern and their manual flying subsequently suffered.

Those who reviewed the data saw that the EFIS pilots who better managed the automation also had better flying skills. While the data did not reveal whether those skills preceded or followed automation, it did indicate that automation management needed to be improved. Recommended “best

practices” and procedures have remedied some of the earlier problems with automation.

Pilots must maintain their flight skills and ability to maneuver aircraft manually within the standards set forth in the PTS. It is recommended that pilots of automated aircraft occasionally disengage the automation and manually fly the aircraft to maintain stick-and-rudder proficiency. It is imperative that the pilots understand that the EFD adds to the overall quality of the flight experience, but it can also lead to catastrophe if not utilized properly. At no time is the moving map meant to substitute for a VFR sectional or low altitude en route chart.

Equipment Use

Autopilot Systems

In a single-pilot environment, an autopilot system can greatly reduce workload. [Figure 2-23] As a result, the pilot is free to focus his or her attention on other flight deck duties. This can improve situational awareness and reduce the possibility of a CFIT accident. While the addition of an autopilot may certainly be considered a risk control measure, the real challenge comes in determining the impact of an inoperative unit. If the autopilot is known to be inoperative prior to departure, this may factor into the evaluation of other risks.

For example, the pilot may be planning for a VHF omnidirectional range (VOR) approach down to minimums on a dark night into an unfamiliar airport. In such a case, the pilot may have been relying heavily on a functioning autopilot capable of flying a coupled approach. This would free the pilot to monitor aircraft performance. A malfunctioning autopilot could be the single factor that takes this from a medium to a serious risk. At this point, an alternative needs to be considered. On the other hand, if the autopilot were to fail at a critical (high workload) portion of this same flight, the pilot must be prepared to take action. Instead of simply being an inconvenience, this could quickly turn into an emergency if not properly handled. The best way to ensure a pilot is prepared for such an event is to carefully study the issue prior to departure and determine well in advance how an autopilot failure is to be handled.

Familiarity

As previously discussed, pilot familiarity with all equipment is critical in optimizing both safety and efficiency. If a pilot is unfamiliar with any aircraft systems, this will add to workload and may contribute to a loss of situational awareness. This level of proficiency is critical and should be looked upon as a requirement, not unlike carrying an adequate supply of fuel. As a result, pilots should not look upon unfamiliarity with the aircraft and its systems as a risk control measure, but instead as a hazard with high risk potential. Discipline is key to success.



Figure 2-22. Two similar flight decks equipped with the same information two different ways, analog and digital. What are they indicating? Chances are that the analog pilot will review the top display before the bottom display. Conversely, the digitally trained pilot will review the instrument panel on the bottom first.



Figure 2-23. An example of an autopilot system.

Respect for Onboard Systems

Automation can assist the pilot in many ways, but a thorough understanding of the system(s) in use is essential to gaining the benefits it can offer. Understanding leads to respect, which is achieved through discipline and the mastery of the onboard systems. It is important to fly the aircraft using minimal information from the primary flight display (PFD). This includes turns, climbs, descents, and being able to fly approaches.

Reinforcement of Onboard Suites

The use of an EFD may not seem intuitive, but competency becomes better with understanding and practice. Computer-based software and incremental training help the pilot become comfortable with the onboard suites. Then the pilot needs to practice what was learned in order to gain experience. Reinforcement not only yields dividends in the use of automation, it also reduces workload significantly.

Getting Beyond Rote Workmanship

The key to working effectively with automation is getting beyond the sequential process of executing an action. If a pilot has to analyze what key to push next, or always uses the same sequence of keystrokes when others are available, he or she may be trapped in a rote process. This mechanical process indicates a shallow understanding of the system. Again, the desire is to become competent and know what to do without having to think about, “what keystroke is next.” Operating the system with competency and comprehension benefits a pilot when situations become more diverse and tasks increase.

Understand the Platform

Contrary to popular belief, flight in aircraft equipped with different electronic management suites requires the same attention as aircraft equipped with analog instrumentation and a conventional suite of avionics. The pilot should review and understand the different ways in which EFD are used in a particular aircraft. [Figure 2-24]

The following are two simple rules for use of an EFD:

- Be able to fly the aircraft to the standards in the PTS. Although this may seem insignificant, knowing how to fly the aircraft to a standard makes a pilot’s airmanship smoother and allows him or her more time to attend to the system instead of managing multiple tasks.
- Read and understand the installed electronic flight systems manuals to include the use of the autopilot and the other onboard electronic management tools.

