AMERICAN FLYERS

FIRC Stage 3

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Chapter 1

Safety Trends in General Aviation

The annual AOPA Air Safety Foundation's *Joseph T. Nall Report* is the nation's foremost review and analysis of general aviation (GA) safety for the preceding year. It is designed to help the aviation community, members of the media, and the public to better understand the factors involved in GA accidents.

GA is defined as all flying except for scheduled airline and military flights, and comprises the majority of aviation activity in the United States.

Statistics used in this report are based on National Transportation Safety Board (NTSB) investigations of GA accidents that occurred in 2009 involving fixed-wing aircraft with a gross weight of 12,500 pounds or less. Such airplanes account for about 90 percent of all GA aircraft.

The *Joseph T. Nall Report* analyzes accident data by cause and category, type of operation, class of aircraft, and other factors. This year's edition explores the characteristics of the different types of GA accidents, with closest attention to those that account for the largest numbers of accidents and fatalities.

The total number of GA accidents is relatively low, but remains significantly higher than the airlines. This is due, in part, to more diverse levels of pilot experience and training, a less restrictive regulatory structure, different aircraft capabilities, and the more challenging operating environment of GA.

Accident Analysis

Non-commercial fixed-wing flight activity continued to decline in 2009. A decrease of almost 10% from 2008 more than accounted for the 5% drop in the number of accidents, while the number of fatal accidents actually increased by 10 (4%). Non-commercial fixed-wing flights accounted for 75% of all GA flight time (Figure 2) but 83% of all GA accidents, 91% of fatal accidents, and 89% of individual fatalities. The reductions in the numbers of fatal accidents in other types of operations that occurred during 2008 were maintained in 2009, leaving non-commercial fixed-wing flights to account for a historically disproportionate share. While the total of 1,181 accidents was the lowest in more than 30 years, the accident rate of 6.60 per 100,000 hours was the second highest of the past decade, and not significantly lower than the 2005 estimate of 6.64. The 233 fatal accidents were 10 more than in 2008, and the number of deaths increased by seven to 401.

Accident Trends

2009 saw the lowest overall number of accidents and second-smallest number of fatal accidents in the past decade, *but once again this was primarily due to decreased flight activity; the accident and fatal accident rates were near the upper ends of their recent ranges*. The fluctuations from the previous year in both the overall and fatal accident rates were again within the margin of error of the estimates of flight time. The proportions attributed to mechanical and pilot-related causes, respectively, are typical of patterns that have been observed for many years.

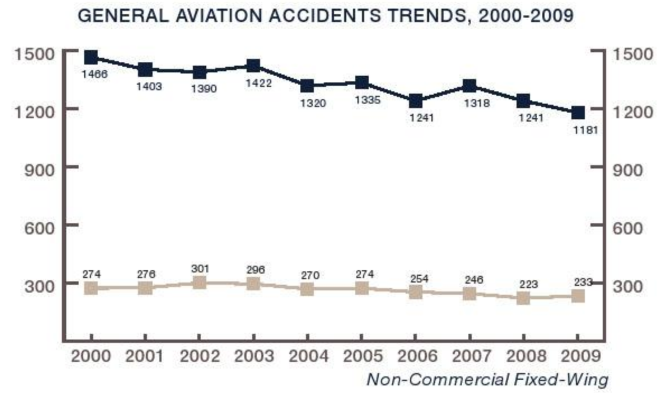

Figure 1 - 2010 Nall Report

Type of Operation

Once again, the vast majority (78%) of accidents occurred during personal flights (Figure 9), although personal flying made up less than 47% of all non-commercial flight time. These included 84% of all fatal accidents and caused 86% of individual fatalities. Instructional flights, on the other hand, occupied 16% of flight time and were involved in 13% of accidents, but only 9% of instructional accidents were fatal compared to 20% of accidents on other types of flights. This likely reflects both the tightly structured environment of flight training and the relatively low weight and speed of most primary training aircraft. Instructional flights also spend a high percentage of time in the traffic pattern, the site of a large number of minor accidents during takeoffs and landings. Corporate transport by professionally operated flight departments continued to have the best safety record in general aviation, with just two accidents, neither of them fatal, in more than 2.3 million hours flown. Business travel flown by people not primarily employed as pilots also fared well, accounting for 13% of overall flight time but just 4% of both fatal and non-fatal accidents. These results follow the pattern consistently reported in previous years, though the proportion of accidents that occurred on personal flights was the highest of the past decade.

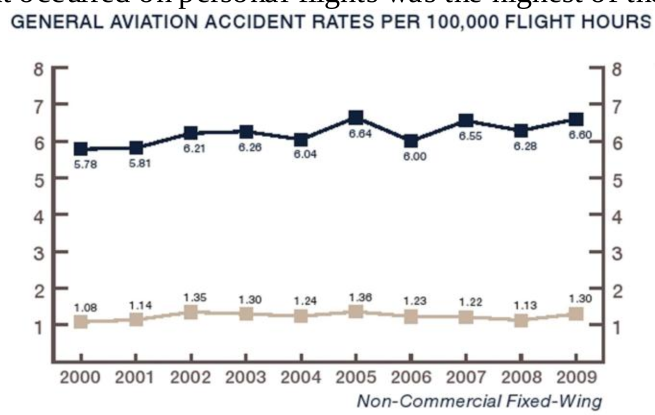

Figure 2 - 2010 Nall Report

Aircraft Class

Another way to study GA accidents is to analyze the classes of aircraft involved. This report studies three classes of fixed-wing GA airplanes: single-engine fixed-gear (SEF), single-engine retractable-gear (SER), and multiengine (ME). These classes are useful because they allow pilots to study safety issues for the type of aircraft they operate.

As in prior years, about three-quarters of the accident aircraft were single engine fixed-gear (SEF). These were underrepresented among fatal accidents, accounting for 64% (Figure 8). Increasing aircraft speed and complexity were associated with fewer mishaps relative to the amount of time flown but more severe outcomes, with lethality increasing from 17% in fixed-gear singles to 27% in retractable singles and 31%

in multiengine aircraft; these figures are similar to those reported in earlier years. Almost half (45%) of the fixed gear singles had conventional landing gear (tailwheels), consistent with the greater proficiency demanded by conventional-gear aircraft that motivates the specific requirement for a tailwheel endorsement. Unlike in 2008, however, there was essentially no difference in SEF accident lethality between taildraggers and airplanes with tricycle gear.

AIRCRAFT CLASS: NON-COMMERCIAL FIXED-WING

Aircraft Class	Accidents	Fatal Accidents	Lethality
Single-engine fixed-gear	888 75%	152 64%	17%
SEF conventional gear	403	63	16%
Single-engine retractable	230 19%	62 26%	27%
Single-engine turbine	19	7	37%
Multiengine	72 6%	22 9%	31%
Multiengine turbine	17	4	24%

Figure 3 - 2010 Nall Report

Accident Causes

For analytical purposes, it's helpful to divide the causes of GA accidents into three groups:

- **Mechanical/maintenance -** accidents arising from mechanical failure of a component or an error in maintenance.
- **Other/unknown -** accidents such as pilot incapacitation and those for which a specific cause could not be determined.
- **Pilot-related -** accidents arising from improper actions or inactions of the pilot.

Mechanical/Maintenance

219 total/19 fatal

When properly maintained, general aviation aircraft are very reliable. It is unusual for a part to fail without warning, especially if the aircraft is being properly cared for. Pilots, owners, and maintenance technicians share responsibility for airworthiness.

Malfunctions causing accidents in 2007 were very similar to those the previous year. Engine and propeller malfunctions accounted for 39.7 percent (87) of the total, with landing gear/brake and fuel system defects representing 27.4 percent (60) and 20.5 percent (45), respectively.

Over the past ten years, the proportion of accidents due to mechanical/maintenance causes has remained fairly constant even as the fleet continues to age, with the average age of a GA aircraft passing 30 years (Figure 4).

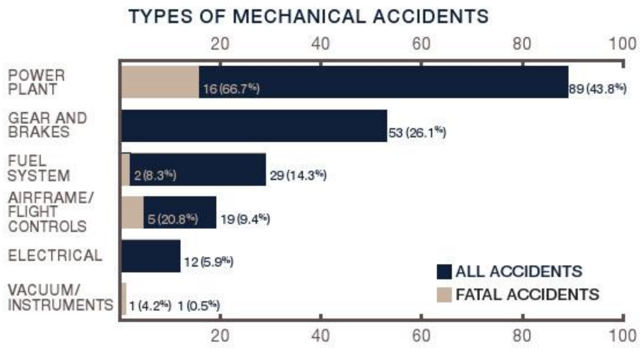

Figure 4 - 2010 Nall Report

Other, Unknown, or Not Yet Determined

149 total / 62 fatal

Almost 13% of 2009's non-commercial fixed-wing accidents (149 of 1,181) could not be clearly ascribed to either mechanical or pilot-related causes, and 42% of these were fatal. In 25 of the 62 fatal accidents, too little information was available at the time of publication to make even preliminary attributions of their causes. More time is typically required to investigate fatal accidents, and 18 out of the 25 occurred in the second half of the year. Five non-fatal accidents also remained unclassified at the time of publication. Just under half of the accidents in the "other or unknown" category (70 of 149) arose from the sudden loss of engine power for reasons that could not be reconstructed afterward: adequate fuel was present and investigators found no evidence of pre-accident discrepancies. Those engines that remained reasonably intact were typically test-run successfully during the investigations, and the pilots involved did not admit making any operational errors. While some may have resulted from carburetor icing or other avoidable hazards, none could be conclusively identified. Twenty-five of these (36%) occurred in amateur-built aircraft, including four of the seven that were fatal, even greater than their share of identified mechanical accidents. As noted earlier, amateur built airplanes were involved in 28% of all non-commercial fixed-wing accidents attributed to mechanical failures, including 13 of the 24 that were fatal, while making up 15% of the fleet and accounting for a little over 6% of flight time.

The remaining 49, 30 of which were fatal, included such rare events as midair collisions, bird and wildlife strikes, pilot death or incapacitation, and injuries caused to airport ground crews.

Midair Collisions
15 total / 7 fatal

Non-commercial fixed-wing aircraft were involved in nine midair collisions in 2009. These included all seven fatal collisions, which resulted in a total of 19 deaths. Three fatal midairs were collisions with other categories of aircraft: the Hudson River tour helicopter, a glider hit by a tow plane, and a powered parachute struck by an unregistered homebuilt. There were also non-fatal collisions between a North American T-6 and a Robinson R22 helicopter and between a Cessna 182 and a Mooney M20; both occurred in airport traffic patterns.

The only other midair in 2009 involved two crop-dusters attempting to land on the same runway. Neither was equipped with a radio. For the second straight year, there was a fatal midair between two airplanes on instructional flights. In this case, a Cessna 152 and a Piper PA-28-161 collided while both were conducting simulated instrument approaches in Arizona. The pilot flying the Cessna was ejected from the airplane during an uncontrolled descent. The fatal collision over Long Beach, California also involved an instructional flight, in this case VFR airwork in a Cessna 172 that collided with a Cessna 310 on a cross-country flight. The other airplanes involved in midairs were all on personal flights, though the R22 was being used for dual instruction and the Eurocopter AS350 hit over the Hudson River was conducting a commercial air tour.

No serious injuries resulted from any of the five on-ground collisions. Four were between taxiing airplanes and one was on a runway, where a Pitts landed on top of a Cessna 172.

Alcohol and Drugs
4 total / 2 fatal

Accidents due to the pilot's impairment by alcohol or other drugs have historically been very rare, and this was the case again in 2009. Only four were attributed to this cause, all on non-commercial fixed-wing flights. Two of the pilots and one passenger were killed and a third pilot was seriously injured, but no one on the ground was hurt. The impairment of three of these pilots was attributed to alcohol, while toxicological evidence of recent marijuana use was cited in the otherwise unexplained loss of control that killed the solo pilot of a Cessna 172.

Pilot Incapacitation
2 total / 2 fatal

Physical incapacitation of pilots is also extremely rare. Only two accidents in 2009 were attributed to physical incapacitation, and both involved apparent hypoxia in unpressurized piston singles operated at high altitudes. The pilot of a Cirrus SR22 lost consciousness at FL 250 after neglecting to have his oxygen system refilled; the airplane held a steady course on autopilot until its fuel was exhausted. The pilot of a Mooney M20M also became unresponsive at FL 250; the airplane passed directly over its destination airport and continued on the same heading until it entered an uncontrolled descent. At this writing, a finding of probable cause has not yet been released for either accident.

Ground Injuries: Off-Airport
1 accident / 1 ground fatality

Only one accident in 2009 caused any serious injury to an uninvolved person on the ground. A Cessna 310 crashed into a house shortly after takeoff, killing both the pilot and one person inside the building.

On-Airport Ground Injuries
4 accidents / 1 fatal

Four accidents caused two deaths and three serious injuries to people on airport grounds. A Piper PA-18 struck a Jeep during an intentional low pass, killing both people in the vehicle. The pilot and the driver had rehearsed this maneuver before. A photographer was struck by the light-sport airplane whose takeoff he was filming, a skydiver's parachute was severed by the Twin Otter jump plane as it returned to land, and a loader suffered a prop strike while cleaning a Piper PA-25 after a crop-dusting run. The engine had been left running as it cooled.

Propeller and Rotor Strike Injuries
3 total / none fatal

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In addition to the ground crewman mentioned above, two pilots were hit by airplane propellers in 2009. All three survived. One of the pilots was attempting to hand-prop a seaplane, while the other was trying to help a passenger apply the brakes after the pilot jump-started the engine.

Pilot-Related Accidents

829 total / 147 fatal

Pilot-related categories made up 70% of non-commercial fixed-wing accidents in 2009 and 63% of fatal accidents. These are slightly lower than the aggregate figures for the previous nine years: 75% of all non-commercial fixed-wing accidents and 80% of fatal accidents between 2000 and 2008 were classified as pilot-related.

While the number of pilot-related accidents has tended to decline in recent years, this mirrors the overall decline in the number of non-commercial fixed-wing accidents, which is largely attributable to decreasing flight activity. The rate of pilot-related accidents has remained essentially constant over the same period, fluctuating between 4.3 and 5.2 per 100,000 flight hours. The rate of 4.63 in 2009 is typical of the past decade, though the rate of fatal pilot-related accidents has declined for four consecutive years. The stability of the pilot-related accident rate suggests that an increasing number of mechanical accidents rather than any improvement in this area is the principal reason a smaller percentage of 2009's accidents were found to be pilot-related.

The number of accidents in each major category is shown in Figure 14. As always, bad landings damaged the most airplanes but were almost never fatal; weather and maneuvering accidents were much less common, but almost 60% were deadly.

The "Other" category of pilot-related accidents includes a wide variety of accident types that accounted for relatively few events apiece. Among them were:

• 25 accidents attributed to inadequate preflight inspections; three were fatal

• 25 accidents, five of them fatal, during attempted go-arounds

• Ten midair collisions of which seven were fatal; five were between two airplanes flown non-commercially, two involved an airplane and a helicopter, and one each involved collisions between a non-commercial airplane and a commercial airplane, a glider, and a powered parachute

• Four accidents, two of them fatal, were blamed on impairment of the pilots by alcohol or drugs

• Four non-fatal collisions with other aircraft while taxiing, and another 20 non-fatal taxi accidents that did not involve other aircraft

• Four fatal accidents in cruise flight; one appeared to be controlled flight into terrain while the other three involved in-flight losses of control

• Two fatal accidents in which the pilots appear to have been incapacitated by hypoxia

• Two non-fatal prop strikes, and one collision with Canada geese during the landing roll

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While the judgment leading to any pilot-related accident could be called into question, fuel-management and weather accidents can be seen primarily as failures of flight planning and in-flight decision-making. Accidents occurring during takeoff and climb, maneuvering, descent and approach, and landing tend to result more directly from deficient airmanship, though it may have been faulty decision making that placed the pilots in situations beyond their skills.

Weather

42 total / 26 fatal

Bad weather caused fewer accidents in 2009, both in absolute numbers and as a percentage of the overall accident record, and a smaller proportion were fatal (Figure 5). The 42 weather accidents represent a 21% decrease from 2008, when there were 53 – itself the lowest count of the preceding decade. The 26 fatal weather accidents constituted 11% of 2009's fatal accidents, one-third less than the average of 16% seen between 2000 and 2008. The 62% lethality of weather accidents was still the highest of any major category, but less than two thirds for the first time, and well below the overall 75% during the preceding nine years. *This is the first meaningful improvement in the weather accident record of the past decade; compared to the peak year of 2004, the number of accidents was more than one-third lower, and the number of fatal accidents decreased by more than half.*

The most common type of weather accident, and one of the most consistently fatal, continues to be the attempt to fly by visual references in instrument meteorological conditions, often called "VFR into IMC". There were 14 VFR-into-IMC accidents in 2009, of which 12 (86%) were fatal. The same lethality was seen in thunderstorm encounters, where six out of seven were fatal, as were all seven attributed to deficient execution of instrument procedures by appropriately rated pilots on instrument flight plans. However, the number of VFR-into-IMC accidents was still one-third lower than a year earlier, when there were 21 (with 18 fatal).

There were 10 icing accidents, about the same as the year before, but nine of these aircraft escaped without fatalities. Only four accidents were attributed to turbulence outside thunderstorm encounters, and everyone on board survived.

The proportion of weather accidents involving multiengine and retractable gear airplanes was only 22%, barely half the 40% seen in 2008. It is not clear whether this reflects improvement in the record of higher end aircraft or a shift of use to simpler and less expensive airplanes, perhaps in reaction to economic conditions. Five of the 42 accident aircraft were amateur-built, including four of the 26 involved in fatal accidents.

Weather was above VFR minimums at 43% (18) of the accident sites, including five where the accident chain began in instrument conditions (Figure 21). These included only 19% of the fatal accidents. Twenty-one of 24 accidents in IMC were fatal (88%). Two-thirds of the pilots involved (69%) held private certificates (Figure 22), a somewhat higher proportion than of accident pilots in general, but more than half of all the pilots in weather accidents were instrument-rated. For the third consecutive year, no student pilots suffered weather accidents.

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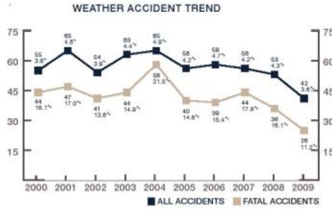

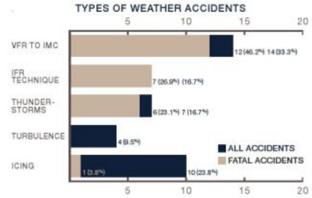

AIRCRAFT INVOLVED IN WEATHER ACCIDENTS: NON-COMMERCIAL FIXED-WING

Aircraft Class	Accidents	Fatal Accidents	Lethality
Single-engine fixed-gear	33 79%	19 73%	58%
SEF conventional gear	11	5	45%
Single-engine retractable	7 17%	5 19%	71%
Multiengine	2 5%	2 8%	100%

Figure 5 - 2010 Nall Report

Flight Planning & Decision Making Fuel Management

74 total / 8 fatal

After declining steadily over the previous ten years, the number of fuel-management accidents leveled off in 2009; the 74 total and eight fatal accidents were just about the same as in 2008. However, fuel management remains one of the brighter points in the GA record. The number of fuel-management accidents has dropped by more than half since 1999, and they now represent about 6% of all non-commercial fixed-wing accidents compared to 10% a decade earlier. Technological improvements involving fuel-flow computers and glass cockpits as well as increased pilot awareness have both contributed to this encouraging trend.

Deficient flight planning – failures to determine the fuel requirements for the intended flights, to verify the quantity of fuel on board, or to make timely decisions to divert for fuel in the face of changing circumstances –remained the most common cause of fuel-management accidents, causing 54% of the total and five of eight fatal accidents. Forty-two percent, including the three remaining fatal accidents, were traced to errors in fuel system management, typically the failure to select a tank with usable fuel or the inappropriate use of boost or transfer pumps. Only three nonfatal accidents were blamed on fuel contamination, all by water.

