FLIGHT INSTRUCTOR OPEN FORUM

PRESENTER'S GUIDE FOR PREVENTING LOSS OF CONTROL ACCIDENTS

Additional Resources

FAASTeam – http://www.faasafety.gov

SAFE – http://www.SafePilots.org

Pilot Training Reform – http://www.PilotTrainingReform.org

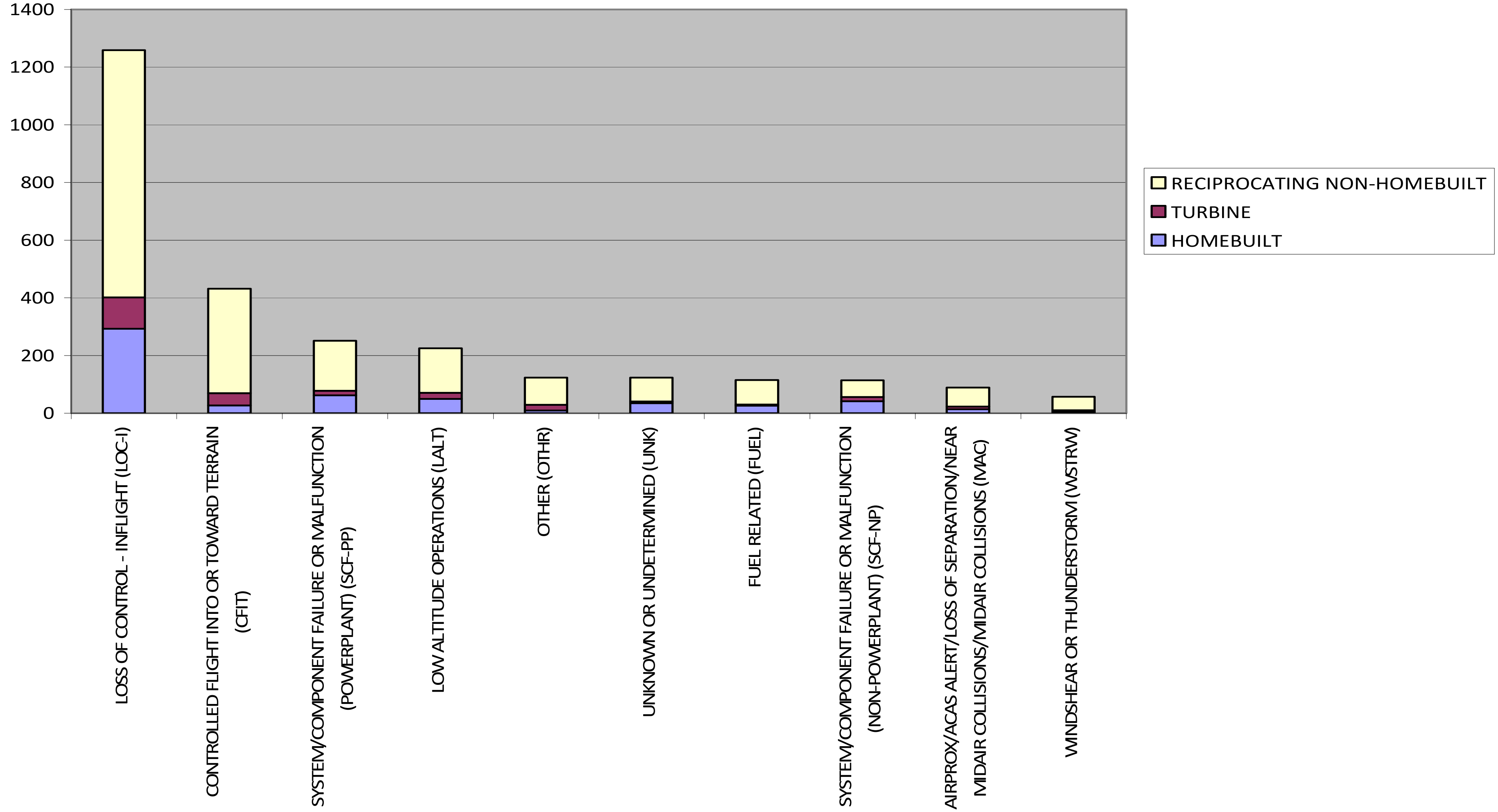
Upset Prevention and Recovery Training Association – http://uprta.org

NTSB Safety Alerts for GA – http://www.safepilots.org/resource-center/ntsb-safety-alerts-for-ga/

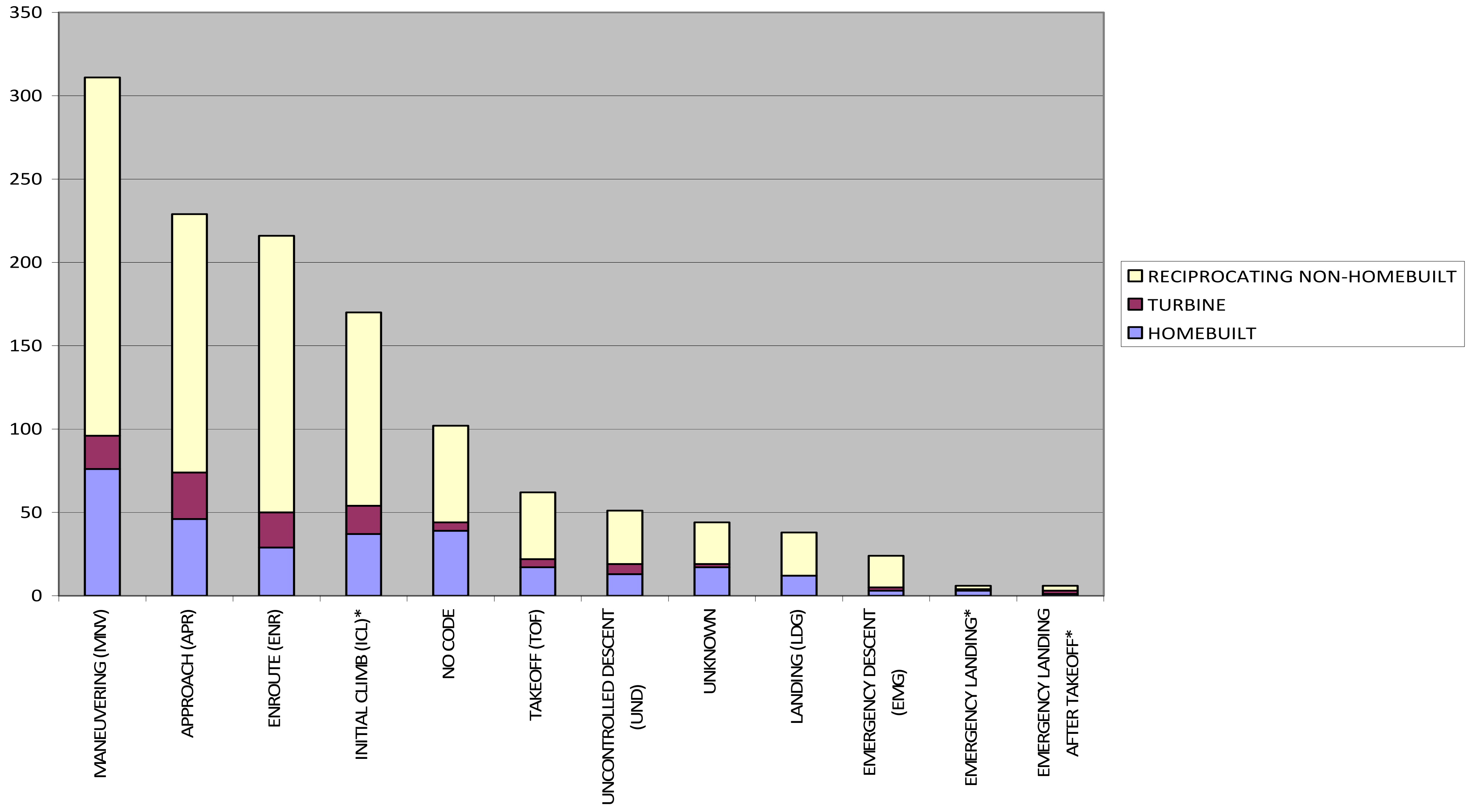
General Aviation Fatal Accidents 2001-2010 by CICTT Occurrence Category

	AIRCRAFT GROUP			
CICTT Occurrence Category	HOMEBUILT	TURBINE	RECIP NON-HOMEBUILT	Grand Total
LOSS OF CONTROL - INFLIGHT (LOC-I)	293	109	857	1259
CONTROLLED FLIGHT INTO OR TOWARD TERRAIN (CFIT)	27	42	363	432
SYSTEM/COMPONENT FAILURE OR MALFUNCTION (POWERPLANT) (SCF-PP)	62	16	173	251
LOW ALTITUDE OPERATIONS (LALT)	49	22	154	225
UNKNOWN OR UNDETERMINED (UNK)	35	6	82	123
OTHER (OTHR)	9	20	94	123
FUEL RELATED (FUEL)	26	4	85	115
SYSTEM/COMPONENT FAILURE OR MALFUNCTION (NON-POWERPLANT) (SCF-NP)	42	14	58	114
AIRPROX/ACAS ALERT/LOSS OF SEPARATION/NEAR MIDAIR COLLISIONS/MIDAIR COLLISIONS (MA	14	9	66	89
WINDSHEAR OR THUNDERSTORM (WSTRW)	5	5	47	57
ICING (ICE)	3	10	39	52
FIRE/SMOKE (POST-IMPACT) (F-POST)	2	6	35	43
ABRUPT MANEUVER (AMAN)	12	4	25	41
TURBULENCE ENCOUNTER (TURB)	1	4	28	33
COLLISION WITH OBSTACLE(S) DURING TAKE-OFF AND LANDING (CTOL)	10	3	20	33
LOSS OF CONTROL - GROUND (LOC-G)	11	1	13	25
UNDERSHOOT/OVERSHOOT (USOS)	3	5	15	23
RUNWAY EXCURSION (RE)	3	5	10	18
GROUND COLLISION (GCOL)	4	4	10	18
ABNORMAL RUNWAY CONTACT (ARC)	3	3	12	18
UNINTENDED FLIGHT IN IMC (UIMC)	2	1	13	16
FIRE/SMOKE (NON-IMPACT) (F-NI)	1	0	13	14
GROUND HANDLING (RAMP)	1	2	2	5
SECURITY RELATED (SEC)	0	0	3	3
CABIN SAFETY EVENTS (CABIN)	0	0	3	3
RUNWAY INCURSION-VEHICLE, AIRCRAFT, OR PERSON (RI-VAP)	0	0	1	1
GLIDER TOWING RELATED EVENTS (GTOW)	0	0	1	1
EVACUATION (EVAC)	0	1	0	1
Grand Total	618	296	2222	3136

General Aviation Fatal Accidents 2001-2010 by Top 10 CICTT Occurrence Category



Loss of Control – Inflight (LOC-I) Events by Flight Phase 2001- 2010



MAINTAINING AIRCRAFT CONTROL

Randy Brooks, Jeff Edwards, Janeen Kochan, Paul Ransbury, Rich Stowell

June 20, 2012

Introduction

Becoming a safe, competent pilot requires proficiency in myriad physical and mental abilities. Regardless of a pilot's certification level, constant practice and refinement are needed to maintain those hard earned skills. Yet despite the overall effectiveness of the system of pilot training and certification in the United States, Loss of Control In-Flight (LOC-I) remains a significant cause of accidents and incidents in general as well as commercial aviation. This paper offers strategies to reduce loss of control accidents through improved education and targeted training, and provides information pilots can use to mitigate the risks associated with common LOC-I events.

Terminology

Regardless of the type of airplane flown or whether operating under 14 CFR Part 91, 121, or 135, all pilots are encouraged to adopt standardized terminology when discussing loss of control. The following are a few of the key terms:

- **Airplane Upset** refers to a departure from the intended flight profile that may or may not involve stalled flight, and that typically involves an excessive angle of bank, an excessive angle of pitch, or both, but that does not involve spinning. As a point of reference, the *Airplane Upset Recovery Training Aid* developed for air carrier operations defines an airplane upset as an airplane "unintentionally exceeding the parameters normally experienced in line operations or training" along with the following general guidelines:
    - A pitch attitude greater than 25° nose up
    - A pitch attitude greater than 10° nose down
    - A bank angle greater than 45°
    - Within the above parameters, but flying at airspeeds inappropriate for the conditions/phase of flight or maneuver

  While the reference to inappropriate airspeeds describes a number of undesired aircraft states, stalls fall into this category, though in that case the problem is directly related to angle of attack, not airspeed.
- **Loss of Control** refers to airplane accidents that result from situations in which the pilot should have maintained, or regained aircraft control, but did not. Loss of control is comprised of two components—in-flight (LOC-I) and ground (LOC-G). An analysis of incident and accident data reveals that LOC-I is the predominate component and will be the focus of this paper.
- **Normal Flight Mode** refers to a typical manipulation of the controls that results in the intended outcome of a flight operation, where the performance of that flight operation can be measured against a set of standards.
- **Unusual Attitude** is a broad phrase that includes, among other things, the unintended attitude that can follow an encounter with an inadvertent stall or spin, wake turbulence, or an uncommanded spiral. Unusual attitudes can arise as a result of pilot–airplane interface issues, inappropriate control inputs, or environmental factors.

For a more comprehensive list, please see http://uprta.org/terminology/.

History

According to the International Civil Aviation Organization (ICAO), loss of control in-flight (LOC-I) can be induced by the pilot, the environment, and/or system anomalies. Loss of control In-flight can occur whenever an aircraft is operated—intentionally or not—outside of its approved operating envelope, be it airspeed, roll, yaw, pitch, angle of attack (AOA), structural, and/or weight and balance limitations. LOC-I can also occur when a pilot's skill level has been exceeded, or when a pilot becomes fatigued, distracted, or is surprised or startled by an unexpected event. Furthermore, loss of control does not discriminate: it can and does happen to pilots at all levels of experience.

Accident Data

LOC-I outpaced other factors as the leading cause of fatal airplane accidents during the last 20 years. According to the General Aviation Joint Steering Committee (GAJSC), LOC-I accidents occurred nearly three times more often than Controlled Flight Into Terrain (CFIT) during the period 2001–2010. In fact, the LOC-I category contained a greater number of accidents than the next five categories combined. LOC-I dominated the three aircraft groups (homebuilt, turbine, reciprocating non-homebuilt) in the GAJSC analysis as well. Moreover, LOC-I events occurred most often during the maneuvering, approach, en route, and initial climb phases. LOC-I has not been a U.S. general aviation problem alone, but was the top cause of all commercial aviation accidents worldwide from 2001 to 2010 according to the Commercial Aviation Safety Team (CAST) and ICAO.

Pilot-Induced Upsets

The likelihood that an upset will lead to LOC-I is influenced by numerous factors, including pilot proficiency, alertness, weather conditions, aircraft energy state, capability, and/or complexity of systems. Human factors, however, remain the primary cause of LOC-I accidents, with distraction chief among them.

Inattention/Neglecting To Monitor Airplane Performance

Airplane upsets can often be traced to an improper instrument crosscheck, fixation, or failure to maintain good visual reference to the ground. At best, inattention or neglecting to monitor airplane performance can result in minor excursions from target parameters; at worst, it can result in extreme deviations from what was intended. For example, the FAA *Instrument Flying Handbook* describes two fundamental skills that must be developed during instrument training: instrument crosscheck and instrument interpretation. These two skills, properly executed, result in positive aircraft control when in instrument meteorological conditions (IMC.)

Diversion from Primary Flight Duties

Critical information can be misinterpreted or missed altogether whenever a pilot's attention is diverted from more urgent flight duties. The familiar saying "*Aviate, Navigate, Communicate*" is a popular checklist that delineates critical priorities for the pilot-in-command (PIC). Fumbling to set avionics or navigation equipment, or becoming preoccupied with an annunciator panel warning, for example, could distract a pilot sufficiently to lead to an inadvertent loss of control.

Spatial Disorientation

Spatial disorientation ("vertigo") has been a significant factor in many LOC-I accidents. As discussed in the chapter on Aeromedical Factors in the FAA Pilot's Handbook of Aeronautical Knowledge, all pilots are susceptible to sensory illusions and the hazards they can present, while flying at night or in certain weather conditions. LOC-I can occur when the pilot allows erroneous bodily sensations to dictate control actions rather than relying on accurate flight instrument indications.

Exceeding Pilot Capabilities

As discussed in the chapter on Aeronautical Decision-Making in the FAA Pilot's Handbook of Aeronautical Knowledge, the margin of safety is the difference between task requirements and pilot capabilities. Loss of control is possible whenever requirements exceed capabilities. For example, an airplane upset event that requires rolling an airplane from a near-inverted to an upright attitude may demand piloting skills beyond those learned during primary training. Or a fatigued pilot who inadvertently encounters IMC at night coupled with a vacuum pump failure could become disoriented and lose control of the aircraft due to the demands of extended—and unpracticed—partial panel flight. Unnecessary low flying and impromptu displays for friends or others on the ground often lead to pilots exceed their capabilities - with fatal results.

Startle Response

The all-too-human response to sudden, unanticipated events has traditionally been underestimated or even ignored during flight training. The reality is that untrained pilots will often have a startle response (i.e., an inappropriate psychological/physiological reaction) to an airplane upset event. Pilots can inoculate themselves against a debilitating startle response through scenario-based training. But to be effective, the controlled training scenarios must have a perception of risk or threat of consequences sufficient to elevate the pilot's stress levels. This will prepare a pilot to override the psychological/physiological reactions to an actual upset in favor of appropriate recovery actions.

Environmentally-Induced Upsets

Wake turbulence from other aircraft, turbulence caused by manmade obstructions and mountainous terrain, wind shear and icing have all resulted in airplane upsets and LOC-I (review the chapters on Aerodynamics of Flight, Airport Operations, and Weather Theory in the FAA Pilot's Handbook of Aeronautical Knowledge). These environmentally-induced upsets often occur in close proximity to the ground, and often while the airplane is at a slower speed and less maneuverable. This "low and slow" combination can make recovery from an upset difficult, if not impossible in many airplanes, even if the pilot is able to apply the appropriate recovery inputs. Hence, awareness and prevention are critical to avoiding upsets generated by environmental factors.

System Anomalies

Improvements in airplane design and equipment components have been a major focus in the aviation industry. Ever increasing reliability is a continuing effort; in spite of this, however, systems and components do occasionally fail. And since some of these failures can lead to loss of control, pilots need to be trained to mitigate or overcome the potential impact of such failures. The good news is most failures are survivable if timely corrective actions are taken.

Flight Instruments

Properly maintained, primary flight instruments tend to be quite reliable. Pilots can gain sufficient knowledge about flight instruments, common failure modes, and procedural alternatives through aircraft flight manuals, checklists, instrument manufacturer literature, and other sources. Remember, it is the instrument rated pilot's responsibility to maintain instrument proficiency and "partial panel" proficiency.

Automation

As discussed in the chapter on Aeronautical Decision-Making in the FAA Pilot's Handbook of Aeronautical Knowledge, automation includes the autopilot (and on larger transport aircraft, autothrottles) as well as systems that provide flight management and guidance (EFDs, MFDs, etc.). Unfortunately, some pilots can become over-reliant on their aircraft automation and thus become complacent about

crosschecking and verifying information, or lose their hand flying instrument proficiency. Loss of control has occurred when automation has failed and the pilots have been unable to trace the cause of the anomaly, or have been unable to revert to more fundamental flying skills.
Advanced automation systems in particular can mask the cause of an automation anomaly. Therefore, pilots should consider reducing the level of automation (e.g., disengage the autopilot) to maintain or regain control of the aircraft should an anomaly occur.

Sensory Overload/Deprivation

Pilots who are faced with airplane upsets may often be confronted with multiple visual, auditory, and tactile warnings. A pilot's ability to adequately sift through the data being presented by simultaneous streams of warnings, annunciations, instrument indications, and other cues, however, can be limited. The ability to separate time-critical information from the rest takes practice and an intimate knowledge of the airplane and its systems.

On the other hand, expected or anticipated warnings occasionally may not be provided when indeed they should be. Crosschecks are necessary not only to corroborate other information that has been presented, but also to determine if information might be missing or invalid. For example, an in-flight stall warning system failure that is unable to warn the pilot of close proximity to a stall while executing a turn with airspeed rapidly approaching the wings-level stall speed may be averted through other methods. Though the pilot may not be receiving an electronic stall warning, aeronautical knowledge about the relationship between bank angle and stall speed along with experience performing similar turns in the past provide clear evidence of an impending stall. Also, aerodynamic cues like airframe buffet may provide a tactile cue of an impending stall.

Flight Control and Other Anomalies

Anomalies involving the flight controls (e.g., flap asymmetry, malfunctioning flight controls, runaway trim) may be addressed in detail in aircraft flight manuals, but generally are not covered during primary flight training. These and other anomalies may require the use of alternate control strategies to prevent or recover from an associated upset.