Managing Aircraft Automation

Before any pilot can master aircraft automation, he or she must first know how to fly the aircraft. Maneuvers training remains an important component of flight training because almost 40 percent of all GA accidents take place in the



Figure 2-24. Examples of different platforms. Top to bottom are the Beechcraft Baron G58, Cirrus SR22, and Cirrus Entega.

landing phase, one realm of flight that still does not involve programming a computer to execute. Another 15 percent of all GA accidents occurs during takeoff and initial climb.

An advanced avionics safety issue identified by the FAA concerns pilots who apparently develop an unwarranted over-reliance in their avionics and the aircraft, believing that the equipment will compensate for pilot shortcomings. Related to the over-reliance is the role of ADM, which is probably the most significant factor in the GA accident record of high performance aircraft used for cross-country flight. The FAA advanced avionics aircraft safety study found that poor decision-making seems to afflict new advanced avionics pilots at a rate higher than that of GA as a whole. The review of advanced avionics accidents cited in this study shows the majority are not caused by something directly related to the aircraft, but by the pilot's lack of experience and a chain of poor decisions. One consistent theme in many of the fatal accidents is continued VFR flight into IMC.

Thus, pilot skills for normal and emergency operations hinge not only on mechanical manipulation of the stick and rudder, but also include the mental mastery of the EFD. Three key flight management skills are needed to fly the advanced avionics safely: information, automation, and risk.

Information Management

For the newly transitioning pilot, the PFD, MFD, and GPS/VHF navigator screens seem to offer too much information presented in colorful menus and submenus. In fact, the pilot may be drowning in information but unable to find a specific piece of information. It might be helpful to remember these systems are similar to computers that store some folders on a desktop and some within a hierarchy.

The first critical information management skill for flying with advanced avionics is to understand the system at a conceptual level. Remembering how the system is organized helps the pilot manage the available information. It is important to understand that learning knob-and-dial procedures is not enough. Learning more about how advanced avionics systems work leads to better memory for procedures and allows pilots to solve problems they have not seen before.

There are also limits to understanding. It is generally impossible to understand all of the behaviors of a complex avionics system. Knowing to expect surprises and to continually learn new things is more effective than attempting to memorize mechanical manipulation of the knobs. Simulation software and books on the specific system used are of great value.

The second critical information management skill is stop, look, and read. Pilots new to advanced avionics often become

fixated on the knobs and try to memorize each and every sequence of button pushes, pulls, and turns. A far better strategy for accessing and managing the information available in advanced avionics computers is to stop, look, and read. Reading before pushing, pulling, or twisting can often save a pilot some trouble.

Once behind the display screens on an advanced avionics aircraft, the pilot's goal is to meter, manage, and prioritize the information flow to accomplish specific tasks. Certificated flight instructors (CFIs), as well as pilots transitioning to advanced avionics, will find it helpful to corral the information flow. This is possible through such tactics as configuring the aspects of the PFD and MFD screens according to personal preferences. For example, most systems offer map orientation options that include "north up," "track up," "DTK" (desired track up), and "heading up." Another tactic is to decide, when possible, how much (or how little) information to display. Pilots can also tailor the information displayed to suit the needs of a specific flight.

Information flow can also be managed for a specific operation. The pilot has the ability to prioritize information for a timely display of exactly the information needed for any given flight operation. Examples of managing information display for a specific operation include:

- Program map scale settings for en route versus terminal area operation.
- Utilize the terrain awareness page on the MFD for a night or IMC flight in or near the mountains.
- Use the nearest airports inset on the PFD at night or over inhospitable terrain.
- Program the weather datalink set to show echoes and METAR status flags.

Enhanced Situational Awareness

An advanced avionics aircraft offers increased safety with enhanced situational awareness. Although aircraft flight manuals (AFM) explicitly prohibit using the moving map, topography, terrain awareness, traffic, and weather datalink displays as the primary data source, these tools nonetheless give the pilot unprecedented information for enhanced situational awareness. Without a well-planned information management strategy, these tools also make it easy for an unwary pilot to slide into the complacent role of passenger in command.

Consider the pilot whose navigational information management strategy consists solely of following the magenta line on the moving map. He or she can easily fly into geographic or regulatory disaster, if the straight-line GPS

course goes through high terrain or prohibited airspace, or if the moving map display fails.

A good strategy for maintaining situational awareness information management should include practices that help ensure that awareness is enhanced, not diminished, by the use of automation. Two basic procedures are to always double-check the system and verbal callouts. At a minimum, ensure the presentation makes sense. Was the correct destination fed into the navigation system? Callouts—even for single-pilot operations—are an excellent way to maintain situational awareness, as well as manage information.