Single-engine airplanes with retractable gear were involved in 34% of 2009's fuel-management accidents but made up only 19% of the accident fleet overall. This is not surprising, since these aircraft fly cross-country to a much higher degree than light fixed-gear singles. Only one occurred in IMC, while 85% took place in visual meteorological conditions in daylight. Private pilots commanded 65% of the accident flights, including five of the eight that were fatal. For the second straight year, there were no fuel-management accidents on student solos.

High-Risk Phases of Flight Takeoff and Climb

153 total / 25 fatal

It is possible that many pilots underestimate the risks inherent in the takeoff phase, when aircraft are operating at high power settings and angles of attack while accelerating close to the ground. Takeoffs consistently see the second highest number of accidents and cause more than 10% of those that are fatal. After five years of modest decline, the number of takeoff and climb accidents jumped to its highest level since 2003, though the number of fatal takeoff and climb accidents was the second-lowest of the decade. The proportion of accidents occurring during takeoff and initial climb increased from 11% in 2008 to 13% in 2009, but as a proportion of fatal accidents they actually decreased slightly.

Loss of aircraft control remains the most common cause of takeoff accidents, accounting for 67, or 44% of the total (Figure 6). The deadliest type of takeoff accident was the departure stall, involved in 27% overall (41 of 153) but 60% of fatal accidents (15 of 25). Eighteen accidents, none fatal, were caused by attempts to take off from runways that were slick, contaminated, or unsuitable for reasons of length, slope, or prevailing winds. Eight (including two fatal) were attributed to overweight aircraft and/or high density altitudes, while the 18 "other" accidents included collisions with vehicles, animals, and other unexpected obstructions, errors in the use of carburetor heat, and overruns due to delayed decisions to abort the takeoff.

Takeoff accidents followed the overall patterns of non-commercial fixed-wing aircraft in terms of the classes of aircraft involved except perhaps for a greater increase in lethality among retractable-gear and multiengine aircraft. Again, this is consistent with the greater impact forces created by heavier weights and greater speed. Every one took place in VMC, and 96% took place during daylight hours, including 23 of 25 (92%) of the fatal accidents. The certificate

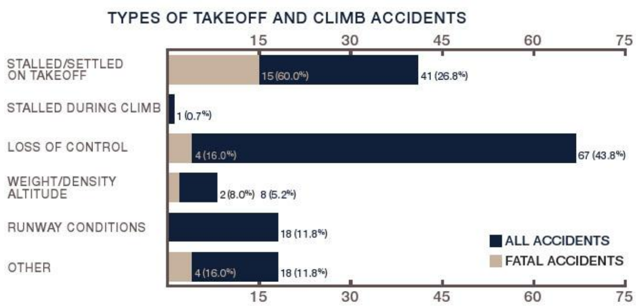

Figure 6 - 2010 Nall Report

Maneuvering

67 total / 39 fatal

While a higher proportion of weather accidents are fatal, more fatal accidents occur in maneuvering flight than any other pilot-related category, a pattern that continued to hold in 2009. Thirty-nine of 67 were fatal (58%), a decrease from 66% the year before but toward the middle of the range for the preceding decade. Some of the accident maneuvers (such as turns in the airport traffic pattern) were necessary but poorly executed. Others were risky activities like buzzing attempts, low-altitude night flights, or attempted aerobatics by untrained pilots and/or in unapproved aircraft. Most were initiated at low altitudes, giving the pilots little time or room to respond if anything went wrong.

More than half (35 of 67) began with stalls or other losses of aircraft control at altitudes too low to allow recovery (Figure 7). This indicates that these accidents were more tied to poor judgment than lack of knowledge or skill, and three-quarters of them were fatal. Collisions with wires, structures, or other obstacles caused 25 of the remaining 32, but in 17 of them everyone on board survived. On the other hand, three of the four aerobatic accidents and two of the three canyon impacts proved fatal.

Most maneuvering accidents happened in fixed-gear singles, and more than half of those had conventional landing gear. Six multiengine airplanes were involved, and half of those accidents were fatal along with eight out of nine in single-engine retractables.

All but one took place in VMC, and only two were at night; 96% occurred in VMC during daylight hours. Commercial or airline transport pilots flew 48% of the accident aircraft, a proportion one third higher than among accident pilots overall. Unlike 2008, only one of the accident aircraft was flown by an unlicensed pilot. Nineteen flights, 28% of the total, had at least one CFI on board, but only nine of these accidents occurred on instructional flights.

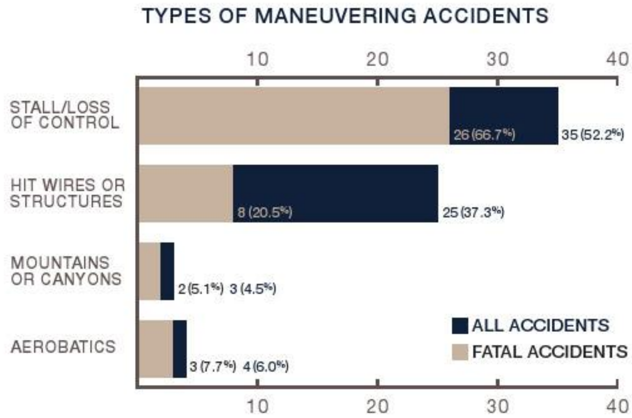

Figure 7 - 2010 Nall Report

Descent/Approach

48 total / 19 fatal

The number of descent and approach accidents also decreased in 2009, both in absolute numbers and as proportions of both fatal and non-fatal accidents, reaching the lowest levels of the past decade. These are defined as accidents occurring between the end of the en route phase of flight and either entry to the airport traffic pattern (if VFR) or the missed approach point or decision height of an instrument approach procedure on instrument flights. Their 40% lethality was likewise more than one-fifth lower than in recent years; it averaged 51% between 2000 and 2008. The 49 resulting fatalities represent a 13% decrease from 56 the year before.

Figure 8 shows that the largest number of these were caused by either stalls or collisions with obstacles or terrain (20 each). Stall/spin accidents caused 29 of the 49 individual casualties (59%), and 15 others died in collisions. The most consistently lethal category was improperly executed instrument approaches, usually involving descents below the published minimum altitude for a segment or descents below the minimum descent altitude or decision height without the required visual references. Three out of four were fatal, causing five deaths. However, four accidents of this type marked a two-thirds reduction from the 12 (all fatal) that occurred in 2008.

The classes of aircraft involved resemble the overall accident distribution, but accident lethality was sharply higher in retractable-gear singles and multiengine airplanes. Higher approach speeds and greater mass contribute to more violent impacts.

More than one-third of descent/ approach accidents (35%) happened at night and/or in IMC, and 11 of 17 (65%) were fatal compared to 26% of accidents in daytime VMC. Sport pilots were involved in just two non-fatal accidents (Figure 34). At all higher certificate levels, about 40% of descent/approach accidents were fatal.

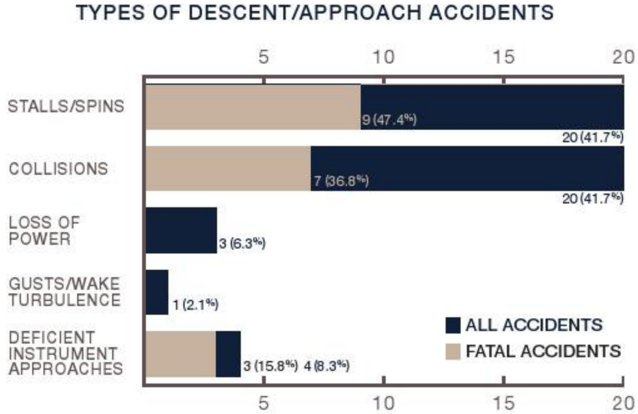

Figure 8 - 2010 Nall Report

Landing

348 total / 6 fatal

The largest number of accidents consistently occur during the landing phase, but these produce almost no fatalities. The number of landing accidents in 2009 decreased by 65 from the 2008 total of 413; this was more than the total decrease of 60 in all non-commercial fixed wing accidents. Landing accidents made up the smallest proportion of all accidents since 2003, the last time they accounted for less than 30%. The number of fatal accidents increased from four to six, still less than 3% of all fatal accidents, and the lethality of landing accidents remained below 2%. The low lethality of landing accidents is usually attributed to the low and decreasing speed of the aircraft and the fact that positive control is generally maintained until very close to the initial point of impact. Being on, or at least close to, the runway usually eliminates most obstacles.

The types of landing accidents remain fairly constant as well (Figure 9). Losses of directional control accounted for more than half (56%), and more than one-third of those were blamed at least in part on wind conditions, most often gusts and crosswinds (or, perhaps more appropriately, the pilot's inability to handle prevailing winds). Stalls (17%), hard landings (7%), and runway conditions (7%) made up almost another third. Eighteen long landings resulted in overruns, and only 13 accidents were caused by errors in operating retractable gear systems. However, the majority of gear-up landings are not considered accidents under the definition set forth in 49 CFR Part 830. Only three aircraft came up short of the runway for reasons unrelated to mechanical problems or powerplant function.

Four-fifths of the accident airplanes were fixed-gear singles, and almost half of those (48%) were tailwheel models. However, half of the six fatal accidents were in multiengine airplanes or retractable-gear singles. Only three landing accidents took place in IMC, and none of those were at night. Just 19 occurred in visual conditions at night, so 94% of all landing accidents were in VMC during the daytime.

Not surprisingly, landing accidents are the only category that includes a disproportionate share of student pilots (Figure 38). Students made up almost one-sixth of the pilots who suffered landing accidents (57 of 348), more than double the share of students among accident pilots overall, and more than 60% of all accidents involving student pilots were landing mishaps. CFIs share some responsibility for this. There has not been a fatal landing accident on a fixed-wing student solo since 2001.

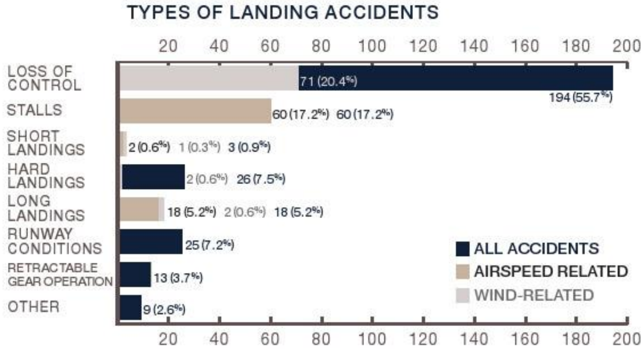

Figure 9 - 2010 Nall Report

Summary

• There were 60 fewer accidents on non-commercial fixed-wing flights than in 2008, but as a percentage the decrease was barely half the estimated reduction in flight activity. There were 10 more fatal accidents and eight more individual fatalities. The estimated total and fatal accident rates both increased, but by amounts that remain within the margins of error of the corresponding flight-time estimates.

• Accidents on non-commercial fixed wing flights continued to follow familiar patterns. More than 70% were judged to have been pilot-related. Almost one-third of all accidents occurred during landing attempts, while weather and maneuvering accidents were the most consistently lethal. Together they accounted for 28% of the fatal accidents even though just 9% of all accidents fell into those categories.

• Mechanical accidents were both more common and more lethal than in recent years, accounting for a record high 17% of all accidents. More than half the fatal mechanical accidents occurred in amateur-built airplanes.

• Personal flights accounted for less than 47% of non-commercial fixed wing flight time but led to 78% of all and 84% of fatal accidents. Not only did these make up 94% of all accidents involving private pilots, but three-fifths of those involving commercial pilots and two-thirds of those suffered by ATPs.

• Amateur-built aircraft continued to have significantly higher rates of both fatal and non-fatal accidents than comparable type-certificated aircraft, suffering particularly from greater numbers of mechanical failures and unexplained losses of engine power.

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Chapter 2

Flight Instructor's Role

One of the top priorities for instructors and the FAA is to reduce the frequency of runway incursions and the risk of a runway collision. The FAA aims to reduce the severity, number and rate of runway incursions by implementing a combination of technology, infrastructure, procedural and training interventions to decrease the prevalence of human errors and increase the error tolerance of airport surface movement operations.

One of the most critical areas is that of pilot training. That is where the flight instructor comes in. It is critically important that the flight instructor be well versed in the "mechanics" of what leads to a runway incursion, the various types of incursions that can and do take place, and the techniques that can prevent these occurrences. The instructor should be made aware of those areas of operation where pilots are failing to properly place their aircraft and to teach them to be aware of and vigilant for the "traps" that can make a pilot unaware of an unsafe condition before it happens. A well-trained instructor can then transfer that awareness to their flying students each time they get into an airplane with them.

Instructor's Role in Safety

Airport/Runway Familiarization

Any task can be made easier and safer by planning ahead. Teach your students the importance of reviewing current data for any airport they intend to use, even if they intend to only operate from a familiar facility. Information such as communication frequencies, services available, closed runways, airport construction, etc, should be collected.

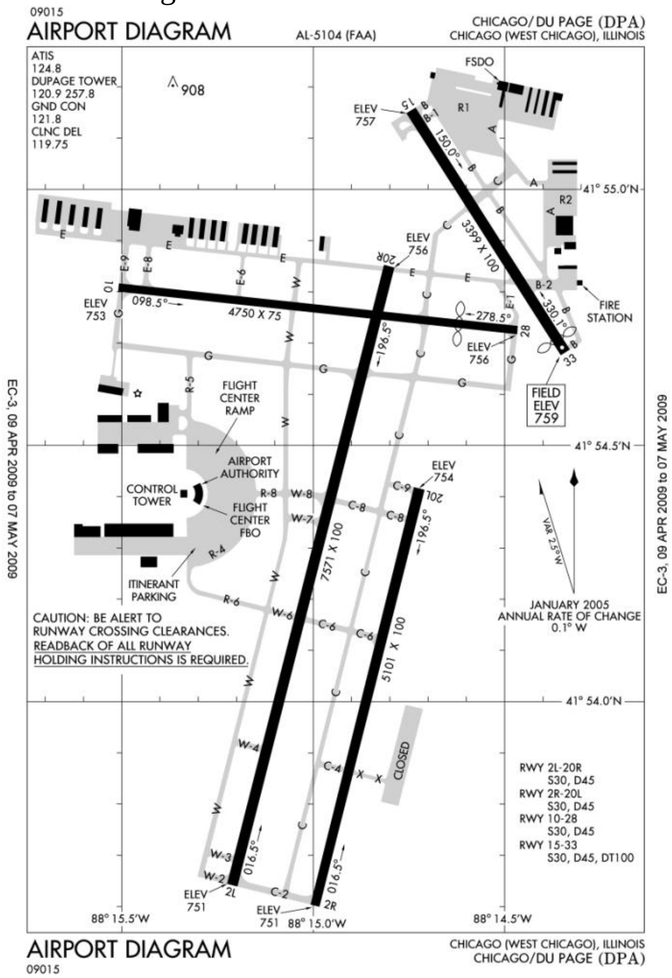
Make your students familiar with the three common sources of airport information:

- Airport Diagrams
- Airport/Facility Directory (A/FD)
- Notices to Airmen (NOTAMs)

Stress the importance of only using current material. Build this habit right from the beginning by discarding old charts and publications as soon as they become obsolete.

Airport Diagrams

Airport Diagrams are a resource available from NOAA, the FAA's website and several commercial vendors. Although these diagrams are normally used by instrument rated pilots, VFR pilots will also find them useful when performing surface operations. Brief your students on how to obtain and use these handy tools to maintain position and routing awareness while navigating on the airport surface. These diagrams along with a working knowledge of airport markings and signage will help prevent disorientation and blunders while taxiing.



Airport Diagram

Airport/Facility Directory (A/FD)

The Airport/Facility Directory (A/FD) provides the most comprehensive information for any given airport, heliport and seaplane base open to the public. The A/FDs are contained in seven books organized by region and revised every eight weeks. As discussed previously, it is important to use only current books.

For a complete listing of the information provided in an A/FD and how to decode that information a pilot should refer to the "Directory Legend Sample" located in the front of each A/FD.

Since these books are only revised every eight weeks, there is a good chance that even a current A/FD may not contain the latest information. Teach your student that it is vitally important to check the latest NOTAMs for possible changes that may have occurred since the last publication.

Notices to Airmen (NOTAMs)

The FAA has set into place a standardized NOTAM format for the National Notice to Airmen (NOTAM) System. NOTAM information is now classified into two categories: NOTAM (D) or distant and Flight Data Center (FDC) NOTAMs.

NOTAM (D) information is disseminated for all navigational facilities that are part of the NAS, all public use airports, seaplane bases, and heliports listed in the Airport/Facility Directory (A/FD). NOTAM (D) information now includes such data as taxiway closures, personnel and equipment near or crossing

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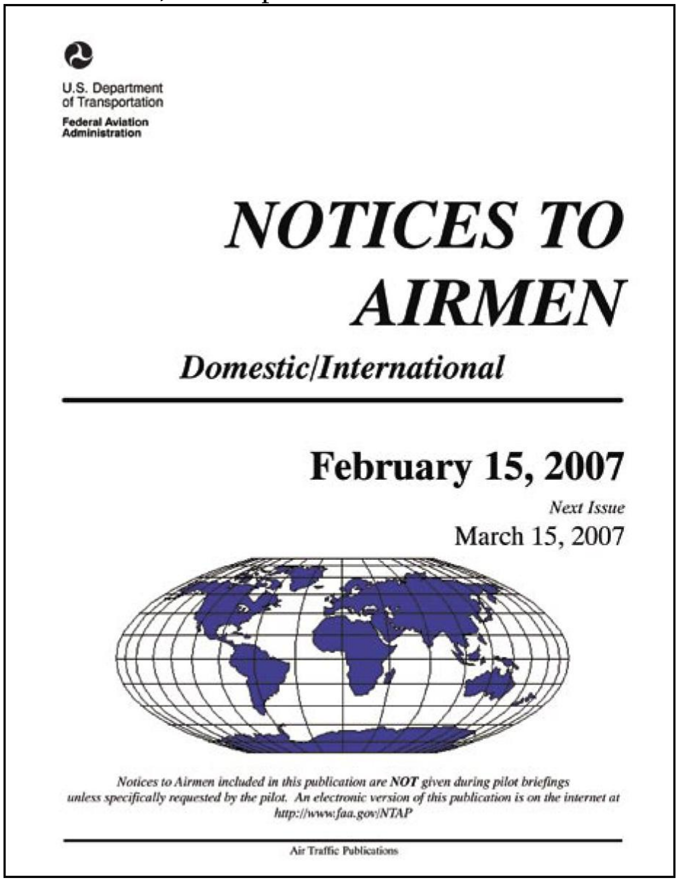
runways, and airport lighting aids that do not affect instrument approach criteria, such as visual approach slope indicator (VASI).
FDC NOTAMs contain such things as amendments to published Instrument Approach Procedures (IAPs) and other current aeronautical charts. They are also used to advertise temporary flight restrictions caused by such things as natural disasters or large-scale public events that may generate a congestion of air traffic over a site.
NOTAMs are available in printed form through subscription from the Superintendent of Documents, from an FSS, or online at The Pilot Web Site, which provides access to current NOTAM information.



Notices To Airmen Publication

Related Links:
The Pilot Website (NOTAMs): http://bit.ly/g5aR6t

Safe Surface Operations

Runway incursions can result from disorientation, which in turn can result in disaster. The FAA defines a runway incursion as: any occurrence at an airport involving an aircraft, vehicle, person, or object on the ground that creates a collision hazard or results in loss of separation with an aircraft taking off or intending to take off, landing or intending to land. Runway incursions have been increasing. Extra care and vigilance by pilots is one of the keys to reversing this trend. While the hazard exists at towered and non-towered airports alike, runway incursions are only officially recognized at airports with operating control towers.
Detailed investigations of runway incursions have identified three major areas where pilots can help:

- Communications
- Airport knowledge/planning
- Cockpit procedures for maintaining orientation

Keep Communications Clear and Concise

Effective pilot/controller communications are key to safe surface operations. Clear understanding of instructions should never be compromised, especially during busy times when the frequency is congested.