Operating Envelope Excursions

However induced, an airplane upset in and of itself does not necessarily culminate in a loss of control accident. Recovery to a normal flight mode needs to be initiated as soon as a developing upset condition is recognized. The amount and rates of control inputs and power adjustments necessary to counter an upset must be in direct proportion to the amount and rates of change of roll, yaw, pitch, and/or airspeed experienced. Early recognition of an upset scenario coupled with appropriate preventive action often can mitigate a situation that otherwise could escalate into a loss of control.

However, it must be understood that not all upsets can be guaranteed to be recoverable even if time and altitude are available, and in some cases, even if the proper recovery technique has been applied. For example, a pilot who is an unnecessarily anxious flyer and thus systematically avoids banks greater than 30 degrees (the pilot's operating envelope) may become incapacitated by fear and unable to recover when confronted with an inadvertent, steep spiral. Similarly, loading an airplane beyond its aft center of gravity limit (the airplane's operating envelope) could prevent a pilot from being able to lower the nose during takeoff (or recovering from an ensuing departure stall) no matter how strong the pilot may be (or how proficient with stall recovery).

Upset Prevention and Recovery Training

Pilots who find themselves outside of their “normal operating envelope” or in conditions beyond their training experience are often unprepared to avoid a loss of control during an upset event. In fact, a pilot’s prior exposure to, and competency with, upset prevention and recovery training (UPRT) scenarios are perhaps the largest predictors regarding whether or not an upset will culminate in an accident. It is for this reason that pilots are encouraged to obtain as much aeronautical and practical knowledge as possible about common upset scenarios. It is imperative for pilots to arm themselves with the capability not only to recognize and avoid potential upsets, but also to safely recover from a developing upset event.

Core Concepts

Airplane upsets are by nature time critical events; they can also place pilots in unusual and unfamiliar attitudes requiring counterintuitive control movements. Upsets have the potential to thrust a pilot into a life threatening situation compounded by panic, diminished mental capacity, and potentially incapacitating spatial disorientation. Therefore, exposing pilots to common LOC-I scenarios in a structured environment is essential so they will be able to learn to squelch their natural startle response in favor of promptly implementing the appropriate recovery procedures. Properly administered, such training instills the knowledge and confidence needed to successfully deal with abnormal flight situations.

By introducing different levels of UPRT at the proper stages in the pilot certification process, trainees are given an opportunity to gain increased familiarity and confidence. It is also crucial for UPRT concepts to be conveyed accurately and in a non-threatening manner to achieve maximum effect. Reinforcing concepts through positive experiences from the outset significantly improves a pilot’s depth of understanding, retention of skills, and desire for continued training.

Regardless of the type of aircraft flown, UPRT exposes pilots to a broad range of concepts and experiences that are applicable to a variety of LOC-I scenarios. The goal should be the ability to recognize an escalating threat pattern or sensory overload, and properly identify and correct an impending upset. Comprehensive UPRT builds on three mutually supportive components: academics, use of flight simulation training devices (FSTDs), and aircraft-based training. Each offers unique benefits; each also has limitations. But when implemented together, the components can offer maximum preparation for upset prevention, avoidance, recognition, and recovery.

Academics

Academic exercises are the foundation from which knowledge and skills evolve. It is important here not only to introduce UPRT material in the proper sequence, but also to use proper terminology and proven methodology—context and consistency are key here. With solid academics in place, simulator- and aircraft-based environments become the laboratories in which to put UPRT concepts into practice. While this overlapping approach offers benefits in virtually all areas of flight training, it is particularly beneficial when addressing the complexities and nuances associated with airplane upsets and LOC-I.

Although academic preparation alone may offer a limited level of mitigation of the LOC-I threat, long-term retention and greater levels of awareness and mitigation are achieved when academics are integrated with hands-on experience.

Flight Simulation Training Devices

Simulation provides another useful level for the conduct of UPRT. Continuous G or spatial disorientation simulators, fixed-base simulators, and full flight simulators might be employed for different elements of this training. For example, the use of a type-specific, full flight simulator enhances the practical skill development associated with that type's systems and performance. Yet while each of the platforms mentioned can and does serve specific purposes, it is important to understand the technical and physiological boundaries when using a particular FSTD for upset training.

Examples of boundaries might include a limited ability to demonstrate yaw–roll coupling from a cross-controlled stall configuration, or an inability to accurately replicate roll instability at high AOA. Simulator training also may not be able to reproduce the same vestibular and physiological inputs a pilot could experience during real-life upset events. Consequently, pilots who only receive upset training in FSTDs may not be able to make sense of such unfamiliar, conflicting, or confusing information during an actual upset. Potentially incapacitating cognitive disorientation could result, leading to LOC-I.

Aircraft-Based Flight Training

Ultimately, the more realistic the training scenario, the more indelible the learning experience. Although creating a visual scene of a 110° banked attitude with the nose 30° below the horizon may not be technically difficult in a modern simulator, the learning achieved while viewing that scene from the security of the simulator is not as complete as when viewing the same scene strapped in an airplane in flight. The acquisition of skills related to correctly responding to an undesirable aircraft state is fundamental to executing a safe recovery, and maximum learning is achieved when placed in the controlled-yet-adrenalized environment of upsets experienced while in flight. Upset prevention and recovery training improves a pilot's ability to overcome fear in an airplane upset event. Through exposure to the upset environment in training, the pilot can be better prepared to not only take effective correct action in a developed upset but also, through awareness and avoidance, intervene in an escalating event sooner than without UPRT knowledge and skill.

Yet even aircraft-based UPRT is not without limitations. The level of upset training possible may be limited by the maneuvers approved in the particular aircraft as well as the flight instructor's own UPRT capabilities. For instance, UPRT conducted in the Normal category by a typical CFI will necessarily be different from UPRT conducted in the Acrobatic category by a CFI who has expertise in all attitude flight.

When discussing upset training conducted in aerobatic-capable aircraft in particular, the importance of employing instructors with specialized UPRT experience in those aircraft cannot be over emphasized. As much as instrument or tailwheel instruction each demand specific skill sets for those operations, UPRT likewise demands that the instructors possess the competence to oversee trainee progress (and be able to intervene if necessary) with consistency and professionalism. On the other hand, the improper delivery of stall, spin, and UPRT often results in negative learning, which could have severe consequences not only during the training itself, but in the skills and mindset pilots take with them into the cockpits of airplanes where the lives of others may be at stake.

Awareness and Prevention

UPRT concepts are best introduced during the certification phase of training. Striving to heighten awareness early makes pilots less susceptible to conditions that could lead to an upset and is an essential building block for accurately assessing risk and acquiring and employing upset recovery skills. For example, operation at high AOA tends to be less familiar to (and uncomfortable for) many pilots since it is seldom encountered during routine flight operations; many LOC-I accidents, however, involve high AOA departures from controlled flight. Thus, developing a deeper awareness of the relationship between AOA, G-load, lift, energy management, and the consequences of their mismanagement is a special emphasis area in UPRT.

The prevention side of UPRT covers information specific to recognizing and avoiding hazards commonly associated with aircraft upset and LOC-I events. Prevention training generally focuses on two aspects: prevention through better aeronautical decision-making (ADM), and prevention through proportional counter response.

Aeronautical Decision-Making

Effective ADM, as discussed in the chapter on Aeronautical Decision-Making in the FAA Pilot's Handbook of Aeronautical Knowledge, is accomplished through analysis, awareness, resource management, and ultimately, the breaking of an error chain early through situational awareness, sound judgment, and basic airmanship skills.

Proportional Counter Response

Proportional counter response is the timely manipulation of flight and power controls, individually or in combination, to manage an unplanned excursion in aircraft attitude and/or the flight envelope. An aware pilot recognizes a developing threat and responds accordingly. The time available for a pilot to counter a developing upset may be a matter of seconds, yet the trained pilot confidently takes proportional actions to avoid a full-blown airplane upset.

Recovery

The recovery side of upset training translates all of the academics into structured practice, be it the visualization of recovery procedures in the classroom, or repetitive skill practice in simulated and/or in flight settings. Recovery training involves developing timely, proportionate, and appropriate use of primary and/or alternate controls to effect recovery from impending and full-blown upset scenarios. Recovery skills are typically complex and perishable; therefore, not only is repetition is needed to establish the correct mental models, but recurrent practice/training may be necessary as well.

The context in which UPRT procedures are introduced and implemented is also an important consideration. The trainee must clearly understand, for example, whether a particular procedure has broad applicability, or is type-specific. To attain the highest levels of learning possible, the best approach usually starts with the broadest form of a given procedure, narrowing then to type-specific alternatives.

Applying Crew Resource Management and **Single Pilot Resource Management**

The concept of crew resource management (CRM) is introduced in the chapter on Aeronautical Decision-Making in the FAA Pilot's Handbook of Aeronautical Knowledge. CRM applies in the upset environment as well, even during single-pilot operations. When available, a coordinated crew response to potential and developing upsets can provide added benefits such as increased situational awareness, mutual support, and an improved margin of safety. Since an untrained crewmember can be the most unpredictable element in an upset scenario, initial UPRT for crewed operations should be mastered individually before being integrated into a multi-crew, CRM environment.

While the fundamental principles of CRM remain valid during an airplane upset, the time line may be intensely compressed; consequently, a crew must be able to accomplish the following:

- Communicate and confirm the situation clearly and concisely;
- Transfer control to the most situationally aware crewmember;
- Using standardized interactions, work as a team to enhance awareness, manage stress, and mitigate fear.

To the extent time and conditions permit, single-pilot operations can similarly benefit by tapping outside resources to assist with troubleshooting, diverting to an alternate landing site, and managing stress. Provided such resources are managed properly, bringing air traffic control, other pilots, or maintenance technicians into the equation may prevent a situation from culminating in a loss of control.

UPRT versus Aerobatics

Since the upset training and aerobatic training environments share a number of common attributes, the two are often—yet erroneously—equated. For example, both incorporate similar language: G-load, spins, rolls, high AOA, stalls in any attitude. At times, both may share the same equipment: aerobatic-capable aircraft, parachutes, waivered airspace. And both types of training certainly have their place, and indeed may be mutually beneficial. But the key distinction lies in the training objectives: the primary goal of upset training is to help pilots overcome sudden onsets of stress to avoid, prevent, and recover from unplanned excursions that could lead to LOC-I accidents in any aircraft type (from this standpoint, an aerobatic-capable aircraft is simply a proxy platform during UPRT); the main goal of aerobatic training, by contrast, is to teach pilots how to intentionally and precisely maneuver aerobatic-capable aircraft in three dimensions.

Also, the type of training platform used for upset training ultimately is less critical in the overall UPRT scheme, though as previously discussed, hands-on upset training in an aerobatic-capable aircraft represents the pinnacle of the UPRT experience.

Summary

According to the Introduction in the FAA Practical Test Standards, the baseline requirement for all pilots is the ability to maneuver an aircraft such that “the successful outcome of the flight is never in doubt.” This applies regardless of aircraft type or size. The foundation of aviation safety rests on a pilot’s ability to control an aircraft safely in any situation that could reasonably be encountered, to guide it clear of danger, and to provide for the safety of passengers and others. Pilots-in-command accept a heavy responsibility for the operation of their aircraft, including flying well within the limits of their and their aircraft’s abilities and avoiding preventable accidents. A commitment to recurrent training to maintain skills that may not be applied on a regular basis is every pilot’s duty.

FAA Safety BRIEFING

March/April 2012

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The March/April 2012 issue of FAA Safety Briefing *focuses on the themes of the 3rd Annual FAA Safety Standdown: loss of control accidents, aeronautical decision making, and advanced preflight. Articles on each of these critical areas provide important insight, tips and resources for improving general aviation safety.*

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JOHN ALLEN
DIRECTOR, FLIGHT STANDARDS SERVICE

Wind Your Watch

Growing up in Kentucky, I was steeped in folksy homespun wisdom that has served me well in life. One especially useful saying is the reminder that "haste makes waste." It rarely pays to act in a hurry, and I can think of too many times when I had to re-learn that particular lesson. I can also remember too many times when, as an Air Force T-37 "Tweet" instructor pilot at Arizona's Williams Air Force Base (now Phoenix-Mesa Gateway Airport - KIWA), I watched undergraduate pilot training (UPT) candidates react in a rush and consequently experience loss of control inflight (LOC-I).

I'm sorry to say that LOC-I continues to bedevil today's pilots. And, as Rich Stowell and Janeen Kochan both note in their excellent contributions to this issue of *FAA Safety Briefing*, LOC-I can happen to anyone, regardless of total time and aviation experience. That's why we are dedicating both the March/April magazine and the FAASTeam's third annual Safety Standdown to raising awareness of LOC-I and — we hope — reducing the number of LOC-I events.

In my days as an instructor pilot, I taught several specific steps to help my student aviators "un-LOC" themselves from the trap of upset scenarios. Since we are declaring war on LOC-I, I offer those steps below in the form of my own aviation acronym: WARR.

W = Wind Your Watch

Even if you've never worn the kind of watch with the traditional (not digital!) clock face and a stem used to wind it every day, you can see where I'm going with this one. In my experience, there are very few aviation situations that require immediate action from the pilot. But there are a great many aviation situations where impulsive, overly-hasty actions squander the time and opportunity required for a considered and more appropriate response. If you have the time, take the time. Unless it is one of the truly rare immediate action situations, pause to figuratively if not literally wind your watch.

A = Assess the Situation

The physican's oath includes the admonition to first do no harm. That's a key part of the rationale for the immediate wind-your-watch pause previously described. Especially when it comes to upset scenarios, the first instinctive thing you think to do is almost always the absolutely wrong action for recovery. The pause also serves as a shock absorber, hoisting your intellect and (just as important) your emotions over the initial "this-can't-be-happening" disbelief. You are then equipped to turn your energy toward the more useful task of objectively assessing the situation. In an upset scenario, calmly assess your aircraft's attitude. Ask yourself questions. Mentally note the answers. Then move to the next step:

R = Respond Appropriately

Only now is it time to act. It takes thinking, training, and repetition to respond in a consistently appropriate way, and I encourage every pilot to consider upset prevention and recovery training (UPRT) with a qualified instructor. In general, your first step is to unload the wing, thus distancing yourself from the stall-spin scenario. Check and set power. Neutralize the rudder. Use flight controls to smoothly roll back to level flight. Recheck power and set attitude for a best-rate climb away from terrain and obstacles.

R = Reassess

No doubt you have heard and repeated the aviator's triad: aviate, navigate, and communicate. Getting the aircraft back under control—aviating—is always the top priority. Once you have "un-LOCed" yourself from the upset scenario trap, it's time to reassess your situation. Confirm that the aircraft is under positive control (aviate). Configure controls and power to keep it that way. Re-establish the desired or assigned direction of flight (navigate). Finally, as necessary, communicate your intentions or requirements for continued safe flight.

There is a lot more information on LOC-I in this issue of *FAA Safety Briefing*, and you will find more still at the FAASTeam's Safety Standdown events around the country. I encourage you to enlist in the war on LOC-I by investing the time to stop, listen, and learn. That way, you won't be surprised—you'll be prepared.

RICH STOWELL, MCFI-A

Photo by Tom Hoffmann

Pilot-in-*Control*

Avoiding Loss of Control Accidents

It can happen to anyone. Although the final report is still in development, data from the "black boxes" recovered from the 2009 crash of Air France flight 447 strongly points to loss of control-inflight (LOC-I) as the cause of this tragic accident. And, sadly, LOC-I accidents do occur on a much-too-frequent basis, especially in general aviation (GA). According to a recent Accident Data Set prepared by the General Aviation Joint Steering Committee (GAJSC), LOC-I was the dominant cause of fatal general aviation accidents over the last decade.

When we talk about loss of control, we are referring to accidents resulting from situations in which the pilot should have either maintained or regained control of the aircraft, but did not. Loss of control is divided into two types: Loss of Control-Ground (LOC-G), and Loss of Control-Inflight (LOC-I).

Forty percent of the fatal accidents during the period 2001-2010 were categorized as LOC-I, outpacing the number two fatal accident category, Controlled Flight Into Terrain (CFIT), by a three-to-one margin. LOC-I events were further subdivided into twelve phases of flight. As shown in Figure 1, most fatal LOC-I accidents happened during the maneuvering phase, occurring about 1.4 times as often as accidents during the approach and en route phases, and 26 times more frequently than accidents during both emergency landing phases combined.

The GAJSC data regarding maneuvering flight in particular are consistent with findings published by the AOPA Air Safety Institute where nearly 27 percent of all fatal accidents occurred during maneuvering flight. Moreover, 41 percent of those fatal accidents ended with a stall/spin. Realize, too, that for each LOC-I accident we can readily analyze, a significantly greater number of related and mostly uncounted incidents and hazards have also transpired. The goal, then, is to reduce not only the number of LOC-I accidents, but also the much larger group of near-accidents.

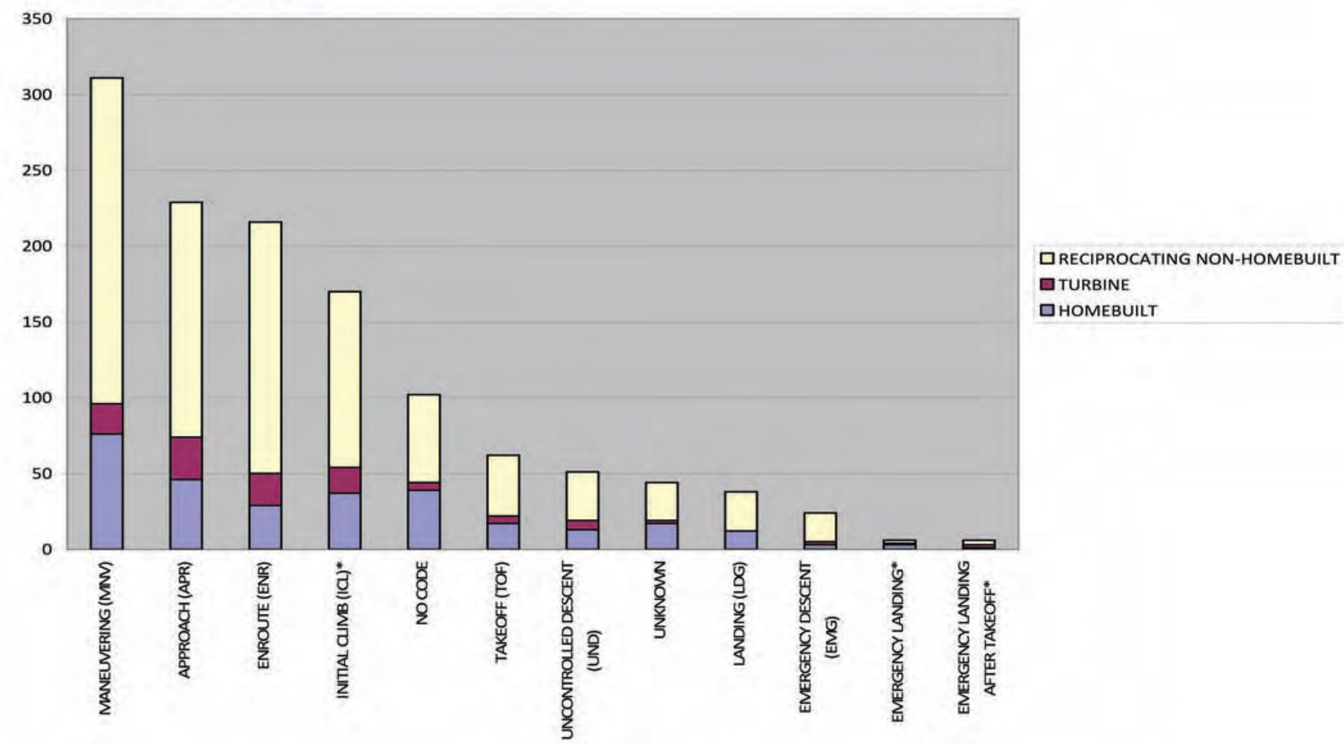
The obvious take-away is this: We need to get better at maneuvering our aircraft. And "we" means each and every one of us. LOC-I does not discriminate. LOC-I happens to low-time and high-time pilots, to student pilots and airline transport pilots alike. Many factors can drive an LOC-I event: inadequate preflight, poor decision-making, faulty risk management, inexperience, complacency, distraction, surprise. But the final act in the accident sequence usually comes down to a misapplication of the controls by the pilot.

Unlike the wings-level, one-G stalls practiced for check rides, most inadvertent stalls are of the less benign, accelerated variety.

Don't Be Surprised

We can and should build a multi-layered defense against LOC-I through better training in the mental skills needed to avoid LOC-I in the first place, coupled with better training in the stick-

Fig.1 Loss of Control – Inflight (LOC-I) Events by Flight Phase 2001- 2010



and-rudder skills needed to prevent and recover from LOC-I scenarios. For example, too few pilots consider what they would or could do to fly an aircraft that has jammed controls. Slips and slipping turns are the necessary piloting skills to counteract stuck ailerons, a stuck rudder, and split flaps. Be aware that practicing such techniques should be accomplished during training sessions with sufficient altitude and preferably with an instructor who is comfortable with the subject of cross-controlled stalls. The same might apply during an asymmetric thrust event in a twin-engine aircraft as well. Many pilots are also unaware that, in the event the elevator control somehow becomes disconnected, certificated aircraft are required to be controllable through landing by using only trim and power adjustments. Of course, it takes training with a qualified instructor to be able to fly, much less land an aircraft without using its primary pitch control.