Other ways to maintain situational awareness include:

- Perform verification check of all programming. Before departure, check all information programmed while on the ground.
- Check the flight routing. Before departure, ensure all routing matches the planned flight route. Enter the planned route and legs, to include headings and leg length, on a paper log. Use this log to evaluate what has been programmed. If the two do not match, do not assume the computer data is correct, double check the computer entry.
- Verify waypoints.
- Make use of all onboard navigation equipment. For example, use VOR to back up GPS and vice versa.
- Match the use of the automated system with pilot proficiency. Stay within personal limitations.
- Plan a realistic flight route to maintain situational awareness. For example, although the onboard equipment allows a direct flight from Denver, Colorado, to Destin, Florida, the likelihood of rerouting around Eglin Air Force Base's airspace is high.
- Be ready to verify computer data entries. For example, incorrect keystrokes could lead to loss of situational awareness because the pilot may not recognize errors made during a high workload period.

Automation Management

Advanced avionics offer multiple levels of automation, from strictly manual flight to highly automated flight. No one level of automation is appropriate for all flight situations, but in order to avoid potentially dangerous distractions when flying with advanced avionics, the pilot must know how to manage the course deviation indicator (CDI), the navigation source, and the autopilot. It is important for a pilot to know the peculiarities of the particular automated system being used. This ensures the pilot knows what to expect, how to monitor

for proper operation, and promptly take appropriate action if the system does not perform as expected.

For example, at the most basic level, managing the autopilot means knowing at all times which modes are engaged and which modes are armed to engage. The pilot needs to verify that armed functions (e.g., navigation tracking or altitude capture) engage at the appropriate time. Automation management is another good place to practice the callout technique, especially after arming the system to make a change in course or altitude.

In advanced avionics aircraft, proper automation management also requires a thorough understanding of how the autopilot interacts with the other systems. For example, with some autopilots, changing the navigation source on the e-HSI from GPS to LOC or VOR while the autopilot is engaged in NAV (course tracking mode) causes the autopilot's NAV mode to disengage. The autopilot's lateral control will default to ROL (wing level) until the pilot takes action to reengage the NAV mode to track the desired navigation source.

Risk Management

Risk management is the last of the three flight management skills needed for mastery of the glass flight deck aircraft. The enhanced situational awareness and automation capabilities offered by a glass flight deck airplane vastly expand its safety and utility, especially for personal transportation use. At the same time, there is some risk that lighter workloads could lead to complacency.

Humans are characteristically poor monitors of automated systems. When asked to passively monitor an automated system for faults, abnormalities, or other infrequent events, humans perform poorly. The more reliable the system, the poorer the human performance. For example, the pilot only monitors a backup alert system, rather than the situation that the alert system is designed to safeguard. It is a paradox of automation that technically advanced avionics can both increase and decrease pilot awareness.

It is important to remember that EFDs do not replace basic flight knowledge and skills. They are a tool for improving flight safety. Risk increases when the pilot believes the gadgets compensate for lack of skill and knowledge. It is especially important to recognize there are limits to what the electronic systems in any light GA aircraft can do. Being PIC requires sound ADM, which sometimes means saying "no" to a flight.

Risk is also increased when the pilot fails to monitor the systems. By failing to monitor the systems and failing to check the results of the processes, the pilot becomes detached

from the aircraft operation and slides into the complacent role of passenger in command. Complacency led to tragedy in a 1999 aircraft accident.

In Colombia, a multi-engine aircraft crewed with two pilots struck the face of the Andes Mountains. Examination of their FMS revealed they entered a waypoint into the FMS incorrectly by one degree resulting in a flight path taking them to a point 60 NM off their intended course. The pilots were equipped with the proper charts, their route was posted on the charts, and they had a paper navigation log indicating the direction of each leg. They had all the tools to manage and monitor their flight, but instead allowed the automation to fly and manage itself. The system did exactly what it was programmed to do; it flew on a programmed course into a mountain resulting in multiple deaths. The pilots simply failed to manage the system and inherently created their own hazard. Although this hazard was self-induced, what is notable is the risk the pilots created through their own inattention. By failing to evaluate each turn made at the direction of automation, the pilots maximized risk instead of minimizing it. In this case, a totally avoidable accident become a tragedy through simple pilot error and complacency.

For the GA pilot transitioning to automated systems, it is helpful to note that all human activity involving technical devices entails some element of risk. Knowledge, experience, and mission requirements tilt the odds in favor of safe and successful flights. The advanced avionics aircraft offers many new capabilities and simplifies the basic flying tasks, but only if the pilot is properly trained and all the equipment is working as advertised.

Chapter Summary

This chapter focused on helping the pilot improve his or her ADM skills with the goal of mitigating the risk factors associated with flight in both classic and automated aircraft. In the end, the discussion is not so much about aircraft, but about the people who fly them.