- Listen before you transmit. If able, monitor radio communications to establish a "mental picture" of airport activity.
- Think before keying your transmitter. Keep communication with the controller clear and concise.
- Never assume. Ensure you understand all instructions.
- Read back runway hold short instructions verbatim.

Be Familiar with the Airport

It sounds simple: know where you are and where you are going. In reality, ground operations can be the most demanding and complex phase of flight. As mentioned before, teach your students how to use airport diagrams to maintain positional awareness and compliance with taxi clearances, especially those with hold short instructions.

- Be alert to airport vehicle and pedestrian activity.
- Review airport diagrams before taxiing or landing.
- Use your heading indicator along with the airport/taxi diagram and airport signage to maintain orientation during ground operations.

Follow Proper Cockpit Procedures

Pilots can use proven and effective procedures in the cockpit to help conduct safe operations on the ground and during takeoff and landing.

- Maintain a sterile cockpit environment. Avoid unnecessary conversation during surface operations, take off, and landing.
- Constantly scan outside the cockpit, especially when approaching, crossing, or while on runways.
- If lost, notify Air Traffic Control immediately.
- Do not hesitate to request progressive taxi instructions if unfamiliar with the airport or your position on the airport.
- Ensure proper radio operation, check audio panel volume control and squelch settings.
- Know and follow lost communication procedures and use good judgment should radio failure occur.
- Never stop on an active runway to ask for directions after landing; clear the runway first. Once you have passed the hold position markings, stop and ask ground control for directions.

Stay Alert When Visibility is Low

Extra vigilance is required when visibility decreases and the ability of pilots and controllers to maintain a desired level of situational awareness becomes significantly more difficult. During periods of reduced visibility, pilots should keep in mind:

- Cockpit workload and distractions tend to increase.
- As cockpit activity increases, attention to communications tends to decrease.
- Fatigue level increases.
- Increased vigilance is needed when snow and other weather conditions obscure surface markings and make signs difficult to see.

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Report Confusing or Deteriorating Surface Markings and Signs

Pilots should report confusing or deteriorating surface markings, signs, and inaccurate airport diagrams to the tower or airport manager. Also, a report to the NASA Aviation Safety Reporting System (ASRS) is strongly recommended. ASRS maintains a database of reported hazards. Alert messages from ASRS are forwarded to appropriate airport authorities for action. Airport authorities are requested to provide responses to ASRS. This serves as an important check on the type of corrective actions being taken and closes the loop in the incident reporting process. To obtain ASRS forms, fax a request to NASA at or write to ASRS, 635 Ellis Street, Suite 305, Mountain View, CA 94043. The reports can now be submitted online on the ASRS website.

If your students do not have a working knowledge of airport markings and signs, even clear and well-maintained indicators will be confusing. So let's take a moment to review this important information.

Related Links:

NASA Aviation Safety Reporting System : http://1.usa.gov/e1Z4nX

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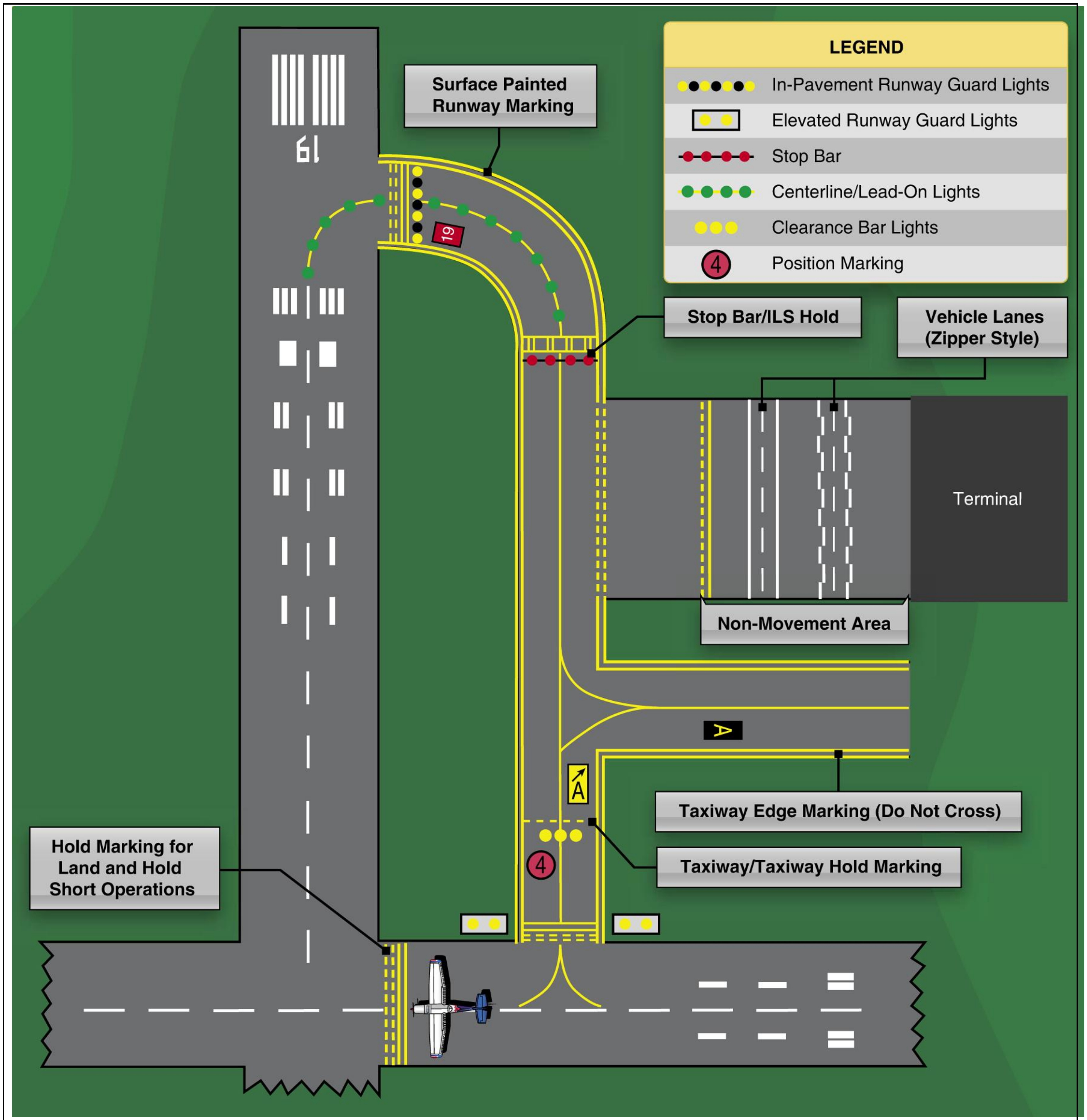
Chapter 3

Types of Airport Markings

Airport pavement markings are grouped into four areas:

- Runway Markings
- Taxiway Markings
- Holding Position Markings
- Other Markings

Markings for runways are white. Markings defining the landing area on a heliport are also white, except for hospital heliports which use a red "H" on a white cross. Markings for taxiways, areas not intended for use by aircraft, and holding positions (even if they are on a runway) are yellow.



Selected Airport Markings and Lighting

Runway Markings

Runway Centerline Marking

The runway centerline identifies the center of the runway and provides alignment guidance during takeoff and landings. The centerline consists of uniformly spaced stripes.

Runway Aiming Point Marking

The aiming point marking serves as a visual aiming point for landing aircraft. These two rectangular markings consist of a broad white stripe located on each side of the runway centerline approximately 1,000 feet from the landing threshold.

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Runway Touchdown Zone Markers

The touchdown zone markings identify the touchdown zone for landing operations and are coded to provide distance information in 500-foot increments. These markings consist of groups of one, two, and three rectangular bars symmetrically arranged in pairs about the runway centerline.

Runway Side Stripe Marking

Runway side stripes delineate the edges of the runway. They provide a visual contrast between runway and the abutting terrain or shoulders. Side stripes consist of continuous white stripes located on each side of the runway.

Runway Shoulder Markings

Runway shoulder stripes may be used to supplement runway side stripes to identify pavement areas contiguous to the runway sides that are not intended for use by aircraft. Runway Shoulder stripes are Yellow.

Runway Threshold Markings

Runway threshold markings come in two configurations. The first consists of eight longitudinal stripes of uniform dimension arranged symmetrically about the runway centerline. For the other, the number of stripes is related to the runway width. A threshold marking helps identify the beginning of the runway that is available for landing. In some instances the landing threshold may be relocated or displaced.

Relocation of a Threshold

Sometimes construction, maintenance or other activities require the threshold to be relocated toward the rollout end of the runway. When a threshold is relocated, it closes not only a portion of the approach end of a runway, but also shortens the length of the opposite direction runway. In these cases, a NOTAM should be issued by the airport operator identifying the portion of the runway that is closed, e.g., 10/28 W 900 CLSD. Because the duration of the relocation can vary from a few hours to several months, methods identifying the new threshold may vary as well. One common practice is to use a ten-foot wide white threshold bar across the width of the runway. Although the runway lights in the area between the old threshold and new threshold will not be illuminated, the runway markings in this area may or may not be obliterated, removed, or covered.

Displaced Threshold

A displaced threshold is a threshold located at a point on the runway other than the designated beginning of the runway. Displacement of a threshold reduces the length of runway available for landing. The portion of runway behind a displaced threshold is available for takeoff in either direction and landing from the opposite direction. A ten-foot wide white threshold bar is located across the width of the runway at the displaced threshold. White arrows are located along the centerline in the area between the beginning of the runway and displaced threshold. White arrow heads are located across the width of the runway just prior to the threshold bar.

Demarcation Bar

A demarcation bar delineates a runway with a displaced threshold from a blast pad, stopway or taxiway that precedes the runway. A demarcation bar is three feet wide and yellow, since it is not located on the runway.

Chevrons

These markings are used to show pavement areas aligned with the runway that are unusable for landing, takeoff, and taxiing. Chevrons are yellow.

Runway Threshold Bar

A threshold bar delineates the beginning of the runway that is available for landing when the threshold has been relocated or displaced. A threshold bar is ten feet wide and extends across the width of the runway.

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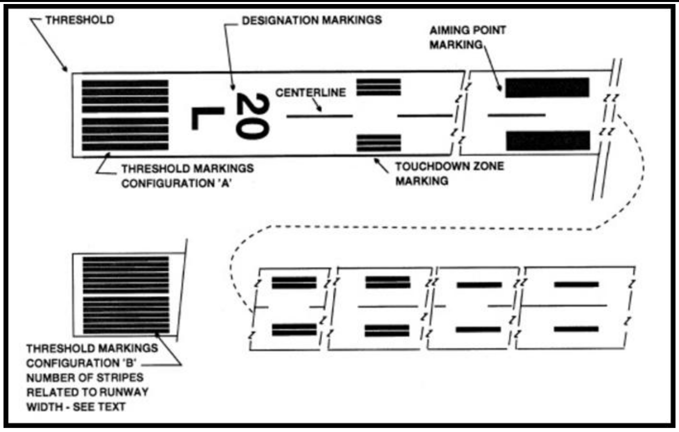
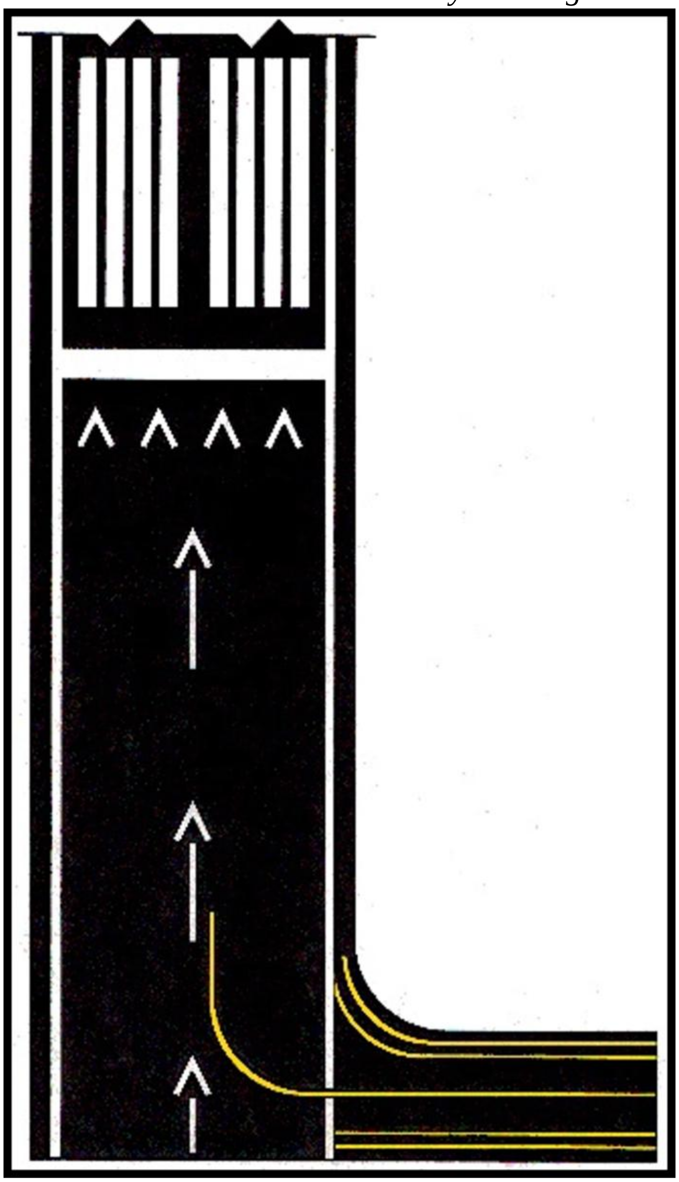
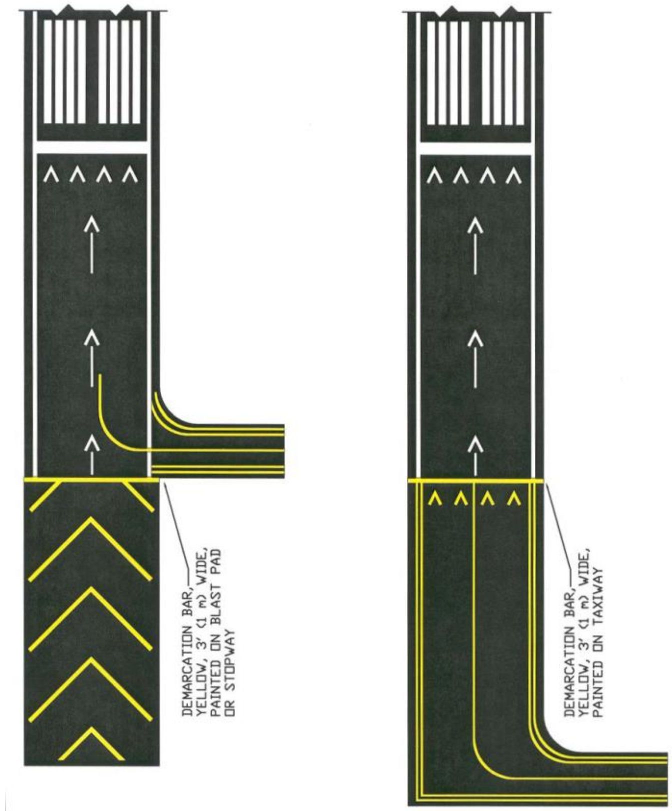


Precision Instrument Runway Markings



Displaced Threshold Markings



Displaced Threshold

Taxiway Markings

All taxiways should have centerline markings and runway holding position markings whenever they intersect a runway. Taxiway edge markings are present whenever there is a need to separate the taxiway from pavement that is not intended for aircraft use or to delineate the edge of the taxiway. Taxiways may also have shoulder markings and holding position markings for Instrument Landing System/Microwave Landing System (ILS/MLS) critical areas, and taxiway/taxiway intersection markings.

Taxiway Centerline Markings

The taxiway centerline is a single continuous yellow line, six to twelve inches in width. This provides a visual cue to permit taxiing along a designated path. The aircraft should be kept centered over this line during taxi to ensure wing-tip clearance.

Taxiway Edge Markings

Taxiway edge markings are used to define the edge of the taxiway. They are primarily used when the taxiway edge does not correspond with the edge of the pavement. There are two types of markings depending upon whether the aircraft is allowed to cross the taxiway edge:

- ***Continuous Markings:*** These consist of a continuous double yellow line, with each line being at least six inches in width spaced six inches apart. They are used to define the taxiway edge from the shoulder or some other abutting paved surface not intended for use by aircraft.
- ***Dashed Markings:*** These markings are used when there is an operational need to define the edge of a taxiway or taxilane on a paved surface where the adjoining pavement to the taxiway edge is intended for use by aircraft, e.g., an apron. Dashed taxiway edge markings consist of a broken double yellow line, with each line being at least six inches in width, spaced six inches apart (edge to edge). These lines are 15 feet in length with 25-foot gaps.

Taxiway Shoulder Markings

Taxiways, holding bays, and aprons are sometimes provided with paved shoulders to prevent blast and water erosion. Although shoulders may have the appearance of full strength pavement they are not intended for use by aircraft, and may be unable to support an aircraft. Usually the taxiway edge marking will define this area. Where conditions exist such as islands or taxiway curves that may cause confusion as to which side of the edge stripe is for use by aircraft, taxiway shoulder markings may be used to indicate the pavement is unusable. Taxiway shoulder markings are yellow.

Surface Painted Taxiway Direction Signs

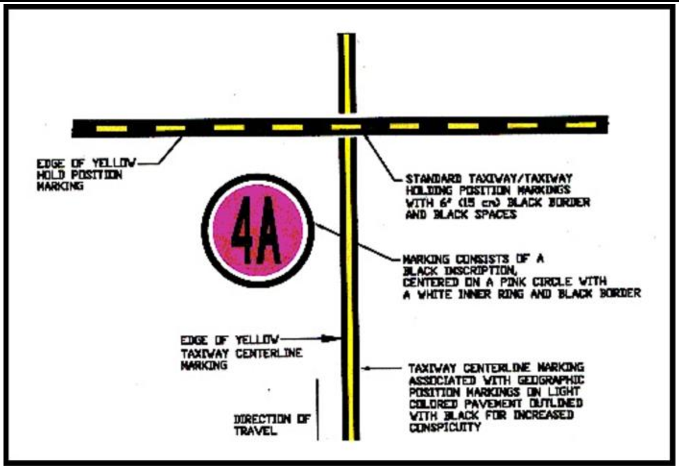
Surface painted taxiway direction signs have a yellow background with a black inscription and are provided when it is not possible to provide taxiway direction signs at intersections, or when necessary to supplement such signs. These markings are located adjacent to the centerline with signs indicating turns to the left being on the left side of the taxiway centerline and signs indicating turns to the right being on the right side of the centerline.