Build a multi-layered defense against LOC-I through better training in the mental skills needed to avoid LOC-I, coupled with better training in the stick-and-rudder skills needed to prevent and recover from LOC-I scenarios.

Stalls and spins continue to be a significant part of LOC-I. Unlike the wings-level, one-G stalls practiced for check rides, most inadvertent stalls are of the less benign, accelerated variety. Indeed, one study found that turning and/or climbing flight preceded 85 percent of fatal stall-only accidents; in other words, while the pilots were maneuvering. Another study found that 93 percent of accidental spins began at or below traffic pattern altitude. Maneuvering in the traffic pattern demands keen stall and spin awareness skills at all times.

During any unexpected or unusual event, it is important (if not cliché) to "fly the airplane" no matter what. This begins by immediately regaining control of the aircraft; or if control has not been lost, by not taking subsequent actions that could cause a loss of control. We can only bring the appropriate flying skills to bear, however, if we maintain control over ourselves first. Our rational brains must override the emotions and natural instincts that are often counterproductive to surviving an inflight emergency. We must be able to work our way through emergency situations by thinking and acting purposefully. This can only be accomplished through repeated and controlled exposure to scenario-based training exercises.

With the airplane under control, avoid becoming absorbed with what is wrong to the exclusion of the bigger picture. Maintain your situational awareness and take inventory of what is going right and what resources are available to you. For example, can you hold altitude? How much fuel remains? Is an airport or suitable off-airport landing site nearby? Whom can you enlist to help: passengers, ATC? And don't let the natural urge to get the aircraft back on the ground ASAP drive subsequent actions. Taking a few deep breaths and some time to think can bring greater clarity to an otherwise tense situation and just might reveal better options as you formulate a plan.

Top Three Tips on LOC-I

We asked Rich to provide three key points pilots should remember about loss of control. Here's what he said:

1. Prevent with the PAVE checklist: Awareness and prevention of conditions that could lead to LOC-I are by far the best strategies; LOC-I typically occurs at low altitude, so relying on the ability to recover to the exclusion of awareness and prevention often proves problematic. PAVE = Pilot, Aircraft, EnVironment, and External Pressures.

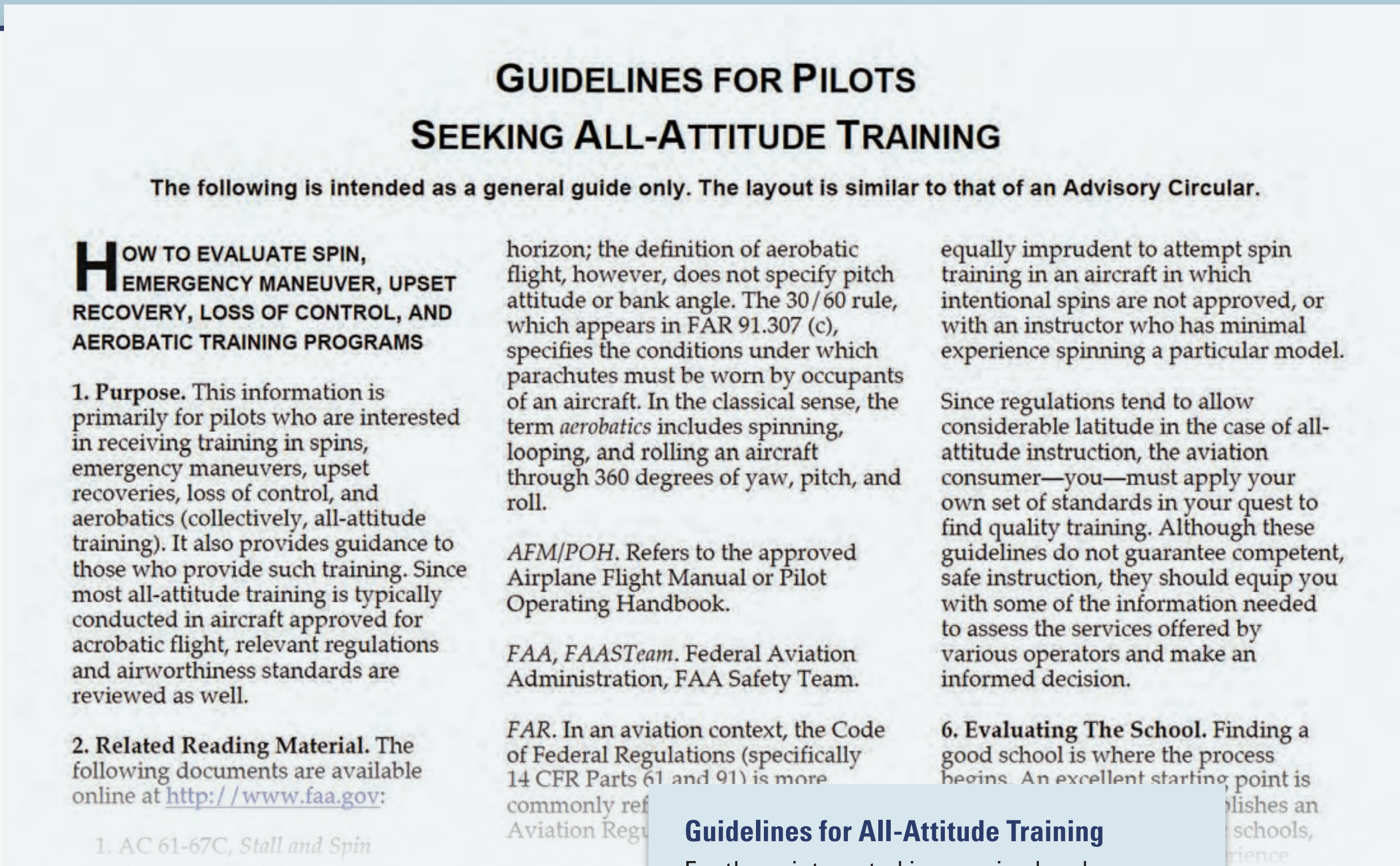
2. Heed the Warnings: LOC-I rarely occurs in a vacuum. Recurrent, scenario-based training not only highlights the warning signs that often precede loss of control events, but also reinforces appropriate mitigation strategies.

3. Learn to Recover: LOC-I recovery actions tend to be contrary to our natural instincts; appropriate recovery responses must be learned well, and because these skills are perishable, they must be rehearsed and/or relearned periodically.

Be Prepared

To reduce the threat of LOC-I resulting from mishandling the controls:

- Keep your mental and physical skills sharp.
- Review and rehearse emergency procedures often.
- Participate in the FAA WINGS and other safety programs.
- Treat the Flight Review not as a biennial chore, but as a great opportunity to learn something new, or to simulate accident scenarios and polish rusty skills.



Guidelines for Pilots Seeking All-Attitude Training

The following is intended as a general guide only. The layout is similar to that of an Advisory Circular.

How to Evaluate Spin, Emergency Maneuver, Upset Recovery, Loss of Control, and Aerobatic Training Programs

1. Purpose. This information is primarily for pilots who are interested in receiving training in spins, emergency maneuvers, upset recoveries, loss of control, and aerobatics (collectively, all-attitude training). It also provides guidance to those who provide such training. Since most all-attitude training is typically conducted in aircraft approved for acrobatic flight, relevant regulations and airworthiness standards are reviewed as well.

2. Related Reading Material. The following documents are available online at http://www.faa.gov:

1. AC 61-67C, *Stall and Spin*

horizon; the definition of aerobatic flight, however, does not specify pitch attitude or bank angle. The 30/60 rule, which appears in FAR 91.307 (c), specifies the conditions under which parachutes must be worn by occupants of an aircraft. In the classical sense, the term *aerobatics* includes spinning, looping, and rolling an aircraft through 360 degrees of yaw, pitch, and roll.

AFM/POH. Refers to the approved Airplane Flight Manual or Pilot Operating Handbook.

FAA, FAASTeam. Federal Aviation Administration, FAA Safety Team.

FAR. In an aviation context, the Code of Federal Regulations (specifically 14 CFR Parts 61 and 91) is more commonly ref... Aviation Regu...

equally imprudent to attempt spin training in an aircraft in which intentional spins are not approved, or with an instructor who has minimal experience spinning a particular model.

Since regulations tend to allow considerable latitude in the case of all-attitude instruction, the aviation consumer—you—must apply your own set of standards in your quest to find quality training. Although these guidelines do not guarantee competent, safe instruction, they should equip you with some of the information needed to assess the services offered by various operators and make an informed decision.

6. Evaluating The School. Finding a good school is where the process begins. An excellent starting point is ...lishes an ... schools, ...rience

Guidelines for All-Attitude Training

For those interested in pursuing hands-on training in loss of control scenarios, Rich has prepared a document entitled, *Guidelines for Pilots Seeking All-Attitude Training*. The document is available for download from the SAFE website at http://www.SafePilots.org/documents/Guidelines for All Attitude Training.pdf.

- Consider enrolling in a spin, emergency maneuver, or upset prevention and recovery training course at some point in your flying career as well.

Note, however, that even though this training typically involves the use of aircraft approved for aerobatic flight, it is not traditional aerobatic training. It is one thing to learn how to perform intentional loops, rolls and other maneuvers with precision, but quite another to develop an awareness of situations that can lead to LOC-I and to learn the altogether different skills needed to recover from unexpected departures from controlled flight. Equally important, quality unusual attitude training creates a unique environment in which to learn how to override the potentially debilitating mental inertia that accompanies the normal shock of an unexpected loss of control.

The context in which unusual attitude training is provided is also critical. For it to be effective, unusual attitude training must be done in the context of typical accident scenarios; otherwise, the training will lack relevance and will prove of little practical value for loss of control prevention and recovery.

Common LOC training scenarios include stalls and spins, especially as they relate to maneuvering flight. For instance, consider scenarios such as the skidding base-to-final turn or the mishandled turn-back to the runway following an engine failure soon after takeoff. Other training scenarios may include wake turbulence and other environmentally induced rolling upsets, spirals under the hood, and alternative ways of controlling an aircraft should any of the primary or secondary controls become inoperative.

Ultimately, applying the triad of good preflight habits, solid aeronautical decision-making, and sharp piloting skills on every flight will increase your margin of safety against a near-accident or accident attributable to an inflight loss of control.

Rich Stowell is serving as a subject matter expert during the 2012 FAA Safety Standdown. He is an internationally-recognized authority on loss of control prevention and recovery. A seven-time Master Instructor and charter member of the Society of Aviation and Flight Educators (SAFE), Stowell has been providing unusual attitude training for twenty-five years, including performing more than 32,400 spins. He is also the 2006 National Flight Instructor of the Year.

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JANEEN ADRION KOCHAN, PH.D.

Keeping an UPRIGHT Attitude

Aviation in itself is not inherently dangerous. But to an even greater degree than the sea, it is terribly unforgiving of any carelessness, incapacity or neglect.

— Captain A. G. Lamplugh, British Aviation Insurance Group

We all love and enjoy aviation, right? So you might be surprised, or even ready to argue, when I say that it pays to be a pessimist in this particular activity. Now that doesn't mean that you have to adopt a grim-faced gloom-and-doom outlook. But, as I hope you learned the very first time you preflighted an aircraft, a healthy sense of "it-*could*-happen-to-me" skepticism goes a long way toward keeping you, your passengers, and your aircraft healthy and whole.

As Rich Stowell suggests in his Pilot-in-*Control* article on page 10, nowhere is that "it-*could*-happen-to-me" outlook more important than in our fight against the leading aviation accident hazard: loss of control—in-flight (LOC-I). Loss of control accidents have been on the constant increase for all categories of flight for the past 25 years. And, if the accidents are on the rise, the number of LOC incidents and unreported events are, no doubt, exponentially higher. That's why countering LOC-I is a focus area for the FAA's 2012 Safety Standdown. No matter how LOC is technically defined or accounted for in accident statistics, the fact remains that pilots—and that means *all* pilots—need to focus harder on staying in control.

UPRT Keeps You Upright

So, how do you pursue staying in control and improve your margin of safety in flying? One answer lies in Upset Prevention and Recovery Training (UPRT)—and if the abbreviation seems like too much of a mouthful, try thinking of it as "UPRight" training.

As with many kinds of aviation training, UPRT requires a variety of skills. The obvious one is physical skill, also known as stick-and-rudder skill. There is no substitute for hands-on practice for knowing how to recover and regain control of your aircraft.

But knowledge and attitudes are important as well. As another aviation cliché so deftly explains, a superior pilot uses superior knowledge to avoid situations that require the use of superior skill. Accordingly, another goal of UPRT is to teach you to maintain awareness of situations that could contribute to LOC and avoid putting yourself in LOC-inducing situations.

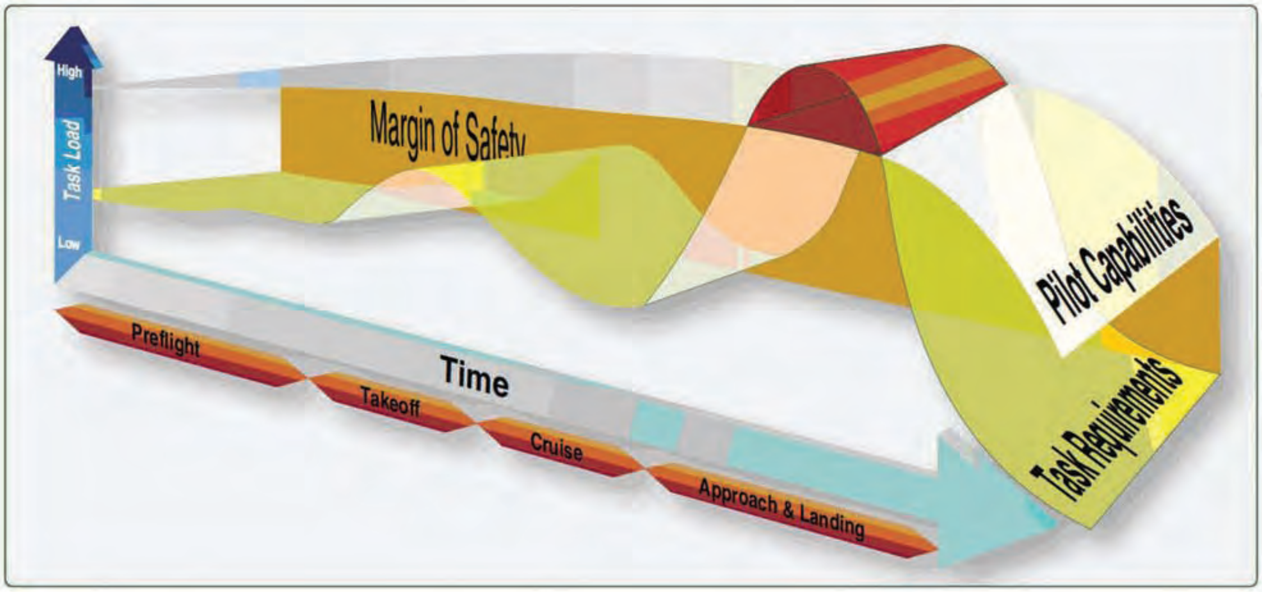
When it comes to awareness, one very important data point is the fact that the margin of safety changes many times throughout a flight. During approach and landing, for example, your task requirements (locating the airport, preparing for an approach to the runway, completing checklists, securing the cabin, etc.) can be significantly greater than the capabilities available to you at the time. Now add the fatigue factor common to the conclusion of any flight, and especially one that was long or replete with weather challenges. This combination of events is precisely how too much workload combined with distractions or other unexpected events (last minute runway change, a go-around, gusty winds, etc.) can lead to LOC.

Research shows that LOC accident pilots often missed, or even ignored, readily available clues and cues that could have prevented the upset or LOC event.

So, with the goal of increasing your margin of safety in mind, let's see how you can develop some of the UP—upset prevention—knowledge, attitudes, and mental habits that will help you avoid LOC.

Clues and Cues

In most accidents or unwanted outcomes, hindsight often reveals a multitude of factors leading up to a potential upset situation. Research shows that pilots often missed, or even ignored, readily available clues and cues that could have prevented



The area in red shows how a pilot's capabilities may be overwhelmed by task demand and reduce his/her margin of safety.

an upset or LOC event. These include such items as icing conditions, flight control malfunctions and wake turbulence. Ultimately, inattention to such clues and cues can lead to inadvertent or deliberate pilot-induced upsets.

The good news is that there are some very practical and straightforward cognitive (thinking) techniques that, if developed into solid mental habits, can help you pay closer attention and more accurately perceive information that could be a precursor to an inflight upset. Human factors scientists who study pilot decision-making have developed a number of models over the years. You may already be familiar with the DECIDE model, an acronym designed to guide the pilot through a series of structured steps you can use to avoid LOC-I. For example:

Detect that a change has occurred (*e.g., aircraft has departed straight-and-level flight*).
Estimate the need to counter or react (*e.g., need to lower pitch and increase airspeed*).
Choose a desirable outcome (*e.g., return to straight-and-level flight*).
Identify actions to control change (*e.g., pitch down, increase power*).
Do the necessary action (*e.g., execute the actions identified in previous step*).
Evaluate the effect of the action (*e.g., confirm resumption of straight-and-level flight*).

For those who find the DECIDE model too lengthy or complex, the FAASTeam has developed a simplified tool: the Perceive, Process, Perform (3P) model. Here's how it works.

Perceive: In order to avoid or mitigate risk factors, you must consciously seek out the clues and cues providing information about yourself and your surroundings. A structured way to perceive is to use the PAVE model to identify hazards associated with the pilot, aircraft, environment, and external pressures. You may have encountered PAVE as a preflight tool, but perceiving clues, cues, and hazards is an ongoing process. Ask yourself: "What am I paying attention to? What am I thinking about? Is my focus where it should be at this point?" Consciously monitor the engine parameters to seek information on the status of your aircraft systems. Look outside for weather, traffic, and UFOs (just seeing if you are paying attention). Though it sounds simple enough, pilots sometimes fail to perceive clues and cues effectively because paying attention takes mental effort and energy. Did you know that actively thinking burns more calories than just watching a video?

Process—Now that you have gathered information about the pilot, the aircraft, the environment, and external pressures, you need to process it. Ask yourself: "How am I doing? How is the aircraft performing? Is the weather as expected? Is there anything that needs to be acted upon? How will the situation be in the future?" And yes, the act of thinking to evaluate and process information also takes mental effort and energy.

Perform—Depending on the outcome of your processing, you may or may not need to act. If all is well, go back to step one and perceive.

Mental Muscle Matters

Now, let's look at an example of how the mental muscle you develop through habitual use of the 3P model can help you avoid LOC-I. Imagine that you are flying a typical four-place GA airplane. You are approaching your destination airport and preparing for the landing. The controller tells you that you will be following a Boeing 737.

You continue to perceive, looking for the B-737 traffic while you complete your approach and landing checklists. You know from training and experience about wake turbulence, and you consciously bring that knowledge into processing the information ATC has provided about the B-737 traffic. Knowing how quickly a wake turbulence encounter can induce LOC, and how dangerous LOC would be this close to the ground, you determinedly scan until you spot the traffic at your 11 o'clock position. You tell the controller you have both the B-737 and the airport in sight, and acknowledge being cleared to land, number two behind the Boeing. You make a special mental note of the controller's standard "caution wake turbulence" admonition. You further process by reviewing wake turbulence avoidance procedures when winds are calm, as they are on final today.

Now it's time to perform. The B-737 is ahead, just below your altitude and descending. Although your normal procedure is to begin your own descent, you know you need to stay above the B-737 to avoid encountering its wake. With the long runway ahead of you, though, you recognize that you will have plenty of room to remain above the B-737, land "long" (i.e., beyond the larger aircraft's touchdown point), and decelerate with room to spare. You carefully maneuver your aircraft in accordance with what you have perceived and processed, and you land without incident.

Imagine, though, what might have happened had you not used your mental muscle. Let's say that you fail to spot the traffic right away, but you acknowledge landing clearance and continue inbound. You finally spot the B-737—wow, it's closer than you realized. You tell the controller you have traffic in sight and set about with your normal approach and landing configuration and routine. You turn final at 1,000 feet AGL. Your aircraft suddenly rolls a full 90 degrees to the left. Startled, you use your physical muscle—all of it—to wrestle the aircraft back toward level flight… descending all the while. You land (probably not one to brag about) and, still shaking from the near-disastrous LOC, taxi to parking.

Whether you performed correctly or (as teachers like to say) with "areas for improvement," there is a final and important step:

Evaluate—What were you thinking? Where did your decision-making process work, and where did it break down? What will you do differently next time? Using the B-737 example, perhaps you could request a turn for more spacing behind a large airplane. Or you could decide to go around and completely avoid the turbulence threat.