Surface Painted Location Signs

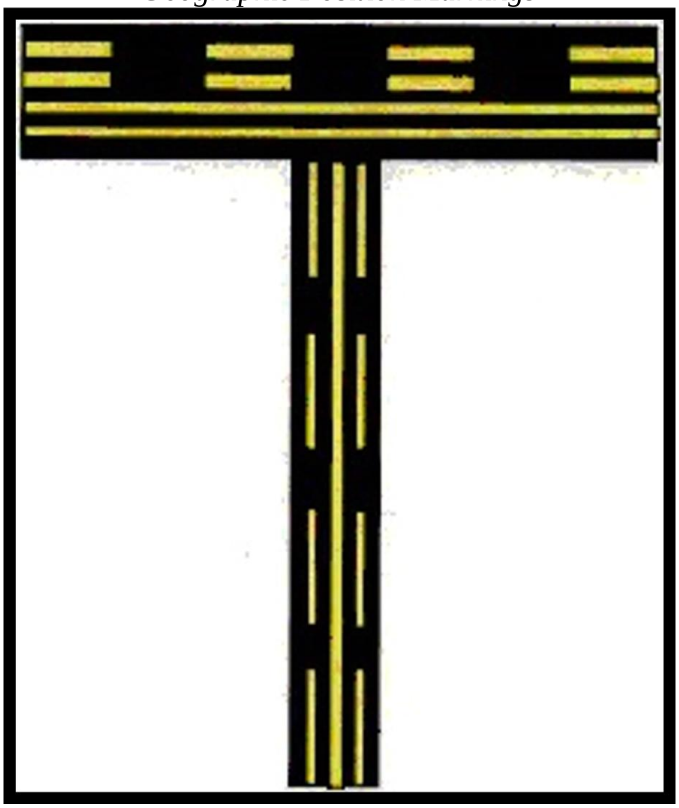
Surface painted location signs have a black background with a yellow inscription. When necessary, these markings are used to supplement location signs located along side the taxiway and assist the pilot in confirming the designation of the taxiway on which the aircraft is located. These markings are located on the right side of the centerline.

Geographic Position Markings

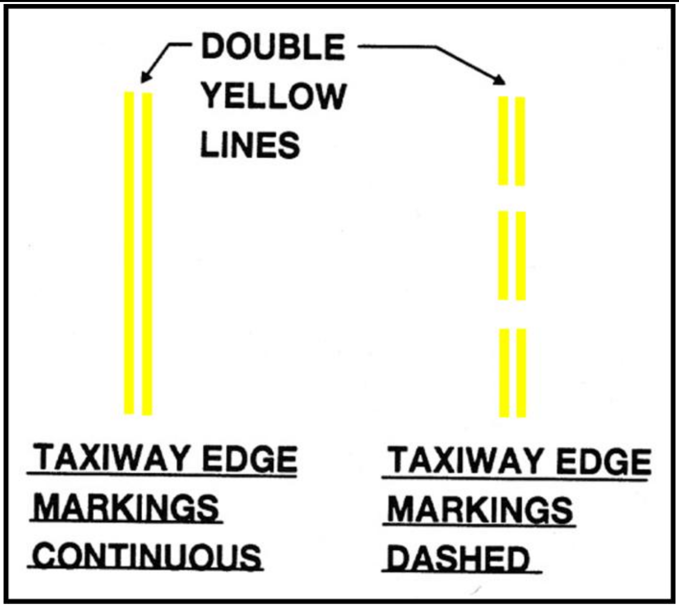
These markings are located at points along low visibility taxi routes designated in the airport's Surface Movement Guidance Control System (SMGCS) plan. They are used to identify the location of taxiing aircraft during low visibility operations. Low visibility operations are those that occur when the runway visible range (RVR) is below 1200 feet. They are positioned to the left of the taxiway centerline in the direction of taxiing. The geographic position marking is a circle comprised of a black outer ring contiguous to an inner white ring with a pink circle in the middle. When installed on asphalt or other dark-colored pavements, the white ring and the black ring are reversed, i.e., the white ring becomes the outer ring and the black ring becomes the inner ring. It is designated with either a number or a number and letter. The number corresponds to the consecutive position of the marking on the route.



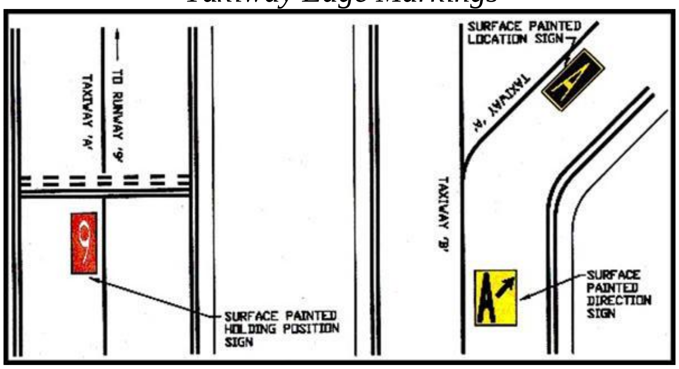
Geographic Position Markings



Enhanced Taxiway Centerline Markings



Taxiway Edge Markings



Surface Painted Signs

Holding Position Markings

Runway Holding Position Markings

Associated with runways, these markings indicate where an aircraft is supposed to stop. They consist of four yellow lines--two solid and two dashed--spaced six or twelve inches apart and extending across the width of the taxiway or runway. The solid lines are always on the side where the aircraft is to hold. There are three locations where runway holding position markings are encountered.

Runway Holding Position Markings on Taxiways

These markings identify the locations on a taxiway where an aircraft is supposed to stop when it does not have clearance to proceed onto the runway. When instructed by ATC to, "Hold short of runway x," the pilot should stop so no part of the aircraft extends beyond the holding position marking. When approaching the holding position marking, a pilot should not cross the marking without ATC clearance at a controlled airport or without making sure of adequate separation from other aircraft at uncontrolled airports. An aircraft exiting a runway is not clear of the runway until all parts of the aircraft have crossed the applicable holding position marking.

Runway Holding Position Markings on Runways

These markings are installed on runways only if the runway is normally used by air traffic control for "land and hold short" operations or taxiing operations and have operational significance only for those two types of operations. A sign with a white inscription on a red background is installed adjacent to these holding position markings. The holding position markings are placed on runways prior to the intersection with another runway, or some designated point. Pilots receiving instructions "cleared to land, runway x," from air traffic control are authorized to use the entire landing length of the runway and should disregard any holding position markings located on the runway. Pilots receiving and accepting instructions "cleared to land runway x, hold short of runway y," from air traffic control must either exit runway "x," or stop at the holding position prior to runway "y."

Taxiways Located in Runway Approach Areas

These markings are used at some airports where it is necessary to hold an aircraft on a taxiway located in the approach or departure area of a runway so that the aircraft does not interfere with the operations on that runway. This marking is collocated with the runway approach area holding position sign.

Holding Position Markings for Instrument Landing System (ILS)

Holding position markings for ILS/MLS critical areas consist of two yellow solid lines spaced two feet apart connected by pairs of solid lines spaced ten feet apart extending across the width of the taxiway as shown. A sign with an inscription in white on a red background is installed adjacent to these hold position markings. When the ILS critical area is being protected, the pilot should stop so no part of the aircraft extends beyond the holding position marking. When approaching the holding position marking, a pilot should not cross the marking without ATC clearance. ILS critical area is not clear until all parts of the aircraft have crossed the applicable holding position marking.

Holding Position Markings for Taxiway/Taxiway Intersections

Holding position markings for taxiways/taxiway intersections consist of a single dashed line extending across the width of the taxiway as shown. They are installed on taxiways where air traffic control normally holds aircraft short of a taxiway intersection. When instructed by ATC "hold short of taxiway x" the pilot should stop so no part of the aircraft extends beyond the holding position marking. When the marking is not present the pilot should stop the aircraft at a point which provides adequate clearance from an aircraft on the intersecting taxiway.

Surface Painted Holding Position Signs

Surface painted holding position signs have a red background with a white inscription and supplement the signs located at the holding position. This type of marking is normally used where the width of the holding position on the taxiway is greater than 200 feet. It is located to the left side of the taxiway centerline on the holding side and prior to the holding position marking.

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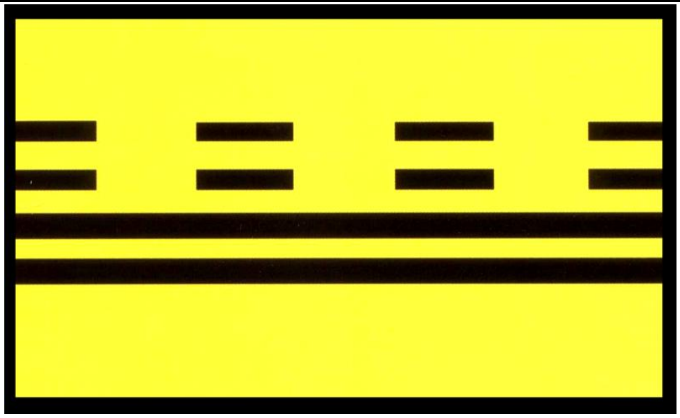
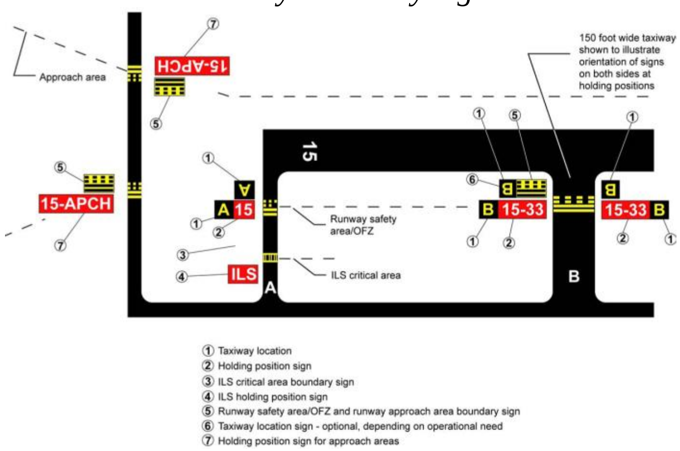


Runway Boundary Sign



Taxiway Located in Runway Approach Area

Other Markings

Vehicle Roadway Markings

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

Nonmovement Area Boundary Markings

These markings delineate the movement area, i.e., area under air traffic control. These markings are yellow and located on the boundary between the movement and nonmovement area. The nonmovement area boundary markings consist of two yellow lines (one solid and one dashed) six inches in width. The solid line is located on the nonmovement area side while the dashed yellow line is located on the movement area side.

Marking and Lighting of Permanently Closed Runways and Taxiways

For runways and taxiways which are permanently closed, the lighting circuits will be disconnected. The runway threshold, runway designation, and touchdown markings are obliterated and yellow crosses are placed at each end of the runway and at 1,000-foot intervals.

Temporarily Closed Runways and Taxiways

To provide a visual indication to pilots that a runway is temporarily closed, crosses are placed on the runway only at each end of the runway. The crosses are yellow in color.

In lieu of the markings described above, a raised and lighted yellow cross may be placed on each runway end to indicate runway closure. A visual indication may not be present depending on the reason for the closure, duration of the closure, airfield configuration and the existence and the hours of operation of an airport traffic control tower. Pilots should check NOTAMs and the Automated Terminal Information System (ATIS) for local runway and taxiway closure information. Temporarily closed taxiways are usually treated as hazardous areas in which no part of an aircraft may enter, and are blocked with barricades. However, as an alternative a yellow cross may be installed at each entrance to the taxiway.

Types of Airport Signs

There are six types of signs installed on airfields:

- Mandatory instruction signs
- Location signs
- Direction signs
- Destination signs
- Information signs
- Runway distance remaining signs

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

Airport Signs

Mandatory Instruction Signs

These signs have a red background with a white inscription and are used to denote:

- An entrance to a runway or critical area
- Areas where an aircraft is prohibited from entering

Typical mandatory signs and applications are:

Runway Holding Position Sign

This sign is located at the holding position on taxiways that intersect a runway or on runways that intersect other runways. The inscription on the sign contains the designation of the intersecting runway. The runway numbers on the sign are arranged to correspond to the respective runway thresholds. For example, "15-33" indicates that the threshold for Runway 15 is to the left and the threshold for Runway 33 is to the right.

On taxiways that intersect the beginning of the takeoff runway, only the designation of the takeoff runway may appear on the sign, while all other signs will have the designation of both runway directions.

If the sign is located on a taxiway that intersects the intersection of two runways, the designations for both runways will be shown on the sign along with arrows showing the approximate alignment of each runway. In addition to showing the approximate runway alignment, the arrow indicates the direction to the threshold of the runway whose designation is immediately next to the arrow.

A runway holding position sign on a taxiway will be installed adjacent to holding position markings on the taxiway pavement. On runways, holding position markings will be located only on the runway pavement adjacent to the sign if the runway is normally used by air traffic control for land and hold short operations or as a taxiway.

Runway Approach Area Holding Position Sign

At some airports, it is necessary to hold an aircraft on a taxiway located in the approach or departure area of a runway so that the aircraft does not interfere with operations on that runway. In these situations, a sign with the designation of the approach end of the runway followed by a dash (-) and the letters "APCH" will be located at the holding position on the taxiway.

ILS Critical Area Holding Position Sign

At some airports, when the instrument landing system is being used, it is necessary to hold an aircraft on a taxiway at another location. In these situations the holding position sign for these operations will have the inscription "ILS," and be located adjacent to the holding position marking on the taxiway.

No Entry Sign

This sign prohibits an aircraft from entering an area. Typically, this sign would be located on a taxiway intended to be used in only one direction or at the intersection of vehicle roadways with runways, taxiways or aprons where the roadway may be mistaken as a taxiway or other aircraft movement surface.

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Runway Holding Position Sign

Holding Position Sign for ILS Critical Area

Holding Position Sign for a Runway Approach Area


Sign Prohibiting Aircraft Entry Into an Area

Location Signs

Location signs are used to identify either a taxiway or runway on which the aircraft is located. Other location signs provide a visual cue to pilots to assist them in determining when they have exited an area. The various location signs are described below.

Taxiway Location Sign

This sign has a black background with a yellow inscription and yellow border. The inscription is the designation of the taxiway on which the aircraft is located. These signs are installed along taxiways either by themselves or in conjunction with direction signs or runway holding position signs.

Runway Location Sign

This sign has a black background with a yellow inscription and yellow border. The inscription is the designation of the runway on which the aircraft is located. These signs are intended to complement the information available to pilots through their magnetic compass and typically are installed where the proximity of two or more runways to one another could cause pilots to be confused as to which runway they are on.

Runway Boundary Sign

This sign has a yellow background with a black inscription with a graphic depicting the pavement holding position marking. This sign, which faces the runway and is visible to the pilot exiting the runway, is located adjacent to the holding position marking on the pavement. The sign is intended to provide pilots with another visual cue which they can use as a guide in deciding when they are clear of the runway.

ILS Critical Area Boundary Sign

This sign has a yellow background with a black inscription with a graphic depicting the ILS pavement holding position marking. This sign is located adjacent to the ILS holding position marking on the pavement and can be seen by pilots leaving the critical area. The sign is intended to provide pilots with another visual cue which they can use as a guide in deciding when they are clear of the ILS critical area.

Direction Signs

Direction signs have a yellow background with a black inscription. The inscription identifies the designation(s) of the intersecting taxiway(s) leading out of the intersection that a pilot would normally be expected to turn onto or hold short of. Each designation is accompanied by an arrow indicating the direction of the turn.

Except as noted previously, each taxiway designation shown on the sign is accompanied by only one arrow. When more than one taxiway designation is shown on the sign each designation and its associated arrow is separated from the other taxiway designations by either a vertical message divider or a taxiway location sign.

Direction signs are normally located on the left prior to the intersection. When used on a runway to indicate an exit, the sign is located on the same side of the runway as the exit.

The taxiway designations and their associated arrows on the sign are arranged clockwise starting from the first taxiway on the pilot's left.

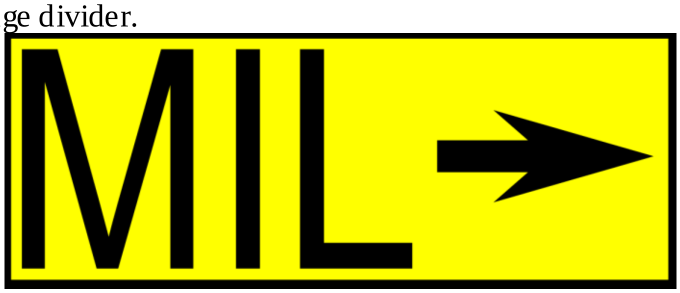
If a location sign is located with the direction signs, it is placed so that the designations for all turns to the left will be to the left of the location sign; the designations for continuing straight ahead or for all turns to the right would be located to the right of the location sign.

When the intersection is comprised of only one crossing taxiway, it is permissible to have two arrows associated with the crossing taxiway. In this case, the location sign is located to the left of the direction sign.

Direction Sign collocated with Location Sign

Destination Signs

Destination signs have a yellow background with a black inscription indicating a destination on the airport. These signs always have an arrow showing the direction of the taxiing route to that destination. When the arrow on the destination sign indicates a turn, the sign is located prior to the intersection. Destinations commonly shown on these types of signs include runways, aprons, terminals, military areas, civil aviation areas, cargo areas, international areas, and fixed base operators. An abbreviation may be used as the inscription on the sign for some of these destinations. When the inscription for two or more destinations having a common taxiing route is placed on a sign, the destinations are separated by a dot (·). When the inscription on a sign contains two or more destinations having different taxiing routes, each destination will be accompanied by an arrow and will be separated from the other destinations on the sign with a vertical black message divider.



Destination Sign for Military Area

Information Signs

Information signs have a yellow background with a black inscription. They are used to provide the pilot with information on such things as areas that cannot be seen from the control tower, applicable radio

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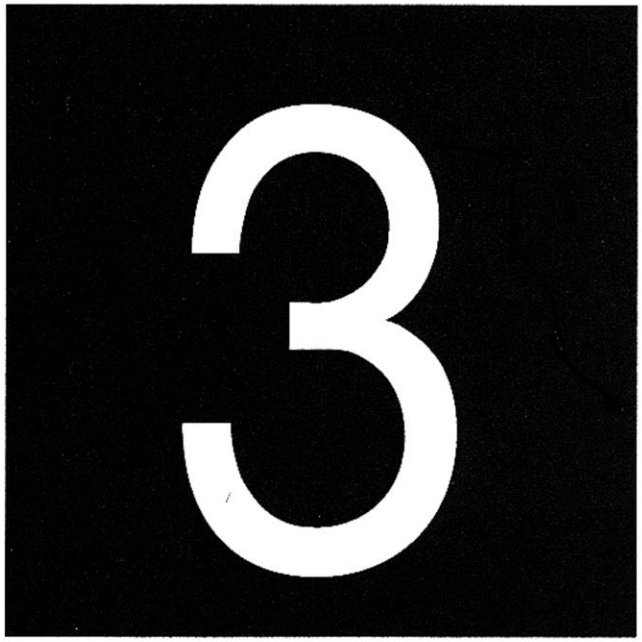
frequencies, and noise abatement procedures. The airport operator determines the need, size, and location for these signs.

Runway Distance Remaining Signs

Runway distance remaining signs have a black background with a white numeral inscription and may be installed along one or both sides of the runway. The number on the sign indicates the distance in thousands of feet of landing runway remaining. The last sign, i.e., the sign with the numeral "1," will be located at least 950 feet from the runway end.



Runway Distance Remaining Sign

Chapter 4

Pilot Responsibilities and Basic Procedures

LAHSO is an acronym for "Land and Hold Short Operations." These operations include landing and holding short of an intersecting runway, an intersecting taxiway, or some other designated point on a runway other than an intersecting runway or taxiway.

LAHSO is an air traffic control procedure that requires pilot participation to balance the needs for increased airport capacity and system efficiency consistent with safety. This procedure can be done safely provided pilots and controllers are knowledgeable and understand their responsibilities. The following paragraphs outline specific pilot/operator responsibilities when conducting LAHSO.

At controlled airports, ATC may clear a pilot to land and hold short. Pilots may accept such a clearance provided that the pilot-in-command determines that the aircraft can safely land and stop within the Available Landing Distance (ALD). ALD data are published in the special notices section of the Airport/Facility Directory (A/FD) and in the U.S. Terminal Procedures Publications. Controllers will also provide ALD data upon request. Student pilots or pilots not familiar with LAHSO should not participate in the program.

The pilot-in-command has the final authority to accept or decline any land and hold short clearance. The safety and operation of the aircraft remain the responsibility of the pilot. Pilots are expected to decline a LAHSO clearance if they determine it will compromise safety.

To conduct LAHSO, pilots should become familiar with all available information concerning LAHSO at their destination airport. Pilots should have, readily available, the published ALD and runway slope information for all LAHSO runway combinations at each airport of intended landing. Additionally, knowledge about landing performance data permits the pilot to readily determine that the ALD for the assigned runway is sufficient for safe LAHSO. As part of preflight planning, pilots should determine if their destination airport has LAHSO. If so, their planning should include an assessment of which LAHSO combinations would work for them given their aircraft's required landing distance. Good pilot decision making is knowing in advance whether one can accept a LAHSO clearance if offered.

If for any reason, such as difficulty in discerning the location of a LAHSO intersection, wind conditions or aircraft condition, the pilot elects to request to land on the full length of the runway, to land on another runway, or to decline LAHSO, a pilot is expected to promptly inform ATC--if possible even before the clearance is issued. Once accepted, a LAHSO clearance must be adhered to, unless an amended clearance is obtained or an emergency occurs. A LAHSO clearance does not preclude a rejected landing.

A pilot who accepts a LAHSO clearance should land and exit the runway at the first convenient taxiway (unless directed otherwise) before reaching the hold short point. Otherwise, the pilot must stop and hold at the hold short point. If a rejected landing becomes necessary after accepting a LAHSO clearance, the pilot should maintain safe separation from other aircraft or vehicles and should promptly notify the controller.

Controllers need a full read back of all LAHSO clearances. Pilots should read back their LAHSO clearance and include the words, "Hold short of (runway, taxiway, etc)," in their acknowledgment of all LAHSO clearances. In order to reduce frequency congestion, pilots are encouraged to read back the LAHSO clearance without prompting. Do not make the controller have to ask for a read back.

Situational awareness is vital to the success of LAHSO. Situational awareness starts with having current airport information in the cockpit readily accessible to the pilot. For example, an airport diagram assists pilots in identifying their location on the airport, thus reducing requests for progressive taxi instructions from controllers. Situational awareness also requires effective pilot/controller radio communication. ATC expects pilots to specifically acknowledge and read back all LAHSO clearances as follows:

ATC: "(Aircraft ID) cleared to land runway six right, hold short of taxiway bravo for crossing traffic (type aircraft)."

Aircraft: "(Aircraft ID), wilco, cleared to land runway six right to hold short of taxiway bravo."

ATC: "(Aircraft ID) cross runway six right at taxiway bravo, landing aircraft will hold short."

Aircraft: "(Aircraft ID), copy, cross runway six right at bravo, landing traffic (type aircraft) to hold."

For those airplanes flown with two crewmembers, effective intra-cockpit communication between the cockpit crew is critical. There have been instances where the pilot working the radios accepted a LAHSO clearance but then simply forgot to tell the pilot flying the aircraft.

Situational awareness also includes a thorough understanding of the airport markings, signage and lighting associated with LAHSO. These visual aids consist of a three-part system of yellow hold short markings, red and white signage and in certain cases, in-pavement lighting. Visual aids assist the pilot in determining where to hold short. Pilots are cautioned that not all airports conducting LAHSO have installed any or all of the markings, signage or lighting.

Pilots should only receive a LAHSO clearance when there is a minimum ceiling of 1,000 feet and three statute miles visibility. The intent of having basic VFR weather conditions is to allow pilots to maintain visual contact with other aircraft and ground vehicle operations. Pilots should consider the effects of prevailing in-flight visibility (such as landing into the sun) and how it may affect overall situational awareness. Additionally, surface vehicles and aircraft being taxied by maintenance personnel may also be participating in LAHSO, especially in those operations that involve crossing an active runway.

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Chapter 5

Making the Aircraft Visible

Pilots need to be taught that whether on the ground or in the air, safety can be greatly enhanced by ensuring their aircraft is visible. Aircraft owners, for example, should avoid the temptation to use camouflage paint schemes. The pattern may look appealing but if the aircraft blends in with ground clutter and cannot be easily seen by aircraft above, the results could be catastrophic. High visibility paint schemes are much more desirable from a safety perspective.

Operation "Lights-On" is an FAA-established voluntary pilot safety program designed to enhance the see-and-be-seen concept. Pilots are encouraged to turn on their landing lights during takeoff, either after takeoff clearance has been received or when beginning takeoff roll. Pilots are further encouraged to turn on their landing lights when operating below 10,000 feet, day or night, especially when within ten miles of any airport or in conditions of reduced visibility, and in areas where flocks of birds may be expected, i.e., coastal areas, lake areas, around refuse dumps, etc. Although turning on aircraft lights does enhance the see-and-avoid concept, pilots should not become complacent about keeping a sharp lookout for other aircraft. Not all aircraft are equipped with lights and some pilots may not have their lights turned on. Maintaining a "Sterile Cockpit" will enhance safety in this area. A "Sterile Cockpit" is maintained by eliminating all unnecessary communication during critical phases of flight such as during ground and low altitude operations. Aircraft manufacturer's recommendations for operation of landing lights and electrical systems should be observed.

Situational Awareness

Situational awareness is vital to successful operations both on the ground and in the air. In addition to methods described previously during ground operations, pilots can request progressive taxi instructions at any airport with an operating control tower. Another important aid is listening to radio communications with other aircraft. Did ground control just give the other aircraft a taxi clearance that will conflict with your taxi route? It happens, not often, but often enough. Is the other aircraft taxiing as cleared or is the other pilot confused and interfering with your taxi route?

The same caution is even more important in flight. Has another aircraft given ATC or CTAF a position report that represents the same as your own? Has ATC given someone a clearance that may interfere with your route of flight? These questions should constantly be running through any pilot's mind.

Expect the unexpected: you acknowledge the tower's clearance to enter right downwind for runway six; another pilot acknowledges the tower's clearance to enter left downwind for the same runway. Your first concern is: are you going to meet the other pilot head-on during base leg? That is an obvious question, but what about not so obvious ones?

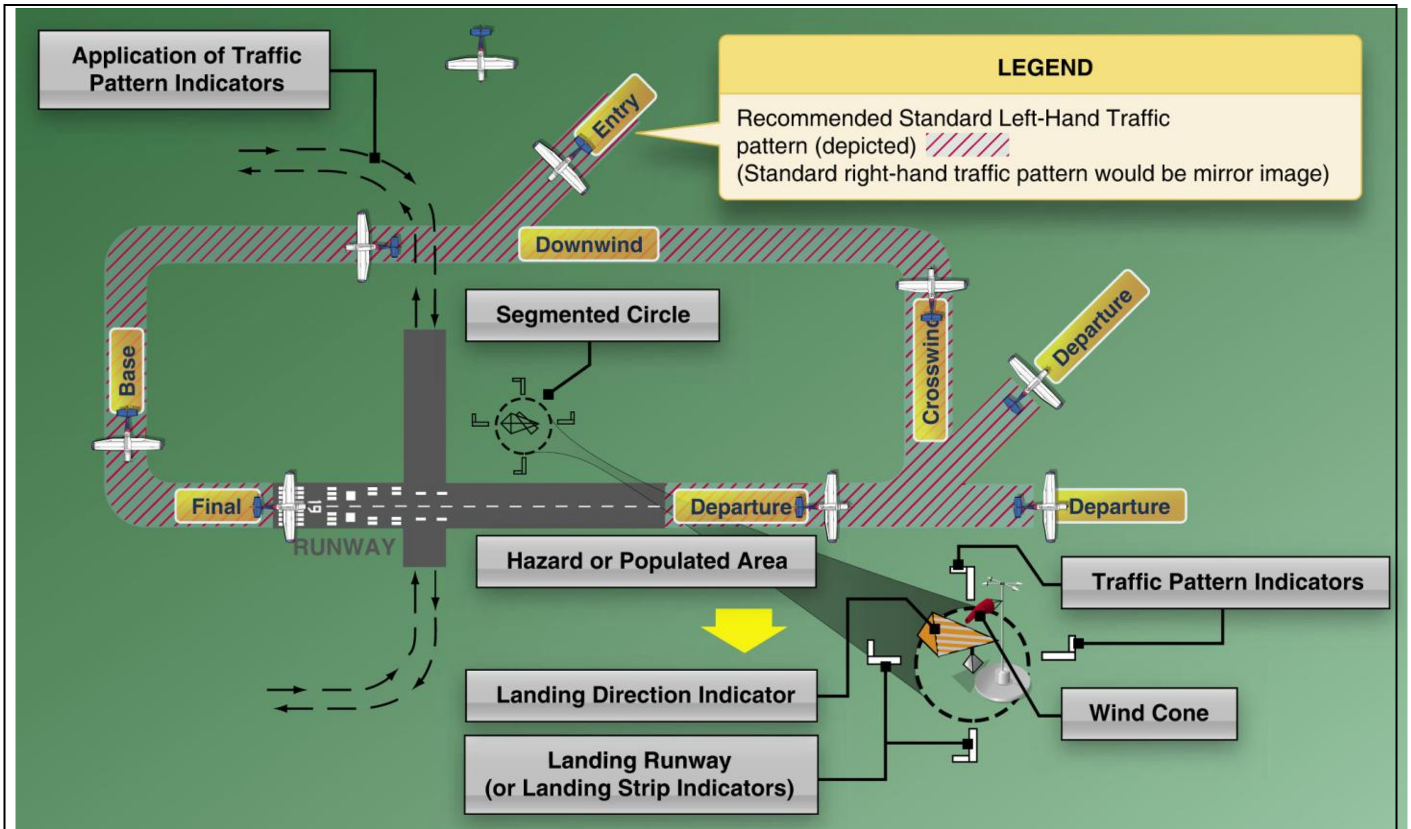
What if the other pilot is disoriented and mistakes runway 24 for runway six? You hear him call left downwind for six right after you report right downwind for six. No problem for now, unless of course he is actually on a left downwind for 24, in which case he will be on a heading toward you right now! If both of you are looking down at the runway (normal for a pilot on downwind) neither of you will see the other and if a midair is avoided, it will be by accident instead of on purpose. Unlikely scenario? Think again. We must all exercise continuous, life-sustaining vigilance, and our students must be taught to do no less.

Takeoffs/Landings/Low Altitude Maneuvering

Approximately 65 percent of all general aviation accidents occur during takeoffs, landings or low altitude maneuvering, and virtually all are pilot-related. We can't eliminate the need to maneuver near the ground to takeoff or land, but we can address the skill issues with the pilots performing those maneuvers. Teaching proper takeoff and landing techniques can be as much an art as a skill, and the instructor needs as much information as he or she can get so that they can better understand the types of difficulties that

pilots are having during those phases of flight and what the latest thinking is regarding how to best deal with them.
There are multiple approaches to teaching takeoffs and landings and instructors may need to vary their training technique from one student to another.
Procedures and methods used during these critical phases of flight will have a significant impact on our students' ability to manage risk. Emphasis areas include:

- Ensuring that students determine the takeoff and landing performance for each departure. This will include knowledge of appropriate V-speeds, performance data, and procedures associated with normal/crosswind, short field, soft field, rejected takeoff, balked landing, and other anticipated emergencies. To allow for student errors, instructors sometimes select airports that have at least twice the runway length required. This minimizes risk but can result in the student developing a habit of complacency. Students must be familiar with the following concepts and computations:
  - V-speeds and procedures
  - Weight and Balance
  - Maximum Structural Take-off Weight
  - Maximum Zero Fuel Weight
  - Maximum Takeoff weight based on the Maximum Landing Weight
  - Maximum Takeoff weight based on runway available
  - Maximum Takeoff weight based on climb requirement
  - Takeoff / Landing Performance
  - Crosswind/Headwind components (to compute takeoff distances and correction for Crosswind)
  - Ground Run Distance
  - Takeoff- to clear a 50-foot obstacle Distance
  - Climb performance (to meet feet per minute or angle of climb requirement)
  - Landing Distance from over a 50-foot obstacle
  - Landing Roll Distance
- Airport familiarization is an important preflight procedure, especially if you have not been to a particular airport recently. Knowing all the airport information that is included in publications, charts, and even the Internet will inform the pilot of hazards they can anticipate and avoid. Information can be gathered from:
  - Airport Facility Directory, Charts, Airport Diagrams, NOTAMS, and Internet Services.
  - AIM procedures for Controlled, Uncontrolled, B, C, and D airports.
  - Local information from Local Control Towers, FSS, Flight Standard Districts Offices, and Fixed Base Operators.
- Sterile cockpit concept--understanding the workload associated with varying phases of flight should convince a pilot to keep all communication and activity limited to that required for the operation of the aircraft. A sterile cockpit as well as cockpit management and single-pilot resource management techniques can be used to eliminate distractions and minimize workload. Common errors associated with poor departure or arrival techniques result in missed communications, improper scanning, loss of positional awareness, or failure to use checklists.
- Lights-on initiative assists in the see-and-avoid concept. All available lights are turned on from engine start to shutdown, especially in busy terminal areas.



Traffic Pattern Operations

Balanced Field Length

Balanced field length is the runway requirement that needs to be met when operating transport category airplanes. It represents the runway required to accelerate to a minimum takeoff speed and then, in the event of an engine failure, have sufficient runway to decelerate the aircraft before reaching the end of the runway. Once the minimum speed is reached in this type of airplane, continued takeoff and climb is expected after the engine failure.

General aviation airplane pilots are not required to meet this requirement but the concept as it applies to safety is something that instructors should demonstrate to their students. Obviously single-engine airplanes do not have the capability of climbing after an engine failure; however, selecting a runway that gives the pilot sufficient room to reject a takeoff if an engine problem occurs is a procedure that can minimize your risk. Additionally, if the pilot is familiar with the takeoff and landing distance, a decision can be more accurately made in the event an engine fails during the climb out. Selecting the longest runway available will keep you in this "balanced field length" for a longer time, allowing you to gain altitude which may prove to be very valuable in the event one encounters an engine problem.

Position Awareness and Reports

Pilots must maintain constant awareness of their position so that they can keep track of their relationship to other aircraft, (on and off airport), terrain, and obstacles. In addition, accurate position reporting to other pilots and ATC will enhance safety by providing the information they need to provide safe separation and avoid traffic conflicts.

Techniques and procedures that can be used include:

- Departure Phase

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- Obtain the most current airport information from sources like ATIS/AWOS/ASOS or Airport Advisory.
    - Use an Airport Diagram.
    - Monitoring frequencies prior to use.
    - Know and monitor the blind spots of the control tower.
    - Know the location of and monitor the windsock.
    - Emphasize proper cockpit organization/management and single-pilot resource management.
    - Use proper phraseology and communication techniques.
    - Use clear and concise communication with ATC or other aircraft.
    - Use proper collision avoidance scanning techniques, i.e., clearing area and checking blind spots.
    - Comply with the departure and arrival procedures contained in the AIM and look for those that are not.
- En route Phase
    - Use all available navigation, i.e., pilotage, dead reckoning, radio navigation.
    - Prepare and use a route log.
    - Use all available FSS/ATC services, flight following, etc.
- Arrival Phase
    - Familiarization of IFR arrival and departure areas and Visual Reporting Points.
    - Know and monitor ATC/CTAF frequencies early for better situational awareness.
    - Receive all available arrival information such as ATIS or Landing Advisory (UNICOM).
    - Comply with the arrival procedures contained in the AIM.
    - Make accurate position reports, referencing navaids or obvious visual references.
    - Use effective resource management techniques and maintain control of the situation.

Departure and Arrival Operations

The time to prepare for the high workload phases of flight is not when you are departing or arriving at an airport. Knowing that you are going to operate into or out of an airport situated in Class B airspace means little if you are not familiarized with the procedures associated with Class B or the services available. Taking the time to research these unfamiliar areas will give pilots the confidence they need to make an uneventful and safe departure or arrival.

The use of modern flight simulation devices with a good instructor can prepare a pilot for operations at seldom-used or new airports. With these flight simulation devices, instructors can create up-to-date and realistic simulations allowing pilots to become "airport and route current" without leaving their home airport.

Flight Training Device

Maneuvering Altitude

Maneuvering altitude is that altitude where, if an engine fails during takeoff and climb, minimum hazard exists for people and/or property. Minimum maneuvering altitude will be no lower than 500 feet AGL.

The maneuvering altitude concept is used to plan an altitude that pilots can use to assist them in their decision-making process in the event an engine fails during takeoff and climb. If a pilot decides that 800 feet of altitude would be required to be reached before a safe landing could be accomplished with a failed engine, then reaching that altitude as quickly as possible would reduce the risk. Maximum best rate of climb procedures should be maintained until maneuvering altitude is reached. Once reaching maneuvering altitude a transition to a different airspeed or power setting may be considered. Combining the balanced field length concept with maneuvering altitude can assist the pilot in runway selection. Reaching maneuvering altitude before reaching a point where the departing runway is no longer available for a rejected takeoff would be ideal but seldom practical. Selecting a takeoff weight and runway which minimizes the time between losing the departure runway and reaching maneuvering altitude would minimize the risk associated with engine problems during takeoff. Additionally, maneuvering altitude would be a practical altitude for instructors to reach before simulating engine failures during the takeoff and climb phase of flight.

Chapter 6

General

Most general aviation airplanes in the single engine and light twin categories are designed to have a capability of operating into and out of airports with unprepared landing surfaces or with relatively short landing/takeoff distances. Because of this capability and the frequent use for such operations it is imperative that the pilot has a complete knowledge and understanding of maximum performance takeoff and landing procedures. The following procedures are general in nature and will apply to most airplanes in the general aviation inventory today. However, it cannot be overemphasized that a thorough knowledge of the particular characteristics and capabilities of each model flown is an absolute necessity before attempting maximum performance operation under actual short or soft field conditions.

Maximum Performance Takeoffs

Short Field Takeoff

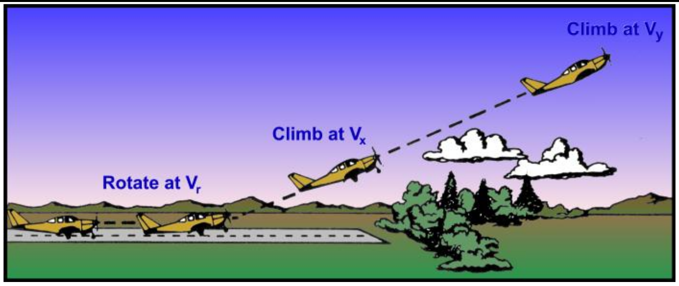
The objective of the short-field takeoff is to become airborne and gain the maximum amount of altitude possible in the shortest horizontal distance. For training purposes, it will always be assumed that there is a 50-foot obstacle to be cleared. The takeoff roll may be started from a rolling turn on to the runway if feasible. (Take into consideration the fact that in some airplanes with a partial fuel load there is a possibility of uncovering the fuel inlet with a rolling turn, causing subsequent fuel starvation). If a rolling takeoff is not possible, increase power with brakes applied. The manufacturer's recommendations with regard to a rolling turn, use of brakes, and the use of flaps should be followed.

When the airplane is aligned with the center of the runway, a smooth application of takeoff power should be made followed by a check to ascertain that full power is indeed being developed. The airplane is then allowed to accelerate in an attitude that will be as near to a zero angle of attack as possible. In most nose wheel equipped airplanes this will require a slight amount of back pressure on the elevator control.

Just prior to best angle of climb speed (Vx) being reached, the attitude should be changed to that required for best angle of climb. The airplane is flown in that attitude until the 50-foot obstacle has been cleared. The nose should then be lowered and the airplane accelerated to best rate of climb speed (Vy) and the flaps, if used, slowly retracted, taking care that the airplane does not settle. Landing gear should be retracted once the airplane is definitely established in a climb and there is no danger of settling back onto the ground. Some airplanes will have better performance if the gear retraction is delayed until the obstacle is cleared. Refer to the airplane manual for recommendations.

In multiengine aircraft, if Vx is below the safe single engine speed (Vsse), initial climb should be at Vsse unless Vx is required to clear the obstacle.