The most important thing is to think it through, either way: a good outcome might be the result of good thinking, but it could also be just lucky—and luck has a way of running out at very inconvenient times. We can have knowledge and perceptions, but fail to process information. We can process information (correctly or incorrectly) and fail to perform, or perform incorrectly. We can evaluate our performance incorrectly and never decrease the probability of having a bad outcome and fail to increase our margin of safety. It is this breakdown in our decision-making that contributes to LOC events, incidents and, unfortunately for some, fatal accidents.

Upset Prevention and Recovery Training (UPRT) can teach awareness and avoidance of situations that contribute to loss of control-inflight.

Stay UPRighT, stay safe, and stay alive!

Janeen Adrion Kochan holds a Ph.D. in Applied Experimental and Human Factors Psychology and an M.S. in Industrial and Systems Engineering. She has been involved in human factors research in medicine and aviation since 1980. A former Boeing 767 captain and CRM instructor for a major U.S. air carrier, Dr. Kochan now flies as a corporate pilot. She also holds A&P/IA, CFI, and DPE privileges.

Learn More

Special Airworthiness Information Bulletin CE-11-17 on Design Maneuvering Speed
http://rgl.faa.gov/Regulatory_and_Guidance_Library/rgSAIB.nsf/dc7bd4f27e5f107486257221005f069d/3c00e5aa64a2827e8625781c00744393/$FILE/CE-11-17.pdf

Advisory Circular 61-67C Stall and Spin Awareness Training
http://rgl.faa.gov/Regulatory_and_Guidance_Library/rgAdvisoryCircular.nsf/list/AC%2061-67C/$FILE/AC61-67C.pdf

International Committee for Aviation Training in Extended Envelopes
http://icatee.org/

Upset Prevention & Recovery Training Association
http://uprta.org/

TOM HOFFMANN

Advanced Preflight

Take Your Preflight Inspection to the Next Level

At an airport near Tulsa, Okla., a pilot, his wife, and their infant grandchild climbed aboard a Cessna 210 *Centurion* one late August afternoon for what should have been a routine flight. The proud grandparents were flying their seven-month old granddaughter back to her home in Joplin, Miss. The scene was set for a safe flight with 10-mile visibility and light winds. But what started without incident ended quickly in tragedy.

On the day of departure the pilot was seen taxiing to the self-serve fuel pump, but no witnesses could say if the pilot had preflighted the aircraft. After topping off with fuel the pilot and his precious cargo departed for their destination. Shortly after take-off, the pilot requested an emergency landing after oil began splattering across his windshield. Another aircraft in the pattern reported seeing the aircraft in distress flying well below pattern altitude, and its pilot witnessed the plane crash and burst into flames after a one-and-a-half turn spin.

The Cessna 210's oil filler cap was found unsecured between cylinders 4 and 6.

On-scene accident investigators determined the engine was producing power at the time of impact and discovered traces of oil on the larger fragments of the windshield. Closer investigation also revealed the "smoking gun"— the oil cap hanging from its chain, wedged between two of the engine cylinders below the oil filler neck. Was this cap left unsecured by an AMT during a previous oil change? Or, did the pilot, perhaps after seeing that the level was low, add extra oil and forget to secure the filler cap? Those two questions remain unanswered.

During the engine teardown and records review of the *Centurion*, it was discovered the annual inspection had been completed five months before the accident. Also, the installed oil filter adapter was found to be out of compliance with a recurring Airworthiness Directive (AD). Further review of the records indicated that at one point the adapter had been replaced by one the AD did not affect. However, evidence suggested that following that installation, someone had replaced it with yet another adapter in which the AD was now applicable again, and then never documented its installation. For the next few years, this item was overlooked during subsequent annual inspections and oil changes by more than one AMT with Inspection Authorization (IA). Although this component was not determined to be the cause of the accident, it was believed to have contributed to an oil leak.

As you can see here, there are a few things that led up to this unfortunate loss of life. However, these red flags could have been easily discovered and mitigated with a more rigorous preflight inspection. The accident also illustrates a couple salient and yet often overlooked points for aircraft owners: Just how well do you know your aircraft, and who exactly is inspecting and maintaining it? Enhancing your relationship with both your aircraft's history and your mechanic are both critical components of an *advanced preflight*.

Advancing Towards Safety

Wait a minute! Advanced preflight? I already follow all the items on my preflight checklist. Do I have to check things differently now, or is this some new checklist I need? That's a typical reaction FAA Airworthiness Inspector Steve Keesey gets when describing the concept of an advanced preflight. While not advocating an outright replacement for your preflight checklist, Keesey does recommend stepping up your approach to a procedure that can quite possibly make the difference between a safe flight and your last flight.

"Advanced preflight is a program that helps aircraft owners and pilots become more aware of all the safety-related data pertaining to their aircraft," says Keesey. "In addition, it focuses on being more aware of who maintains your aircraft, and how to apply a detailed approach to your preflight inspection based on a review of the aircraft's maintenance history."

As evidence of its importance in helping reduce GA accidents, the FAA Safety Team (FAASTeam) has adopted "advanced preflight" as one of the three core topics of its annual Safety Standown, a nationwide event designed to raise safety awareness for pilots. While loss of control events lead the pack when it comes to GA fatalities, NTSB accident data from 2000-2009 shows poor preflight inspections caused or contributed to 156 GA accidents and 41 fatalities. No one knows how many other accidents may have been indirectly affected by an improper preflight inspection.

Referring to the *Centurion* accident, Keesey notes that an advanced preflight could have helped change the tragic outcome of that flight. "Had the pilot applied better aircraft maintenance history research techniques, he would have discovered the oil filter adapter was out of compliance and had it corrected or replaced well before the flight," he says. "A similar conclusion may have been reached if the pilot had probed a little more into the knowledge and expertise of the AMT working on his aircraft, perhaps prompting a discussion and discovery of the noncompliant part." Keesey also observes that a more thorough walk-around inspection immediately before flight could have made a big difference in this case by allowing the pilot an opportunity to realize the oil filler cap may not have been secured.

Know Your Aircraft

The backbone of any good preflight inspection begins with knowledge: knowledge of your aircraft's history, its systems and components, and its propensity for possible failures or weak spots—the sometimes inconspicuous items not always covered in an AD or Service Bulletin. A quality records review is the best way to acquire an intimate knowledge of an aircraft's maintenance history. You'll need to include all available resources: logbooks and records, maintenance manuals, ADs, manufac-

Opposite page top: During the empennage preflight, apply forward, aft, and lifting pressures to all surfaces. Inspect attaching hardware for proper installation and security.

Below: (top) Inspect the condition of the control surface structure and associated hardware. Hint: If you see a castellated nut, it should have a cotter pin securing it. If it's a self-locking nut, or one with a locking type washer, rule-of-thumb is to see at least one full thread protrude beyond the top of the securing nut.

(bottom) Checking proper operation and position of trim controls is especially important after maintenance or before each flight if you rent/borrow an aircraft. Does the trim move in the correct direction and is there any abnormal noise during operation?

Advanced Preflight Highlighted at Safety Standdown

For more information on Advanced Preflight, be sure to check out one of the many FAASTeam Safety Standdown seminars in your area this April. A list of events can be found at http://faasafety.gov/standdown/.

turer's service letters and bulletins as well as any repair and alteration history. This can take some detective work, so be sure to ask an AMT, a type club member, or even your local FAASTeam representative for help. Many of the tools to help you find what you need are conveniently available on www.FAA.gov. You can also request a complete copy of records for your aircraft by going to http://aircraft.faa.gov/e.gov/ND/.

If you're not the original owner, you'll also want to know how and where it has been stored (hangar or ramp) and what types of environments it has been exposed to (high humidity, salt-water, extreme heat, etc.). Also, ask how much and what type of flying was done (flight training, banner towing, etc.). All of these conditions affect aircraft in different ways, and many can accelerate the aging process.

Advanced preflight is a program that helps aircraft owners and pilots become more aware of all the safety-related data pertaining to their aircraft

Know Your AMT

Do you know who's maintaining your aircraft? Part of an advanced preflight is getting to know your AMT. Ask questions before a procedure or repair is done to ensure that the AMT is qualified and has the proper experience with your type of aircraft or component. You can always get a second opinion if you're not comfortable with a specific suggestion or mechanical diagnosis. Building a relationship with an AMT will not only help you learn more about your aircraft, but it may also enable you to feel more comfortable with pointing out items that you're unsure of, or believe need corrective action. Type club members are another good source of information for helping you perform a more advanced preflight. Their expertise with your particular aircraft or flying environment could prove invaluable.

Putting it All Together

Armed with a greater knowledge of your aircraft and who is maintaining it, you are now ready for the practical application of an advanced preflight: the walk-around inspection. "This inspection is likely your last chance to determine the safe operational condition before a flight," says Keesey, who recommends starting with the manufacturer's checklist if one is available. While most checklists are thorough, they won't always cover everything you need to check. Keesey advises letting a checklist form the basis of your preflight inspection, but warns not to let it set the limits of what you check. "There's no one-size-fits-all when it comes to checklists," says Keesey. "Every aircraft is unique, and so it only follows its preflight be unique too."

For example, if an aircraft's history shows a repair was made (let's say a spar splice) ensure you check the area around that repair during every preflight. Even if the item or area is not easily visible or

Left to right: 1. During the prop inspection, look for signs of erosion, pitting, and leading or trailing edge damage (nicks). If any of these items are discovered, notify an AMT for assistance in corrective action. Refer to your prop manufacturer's service manual for damage allowable limits.
2. During pitot tube inspection, look for blockage, attaching hardware, and all visible wiring, fittings, and lines.

two things I don't know but I told him, "About 95 to 98 percent." He laughed. I wonder why. But I think that's pretty accurate since I scored an 80 percent on my CFI knowledge test and I've learned some more since then. Why waste a Saturday to add a couple of percent more knowledge?

Stories are the nails that we hang principles on. Listen to them, think and learn. Each story contains a lesson that you won't have to learn the hard way. And by the way, if you ask an older guy how much of the world's aviation knowledge he knows, he'll probably give you a very, very, very small number.

Reason (Excuse) Number Four

Let me tell you. Even if I didn't have lots to do on that Saturday, I probably wouldn't have gone to the FAA Standdown anyway. Why? I would have partied, or recovered from Friday's party, or gone to the beach with friends or worked at my part-time bartending job. Those FAA meetings are so serious. Always safety, safety, safety. I have never been in an accident. Okay, so my students have banged up a couple of airplanes, but that's not my fault. Those guys should lighten up.

Yes, you have a different set of priorities. That's OK. Just recognize that no airline is going to hire you unless you can convince the chief pilot that you are a serious professional who has the maturity necessary to accept the responsibility for the safety of your passengers. Aviation is a profession with professional standards. We would have told you about these at the FAA Standdown. And by the way—those bent airplanes are your responsibility. You are responsible for the safety culture in your student's cockpit.

Reason (Excuse) Number Five

The last time I flew, I was so good that I don't think I could have been better. On takeoff, I was looking at the PFD and it showed a perfect six and a half degrees nose up attitude. And I held it there. I was able to do perfect steep turns at a much steeper bank that 60 degrees. My landings were right on. I put it down *before* the numbers. What can those guys at the FAA meeting tell me about technique? I can crank and bank with the best of 'em. And those old guys say some really dumb things. I was flying the *Arrow* on an early morning flight. We took off in the dark but it was light when we landed. I put the gear lever down but no three green. I promptly declared an emergency with the tower and this old guy gets on the radio in the middle of my emergency and asks if I have my nav lights on? How dumb! I landed it smooth as silk. The mechanics couldn't find anything wrong but I think all three bulbs burned out at the same time.

Whoops! We could have let you know that staring at the PFD is one of the major safety errors made by pilots flying glass. Try 70-80 percent outside, 20-30 percent inside. You may have busted a reg on that steep turn. We talked about the relationship between the regulations and safety at the standdown, along with G forces, definition of acrobatic flight, parachute requirements, stuff like that. The fixed distance markers and the VASI could have helped you make a stabilized approach and a safer landing. For short field technique, you could have listened to a story from a former Air America pilot on landing and taking off on a 50-foot runway on the top of a mountain in Laos in a Pilatus Porter. We also discussed the importance of aircraft systems knowledge. You do know about the auto-dim feature of Piper landing gear indicators, don't you?

Scott Allen, Jim Hein, and Dave Lohmann are safety-minded pilots who make it a point to attend the FAA Safety Standdown and continue adding to their aviation knowledge and skill.

SUSAN PARSON

Checklist

Don't Get Upset!

As required by the aeronautical knowledge and practical test standards that 14 CFR part 61 sets out for the flight instructor certificate, my instructor and I strapped ourselves into a very carefully preflighted Cessna 150 one fine summer day and went forth for me to acquire proficiency in spin entries and recoveries. Although I like to think I camouflaged it pretty well at the time, I was apprehensive to say the least. The first—demonstrated—spin was terrifying. The second, with me at the controls, was easier. We finished the initial spin training session and after a couple more the following weekend, I was even enjoying them—sort of, anyway.

I met the requirement, got my spin training endorsement, and shortly thereafter passed the practical test for my flight instructor certificate. Then it was on to teaching. I was quite determined that no student of mine would ever get me even close to a spin or other loss of control-inflight (LOC-I) situation. But of course it didn't work out that way. When an early student botched his first attempt at the power-on stall recovery in a Cessna 152, I was mighty grateful that the FAA's flight instructor certification standards included experience in spin entries and recoveries. Though my inexperience let his mistake catch me by surprise, I was at least sufficiently prepared to recognize and recover well before it became a fully-developed spin.

More than the Minimum

Though I had passed both the official (check ride) test and a modest real-life test with my student, my scant experience with spins and extreme unusual attitudes—the kind that lead to LOC-I—gnawed at me. And so, a few years ago, I found my way to a school that specializes in upset recovery training. The three-day course I took included intensive preflight and postflight "academics," which provided a confidence-building enhancement of my aerodynamics knowledge. But nothing created confidence more quickly than intensive hands-on flights that let me safely explore the edge of the flight envelope. For the first time, I really got the picture on how, and why, a cross-controlled skidding stall could put me in a place I didn't want to be. The school's highly trained instructors were fiendishly skilled at setting me up for "surprise" encounters with simulated, but very realistic, wake turbulence. We also had opportunities to practice coping with flight control failures. This training—all on my dime, by the way—was not cheap. By my reckoning, though, the knowledge, practice, and confidence it provided were priceless.

Several of the expert contributors to this issue of *FAA Safety Briefing* strongly encourage pilots to seek out Upset Prevention and Recovery Training (UPRT). If you're interested in pursuing this advice, you will find some very helpful information on what to look for at www.uprta.org, the website of the non-profit Upset Prevention and Recovery Training Association (UPRTA), which bills itself as "an international aviation organization devoted to flight training quality assurance and instructor pilot standardization." Managed by internationally-recognized experts in upset recovery, stall/spin recovery, and advanced training maneuvers, UPRTA provides quality assurance through certification programs for upset prevention and recovery training.

You might also be interested in checking out the website for ICATEE, which is the International Committee for Aviation Training in Extended Envelopes (www.icatee.org). ICATEE's 80 members include the main airframe manufacturers, major and regional airlines, national aviation authorities, safety boards, simulator manufacturers, providers specializing in upset recovery training, research institutions, and pilot representatives. ICATEE also provided support to the FAA/Industry Stall-Stick-Pusher Working Group, as well as the Aviation Rulemaking Committee on Stick Pusher and Adverse Weather.

What you learn about upset recovery prevention and training could truly save your life someday.

Susan Parson is a Special Assistant in the FAA's Flight Standards Service and editor of FAA Safety Briefing*. She is an active general aviation pilot and flight instructor.*

TOM HOFFMANN

Angle of Attack

Taking Back Control

Loss of Control Workgroup Focused on Tangible Solutions

As you may have noticed elsewhere in this issue, there is a definite focus on one of the leading causes of general aviation (GA) accidents: loss of control (LOC). In just the last decade, LOC has accounted for more than 1,100 GA accidents. That's according to a study done by the General Aviation Joint Steering Committee (GAJSC) and the Safety Assessment Team (SAT), both mechanisms for government/industry cooperation, communication and coordination on GA safety issues. Based on its findings, the GAJSC/SAT formed a special LOC workgroup dedicated to researching, analyzing—and most importantly—developing solutions for this leading culprit of accidents. And after a year of intense focus, the workgroup is beginning to see the fruit of its labor.

The International Civil Aviation Organisation (ICAO) and the Commercial Aviation Safety Team (CAST) define LOC as loss of aircraft control or a deviation from an intended flightpath while inflight. In his article "Pilot-In-Control" on page 10, author Rich Stowell further explains that LOC accidents result from situations in which the pilot should have either maintained or regained control of the aircraft, but did not. Understanding what leads to and ultimately causes the misapplication of the controls in these accidents has been the unwavering goal of the LOC workgroup from its onset.

Beginning with those LOC accidents that occurred during the approach and landing phase of flight, the LOC workgroup focused on a set of 90 fatal accidents that were selected using a customized random sampling methodology. The 90 accidents were divided equally among three categories: amateur-built, turbine, and reciprocating non-amateur-built. A mix of industry and government experts analyzed each of these accidents in detail, following the same root-cause analysis methodology used to successfully reduce the commercial accident rate in recent years—the CAST model.

"The CAST model provides us greater detail and allows us to cull more pertinent information during our analyses," says National FAASTeam Operations Lead Kevin Clover, who, along with David Oord of the Experimental Aircraft Association (EAA), is co-chair of the LOC workgroup. "From these results, we can more accurately determine the contributing factors, then establish a set of intervention strategies to mitigate the underlying problem," says Clover.

The LOC workgroup is currently working towards condensing the various intervention strategies it has developed into more specific categories, such as Aeronautical Decision Making or transitioning to a different aircraft. Using the CAST model, those strategies will then be scored on how attainable and effective they are. Once finalized, the strategies will be sent to the GAJSC as part of a report expected this June. Leveraging its organizational resources both in industry and government, the GAJSC will then decide how to begin implementing the strategies.

"Outcomes for these strategies will likely evolve into aviation technology changes and/or enhancements," says Clover. "Other strategies will focus on enhanced training and educational outreach and will involve a greater working relationship with the FAA Safety Team."

Stay tuned for more information on new GA accident mitigation strategies in future issues.

Tom Hoffmann is an editor of FAA Safety Briefing. He is a commercial pilot and holds an A&P certificate.

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Airplane Flying Handbook

Airplane Flying Handbook

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AIRPLANE FLYING HANDBOOK

2004

U.S. DEPARTMENT OF TRANSPORTATION
FEDERAL AVIATION ADMINISTRATION
Flight Standards Service

often overlooked basic flying skill. An improperly trimmed airplane requires constant control pressures, produces pilot tension and fatigue, distracts the pilot from scanning, and contributes to abrupt and erratic airplane attitude control.

Because of their relatively low power and speed, not all light airplanes have a complete set of trim tabs that are adjustable from the cockpit. In airplanes where rudder, aileron, and elevator trim are available, a definite sequence of trim application should be used. Elevator/stabilator should be trimmed first to relieve the need for control pressure to maintain constant airspeed/pitch attitude. Attempts to trim the rudder at varying airspeed are impractical in propeller driven airplanes because of the change in the torque correcting offset of the vertical fin. Once a constant airspeed/pitch attitude has been established, the pilot should hold the wings level with aileron pressure while rudder pressure is trimmed out. Aileron trim should then be adjusted to relieve any lateral control yoke pressure.

A common trim control error is the tendency to overcontrol the airplane with trim adjustments. To avoid this the pilot must learn to establish and hold the airplane in the desired attitude using the primary flight controls. The proper attitude should be established with reference to the horizon and then verified by reference to performance indications on the flight instruments. The pilot should then apply trim in the above sequence to relieve whatever hand and foot pressure had been required. The pilot must avoid using the trim to establish or correct airplane attitude. The airplane attitude must be established and held first, then control pressures trimmed out so that the airplane will maintain the desired attitude in "hands off" flight. Attempting to "fly the airplane with the trim tabs" is a common fault in basic flying technique even among experienced pilots.

A properly trimmed airplane is an indication of good piloting skills. Any control pressures the pilot feels should be a result of deliberate pilot control input during a planned change in airplane attitude, not a result of pressures being applied by the airplane because the pilot is allowing it to assume control.

LEVEL TURNS

A turn is made by banking the wings in the direction of the desired turn. A specific angle of bank is selected by the pilot, control pressures applied to achieve the desired bank angle, and appropriate control pressures exerted to maintain the desired bank angle once it is established. [Figure 3-5]

Figure 3-5. Level turn to the left.

All four primary controls are used in close coordination when making turns. Their functions are as follows.

- The ailerons bank the wings and so determine the rate of turn at any given airspeed.
- The elevator moves the nose of the airplane up or down in relation to the pilot, and perpendicular to the wings. Doing that, it both sets the pitch attitude in the turn and "pulls" the nose of the airplane around the turn.
- The throttle provides thrust which may be used for airspeed to tighten the turn.
- The rudder offsets any yaw effects developed by the other controls. The rudder does not turn the airplane.