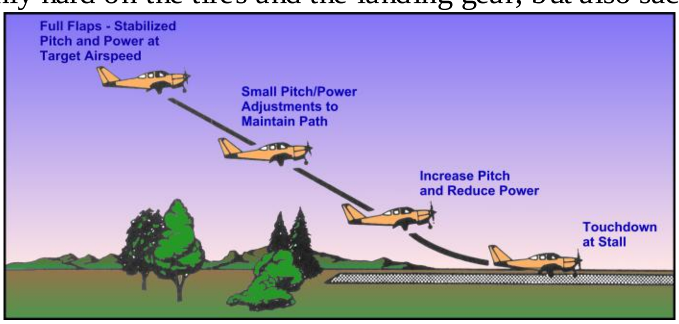
Excessive use of the rudder and elevator controls should be avoided during the takeoff run. The use of brakes to aid in directional control is unacceptable. If a crosswind condition exists, normal crosswind procedures should be applied.



Short Field Takeoff

Short Field Landing

The objective of the short-field landing is to land the airplane at the slowest possible speed and stop it in the shortest possible distance. All training in short-field approaches and landings will assume a 50-foot obstacle. Because of the requirements of this landing, full flaps and power, which allow a fairly steep approach path, are recommended.
The airplane should be set up on the final approach at 1.3 Vso. The approach should be a continuous descent with the attitude, rate of descent and airspeed held constant and controlled with coordinated use of the throttle and flight controls. Once the proper descent has been established there should be very little need to change the attitude to any great degree until the flare for landing is started.
Power should be reduced during the flare and the airplane should touch down in a nose-high attitude at the minimum controllable airspeed. Power should not be removed prior to the flare.
In some aircraft models, aerodynamic braking in the early stages of the rollout may be effective. In this case the nose wheel should be held off the runway to take advantage of the increased drag in this attitude. If such is not the case, the nose should be lowered immediately after touchdown and wheel braking used to stop the airplane in the shortest possible distance. The raising of the flaps after the nose wheel is on the ground will put additional weight on the main wheels and increase the effectiveness of the wheel brakes. Caution must be used in raising the flaps under these conditions to ensure that the landing gear is not inadvertently retracted. Maximum braking should be used up to the point of locking the wheels and sliding the tires. Doing so is not only hard on the tires and the landing gear, but also sacrifices braking efficiency.



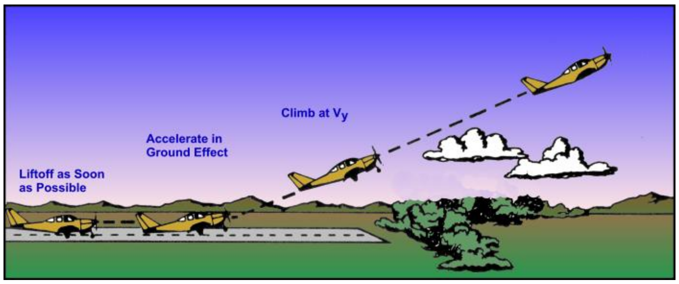
Short Field Landing

Soft Field Takeoff

The soft-field takeoff procedure is designed primarily to be used from a surface which is mud, snow, sand, high grass, etc. It is also useful from a surface which is very rough where it would be advantageous to become airborne in the shortest possible distance to minimize or prevent damage to the airplane. It is normally practiced with no regard to the 50-foot obstacle.
The takeoff should be started from a rolling turn onto the runway, if practical, with the flaps set in accordance with the manufacturer's recommendations. Once the roll is started it should not be stopped or slowed so the airplane will not be allowed to bog down. This will require some planning and perhaps an inspection of the runway surface before the takeoff is attempted.
As in any takeoff, apply full power when the airplane is aligned with the runway heading. Transfer as much of the airplane's weight to the wings as soon as possible by holding back elevator pressure. As the

airplane accelerates in this attitude, liftoff should occur somewhat below normal takeoff speed. As the wheels clear the ground, some back pressure is released and the airplane is held as close to the ground as practical so it can accelerate in ground effect. Once the best rate of climb speed has been reached a normal climb may be started, and the gear and flaps retracted as altitude permits.
If an obstacle is present, initial acceleration in ground effect would be to best angle of climb speed and the climb continued as in the short field takeoff.
Care must be taken in practicing this maneuver to avoid the following common errors:

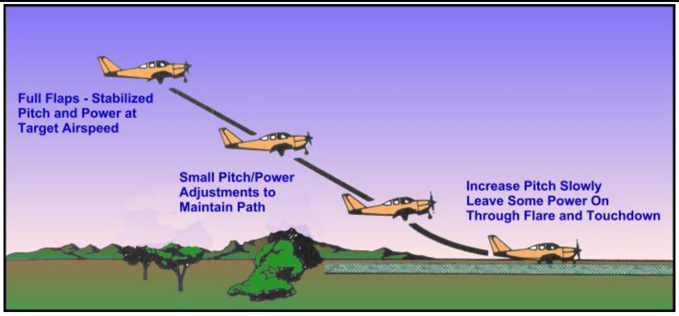
- Raising the nose too high on the takeoff roll, resulting in such an extreme angle of attack that it may be impossible to attain sufficient speed to lift off.
- Climbing out of ground effect too soon, resulting in a possible stall or settling onto the ground when induced drag takes full effect.
- Releasing too much back pressure after liftoff and flying back onto the ground.
- Failing to keep the airplane rolling and getting mired in the soft surface.



Soft Field Takeoff

Soft Field Landing

The primary objective in the soft-field landing procedure is to touch down at the slowest possible airspeed and as softly as possible in order to avoid damage to the airframe caused by the type of surface and the rapid deceleration expected from the surface. Obstructions in the flight path and limited field length are normally not considered when practicing this landing.
The approach is made at normal airspeeds and recommended flap settings. Touchdown should be in the full stall attitude at minimum controllable airspeed. Consideration may be given to using a small amount of power at touchdown to decrease the sink rate and assist in making the touchdown as soft as possible. The nose wheel is held in the air as long as possible, since this is the weakest part of the structure. Deceleration on the soft surface should be fairly rapid. Wheel brakes are rarely, if ever, used since their use in this situation could impose unwanted loads on the nose wheel structure.
Ideally the approach and landing will be made with full flaps extended to allow the slowest possible touchdown. Field conditions and the possibilities of flap damage should be taken into consideration, particularly in the case of a low wing airplane where flying mud, stones, etc. are a possibility. Power-off landings should also be mastered to prepare for the possibility of an emergency landing under similar circumstances.



Soft Field Landing

Crosswind Takeoff and Landing

Unless the wind is calm or straight down the runway, crosswind takeoff procedures will have to be used. The recommended procedure is as follows: the takeoff roll is begun with the ailerons fully deflected into the wind, as though slipping. Heading control is maintained with rudder and nosewheel steering if available. As speed is gained some of the aileron deflection will have to be taken out but the airplane should become airborne in a slip, with the upwind wheel being the last to leave the ground.

Unless gusting winds are present, rotation and lift-off speeds are the same as for a normal takeoff. The airplane is maintained in slipping flight until definitely airborne. A coordinated turn is then made into the wind to establish the necessary crab angle to allow a straight track with the runway.

The crosswind landing is performed in much the same way as the takeoff. If the final is long or straight-in, such as would be the case on an instrument approach, the airplane should be kept aligned with the runway centerline by crabbing into the wind. As short final is approached, the longitudinal axis should be aligned with the runway, and any tendency to drift stopped by lowering the upwind wing and keeping the airplane from turning by the use of opposite rudder.

The airplane should touch down on the upwind wheel first. As speed decreases the downwind wheel and then the nose wheel will make contact with the ground. As the speed slows, the amount of aileron into the wind should be increased until a full deflection is being held. Directional control is maintained by the rudder and brakes as necessary until taxi speed is attained.


Crosswind Landing

Power-Off Accuracy Approaches

The objective of power-off accuracy approaches and landings is to instill in the pilot the judgment and procedures necessary for accurately flying the airplane, without power, to a safe landing.

90 Degree Power-off Approach

The 90-degree power-off approach is made from a base leg and requires only a 90-degree turn onto the final approach. The approach path may be varied by positioning the base leg closer to or father out from the approach end of the runway according to wind conditions.

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The glide from the key position on the base leg through the 90-degree turn to the final approach is the final part of all accuracy landing maneuvers.

The 90-degree power-off approach usually begins from a rectangular pattern at approximately 1,000 feet AGL or at normal traffic pattern altitude. The airplane should be flown onto a downwind leg at the same distance from the landing surface as in a normal traffic pattern. The before landing checklist should be completed on the downwind leg, including extension of the landing gear if the airplane is equipped with retractable gear.

After a medium-banked turn onto the base leg is completed, the throttle should be retarded slightly and the airspeed allowed to decrease to the normal base leg speed. On the base leg, the airspeed, wind drift correction and altitude should be maintained while proceeding to the 45-degree key position. At this position, the intended landing spot will appear to be on a 45-degree angle from the airplane's nose.

At the 45-degree position, the throttle should be closed completely, the propeller control (if equipped) advanced to the full (increased) r.p.m. position and altitude maintained until the airspeed decreases to the manufacturer's recommended glide speed. In the absence of a recommended speed, use 1.4 Vso. When this airspeed is attained, the nose should be lowered to maintain the gliding speed and the controls retrimmed.

The base-to-final turn should be planned and accomplished so that upon rolling out of the turn the airplane will be aligned with the runway centerline. When on final approach, the wing flaps are lowered and the pitch attitude adjusted as necessary to establish the proper descent angle and airspeed (1.3Vso), then the controls are retrimmed. Slight adjustments in pitch attitude or flap settings may be necessary to control the glide angle and airspeed. However, never try to stretch the glide or retract the flaps to reach the desired landing spot. The final approach may be made with or without the use of slips. Once the final approach has been established, full attention is given to landing.

180 Degree Power-off Approach

The 180-degree power-off approach is executed by gliding with the power off from a given point on a downwind leg to a preselected landing spot. Its objective is to further develop judgment in estimating distances and glide ratios in that the airplane is flown without power from a higher altitude through a 90-degree turn to reach the base leg position at a proper altitude for executing the 90-degree approach. The 180-degree power-off approach requires more planning and judgment than the 90-degree power-off approach.

In the execution of 180-degree power-off approaches, the airplane is flown on a downwind heading parallel to the landing runway with the landing gear extended (if retractable). The altitude from which this type of approach should be started will vary with the type of airplane, but it should usually not exceed 1,000 feet above the ground, except with large airplanes. Greater accuracy in judgment and maneuvering is required at higher altitudes.

When abeam of or opposite the desired landing spot, the throttle should be closed and altitude maintained while decelerating to the manufacturer's recommended glide speed, or 1.4 Vso. The point at which the throttle is closed is the downwind key position.

The turn from the downwind leg to the base leg should be a uniform turn with a medium or slightly steeper bank. The degree of bank and amount of this initial turn will depend upon the glide angle of the airplane and the velocity of the wind. Again, the base leg should be positioned as needed for the altitude or wind condition. Position the base leg to conserve or dissipate altitude so as to reach the desired landing spot.

The turn onto the base leg should be made at an altitude high and close enough to permit the airplane to glide to what would normally be the base key position in a 90-degree power-off approach.

Although the key position is important, it must not be overemphasized nor considered as a fixed point on the ground. Many inexperienced pilots may gain a conception of it as a particular landmark, such as a tree, crossroad or other visual reference to be reached at a certain altitude. This will result in a mechanical

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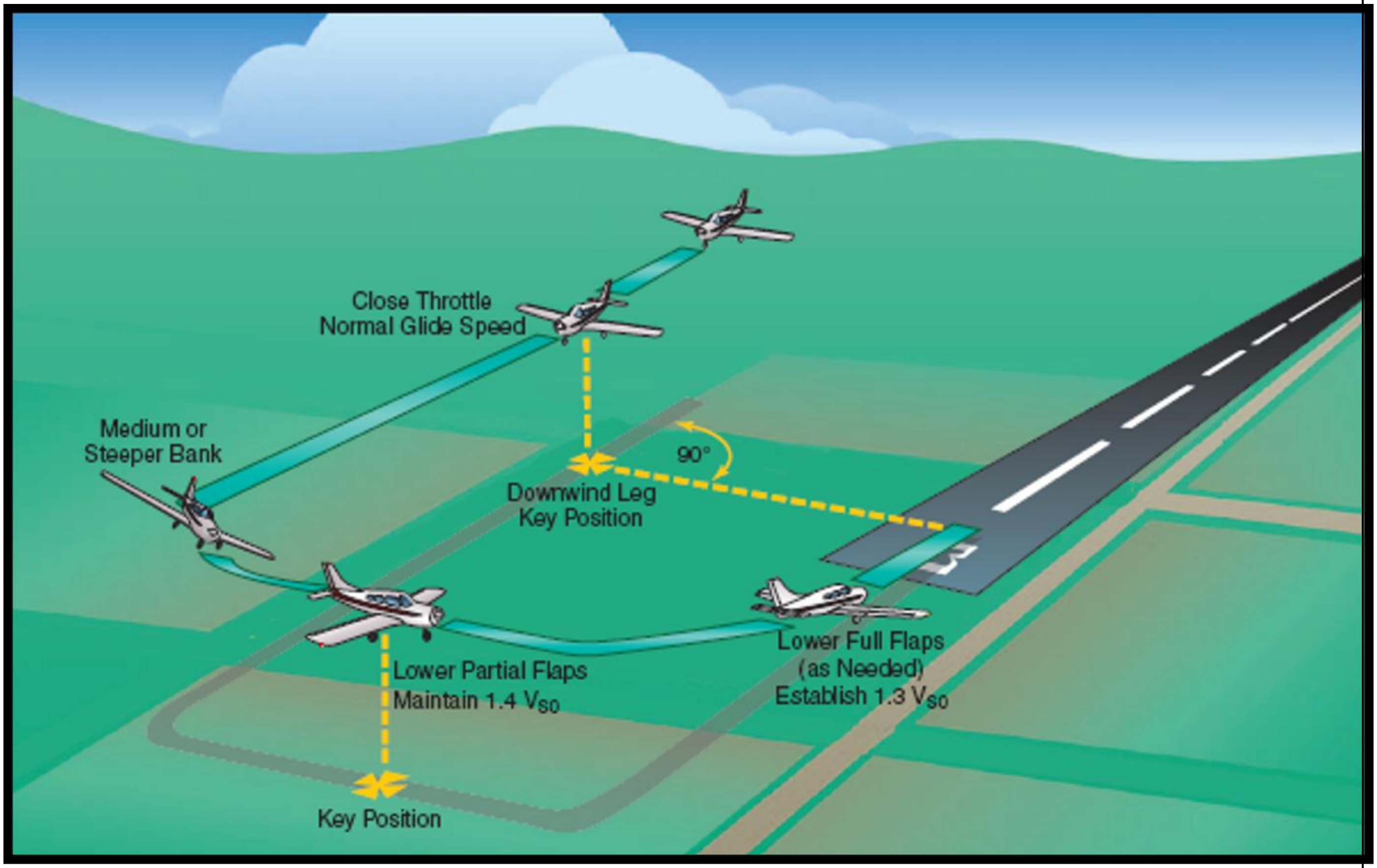
conception and leave the pilot at a total loss any time such objects are not present. Both altitude and geographical location should be varied as much as practical to eliminate any such conception.



Power-off 180 Degree Accuracy Approach and Landing

360 Degree Power-off Approach

The 360-degree power-off approach is one in which the airplane glides through a 360-degree change of direction to a preselected landing spot. The entire pattern is designed to be circular, but the turn may be shallowed, steepened or discontinued at any point to adjust the accuracy of the flight path.

The 360-degree approach is started from a position over the approach end of the landing runway or slightly to the side of it, with the airplane headed in the proposed landing direction with landing gear and flaps retracted.

It is usually initiated from approximately 2,000 feet or more above the ground where the wind may vary significantly from that at lower altitudes. This must be taken into account when maneuvering the airplane to a point from which a 90- or 180-degree power-off approach can be completed.

After the throttle is closed over the intended point of landing, the proper glide speed should immediately be established and a medium-banked turn be made in the desired direction so as to arrive at the downwind key position opposite the intended landing spot. At or just beyond the downwind key position, the landing gear may be extended if the airplane is equipped with retractable gear. The altitude at the downwind key position should be approximately 1,000 to 1,200 feet above the ground.

After reaching that point, the turn should be continued to arrive at a base leg key position at an altitude of about 800 feet above the terrain. Flaps may be used at this position as necessary, but full flaps should not be used until established on the final approach.

The angle of bank can be varied as needed throughout the pattern to correct for wind conditions and to align the airplane on final approach. The turn-to-final should be completed at a minimum altitude of 300 feet AGL.

Common Errors in Power-off Approaches

- Downwind leg too far from the runway/landing area.
- Overextension of downwind leg resulting from tailwind.
- Inadequate compensation for wind drift on base leg.
- Skidding turns in an effort to increase gliding distance.
- Failure to lower landing gear.
- Attempting to stretch the glide during an undershoot.
- Premature flap/landing gear extension.
- Use of throttle to increase the glide instead of merely clearing the engine.
- Forcing the airplane onto the runway in order to avoid overshooting the designated landing spot.

Stabilized Approach Concept

A stabilized approach is one in which the pilot establishes and maintains a constant angle glidepath toward a predetermined point on the landing runway. It is based on the pilot's judgment and perception of certain visual cues and depends on the maintenance of a constant final descent airspeed and configuration.

An airplane descending on final approach at a constant rate and airspeed will be traveling in a straight line toward a spot on the ground ahead. This will not be the spot on which the airplane will touch down because some float will inevitably occur during the roundout. Neither will it be the spot toward which the airplane's nose is pointed, because the airplane is flying at a fairly high angle of attack and the component of lift exerted parallel to the earth's surface by the wings tends to carry the airplane forward horizontally. The point toward which the airplane is progressing is termed the "aiming point." It is the point on the ground at which, if the airplane maintains a constant glidepath and was not flared for landing, it would strike the ground.

To a pilot moving straight ahead toward an object, it appears to be stationary. This is how the aiming point can be distinguished: it does not move. However, objects in front of and beyond the aiming point do appear to move as the distance is closed, and they appear to move in opposite directions. During instruction in landings, one of the most important skills a student pilot must acquire is how to use visual cues to accurately determine the true aiming point from any distance out on final approach. From this, the pilot will not only be able to determine if the glidepath will result in an undershoot or overshoot, but, taking into account float during roundout, the pilot will be able to predict the touchdown point to within a very few feet.

For a constant angle glidepath, the distance between the horizon and the aiming point will remain constant. If a final approach descent has been established but the distance between the perceived aiming point and the horizon appears to increase (aiming point moving down away from the horizon), then the true aiming point, and subsequent touchdown point, is farther down the runway. If the distance between the perceived aiming point and the horizon decreases (aiming point moving up toward the horizon), that means the true aiming point is closer than perceived.

When the airplane is established on final approach, the shape of the runway image also presents clues as to what must be done to maintain a stabilized approach to a safe landing.

A runway, obviously, is normally shaped in the form of an elongated rectangle. When viewed from the air during the approach, the phenomenon known as perspective causes the runway to assume the shape of a trapezoid, with the far end looking narrower than the approach end and the edge lines converging ahead. If the airplane continues to fly down the glidepath at a constant angle, the image the pilot sees will still be trapezoidal but of proportionately larger dimensions. In other words, during a stabilized approach the runway shape does not change. If the approach becomes shallower however, the runway will appear to

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shorten and become wider. Conversely, if the approach is steepened, the runway will appear to become longer and narrower.

The objective of a stabilized approach is to select an appropriate touchdown point on the runway and adjust the glidepath so that the true aiming point and the desired touchdown point basically coincide. Immediately after rolling out on final approach, the pilot should adjust the pitch attitude and power so that the airplane is descending directly toward the aiming point at the appropriate airspeed. The airplane should be in the landing configuration, and trimmed for "hands off" flight. With the approach set up in this manner, the pilot will be free to devote full attention toward outside references.

The pilot should not stare at any one place, but rather scan from one point to another, such as from the aiming point to the horizon, to the trees and bushes along the runway, to an area well short of the runway, and back to the aiming point. In this way, the pilot will be more apt to perceive a deviation from the desired glidepath and whether or not the airplane is proceeding directly toward the aiming point.

If the pilot perceives any indication that the aiming point on the runway is not where desired, an adjustment must be made to the glidepath. This in turn will move the aiming point. For instance, if the pilot perceives that the aiming point is short of the desired touchdown point and will result in an undershoot, an increase in pitch attitude and engine power is warranted. As a constant airspeed must be maintained, the pitch and power change must be made smoothly and simultaneously. This will result in a shallowing of the glide path with the resultant aiming point moving toward the desired touchdown point.

Conversely, if the pilot perceives that the aiming point is farther down the runway than the desired touchdown point and will result in an overshoot, the glidepath should be steepened by a simultaneous decrease in pitch attitude and power. Once again, the airspeed must be held constant. It is essential that deviations from the desired glidepath be detected early so that only slight and infrequent adjustments to glidepath are required.

The closer the airplane gets to the runway, the larger (and possibly more frequent) the required corrections become, resulting in an unstabilized approach.

Common errors in the performance of normal approaches and landings are:

- Inadequate wind drift correction on the base leg.
- Overshooting or undershooting the turn onto final approach resulting in too steep or too shallow a turn onto final.
- Flat or skidding turns from base leg to final approach as a result of overshooting/inadequate wind drift correction.
- Poor coordination during turn from base to final approach.
- Failure to complete the landing checklist in a timely manner.
- Unstabilized approach.
- Failure to adequately compensate for flap extension.
- Poor trim technique on final approach.
- Attempting to maintain altitude or reach the runway using elevator alone.
- Focusing too close to the airplane resulting in a too high roundout.
- Focusing too far from the airplane resulting in a too low roundout.
- Touching down prior to attaining proper landing attitude.
- Failure to hold sufficient back-elevator pressure after touchdown.
- Excessive braking after touchdown.

The stabilized approach technique described for flying jet airplanes reflects not only the concepts already discussed, but goes further to assign specific performance targets and tolerances that must be maintained during final approach. The numbers can and should be changed for your aircraft and your operation, but establishing targets and tolerances on final approach will help your student identify an unstable approach, and that will help them effectively identify when a go-around needs to be accomplished.

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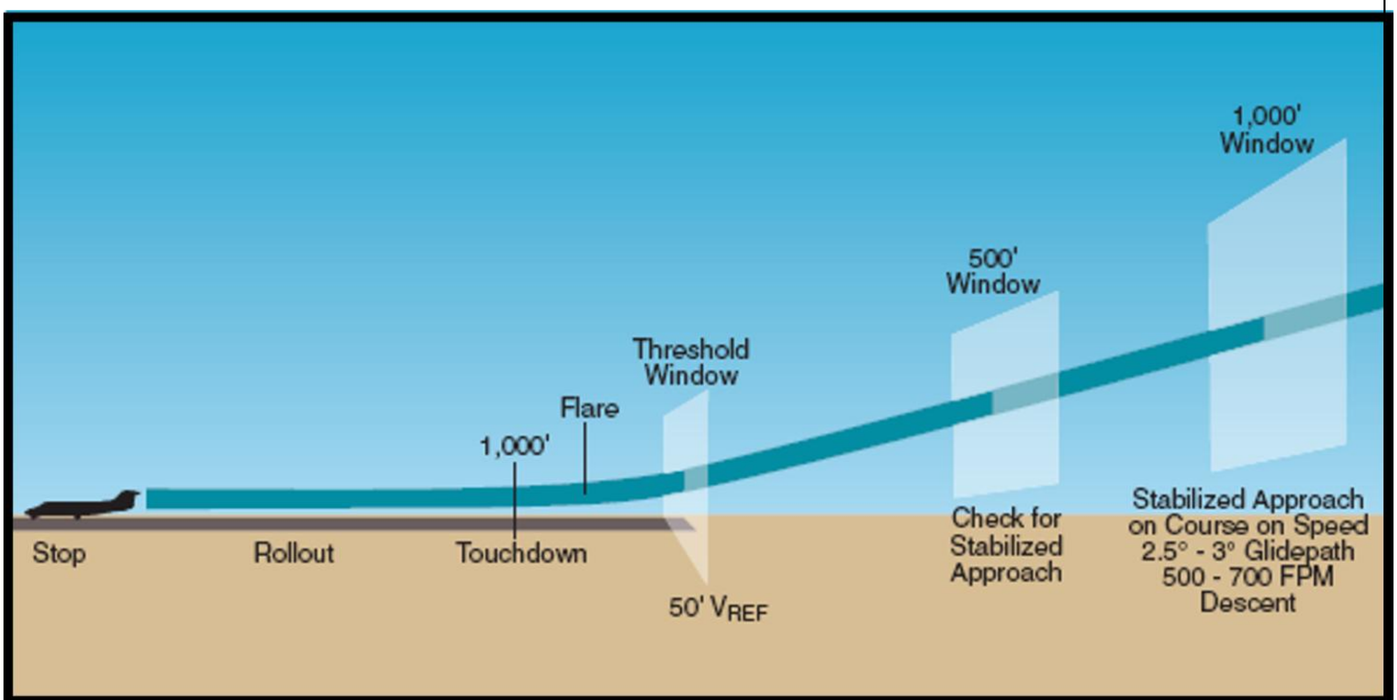
The image below depicts how a typical stabilized approach technique is described in a jet aircraft, air carrier operation.
The performance charts and the limitations contained in the FAA-approved Airplane Flight Manual are predicated on momentum values that result from programmed speeds and weights. Runway length limitations assume an exact 50-foot threshold height at an exact speed of 1.3 Vso. That "window" is critical and is a prime reason for the stabilized approach. Performance figures also assume that once through the target threshold window, the airplane will touch down in a target touchdown zone approximately 1,000 feet down the runway, after which maximum stopping capability will be used.
There are five basic elements to the stabilized approach:

- The airplane should be in the landing configuration early in the approach. The landing gear should be down, landing flaps selected, trim set, and fuel balanced. Ensuring that these tasks are completed will help keep the number of variables to a minimum during the final approach.
- The airplane should be on profile before descending below 1,000 feet. Configuration, trim, speed, and glidepath should be at or near the optimum parameters early in the approach to avoid distractions and conflicts as the airplane nears the threshold window. An optimum glidepath angle of 2.5 to 3 degrees should be established and maintained.
- Indicated airspeed should be within ten knots of the target airspeed. There are strong relationships between trim, speed, and power in most jet airplanes and it is important to stabilize the speed in order to minimize those other variables.
- The optimum descent rate should be 500 to 700 feet per minute. The descent rate should not be allowed to exceed 1,000 feet per minute at any time during the approach.
- The engine speed should be at an rpm that allows best response when and if a rapid power increase is needed.

Every approach should be evaluated at 500 feet. In a typical jet airplane, this is approximately one minute from touchdown. If the approach is not stabilized at that height, a go-around should be initiated.



Sample Stabilized Approach Technique

Go-around/Balked Landing

Whenever landing conditions are not satisfactory, a go-around is warranted. There are many factors that can contribute to unsatisfactory landing conditions. Situations such as air traffic control requirements, an unexpected appearance of hazards on the runway, overtaking another airplane, wind shear, wake turbulence, mechanical failure and/or an unstabilized approach are all examples of reasons to discontinue a landing approach and make another approach under more favorable conditions. The assumption that an aborted landing is invariably the consequence of a poor approach, which in turn is due to insufficient experience or skill, is a fallacy. The go-around is not strictly an emergency procedure. It is a normal maneuver that may at times be used in an emergency situation. Like any other normal maneuver, the go-around must be practiced and perfected. The flight instructor should emphasize early on, and the student pilot should be made to understand, that the go-around maneuver is an alternative to any approach and/or landing.

Although the need to discontinue a landing may arise at any point in the landing process, the most critical go-around will be one started when very close to the ground. Therefore, the earlier a condition that warrants a go-around is recognized, the safer the go-around/rejected landing will be. Although the go-around maneuver is not inherently dangerous in itself, it can become dangerous when unduly delayed or executed improperly.

Delay in initiating the go-around normally stems from two sources: landing expectancy or set--the anticipatory belief that conditions are not as threatening as they are and that the approach will surely be terminated with a safe landing, and pride--the mistaken belief that the act of going around is an admission of failure. The improper execution of the go-around maneuver stems from a lack of familiarity with the three cardinal principles of the procedure: power, attitude, and configuration.

Power is the pilot's first concern. The instant the pilot decides to go around, full or maximum allowable takeoff power must be applied smoothly and without hesitation, and held until flying speed and controllability are restored. Applying partial power in a go-around is never appropriate. The pilot must be aware of the degree of inertia that must be overcome before an airplane that is settling towards the ground can regain sufficient airspeed to become fully controllable and capable of turning safely or climbing. The application of power should be smooth as well as positive. Abrupt movements of the throttle in some airplanes will cause the engine to falter. Carburetor heat should be turned off for maximum power.

Attitude is always critical when close to the ground, and when power is added a deliberate effort on the part of the pilot will be required to keep the nose from pitching up prematurely. The airplane executing a go-around must be maintained in an attitude that permits a buildup of airspeed well beyond the stall point before any effort is made to gain altitude or execute a turn. Raising the nose too early may produce a stall from which the airplane cannot recover if the go-around is performed at a low altitude.

A concern for quickly regaining altitude during a go-around produces a natural tendency to pull the nose up. The pilot executing a go-around must accept the fact that an airplane will not climb until it can fly, and it will not fly below stall speed. In some circumstances, it may be desirable to lower the nose briefly to gain airspeed. As soon as the appropriate climb airspeed and pitch attitude are attained, the pilot should "rough trim" the airplane to relieve any adverse control pressures. Later, more precise trim adjustments can be made when flight conditions have stabilized.

In cleaning up the airplane during the go-around, the pilot should be concerned first with flaps and secondly with the landing gear (if retractable). When the decision is made to perform a go-around, takeoff power should be applied immediately and the pitch attitude changed so as to slow or stop the descent. After the descent has been stopped, the landing flaps may be partially retracted or placed in the takeoff position as recommended by the manufacturer. Caution must be used, however, in retracting the flaps. Depending on the airplane's altitude and airspeed, it may be wise to retract the flaps in small increments to allow time for the airplane to accelerate progressively as they are being raised. A sudden and complete retraction of the flaps could cause a loss of lift resulting in the airplane settling into the ground.

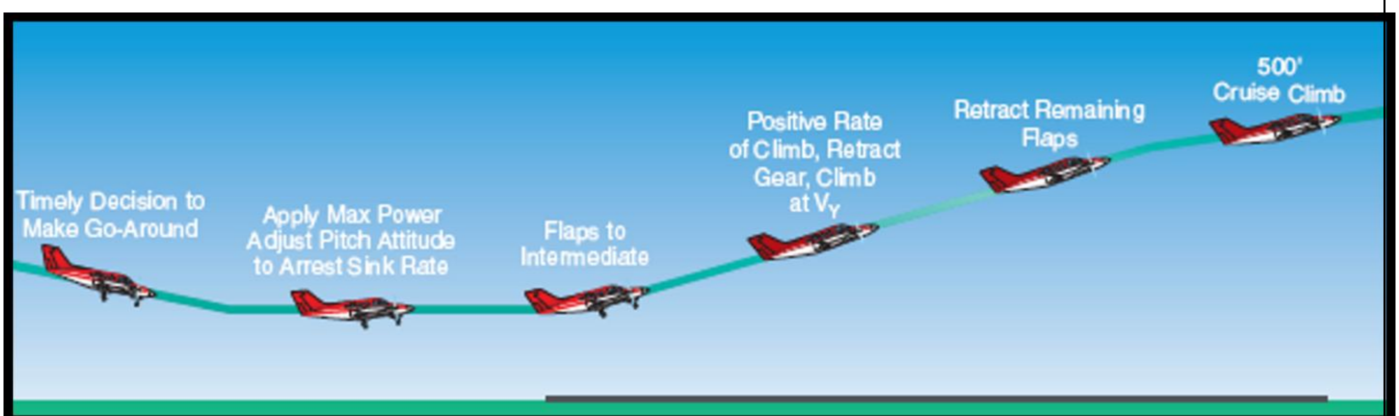
Unless otherwise specified in the AFM/POH, it is generally recommended that the flaps be retracted (at least partially) before retracting the landing gear for two reasons. First, on most airplanes full flaps produce more drag than the landing gear; secondly, in case the airplane should inadvertently touch down as the go-around is initiated it is desirable to have the landing gear in the down-and-locked position. After a positive rate of climb is established, the landing gear can be retracted.

When takeoff power is applied, it will usually be necessary to hold considerable pressure on the controls to maintain straight flight and a safe climb attitude. Since the airplane has been trimmed for the approach (a low power and low airspeed condition), application of maximum allowable power will require considerable control pressure to maintain a climb pitch attitude. The addition of power will tend to raise the airplane's nose suddenly and pull it to the left. Forward elevator pressure must be anticipated and applied to hold the nose in a safe climb attitude. Right rudder pressure must be increased to counteract torque and P-factor, and to keep the nose straight. The airplane must be held in the proper flight attitude regardless of the amount of control pressure that is required.

Trim should be used to relieve adverse control pressures and assist the pilot in maintaining a proper pitch attitude. On airplanes that produce high control pressures when using maximum power on go-arounds, pilots should use caution when reaching for the flap handle. Airplane control may become critical during this high workload phase.

The landing gear should be retracted only after the initial or rough trim has been accomplished and when it is certain the airplane will remain airborne. During the initial part of an extremely low go-around, the airplane may settle onto the runway and bounce. This situation is not particularly dangerous if the airplane is kept straight and a constant safe pitch attitude is maintained. The airplane will be approaching safe flying speed rapidly and the advanced power will cushion any secondary touchdown.

If the pitch attitude is increased excessively in an effort to keep the airplane from contacting the runway, it may cause the airplane to stall. This would be especially likely if no trim correction is made and the flaps remain fully extended. The pilot should not attempt to retract the landing gear until after a rough trim is accomplished and a positive rate of climb is established.



Go-around/Balked Landing

Chapter 7

Performance with One Engine Inoperative

It is obvious that when a twin-engine airplane loses one engine, it has lost 50 percent of its power. What is not so obvious is that the actual performance loss is around 80 percent or more, even if proper and immediate corrective action is taken to recover from the failure.

The actual loss of performance can be calculated by use of the charts in the airplane flight manual. (For this example we will use the C-310R performance charts.) The two engine best rate of climb at a pressure altitude of 4000', standard temperature, and maximum gross takeoff weight is 1350 feet per minute; the best single engine rate of climb with the same conditions is only 200 feet per minute. That represents a climb performance decrease of 85 percent--if everything goes according to the book.

The angle of climb (which regulates the rate of climb) is controlled by the thrust horsepower available above that required for level flight at a given airspeed (ETHP). By use of the following formula, the actual ETHP loss can be determined to further support the 85 percent performance loss.

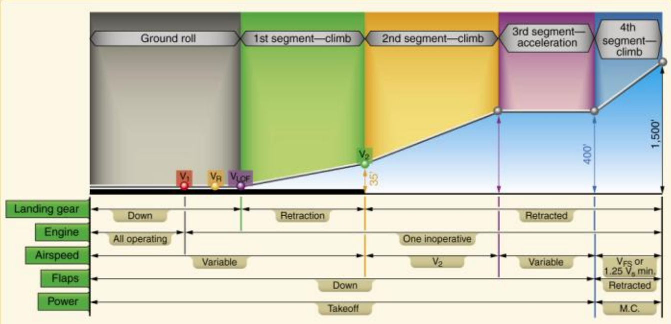
ethp = R/C x GW ÷ 33,000

ethp = 1350 x 5500 ÷ 33,000 = 225 hp (both engines)

ethp = 200 x 5500 ÷ 33,000 = 33 hp (single engine) (192 hp loss)

ethp = 192/225 = 85% loss

Establishment of this 85 percent performance loss for the C-310 (similar results will occur with most light twins) should emphasize the necessity of understanding and using proper engine failure procedures.



Items		1st T/O segment	2nd T/O segment	Transition (acceleration)	Final T/O segment
	2 Engine	Positive	2.4%	Positive	1.2%
★	3 Engine	3.0%	2.7%	Positive	1.5%
	4 Engine	5.0%	3.0%	Positive	1.7%
Wing flaps		T.O.	T.O.	T.O.	Up
Landing gear		Down	Up	Up	Up
Engines		1 Out	1 Out	1 Out	1 Out
Power		T.O.	T.O.	T.O.	M.C.
Air speed		$V_{LOF} \rightarrow V_2$	V_2	$V_2 \rightarrow 1.25\ V_S$(Min)	1.25 V_S(Min)

★ Required Absolute Minimum Gradient of Flightpath

M.C. = Maximum continuous
V_1 = Critical-engine-failure speed
V_2 = Takeoff safety speed
V_S = Calibrated stalling speed, or minimum steady flight speed at which the aircraft is controllable
V_R = Speed at which aircraft can start safely raising nose wheel off surface (Rotational Speed)
V_{LOF} = Speed at point where airplane lifts off

One Engine Inoperative After Takeoff

ENGINE FAILURE AFTER TAKEOFF

Airspeed .... Maintain V_{YSE}
Mixtures .... RICH
Propellers .... HIGH RPM
Throttles .... FULL POWER
Flaps .... UP
Landing Gear .... UP
Identify .... Determine failed engine
Verify .... Close throttle of failed engine
Propeller .... FEATHER
Trim Tabs .... ADJUST
Failed Engine .... SECURE
As soon as practical .... LAND

Bold-faced items require immediate action and are to be accomplished from memory.