For purposes of this discussion, turns are divided into three classes: shallow turns, medium turns, and steep turns.

- Shallow turns are those in which the bank (less than approximately 20°) is so shallow that the inherent lateral stability of the airplane is acting to level the wings unless some aileron is applied to maintain the bank.
- Medium turns are those resulting from a degree of bank (approximately 20° to 45°) at which the airplane remains at a constant bank.

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> Steep turns are those resulting from a degree of bank (45° or more) at which the "overbanking tendency" of an airplane overcomes stability, and the bank increases unless aileron is applied to prevent it.

Changing the direction of the wing's lift toward one side or the other causes the airplane to be pulled in that direction. [Figure 3-6] Applying coordinated aileron and rudder to bank the airplane in the direction of the desired turn does this.

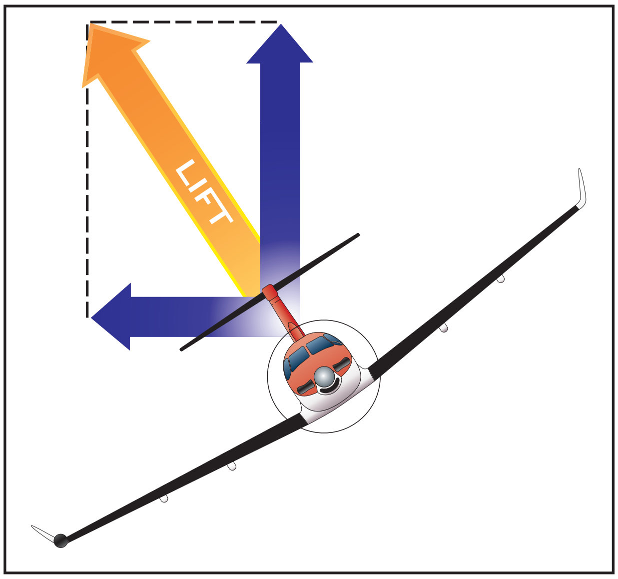

Figure 3-6. Change in lift causes airplane to turn.

When an airplane is flying straight and level, the total lift is acting perpendicular to the wings and to the Earth. As the airplane is banked into a turn, the lift then becomes the resultant of two components. One, the vertical lift component, continues to act perpendicular to the Earth and opposes gravity. Second, the horizontal lift component (centripetal) acts parallel to the Earth's surface and opposes inertia (apparent centrifugal force). These two lift components act at right angles to each other, causing the resultant total lifting force to act perpendicular to the banked wing of the airplane. It is the horizontal lift component that actually turns the airplane—not the rudder. When applying aileron to bank the airplane, the lowered aileron (on the rising wing) produces a greater drag than the raised aileron (on the lowering wing). [Figure 3-7] This increased aileron yaws the airplane toward the rising wing, or opposite to the direction of turn. To counteract this adverse yawing moment, rudder pressure must be applied simultaneously with aileron in the desired direction of turn. This action is required to produce a coordinated turn.

After the bank has been established in a medium banked turn, all pressure applied to the aileron may be relaxed. The airplane will remain at the selected bank

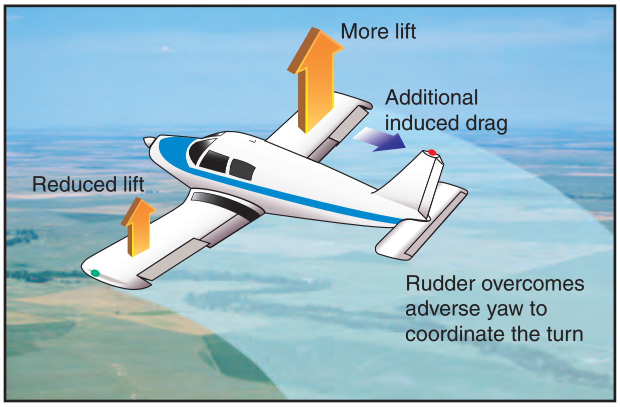

Figure 3-7. Forces during a turn.

with no further tendency to yaw since there is no longer a deflection of the ailerons. As a result, pressure may also be relaxed on the rudder pedals, and the rudder allowed to streamline itself with the direction of the slipstream. Rudder pressure maintained after the turn is established will cause the airplane to skid to the outside of the turn. If a definite effort is made to center the rudder rather than let it streamline itself to the turn, it is probable that some opposite rudder pressure will be exerted inadvertently. This will force the airplane to yaw opposite its turning path, causing the airplane to slip to the inside of the turn. The ball in the turn-and-slip indicator will be displaced off-center whenever the airplane is skidding or slipping sideways. [Figure 3-8] In proper coordinated flight, there is no skidding or slipping. An essential basic airmanship skill is the ability of the pilot to sense or "feel" any uncoordinated condition (slip or skid) without referring to instrument reference. During this stage of training, the flight instructor should stress the development of this ability and insist on its use to attain perfect coordination in all subsequent training.

In all constant altitude, constant airspeed turns, it is necessary to increase the angle of attack of the wing when rolling into the turn by applying up elevator. This is required because part of the vertical lift has been diverted to horizontal lift. Thus, the total lift must be increased to compensate for this loss.

To stop the turn, the wings are returned to level flight by the coordinated use of the ailerons and rudder applied in the opposite direction. To understand the relationship between airspeed, bank, and radius of turn, it should be noted that the rate of turn at any given true airspeed depends on the horizontal lift component. The horizontal lift component varies in proportion to the amount of bank. Therefore, the rate of turn at a given true airspeed increases as the angle of bank is increased. On the other hand, when a turn is made at a higher true airspeed at a given bank angle, the inertia is greater and the horizontal lift component required for the turn is greater, causing the turning rate

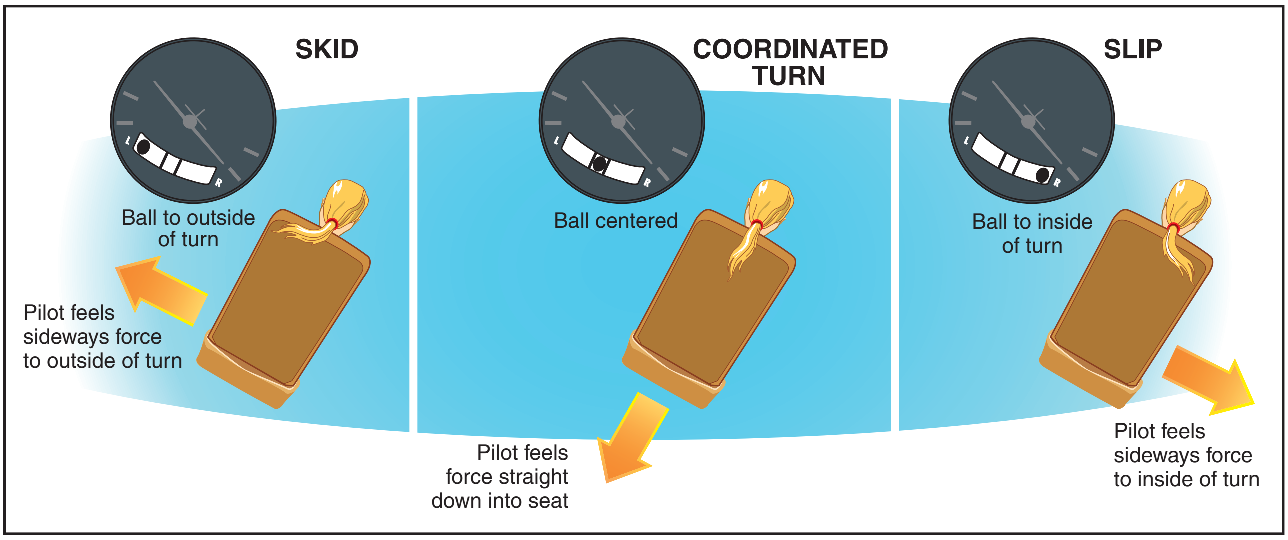

Figure 3-8. Indications of a slip and skid.

to become slower. [Figure 3-9 on next page] Therefore, at a given angle of bank, a higher true airspeed will make the radius of turn larger because the airplane will be turning at a slower rate.

When changing from a shallow bank to a medium bank, the airspeed of the wing on the outside of the turn increases in relation to the inside wing as the radius of turn decreases. The additional lift developed because of this increase in speed of the wing balances the inherent lateral stability of the airplane. At any given airspeed, aileron pressure is not required to maintain the bank. If the bank is allowed to increase from a medium to a steep bank, the radius of turn decreases further. The lift of the outside wing causes the bank to steepen and opposite aileron is necessary to keep the bank constant.

As the radius of the turn becomes smaller, a significant difference develops between the speed of the inside wing and the speed of the outside wing. The wing on the outside of the turn travels a longer circuit than the inside wing, yet both complete their respective circuits in the same length of time. Therefore, the outside wing travels faster than the inside wing, and as a result, it develops more lift. This creates an overbanking tendency that must be controlled by the use of the ailerons. [Figure 3-10] Because the outboard wing is developing more lift, it also has more induced drag. This causes a slight slip during steep turns that must be corrected by use of the rudder.

Sometimes during early training in steep turns, the nose may be allowed to get excessively low resulting in a significant loss in altitude. To recover, the pilot should first reduce the angle of bank with coordinated use of the rudder and aileron, then raise the nose of the airplane to level flight with the elevator. If recovery from an excessively nose-low steep bank condition is attempted by use of the elevator only, it will cause a steepening of the bank and could result in overstressing the airplane. Normally, small corrections for pitch during steep turns are accomplished with the elevator, and the bank is held constant with the ailerons.

To establish the desired angle of bank, the pilot should use outside visual reference points, as well as the bank indicator on the attitude indicator.

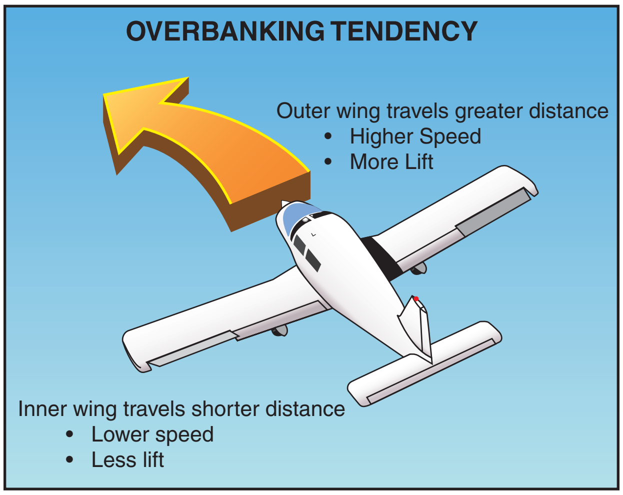

Figure 3-10. Overbanking tendency during a steep turn.

The best outside reference for establishing the degree of bank is the angle formed by the raised wing of low-wing airplanes (the lowered wing of high-wing airplanes) and the horizon, or the angle made by the top of the engine cowling and the horizon. [Figure 3-11 on page 3-11] Since on most light airplanes the engine cowling is fairly flat, its horizontal angle to the horizon will give some indication of the approximate degree of bank. Also, information obtained from the attitude indicator will show the angle of the wing in relation to the horizon. Information from the turn coordinator, however, will not.

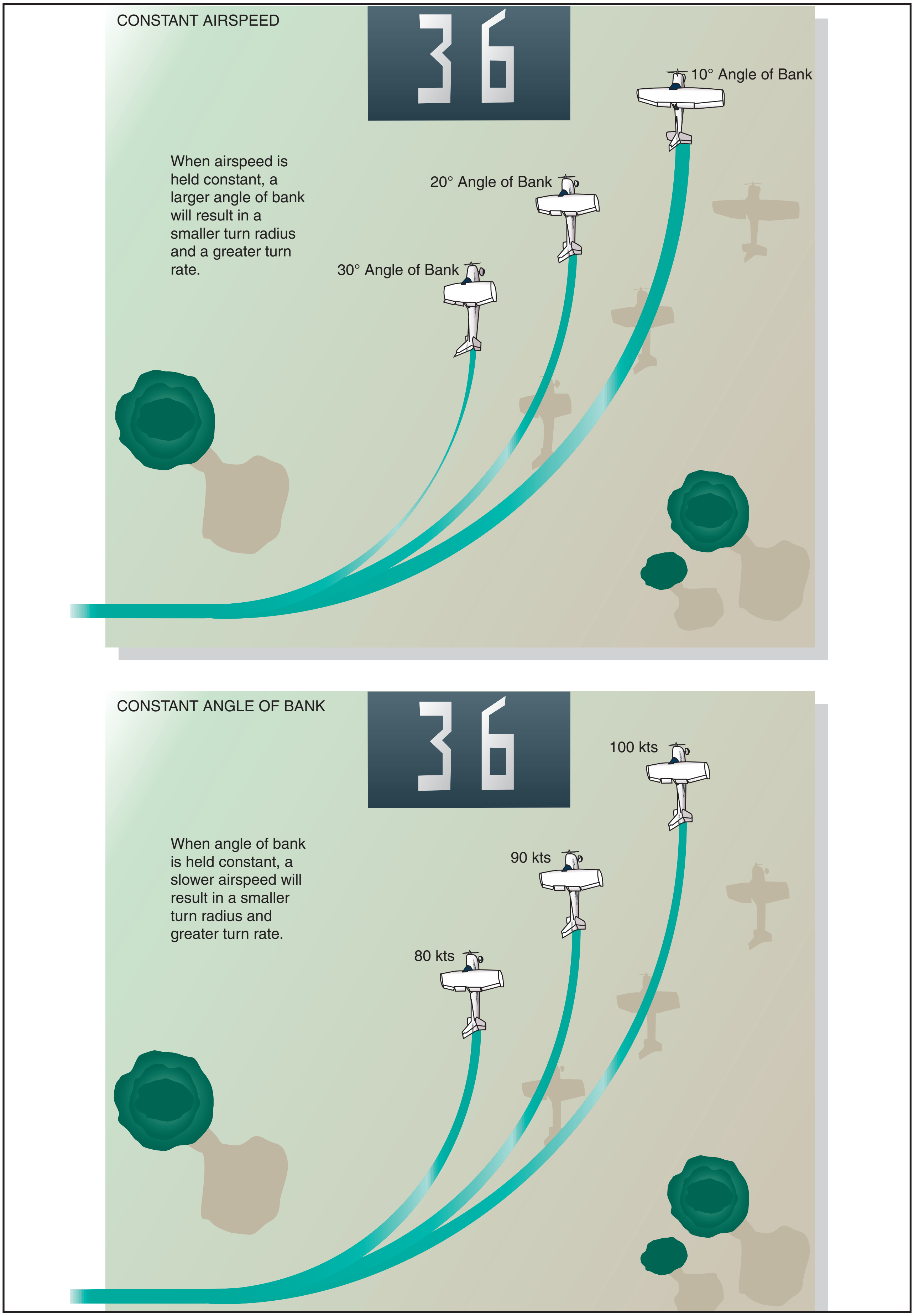

Figure 3-9. Angle of bank and airspeed regulate rate and radius of turn.

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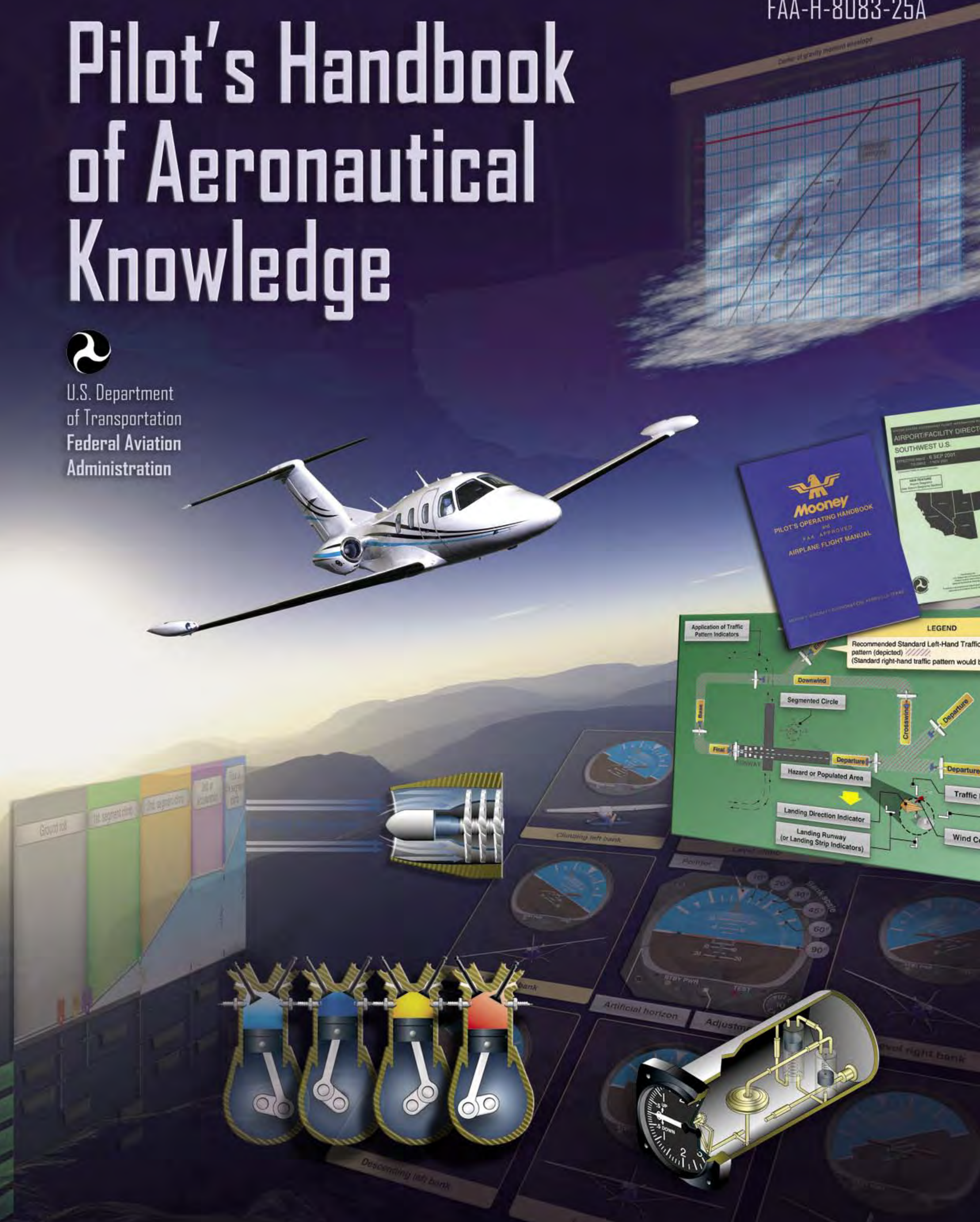

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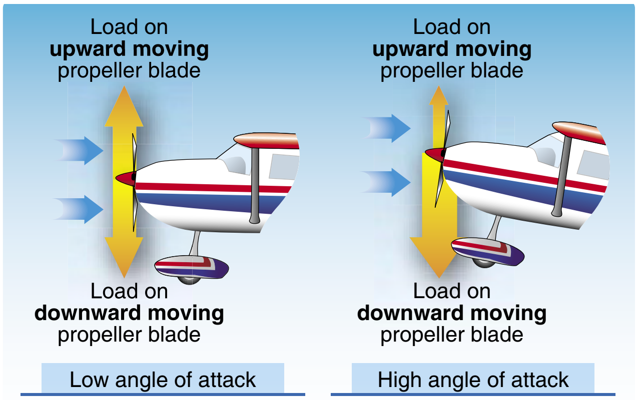


Figure 4-43. *Asymmetrical loading of propeller (P-factor).*

propeller itself, identical sections of each blade would have the same airspeed. With air moving horizontally across this vertically mounted propeller, the blade proceeding forward into the flow of air has a higher airspeed than the blade retreating with the airflow. Thus, the blade proceeding into the horizontal airflow is creating more lift, or thrust, moving the center of thrust toward that blade. Visualize rotating the vertically mounted propeller shaft to shallower angles relative to the moving air (as on an aircraft). This unbalanced thrust then becomes proportionately smaller and continues getting smaller until it reaches the value of zero when the propeller shaft is exactly horizontal in relation to the moving air.

The effects of each of these four elements of torque vary in value with changes in flight situations. In one phase of flight, one of these elements may be more prominent than another. In another phase of flight, another element may be more prominent. The relationship of these values to each other varies with different aircraft—depending on the airframe, engine, and propeller combinations, as well as other design features. To maintain positive control of the aircraft in all flight conditions, the pilot must apply the flight controls as necessary to compensate for these varying values.

Load Factors

In aerodynamics, load factor is the ratio of the maximum load an aircraft can sustain to the gross weight of the aircraft. The load factor is measured in Gs (acceleration of gravity), a unit of force equal to the force exerted by gravity on a body at rest and indicates the force to which a body is subjected when it is accelerated. Any force applied to an aircraft to deflect its flight from a straight line produces a stress on its structure, and the amount of this force is the load factor. While a course in aerodynamics is not a prerequisite for obtaining a pilot's license, the competent pilot should have a solid understanding of the forces that act on the aircraft, the advantageous use of these forces, and the operating limitations of the aircraft being flown.

For example, a load factor of 3 means the total load on an aircraft's structure is three times its gross weight. Since load factors are expressed in terms of Gs, a load factor of 3 may be spoken of as 3 Gs, or a load factor of 4 as 4 Gs.

If an aircraft is pulled up from a dive, subjecting the pilot to 3 Gs, he or she would be pressed down into the seat with a force equal to three times his or her weight. Since modern aircraft operate at significantly higher speeds than older aircraft, increasing the magnitude of the load factor, this effect has become a primary consideration in the design of the structure of all aircraft.

With the structural design of aircraft planned to withstand only a certain amount of overload, a knowledge of load factors has become essential for all pilots. Load factors are important for two reasons:

1. It is possible for a pilot to impose a dangerous overload on the aircraft structures.
2. An increased load factor increases the stalling speed and makes stalls possible at seemingly safe flight speeds.

Load Factors in Aircraft Design

The answer to the question "How strong should an aircraft be?" is determined largely by the use to which the aircraft is subjected. This is a difficult problem because the maximum possible loads are much too high for use in efficient design. It is true that any pilot can make a very hard landing or an extremely sharp pull up from a dive, which would result in abnormal loads. However, such extremely abnormal loads must be dismissed somewhat if aircraft are built that take off quickly, land slowly, and carry worthwhile payloads.

The problem of load factors in aircraft design becomes how to determine the highest load factors that can be expected in normal operation under various operational situations. These load factors are called "limit load factors." For reasons of safety, it is required that the aircraft be designed to withstand these load factors without any structural damage. Although the Code of Federal Regulations (CFR) requires the aircraft structure be capable of supporting one and one-half times these limit load factors without failure, it is accepted that parts of the aircraft may bend or twist under these loads and that some structural damage may occur.

This 1.5 load limit factor is called the "factor of safety" and provides, to some extent, for loads higher than those expected under normal and reasonable operation. This strength reserve is not something which pilots should willfully abuse; rather, it is there for protection when encountering unexpected conditions.

The above considerations apply to all loading conditions, whether they be due to gusts, maneuvers, or landings. The gust load factor requirements now in effect are substantially the same as those that have been in existence for years. Hundreds of thousands of operational hours have proven them adequate for safety. Since the pilot has little control over gust load factors (except to reduce the aircraft's speed when rough air is encountered), the gust loading requirements are substantially the same for most general aviation type aircraft regardless of their operational use. Generally, the gust load factors control the design of aircraft which are intended for strictly nonacrobatic usage.

An entirely different situation exists in aircraft design with maneuvering load factors. It is necessary to discuss this matter separately with respect to: (1) aircraft designed in accordance with the category system (i.e., normal, utility, acrobatic); and (2) older designs built according to requirements which did not provide for operational categories.

Aircraft designed under the category system are readily identified by a placard in the flight deck, which states the operational category (or categories) in which the aircraft is certificated. The maximum safe load factors (limit load factors) specified for aircraft in the various categories are:

CATEGORY	LIMIT LOAD FACTOR
Normal[1]	3.8 to −1.52
Utility (mild acrobatics, including spins)	4.4 to −1.76
Acrobatic	6.0 to −3.00

[1] For aircraft with gross weight of more than 4,000 pounds, the limit load factor is reduced. To the limit loads given above, a safety factor of 50 percent is added.

There is an upward graduation in load factor with the increasing severity of maneuvers. The category system provides for maximum utility of an aircraft. If normal operation alone is intended, the required load factor (and consequently the weight of the aircraft) is less than if the aircraft is to be employed in training or acrobatic maneuvers as they result in higher maneuvering loads.

Aircraft that do not have the category placard are designs that were constructed under earlier engineering requirements in which no operational restrictions were specifically given to the pilots. For aircraft of this type (up to weights of about 4,000 pounds), the required strength is comparable to present-day utility category aircraft, and the same types of operation are permissible. For aircraft of this type over 4,000 pounds, the load factors decrease with weight. These aircraft should be regarded as being comparable to the normal category aircraft designed under the category system, and they should be operated accordingly.

Load Factors in Steep Turns

In a constant altitude, coordinated turn in any aircraft, the load factor is the result of two forces: centrifugal force and gravity. *[Figure 4-44]* For any given bank angle, the ROT varies with the airspeed—the higher the speed, the slower the ROT. This compensates for added centrifugal force, allowing the load factor to remain the same.

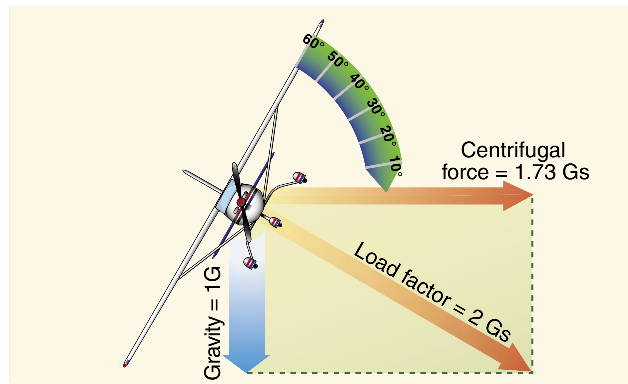


Figure 4-44. *Two forces cause load factor during turns.*

Figure 4-45 reveals an important fact about turns—the load factor increases at a terrific rate after a bank has reached 45° or 50°. The load factor for any aircraft in a 60° bank is 2 Gs. The load factor in an 80° bank is 5.76 Gs. The wing must produce lift equal to these load factors if altitude is to be maintained.

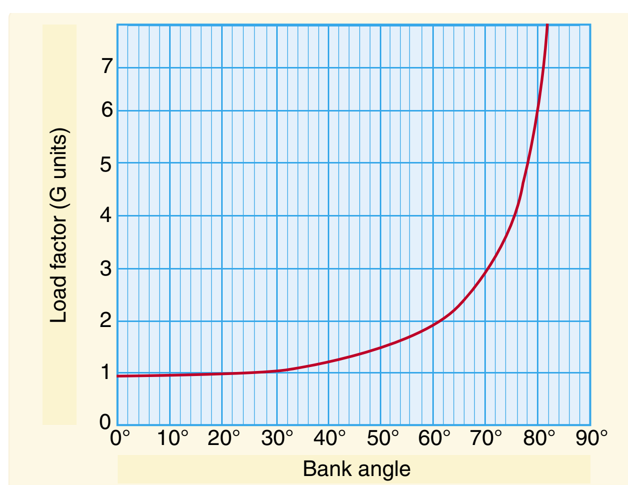


Figure 4-45. *Angle of bank changes load factor.*

It should be noted how rapidly the line denoting load factor rises as it approaches the 90° bank line, which it never quite reaches because a 90° banked, constant altitude turn is not mathematically possible. An aircraft may be banked to 90°, but not in a coordinated turn. An aircraft which can be held in a 90° banked slipping turn is capable of straight knife-edged flight. At slightly more than 80°, the load factor exceeds the limit of 6 Gs, the limit load factor of an acrobatic aircraft.

For a coordinated, constant altitude turn, the approximate maximum bank for the average general aviation aircraft is 60°. This bank and its resultant necessary power setting reach the limit of this type of aircraft. An additional 10° bank increases the load factor by approximately 1 G, bringing it close to the yield point established for these aircraft. *[Figure 4-46]*

Load Factors and Stalling Speeds

Any aircraft, within the limits of its structure, may be stalled at any airspeed. When a sufficiently high AOA is imposed, the smooth flow of air over an airfoil breaks up and separates, producing an abrupt change of flight characteristics and a sudden loss of lift, which results in a stall.

A study of this effect has revealed that the aircraft's stalling speed increases in proportion to the square root of the load factor. This means that an aircraft with a normal unaccelerated stalling speed of 50 knots can be stalled at 100 knots by inducing a load factor of 4 Gs. If it were possible for this aircraft to withstand a load factor of nine, it could be stalled at a speed of 150 knots. A pilot should be aware:

- Of the danger of inadvertently stalling the aircraft by increasing the load factor, as in a steep turn or spiral;
- When intentionally stalling an aircraft above its design maneuvering speed, a tremendous load factor is imposed.

Figures 4-45 and *4-46* show that banking an aircraft greater than 72° in a steep turn produces a load factor of 3, and the stalling speed is increased significantly. If this turn is made in an aircraft with a normal unaccelerated stalling speed of 45 knots, the airspeed must be kept greater than 75 knots to prevent inducing a stall. A similar effect is experienced in a quick pull up, or any maneuver producing load factors above 1 G. This sudden, unexpected loss of control, particularly in a steep turn or abrupt application of the back elevator control near the ground, has caused many accidents.

Since the load factor is squared as the stalling speed doubles, tremendous loads may be imposed on structures by stalling an aircraft at relatively high airspeeds.

The maximum speed at which an aircraft may be stalled safely is now determined for all new designs. This speed is called the "design maneuvering speed" (V_A) and must be entered in the FAA-approved Airplane Flight Manual/Pilot's Operating Handbook (AFM/POH) of all recently designed aircraft. For older general aviation aircraft, this speed is approximately 1.7 times the normal stalling speed. Thus, an older aircraft which normally stalls at 60 knots must never be stalled at above 102 knots (60 knots x 1.7 = 102 knots). An aircraft with a normal stalling speed of 60 knots stalled at 102 knots undergoes a load factor equal to the square of the increase in speed, or 2.89 Gs (1.7 x 1.7 = 2.89 Gs). (The above figures are approximations to be considered as a guide, and are not the exact answers to any set of problems. The design maneuvering speed should be determined from the particular aircraft's operating limitations provided by the manufacturer.)

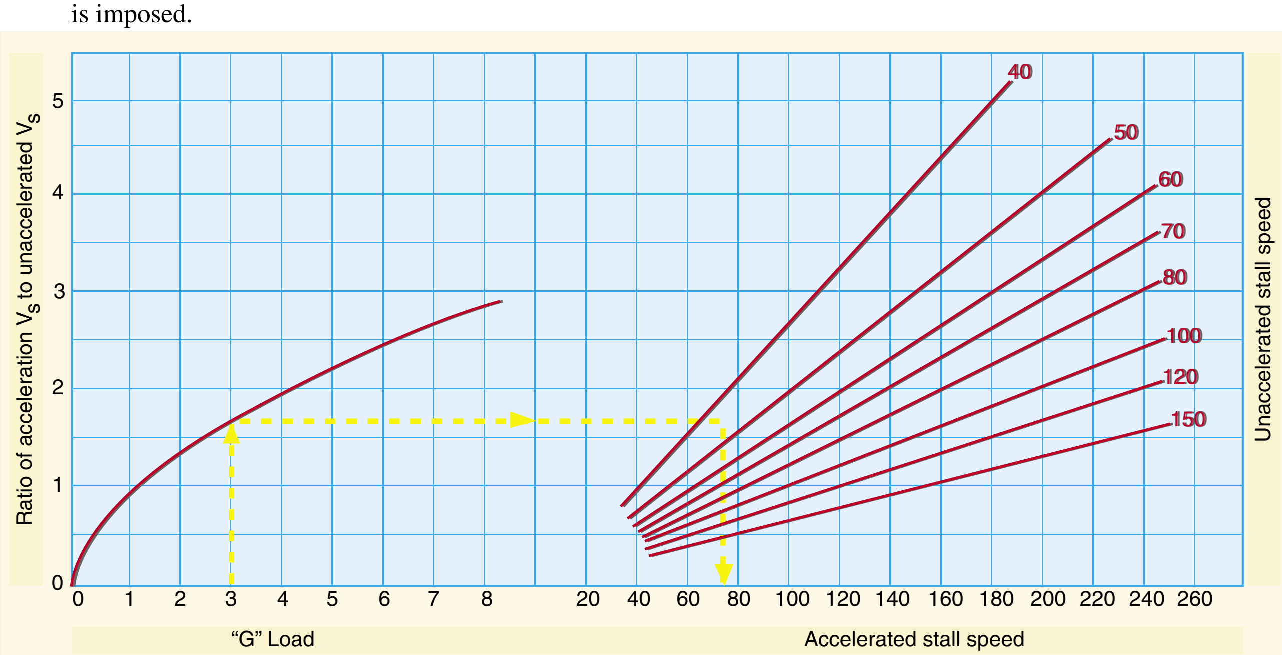


Figure 4-46. *Load factor changes stall speed.*

Since the leverage in the control system varies with different aircraft (some types employ "balanced" control surfaces while others do not), the pressure exerted by the pilot on the controls cannot be accepted as an index of the load factors produced in different aircraft. In most cases, load factors can be judged by the experienced pilot from the feel of seat pressure. Load factors can also be measured by an instrument called an "accelerometer," but this instrument is not common in general aviation training aircraft. The development of the ability to judge load factors from the feel of their effect on the body is important. A knowledge of these principles is essential to the development of the ability to estimate load factors.

A thorough knowledge of load factors induced by varying degrees of bank and the V_A aids in the prevention of two of the most serious types of accidents:

1. Stalls from steep turns or excessive maneuvering near the ground
2. Structural failures during acrobatics or other violent maneuvers resulting from loss of control

Load Factors and Flight Maneuvers

Critical load factors apply to all flight maneuvers except unaccelerated straight flight where a load factor of 1 G is always present. Certain maneuvers considered in this section are known to involve relatively high load factors.

Turns

Increased load factors are a characteristic of all banked turns. As noted in the section on load factors in steep turns, load factors become significant to both flight performance and load on wing structure as the bank increases beyond approximately 45°.

The yield factor of the average light plane is reached at a bank of approximately 70° to 75°, and the stalling speed is increased by approximately one-half at a bank of approximately 63°.

Stalls

The normal stall entered from straight-and-level flight, or an unaccelerated straight climb, does not produce added load factors beyond the 1 G of straight-and-level flight. As the stall occurs, however, this load factor may be reduced toward zero, the factor at which nothing seems to have weight. The pilot experiences a sensation of "floating free in space." If recovery is effected by snapping the elevator control forward, negative load factors (or those that impose a down load on the wings and raise the pilot from the seat) may be produced.

During the pull up following stall recovery, significant load factors are sometimes induced. These may be further increased inadvertently during excessive diving (and consequently high airspeed) and abrupt pull ups to level flight. One usually leads to the other, thus increasing the load factor. Abrupt pull ups at high diving speeds may impose critical loads on aircraft structures and may produce recurrent or secondary stalls by increasing the AOA to that of stalling.

As a generalization, a recovery from a stall made by diving only to cruising or design maneuvering airspeed, with a gradual pull up as soon as the airspeed is safely above stalling, can be effected with a load factor not to exceed 2 or 2.5 Gs. A higher load factor should never be necessary unless recovery has been effected with the aircraft's nose near or beyond the vertical attitude, or at extremely low altitudes to avoid diving into the ground.

Spins

A stabilized spin is not different from a stall in any element other than rotation and the same load factor considerations apply to spin recovery as apply to stall recovery. Since spin recoveries are usually effected with the nose much lower than is common in stall recoveries, higher airspeeds and consequently higher load factors are to be expected. The load factor in a proper spin recovery usually is found to be about 2.5 Gs.

The load factor during a spin varies with the spin characteristics of each aircraft, but is usually found to be slightly above the 1 G of level flight. There are two reasons for this:

1. Airspeed in a spin is very low, usually within 2 knots of the unaccelerated stalling speeds.
2. Aircraft pivots, rather than turns, while it is in a spin.

High Speed Stalls

The average light plane is not built to withstand the repeated application of load factors common to high speed stalls. The load factor necessary for these maneuvers produces a stress on the wings and tail structure, which does not leave a reasonable margin of safety in most light aircraft.

The only way this stall can be induced at an airspeed above normal stalling involves the imposition of an added load factor, which may be accomplished by a severe pull on the elevator control. A speed of 1.7 times stalling speed (about 102 knots in a light aircraft with a stalling speed of 60 knots) produces a load factor of 3 Gs. Only a very narrow margin for error can be allowed for acrobatics in light aircraft. To illustrate how rapidly the load factor increases with airspeed, a high-speed stall at 112 knots in the same aircraft would produce a load factor of 4 Gs.

Chandelles and Lazy Eights

A chandelle is a maximum performance climbing turn beginning from approximately straight-and-level flight, and ending at the completion of a precise 180° of turn in a wings-level, nose-high attitude at the minimum controllable airspeed. In this flight maneuver, the aircraft is in a steep climbing turn and almost stalls to gain altitude while changing direction. A lazy eight derives its name from the manner in which the extended longitudinal axis of the aircraft is made to trace a flight pattern in the form of a figure "8" lying on its side. It would be difficult to make a definite statement concerning load factors in these maneuvers as both involve smooth, shallow dives and pull ups. The load factors incurred depend directly on the speed of the dives and the abruptness of the pull ups during these maneuvers.

Generally, the better the maneuver is performed, the less extreme the load factor induced. A chandelle or lazy eight in which the pull-up produces a load factor greater than 2 Gs will not result in as great a gain in altitude, and in low-powered aircraft it may result in a net loss of altitude.

The smoothest pull up possible, with a moderate load factor, delivers the greatest gain in altitude in a chandelle and results in a better overall performance in both chandelles and lazy eights. The recommended entry speed for these maneuvers is generally near the manufacturer's design maneuvering speed which allows maximum development of load factors without exceeding the load limits.

Rough Air

All standard certificated aircraft are designed to withstand loads imposed by gusts of considerable intensity. Gust load factors increase with increasing airspeed, and the strength used for design purposes usually corresponds to the highest level flight speed. In extremely rough air, as in thunderstorms or frontal conditions, it is wise to reduce the speed to the design maneuvering speed. Regardless of the speed held, there may be gusts that can produce loads which exceed the load limits.

Each specific aircraft is designed with a specific G loading that can be imposed on the aircraft without causing structural damage. There are two types of load factors factored into aircraft design, limit load and ultimate load. The limit load is a force applied to an aircraft that causes a bending of the aircraft structure that does not return to the original shape. The ultimate load is the load factor applied to the aircraft beyond the limit load and at which point the aircraft material experiences structural failure (breakage). Load factors lower than the limit load can be sustained without compromising the integrity of the aircraft structure.

Speeds up to but not exceeding the maneuvering speed allows an aircraft to stall prior to experiencing an increase in load factor that would exceed the limit load of the aircraft.

Most AFM/POH now include turbulent air penetration information, which help today's pilots safely fly aircraft capable of a wide range of speeds and altitudes. It is important for the pilot to remember that the maximum "never-exceed" placard dive speeds are determined for smooth air only. High speed dives or acrobatics involving speed above the known maneuvering speed should never be practiced in rough or turbulent air.

Vg Diagram

The flight operating strength of an aircraft is presented on a graph whose vertical scale is based on load factor. *[Figure 4-47]* The diagram is called a Vg diagram—velocity versus G loads or load factor. Each aircraft has its own Vg diagram which is valid at a certain weight and altitude.

The lines of maximum lift capability (curved lines) are the first items of importance on the Vg diagram. The aircraft in the *Figure 4-47* is capable of developing no more than +1 G at 62 mph, the wing level stall speed of the aircraft. Since the maximum load factor varies with the square of the airspeed, the maximum positive lift capability of this aircraft is 2 G at 92 mph, 3 G at 112 mph, 4.4 G at 137 mph, and so forth. Any load factor above this line is unavailable aerodynamically (i.e., the aircraft cannot fly above the line of maximum lift capability because it stalls). The same situation exists for negative lift flight with the exception that the speed necessary to produce a given negative load factor is higher than that to produce the same positive load factor.

If the aircraft is flown at a positive load factor greater than the positive limit load factor of 4.4, structural damage is possible. When the aircraft is operated in this region, objectionable permanent deformation of the primary structure may take place and a high rate of fatigue damage is incurred. Operation above the limit load factor must be avoided in normal operation.

There are two other points of importance on the Vg diagram. One point is the intersection of the positive limit load factor and the line of maximum positive lift capability. The airspeed at this point is the minimum airspeed at which the limit load can be developed aerodynamically. Any airspeed greater than this provides a positive lift capability sufficient to damage the aircraft. Conversely, any airspeed less than this does not provide positive lift capability sufficient to cause damage from excessive flight loads. The usual term given to this speed is "maneuvering speed," since consideration of subsonic

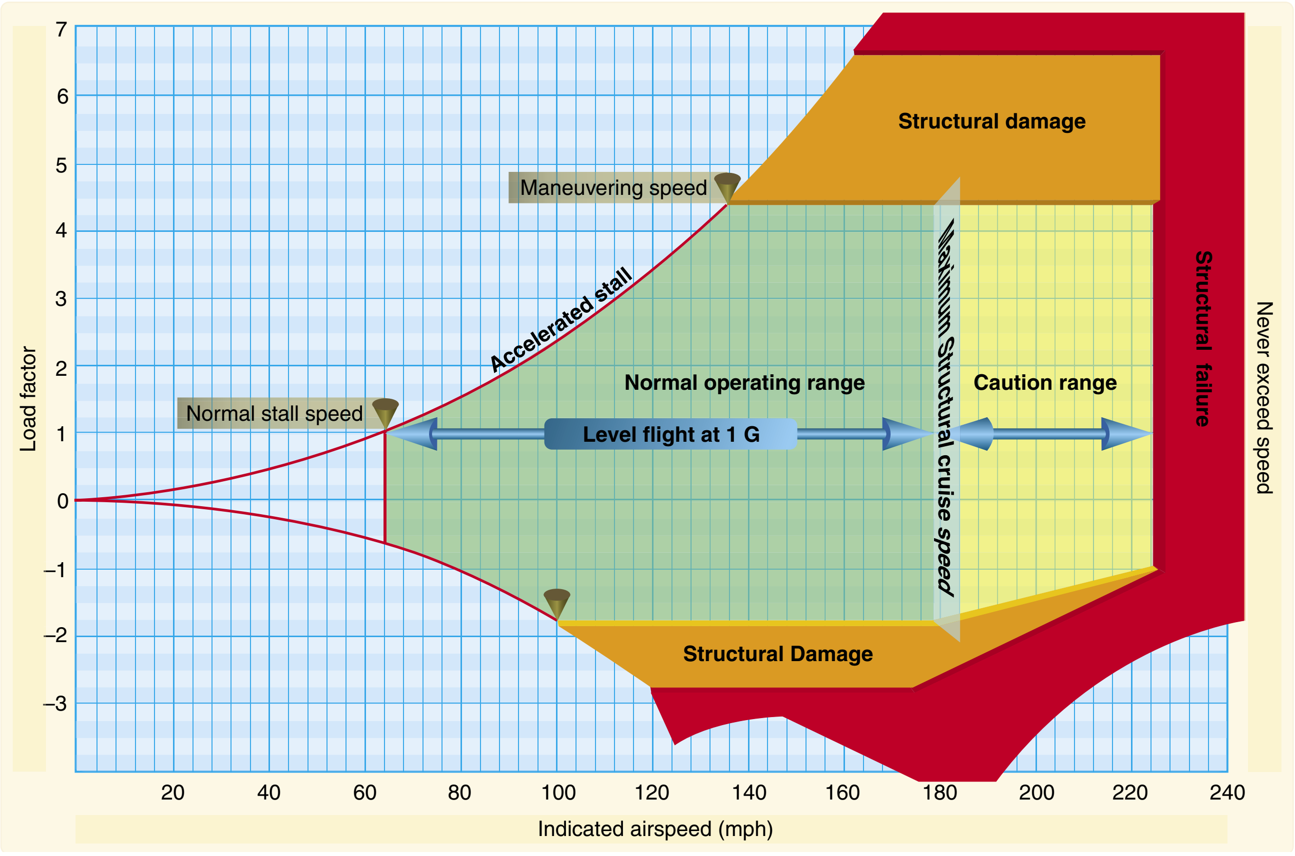


Figure 4-47. *Typical Vg diagram.*

aerodynamics would predict minimum usable turn radius or maneuverability to occur at this condition. The maneuver speed is a valuable reference point, since an aircraft operating below this point cannot produce a damaging positive flight load. Any combination of maneuver and gust cannot create damage due to excess airload when the aircraft is below the maneuver speed.

The other point of importance on the Vg diagram is the intersection of the negative limit load factor and line of maximum negative lift capability. Any airspeed greater than this provides a negative lift capability sufficient to damage the aircraft; any airspeed less than this does not provide negative lift capability sufficient to damage the aircraft from excessive flight loads.

The limit airspeed (or redline speed) is a design reference point for the aircraft—this aircraft is limited to 225 mph. If flight is attempted beyond the limit airspeed, structural damage or structural failure may result from a variety of phenomena.

The aircraft in flight is limited to a regime of airspeeds and Gs which do not exceed the limit (or redline) speed, do not exceed the limit load factor, and cannot exceed the maximum lift capability. The aircraft must be operated within this "envelope" to prevent structural damage and ensure the anticipated service lift of the aircraft is obtained. The pilot must appreciate the Vg diagram as describing the allowable combination of airspeeds and load factors for safe operation. Any maneuver, gust, or gust plus maneuver outside the structural envelope can cause structural damage and effectively shorten the service life of the aircraft.

Rate of Turn

The rate of turn (ROT) is the number of degrees (expressed in degrees per second) of heading change that an aircraft makes. The ROT can be determined by taking the constant of 1,091, multiplying it by the tangent of any bank angle and dividing that product by a given airspeed in knots as illustrated in *Figure 4-48.* If the airspeed is increased and the ROT desired is to be constant, the angle of bank must be increased, otherwise, the ROT decreases. Likewise, if the airspeed is held constant, an aircraft's ROT increases if the bank angle is increased. The formula in *Figures 4-48* through *4-50* depicts the relationship between bank angle and airspeed as they affect the ROT.

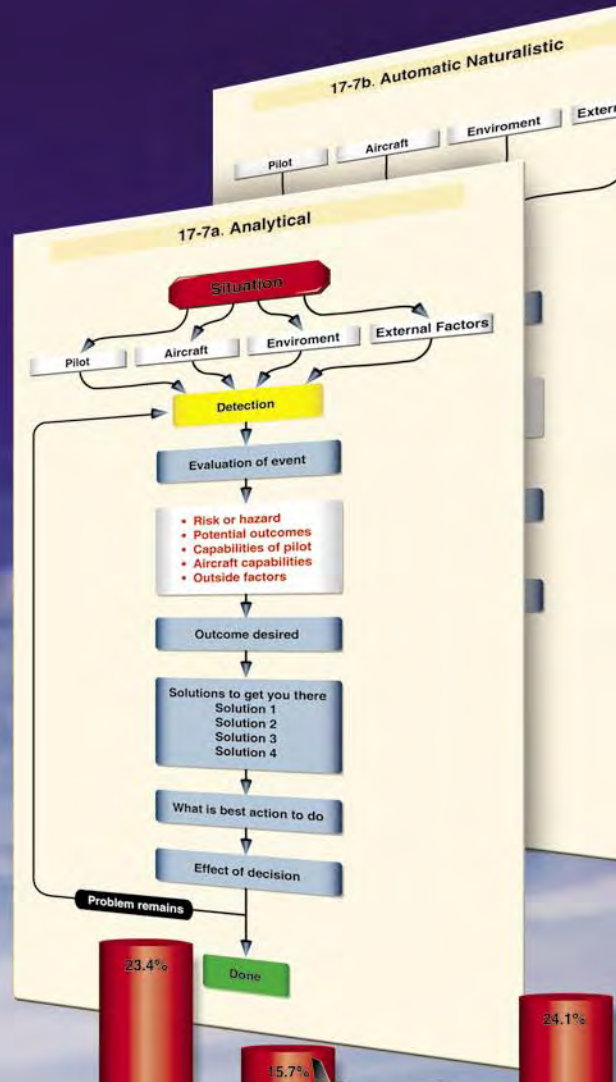
NOTE: All airspeed discussed in this section is true airspeed (TAS).

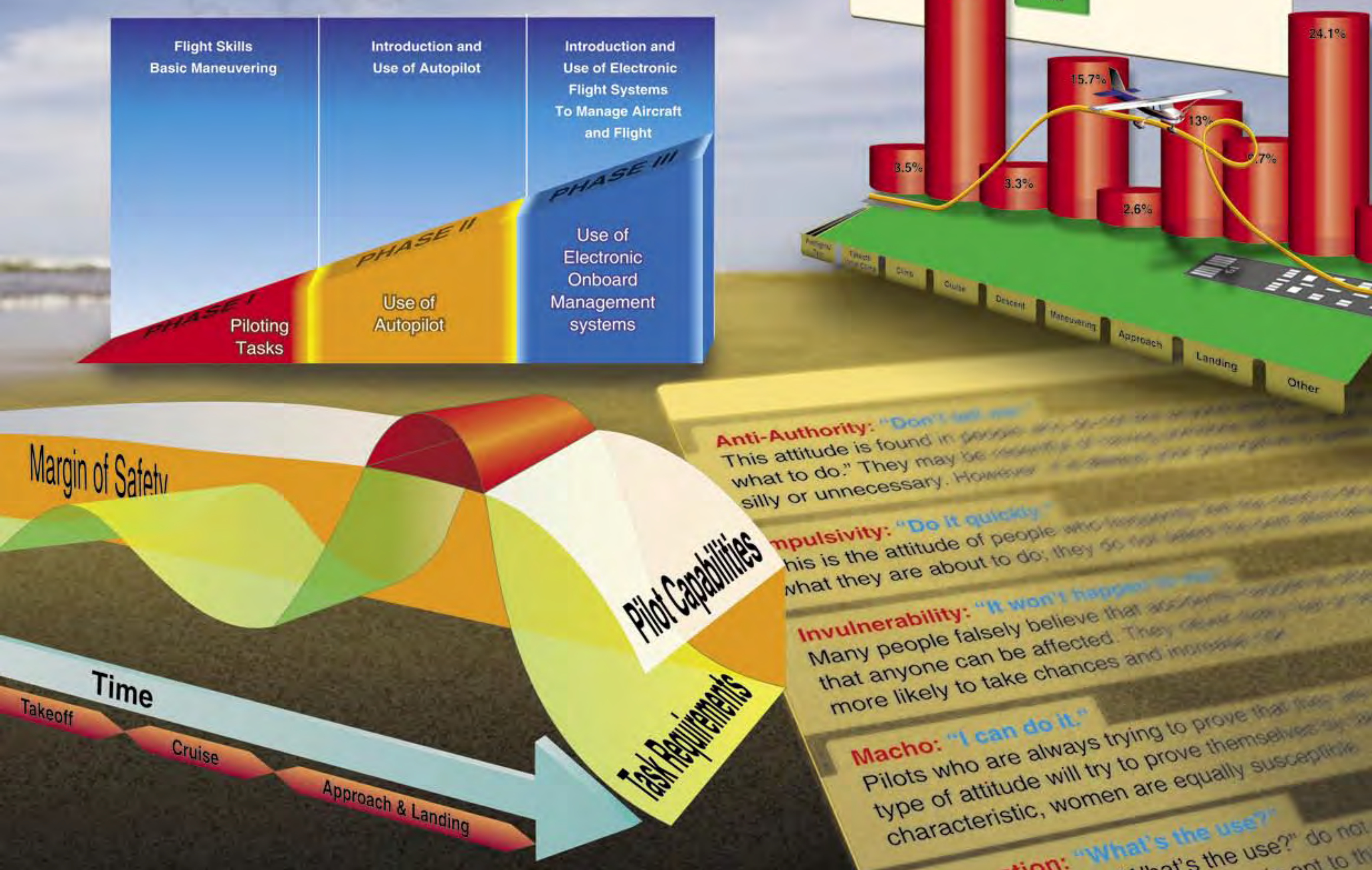
Chapter 17

Aeronautical Decision-Making

Introduction

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





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 17-1]*

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 17-2]*

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 inflight errors than those who had

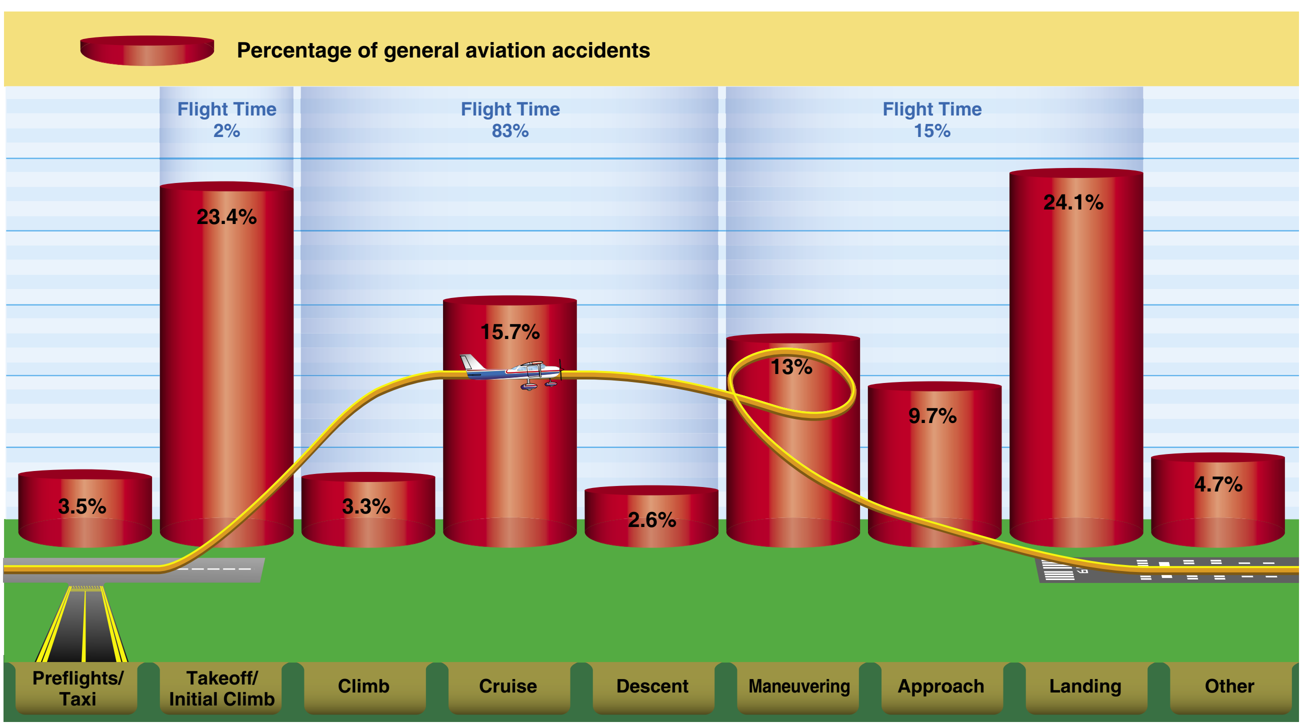


Figure 17-1. *The percentage of aviation accidents as they relate to the different phases of flight. Note that the greatest percentage of accidents take place during a minor percentage of the total flight.*

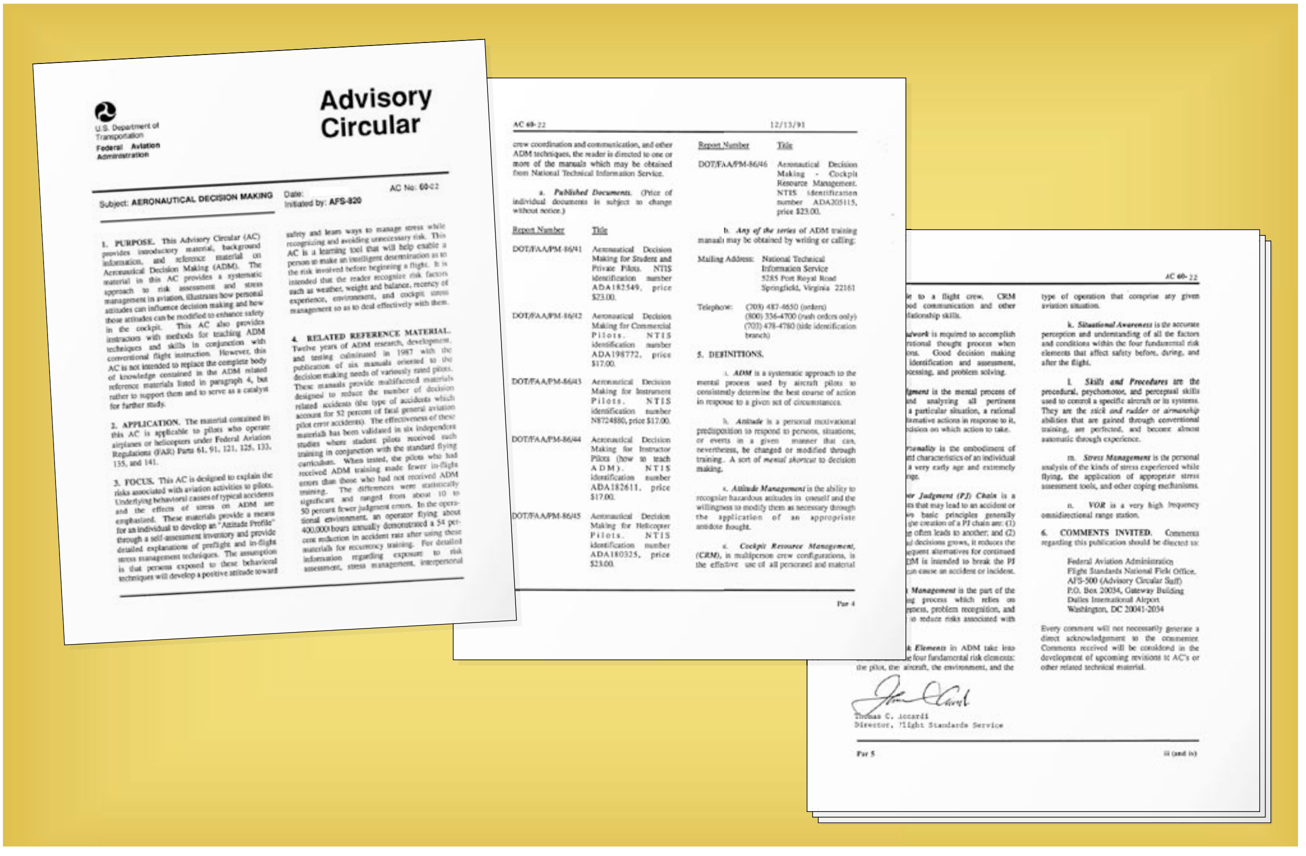


Figure 17-2. *Advisory Circular (AC) 60-22, Aeronautical Decision Making, carries a wealth of information for the pilot to learn.*

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 a flight's safe outcome. 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 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.

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.

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 and during flight) to ensure that 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 air traffic control (ATC) and flight service station (FSS) 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 doesn't expect it to propagate a crack which 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 prop's operation 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 will affect 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 17-3]*

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.

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 risk.

The Five Hazardous Attitudes

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.

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.

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

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

Resignation: "What's the use?"
Pilots who think, "What's the use?" do not see themselves as being able to make a great deal of difference in what happens to them. When things go well, the pilot is apt to think that it is good luck. When things go badly, the pilot may feel that someone is out to get me, 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."

Figure 17-3. *The five hazardous attitudes identified through past and contemporary study.*

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 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. Two are illustrated below.

The most basic tool is the risk matrix. *[Figure 17-4]* It assesses two items: the likelihood of an event occurring and the consequence of that event.

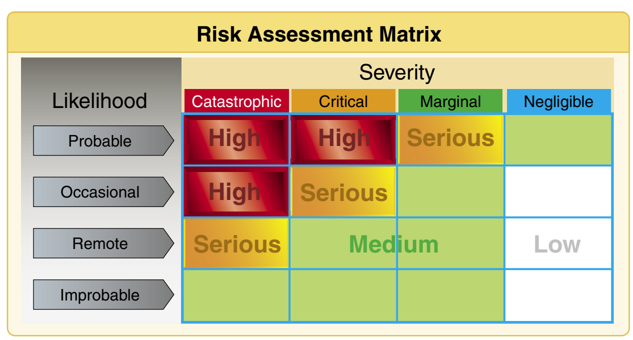


Figure 17-4. *This risk matrix can be used for almost any operation by assigning likelihood and consequence. In the case presented, the pilot assigned a likelihood of occassional and the severity as catastrophic. As one can see, this falls in the high risk area.*

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 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 flight rules (IFR) 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 17-4* 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 17-4* provides a general viewpoint of a generic situation, a more comprehensive program can be made that is tailored to a pilot's flying. *[Figure 17-5]* This program includes a wide array of aviation related activities specific to the pilot and assesses health, fatigue, weather, 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 a pilot who is certified as an IFR pilot.
- Delay the flight.
- Cancel the flight.
- Drive.

One of the best ways to 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. Eating—Have I eaten enough of the proper foods to keep adequately nourished during the entire flight?

The PAVE Checklist

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

RISK ASSESSMENT

Pilot's Name ______ Flight From ______ To ______

SLEEP

1. Did not sleep well or less than 8 hours	2
2. Slept well	0

HOW DO YOU FEEL?

1. Have a cold or ill	4
2. Feel great	0
3. Feel a bit off	2

WEATHER AT TERMINATION

1. Greater than 5 miles visibility and 3,000 feet ceilings	1
2. At least 3 miles visibility and 1,000 feet ceilings, but less than 3,000 feet ceilings and 5 miles visibility	3
3. IMC conditions	4

Column total ______

HOW IS THE DAY GOING?

1. Seems like one thing after another (late, making errors, out of step)	3
2. Great day	0

IS THE FLIGHT

1. Day?	1
2. Night?	3

PLANNING

1. Rush to get off ground		3
2. No hurry		1
3. Used charts and computer to assist		0
4. Used computer program for all planning	Yes	3
	No	0
5. Did you verify weight and balance?	Yes	0
	No	3
6. Did you evaluate performance?	Yes	0
	No	3
7. Do you brief your passangers on the ground and in flight?	Yes	0
	No	2

Column total ______

TOTAL SCORE ______

Figure 17-5. *Example of a more comprehensive risk assessment program.*

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 knots crosswind component without additional training. Therefore, the 10 kts 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 an 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 are 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 (NOTAMS) 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 amd/or alternate airports?

Airspace

- If the trip is over remote areas, are 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?
- Preflight 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.
- 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 17-6]*

Pilot

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

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

Environment

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

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

Aircraft

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

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

External Pressures

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

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

Figure 17-6. *The PAVE checklist.*

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, were considered industrious and cooperative with others, but were not considered physically inclined. The accident-repeater group had better gymnastic skills, were 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 required 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, 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.
- A disregard for or under utilization of outside sources of information, including copilots, flight attendants, flight service personnel, flight instructors, and air traffic controllers.

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 risk 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 5-P, the 3P, the 3 with CARE and TEAM, the OODA, 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.

SRM and the 5P Check

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.

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 17-7]* The

The SRM Five "P" Check

- The Plan
- The Plane
- The Pilot
- The Passengers
- The Programming

Figure 17-7. *The Five P checklist.*

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 face a single pilot. And each 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 visual flight rules (VFR) operations, just prior to entering the traffic pattern.

The 5 Ps are based on the idea that the pilots have essentially five variables that impact his or her environment and that can cause the pilot 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 use risk management sheets that are filled out by the pilot prior to takeoff. These form a catalog of risks that may be encountered that day and turn them into numerical values. If the total exceeds a certain 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 5P 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 point 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 mid point of the flight. Often, pilots may wait until the Automated Terminal information Service (ATIS) is in range to check weather, yet at this point in the flight many good options have already passed behind the aircraft and pilot. Additionally, fatigue and low-altitude hypoxia serve to rob the pilot of much of his or her energy by the end of a long and tiring flight day. This leads to a transition from a decision-making mode to an acceptance mode on the part of the pilot. If the flight is longer than 2 hours, the 5P 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 5P 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 give 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 a Flight Service Station (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 used for business transportation, can expose the pilot to high altitude flying, long distance and endurance, and more challenging weather. An advanced avionics aircraft, simply due to their advanced capabilities can expose a pilot to even more of these stresses. The traditional "IMSAFE" checklist (see page 17-6) is a good start.

The combination of late night, 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 5P process helps a pilot recognize the physiological situation at the end of the flight before takeoff, and continues to update personal conditions as the flight progresses. Once risks are identified, the pilot is in an infinitely 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 has entered into a very personal relationship with the passengers. In fact, the pilot and passengers sit within an arm's reach all of the time.

The desire of the passengers to make airline connections or important business meetings easily enters into this pilot's decision-making loop. Done in a healthy and open way, this can be a positive factor. Consider a flight to Dulles Airport and the passengers, both close friends and business partners, need to get to Washington, D.C., for an important meeting. The weather is VFR all the way to southern Virginia then turns to low IFR as the pilot approaches Dulles. A pilot employing the 5P 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 the 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 air traffic control 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)

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.

In the first step, the goal is to develop situational awareness by perceiving hazards, which are present events, objects, or circumstances that could contribute to an undesired future event. In this step, the pilot will systematically identify and list hazards associated with all aspects of the flight: pilot, aircraft, environment, and external pressures. It is important to consider how individual hazards might combine. Consider, for example, the hazard that arises when a new instrument pilot with no experience in actual instrument conditions wants to make a cross-country flight to an airport with low ceilings in order to attend an important business meeting.

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). If the hazard is low ceilings, for example, the level of risk depends on a number of other factors, such as pilot training and experience, aircraft equipment and fuel capacity, and others.

In the third step, 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, 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. The 3P model has been expanded to include the CARE and TEAM models which offers pilots another way to assess and reduce risks associated with flying.

Perceive, Process, Perform with CARE and TEAM

Most flight training activities take place in the "time-critical" timeframe for risk management. *Figures 17-8* and *17-9* combine the six steps of risk management into an easy-to-remember 3P model for practical risk management: Perceive, Process, Perform with the CARE and TEAM models. 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. These concepts are relatively new in the GA training world, but have been shown to be extraordinarily useful in lowering accident rates in the world of air carriers.

Pilots can perceive hazards by using the PAVE checklist:

Pilot

Gayle is a healthy and well-rested private pilot with approximately 300 hours total flight time. Hazards include her lack of overall and cross-country experience and the fact that she has not flown at all in two months.

Aircraft

Although it does not have a panel-mount GPS or weather avoidance gear, the aircraft—a C182 Skylane with long-range fuel tanks—is in good mechanical condition with no inoperative equipment. The instrument panel is a standard "six-pack."

EnVironment

Departure and destination airports have long runways. Weather is the main hazard. Although it is VFR, it is a typical summer day in the Mid-Atlantic region: hot (near 90 °F) hazy (visibility 7 miles), and humid with a density altitude of 2,500 feet. Weather at the destination airport (located in the mountains) is still IMC, but forecast to improve to visual meteorological conditions (VMC) prior to her arrival. En route weather is VMC, but there is an AIRMET Sierra for pockets of IMC over mountain ridges along the proposed route of flight.

External Pressures

Gayle is making the trip to spend a weekend with relatives she does not see very often. Her family is very excited and has made a number of plans for the visit.

Pilots can perform risk management by using the TEAM choice list:

Pilot

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

- Transfer the risk entirely by having another pilot act as PIC.
- Eliminate the risk by canceling the trip.
- Accept the risk and fly anyway.
- Mitigate 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:

- Transfer the risk by using a different airplane.
- Eliminate the risk by canceling the trip.
- Accept the risk.
- Mitigate 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:

- Transfer the risk of VFR in these conditions by asking an instrument-rated pilot to fly the trip under IFR.
- Eliminate the risk by canceling the trip.
- Accept the risk.
- Mitigate 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:

- Transfer the risk by having her co-pilot act as PIC and make the continue/divert decision.
- Eliminate the risk by canceling the trip.
- Accept the risk.
- Mitigate 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 17-8. *A real-world example of how the 3P model guides decisions on a cross-country trip.*

Pilots can perceive hazards by using the CARE checklist:

Pilot

- Consequences: Gayle's inexperience and lack of recent flight time create some risk of 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.
- Alternatives: 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.
- Reality: Accepting the reality that limited experience can create additional risk is a key part of sound risk management and mitigation.
- External 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

- Consequences: 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.
- Alternatives: Options include postponing the trip until the visibility improves, or modifying the route to avoid extended periods of time over the mountains.
- Reality: Hazy conditions and mountainous terrain clearly create risk for an inexperienced VFR-only pilot.
- External 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

- Consequences: This area presents low risk because the aircraft is in excellent mechanical condition and Gayle is familiar with its avionics.
- Alternatives: 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.
- Reality: 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.
- External 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

- Consequences: Any number of factors can create 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 risk.
- Alternatives: Gayle clearly needs to develop a mitigating strategy for each of the external factors associated with this trip.
- Reality: 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.
- External Factors: (see above)

Figure 17-9. *Additional real-world examples of how the 3P model guides decisions on a cross-country trip.*

Forming Good Safety Habits

While the 3P model is similar to other methods, there are two good reasons to use the 3P model. First, the 3P model gives pilots a structured, efficient, and systematic way to identify hazards, assess risk, and implement effective risk controls. Second, practicing risk management needs to be as automatic in GA flying as basic aircraft control. As is true for other flying skills, risk management thinking habits are best developed through repetition and consistent adherence to specific procedures.

The OODA Loop

Colonel John Boyd, United States Air Forces (Retired), coined the term and developed the concept of the "OODA Loop" (Observation, Orientation, Decision, Action). The ideas, words, and phrases contained in Boyd's briefings have penetrated not only the United States military services, but the business community and worldwide academia. The OODA Loop is now used as a standard description of decision-making cycles.

The Loop is an interlaced decision model which provides immediate feedback throughout the decision-making process. For SRM purposes, an abbreviated version of the concept *[Figure 17-10]* provides an easily understood tool for the pilot.

The first node of the Loop, Observe, reflects the need for situational awareness. A pilot must be aware of those things around him or her that may impact the flight. Continuous monitoring of aircraft controls, weather, etc., provides a constant reference point by which the pilot knows his or her starting point on the loop which permits the ability to immediately move to the next step.

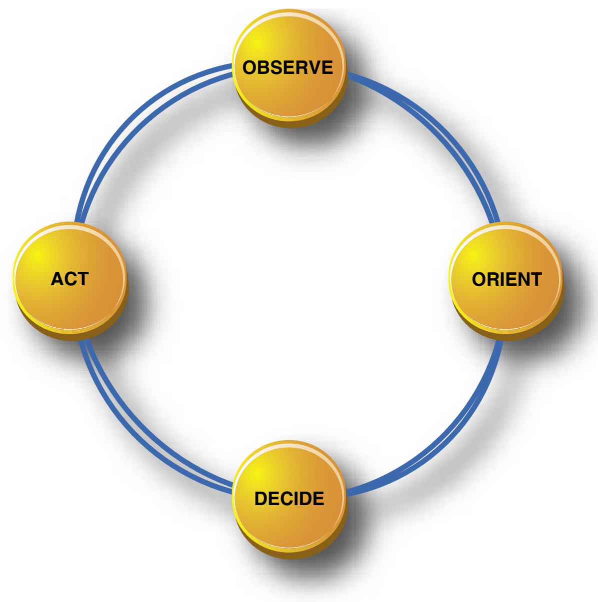


Figure 17-10. *The OODA Loop.*

Orient, the second node of the Loop, focuses the pilot's attention on one or more discrepancies in the flight. For example, there is a low oil pressure reading. The pilot is aware of this deviation and considers available options in view of potential hazards to continued flight.

The pilot then moves to the third node, Decide, in which he or she makes a positive determination about a specific effect. That decision is made based on experience and knowledge of potential results, and to take that particular action will produce the desired result. The pilot then Acts on that decision, making a physical input to cause the aircraft to react in the desired fashion.

Once the loop has been completed, the pilot is once again in the Observe position. The assessment of the resulting action is added to the previously perceived aspects of the flight to further define the flight's progress. The advantage of the OODA Loop model is that it may be cumulative, as well as having the potential of allowing for multiple progressions to occur at any given point in the flight.

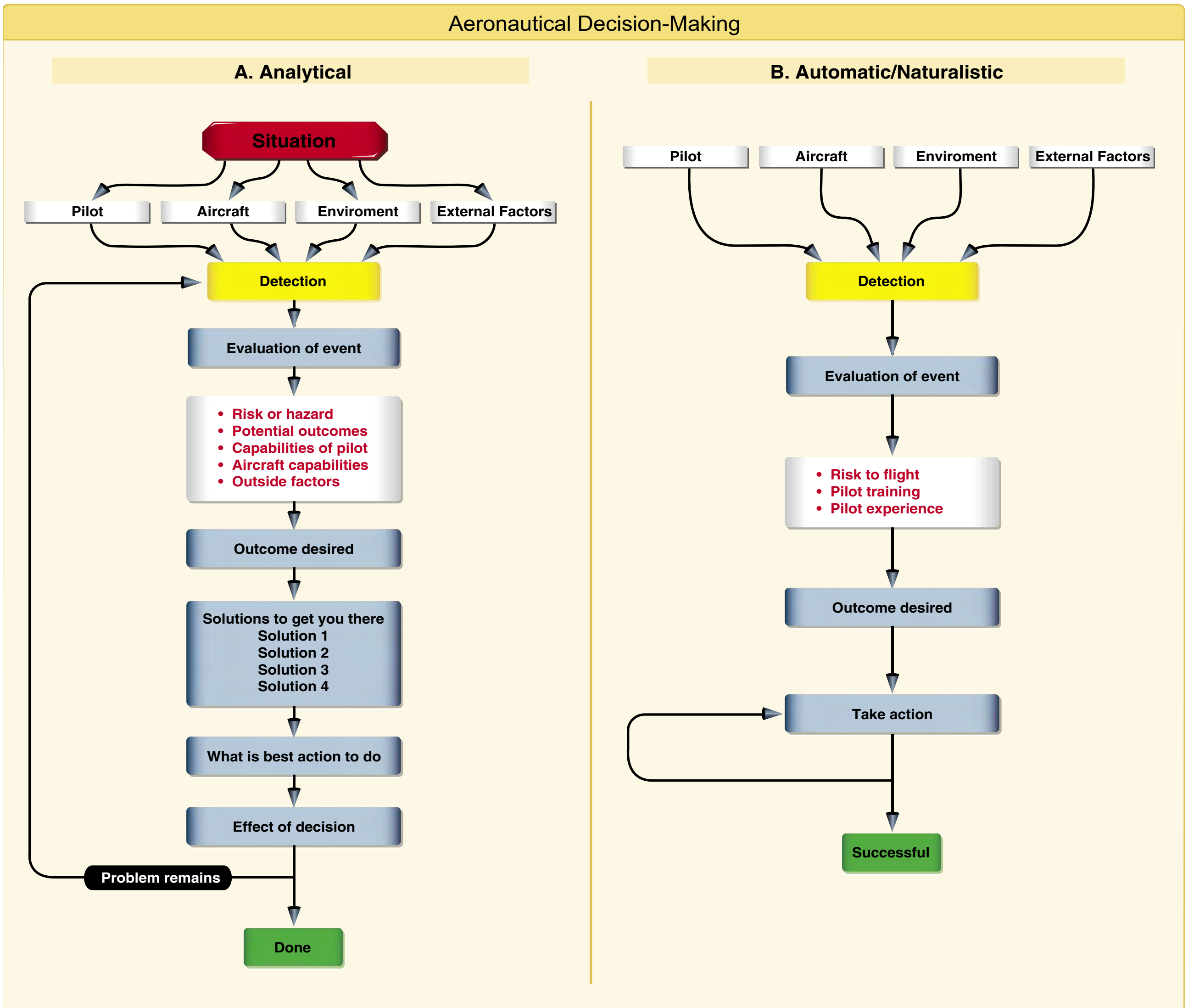
The DECIDE Model

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 17-11]* 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, bring power to maximum controllable 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 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.



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 17-11. *The DECIDE model has been recognized worldwide. Its application is illustrated in A while automatic/naturalistic decision-making is shown in B.*

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 example above, 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 air traffic control (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 will influence 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

The common approach to decision-making has been through the use of analytical models such as 5P, 3P, OODA, 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 isn't 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 17-11B]*

Automatic Decision-Making

In an emergency situation, a pilot might not survive if he or she rigorously applied analytical models to every decision made; there is not enough time to go through all the options. But under these circumstances does he or she 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 fire fighters 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 17-12.*

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 16, Aeromedical Factors.

Factors referred to as stressors can increase a pilot's risk of error in the flight deck. *[Figure 17-13]* 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 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. 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.

Operational Pitfalls
Peer Pressure Poor decision-making may be based upon an emotional response to peers, rather than evaluating a situation objectively.
Mind Set 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 17-12. *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 17-13. *System stressors. Environmental, physiological, and psychological stress are factors which affect decision-making skills. These stressors have a profound impact especially during periods of high workload.*

- 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 17-14]* 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.

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 inflight 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 inflight equipment malfunctions. However, the most valuable resource a pilot has is the ability to manage workload whether alone or with others.

External Resources

Air traffic controllers 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 17-15]* For example, if a pilot needs to level off, be given a vector, or decrease speed, ATC assists and

Figure 17-14. *When possible, have a passenger reconfirm that critical tasks are completed.*

Figure 17-15. *Controllers work to make flights as safe as possible.*

becomes integrated as part of the crew. The services provided by ATC can not only decrease pilot workload, but also help pilots make informed inflight decisions.

The FSS 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.

Another external resource available to pilots is the VHF Direction Finder (VHF/DF). This is one of the common systems that helps pilots without their being aware of its operation. FAA facilities that provide VHF/DF service are identified in the A/FD. DF equipment has long been used to locate lost aircraft and to guide aircraft to areas of good weather or to airports. DF instrument approaches may be given to aircraft in a distress or urgency condition.

Experience has shown that most emergencies requiring DF assistance involve pilots with little flight experience. With this in mind, DF approach procedures provide maximum flight stability in the approach by using small turns, and wings-level descents. The DF specialist will give the pilot headings to fly and tell the pilot when to begin descent. If followed, the headings will lead the aircraft to a predetermined point such as the DF station or an airport. To become familiar with the procedures and other benefits of DF, pilots are urged to request practice DF guidance and approaches in VFR weather conditions.

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 to properly control the aircraft.

Workload Management

Effective workload management ensures essential operations are accomplished by planning, prioritizing, and sequencing tasks to avoid work overload. *[Figure 17-16]* 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

Figure 17-16. *Balancing workloads can be a difficult task.*

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 17-17]*

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 will change. Therefore, placing a situation in the proper perspective, 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 risk begins with preparation. Here are some things a pilot can do to manage overall risk:

- 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 low IMC training, it is probably a good idea to cancel the flight.

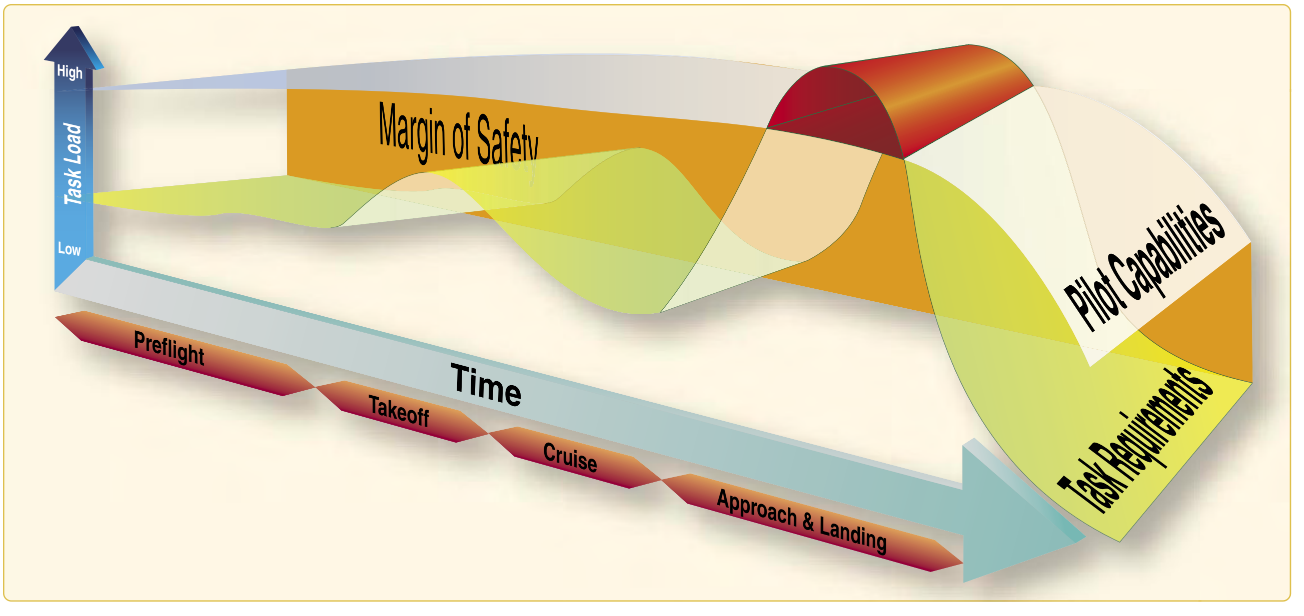


Figure 17-17. *The pilot has a certain capacity of doing work and handling tasks. However, there is a point where the tasking exceeds the pilot's capability. When this happens, tasks are either not done properly or some are not done at all.*

- 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 an advanced avionics aircraft. In an advanced avionics aircraft, there are typically two display (computer) screens, PFD (left display screen) and the MFD.

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 17-18]*

Multifunction displays (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

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 inflight 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

Figure 17-18. *Electronic flight instrumentation comes in many systems and provides a myriad of information to the pilot.*

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.

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 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 17-19]*

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 need to 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 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.

Figure 17-19. *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.*

Equipment Use

Autopilot Systems

In a single-pilot environment, an autopilot system can greatly reduce workload. *[Figure 17-20]* 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 other risks.

Figure 17-20. *An example of an autopilot system.*

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.

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 airplane 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 electronic flight display 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 17-21]*

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.

Figure 17-21. *Examples of different platforms. Top to bottom are the Beechcraft Baron G58, Cirrus SR22, and Cirrus Entega.*

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 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 which 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 understanding 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 by the use of automation, not diminished. 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) will cause 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 electronic flight displays do not replace basic flight knowledge and skills. They are a tool for improving flight safety. Risk increases when the pilot believes the gadgets will 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 flightpath 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.