Engine Failure after Takeoff Checklist (Multi-engine)

Control after Engine Failure

Immediately upon engine failure the airplane will roll and yaw in the direction of the failed engine. The actual forces are caused by:

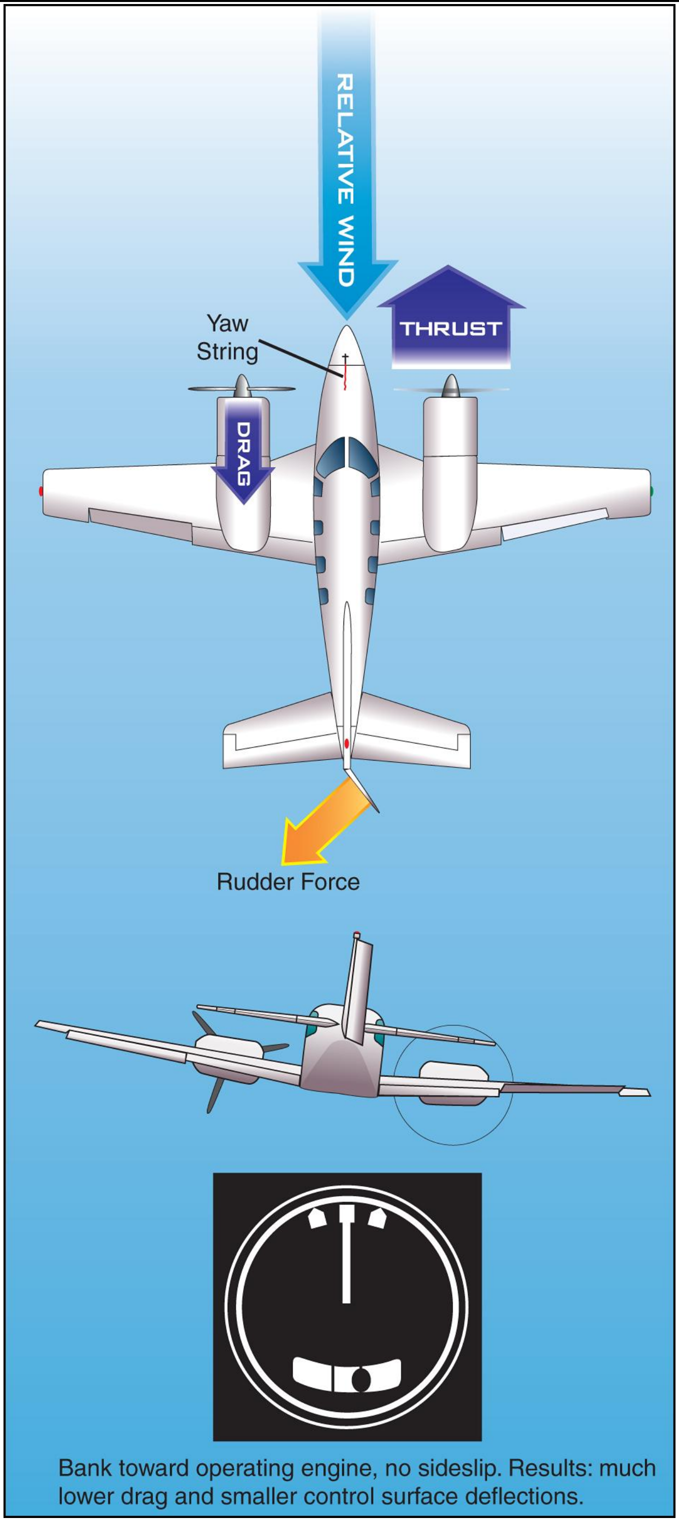
- Roll
  - Loss of induced propeller flow
  - Skid created by the yawing moment
- Yaw
  - Drag due to the windmilling propeller
  - Thrust from the operating engine
  - Adverse yaw during the recovery
- Pitch
  - Pitch-down moment due to loss of power

The first and most important duty the pilot has is to keep the airplane flying. To do this during an engine failure requires prompt control inputs to stop the rolling, yawing and pitching moments. When able, it is recommended that a checklist be used to help ensure that crucial items are checked in a logical sequence. To know the proper inputs requires an understanding of what has caused the change in the flight path and the proper control to counteract this change.

The most dramatic action is about the vertical axis. The control used for yaw is rudder and the amount of deflection required will depend on the airspeed and thrust developed by the operating engine. However, in most cases full rudder will be necessary until the airplane is under control and power has been reduced on the operating engine.

Roll is about the longitudinal axis and is controlled with the ailerons. This rolling is in the direction of the failed engine and recovery requires lowering the aileron on the same side. This further increases the drag on that side of the airplane which necessitates more rudder deflection if available. Once under control, the airplane should be banked a maximum of five degrees towards the operating engine. Due to the banked condition, the ball should be offset on the same side as the good engine (i.e., not centered). Banking into the good engine decreases the Vmc and the overall performance is increased due to the reduction in drag associated with maintaining a zero sideslip.

The decrease in thrust coupled with an increase in drag will slow the airspeed rapidly, requiring a pitch change to maintain the desired flight path. At low density altitudes the airplane should be able to maintain altitude or even climb, but at high density altitudes a descent may be required to keep the airspeed at Vyse, even with the airplane cleaned up and full power on the operating engine.



Zero Sideslip Engine-out Flight

Definitions

Vmc: (Lower Red Line) The minimum airspeed at which the airplane is controllable with the critical engine suddenly made inoperative under the following conditions:

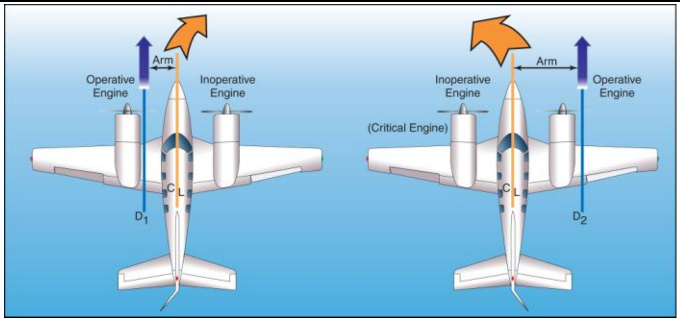
- CG located at the most rearward position allowable.
- Maximum gross takeoff weight.
- Sea level, standard conditions.

- Landing gear raised.
- Flaps set at takeoff position.
- Takeoff power set on the operating engine.
- Windmilling propeller on the inoperative engine.
- Airplane banked five degrees toward the operating engine.

Note:

1. CG location affects the rudder and thrust arms. The most rearward CG location gives the shortest rudder arm and the longest thrust arm, thus increasing the speed (highest Vmc) at which the rudder is incapable of countering the engine's yawing moment.
2. Increased weight has little effect on Vmc, but does decrease performance. Decreasing weight increases the Vmc.
3. As the density altitude decreases, the engine's performance (thrust) increases. This increases the yawing moment from the operating engine which results in an increase in Vmc.
4. The landing gear has a stabilizing effect on the airplane when it is extended. Conversely, when retracted, the airplane is less stable and yawing moments have a greater effect.
5. Extended flaps change the lift and drag coefficient of the airfoil. This increase in drag decreases the performance. Also, the aerodynamic nose-down pitching moment is countered by increased down loading on the horizontal stabilizer which increases the aerodynamic loading; this decreases performance. Flaps however, increase stability about the lateral axis.
6. The more power (thrust) used, the greater the yawing moment, resulting in a higher Vmc.
7. The drag created by the windmilling propeller combines with the yaw moment from the operating engine to increase the total yaw which the rudder must overcome, again increasing the Vmc.
8. Banking in the direction of the operating engine helps to counteract the yaw towards the inoperative engine. However, this does decrease overall performance due to the reduction in vertical lift associated with a banked condition.

Vsse: Safe Single Engine speed. The airspeed below which no intentional engine cuts will be made while conducting multi-engine training. To maintain flight at and below this airspeed, the angle of attack is high with a corresponding high induced drag. Coupled with decreased propeller efficiency at slower speeds, this places the airplane behind the power curve with one engine inoperative. Even with the airplane in a clean configuration and full power on the operating engine, the only way to increase the airspeed will be to start a descent. That is why, even though the airplane is controllable below this airspeed, it is recommended that engines not be intentionally made inoperative below Vsse. Taking this thought one step further, do not fly at speeds less than Vsse even with both engines operating to avoid this problem in the event one engine should fail.
Vxse: Best angle of climb speed with one engine inoperative. This speed should be used only when it becomes necessary to clear an obstruction while operating on one engine.
Vyse: (Blue Line) Best rate of climb speed with one engine inoperative. This speed will yield the maximum rate of climb (or slowest rate of descent) when flying on one engine. Refer to the charts for the proper speeds at different gross weights and altitudes. Vyse is the initial reference speed after engine failure. Start at Vyse and adjust power and attitude to achieve desired performance.
Critical Engine: The engine whose failure would most adversely affect the airplane's performance or handling qualities is the critical engine. On any airplane with both engines rotating clockwise, the left engine is critical. Aerodynamically, this is due to asymmetrical thrust or P-factor. The center of thrust is offset to the right side of the propeller hub, creating a greater distance (arm) from the longitudinal axis to the thrust line of the right engine. This longer arm in turn creates a greater yawing moment, and with rudder deflection fixed at its maximum value, airplane speed must be higher to overcome the effects of P-factor. Failure of the left engine, therefore, creates the more "critical" situation (need for higher Vmc).



Forces Created During Single-engine Operations

Chapter 8

Illusions Leading to Landing Errors

Various surface features and atmospheric conditions encountered during landing can create illusions of incorrect height above and distance from the runway threshold. Landing errors from these illusions can be prevented by anticipating them during approaches, overflying and making visual inspection of unfamiliar airports before landing, using visual glide slope systems when available and maintaining proficiency in landing procedures.

Runway Width Illusion

A narrower-than-usual runway can create the illusion that the aircraft is at a higher altitude than it actually is. The pilot who does not recognize this illusion will fly a lower approach, increasing the risk of striking objects along the approach path or landing short. A wider-than-usual runway can have the opposite effect, with the risk of leveling out high and landing hard or overshooting the runway.

Runway and Terrain Slope Illusion

An up-sloping runway, up-sloping terrain, or both, can create the illusion that the aircraft is at a higher altitude than it actually is. The pilot who does not recognize this illusion will fly a lower approach. A down-sloping runway, down-sloping approach terrain, or both, can have the opposite effect.

Featureless Terrain Illusion

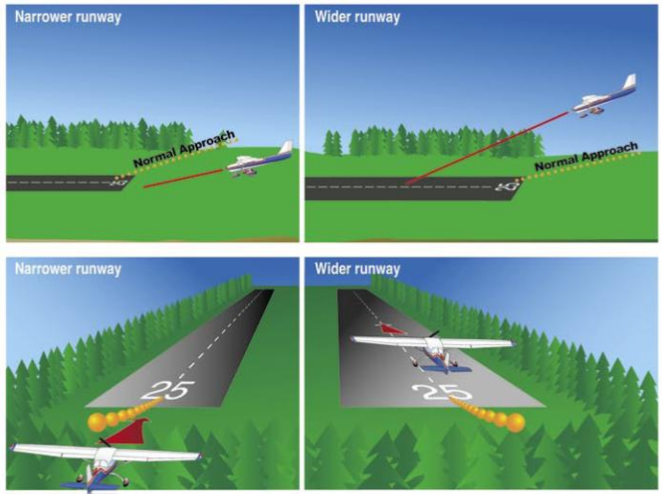
An absence of ground features, as when landing over water or darkened areas and terrain made featureless by snow, can create the illusion that the aircraft is at a higher altitude than it actually is. The pilot who does not recognize this illusion will fly a lower approach.

Atmospheric Illusions

Rain on the windshield can create the illusion of greater height and atmospheric haze the illusion of being at a greater distance from the runway. The pilot who does not recognize these illusions will fly a lower approach. Penetration of fog can create the illusion of pitching up. The pilot who does not recognize this illusion will steepen the approach, often quite abruptly.

Ground Lighting Illusions

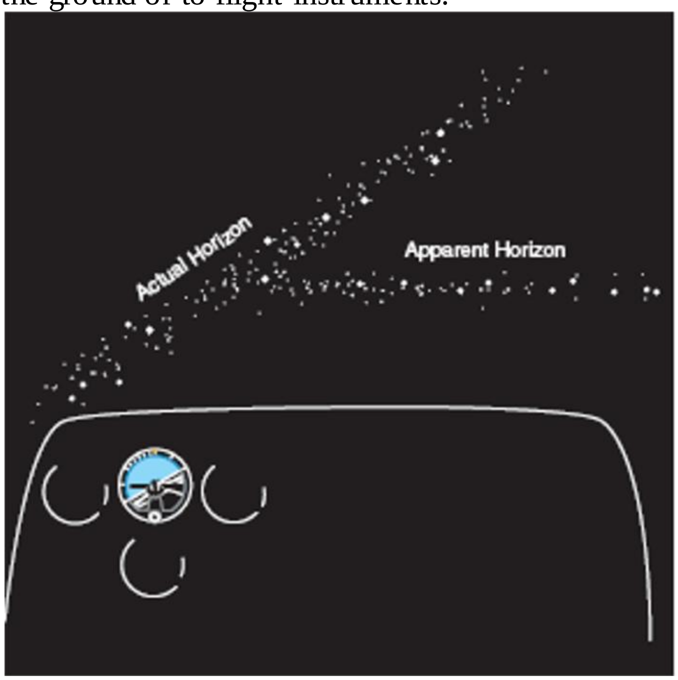
Lights along a straight path, such as a road or even lights on moving trains, can be mistaken for runway and approach lights. Bright runway and approach lighting systems, especially where few lights illuminate the surrounding terrain, may create the illusion of less distance to the runway. The pilot who does not recognize this illusion will fly a higher approach. Conversely, the pilot overflying terrain which has few lights to provide height cues may make a lower than normal approach.



Runway Width Illusion

Illusions in Flight

Many different illusions can be experienced in flight. Some can lead to spatial disorientation. Others can lead to landing errors. Illusions rank among the most common factors cited as contributing to fatal aircraft accidents.
Various complex motions and forces and certain visual scenes encountered in flight can create illusions of motion and position. Spatial disorientation from these illusions can be prevented only by visual reference to reliable, fixed points on the ground or to flight instruments.



False Horizon

Chapter 9

Definition of CFIT

Controlled Flight into Terrain (CFIT) occurs when an airworthy aircraft is flown, under the control of a qualified pilot, into terrain (water or obstacles) with inadequate awareness on the part of the pilot of the impending collision. According to FAA information, general aviation CFIT accidents account for 17 percent of all general aviation fatalities. More than half of these CFIT accidents occurred during IMC.

VFR-Only Pilots Operating in Marginal VFR/IMC

Operating in marginal VFR/IMC conditions is more commonly known as "scud-running." According to National Transportation Safety Board (NTSB) and FAA data, one of the leading causes of GA accidents is continued VFR flight into IMC. As defined in 14 CFR part 91, ceiling, cloud, or visibility conditions less than that specified for VFR or Special VFR is IMC; thus IFR applies. However, some pilots, including some with instrument ratings, continue to fly VFR in conditions less than that specified for VFR. The result is often a CFIT accident when the pilot tries to continue flying or maneuvering beneath a lowering ceiling and hits an obstacle or terrain or impacts water. The accident may or may not be a result of a loss of control before the aircraft impacts the obstacle or surface. The importance of complete weather information, understanding the significance of that weather information, and being able to correlate the pilot's skills and training, aircraft capabilities, and operating environment with an accurate forecast cannot be emphasized enough.

Continued flight in reduced visual conditions compounded by night operations and/or overwater flight poses some risks. VFR pilots in reduced visual conditions may develop spatial disorientation and lose control, possibly going into a graveyard spiral, or descend to an unsafe altitude while trying to maintain visual contact with the surface. The pilot then impacts terrain, the surface, or an obstacle while trying to maneuver. The following are some of the CFIT risks associated with such flight:

- Loss of aircraft control.
- Loss of situational awareness.
- Reduced reaction time to see and avoid rising terrain or obstacles.
- Inability of the pilot to operate the aircraft at its minimum controllable airspeed.
- Getting lost or being off the preplanned flight path and impacting terrain or obstacle.
- Reduced pilot reaction time in the event of an aircraft maintenance problem because of a low or lowering altitude.
- Failure to adequately understand the weather conditions that resulted in the reduced conditions.
- Breakdown in good aeronautical decision making.
- Failure to comply with appropriate regulations.
- Failure to comply with minimum safe altitudes.
- Increased risk of hitting one of many new low altitude towers installed for cellular telephones and other types of transmissions. This risk is especially great along major highways if VFR pilots try to follow a highway when lost, or trying to stay under a lowering ceiling.
- Failure to turn around and avoid deteriorating conditions when able.

Marginal VFR

IFR Operations in IMC Conditions on an IFR Flight

Whether it is failure to follow safe takeoff and departure techniques, recommended en route procedures or failure to maneuver safely to a landing, IFR operations can be dangerous for those not prepared to operate or not current and proficient in the IMC/IFR environments; many of these accidents result in fatalities. Techniques or suggestions for avoiding some of these IFR risk factors include:

- Importance of the pilot-in-command being qualified, current, and proficient for the intended flight.
- Importance of the aircraft being properly equipped for the intended flight.
- Having the proper charts and approach plates for the intended flight. VFR charts, although not required, should be onboard because they can provide important obstacle and terrain data for an IFR flight.
- Knowing the planned procedure well enough to know if air traffic control is issuing an unsafe clearance or if the pilot flying, when in a crewed aircraft, is not following the published procedure.
- If in a crewed aircraft, both pilots have adequately briefed the flight and operation of the aircraft, including shared responsibilities.
- Having complete weather data for the flight, including knowing where visual meteorological conditions exist or a safe alternative is, since many GA aircraft flown IFR have limited range or speed to fly out of unforecasted weather conditions.
- Importance of maintaining situational awareness, both horizontal and vertical, throughout the flight to avoid flying into hazardous terrain or known obstacles.
- Complete knowledge on how to operate all equipment onboard the aircraft. This includes the limitations and operations of new types of navigation equipment.

- If a crewed aircraft, the crew is aware of and follows FAA and industry recommended crew resource management principles. If a single-pilot flight, the pilot should know how to use all available resources to ensure a safe flight such as air traffic control, as well as any onboard resource such as a passenger, charts or manuals.
- Pilot-in-command follows the rules for making a missed approach and is prepared to make a missed approach when conditions fall below minimums as specified in the regulations, company policy, pilot's personal minimums checklist, or the approach becomes destabilized.
- Knowledge of minimum safe or sector altitudes and of the highest terrain in the area.
- Pilot-in-command is aware of the risks involved when transitioning from visual to instrument or from instrument to visual procedures on takeoff or landing.
- Pilot-in-command uses all available safety equipment installed in the aircraft and on the ground.
- Pilot-in-command is aware of the risks involved in setting the aircraft's altimeter, including inherent limitations of barometric altimeters.
- Knowing the air traffic control system well enough to be proficient in it.
- Knowing when not to fly.
- Properly using an autopilot, if so equipped, to reduce pilot workload.
- Proper use of checklists as outlined in the aircraft manual, or if not listed, before reaching 1,000 feet above ground level (AGL) to minimize any distractions when operating close to the ground.
- The importance of flying a stabilized approach. A common definition of a stabilized approach is maintaining a stable speed, descent rate, vertical flight path, and configuration throughout the final segment of the approach. Although originally designed for turbojet aircraft, a stabilized approach is also recommended for propeller-driven aircraft. The idea is to reduce pilot workload and aircraft configuration changes during the critical final approach segment of an approach. The goal is to have the aircraft in the proper landing configuration, at the proper approach speed, and on the proper flight path before descending below the minimum stabilized approach height. The following are recommended minimum stabilized approach heights:
  - 500 feet above the airport elevation during VFR weather conditions.
  - MDA or 500 feet above airport elevation, whichever is lower, for a circling approach.
  - 1,000 feet above the airport or touch down zone elevation during IMC.
- The increased CFIT risk of non-precision approaches.
- The increased CFIT risk of high descent rates near the ground.
- The importance of good communications between the pilot and air traffic control concerning any flight instruction or clearance. Ask for clarification whenever in doubt about any instruction or clearance.
- The dangers of complacency for the single-pilot, as well as multi-piloted crews, when making routine flights.
- The dangers of misunderstanding air traffic control instructions or accepting an incorrect clearance.
- The dangers of not knowing the safe altitudes for the en route and terminal areas.

Low-Flying Aircraft Operating in VFR Conditions

Although many of the factors listed previously apply to low-flying aircraft operating in VFR conditions, this is a special category for those pilots flying below minimum safe altitudes. Such operators include agriculture applicators and helicopter pilots who routinely operate near trees, telephone lines and power lines, or other such obstacles. In many cases, the pilot may be aware of obstacles but environmental factors such as time of day, minimal light, shadows, darkness, sun glare, cockpit blind spots, fatigue, or other such factors result in the pilot losing situational awareness and hitting an obstacle or impacting the ground. In other cases, pilots are unable to avoid a collision because they do not see the danger in time, or they see the danger but fail to react in time to avoid an accident. Density altitude and aircraft performance

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limitations may also pose risk factors for such flights. These same factors can also result in a CFIT accident for someone flying in mountainous terrain. Some common low altitude CFIT factors are:

- Wind shear and loss of flying speed.
- Density altitude.
- Failure to operate aircraft within operating limitations.
- Failure to check an area from a safe altitude before descending into it (high reconnaissance and low reconnaissance).
- Flying between hills or over rivers below hill tops can result in a CFIT accident if a power line or cable is strung between the hills. Not all such lines are marked or charted.
- Flying up a box canyon and not being able to fly up and out of it before impacting terrain.
- Flying over rising terrain that exceeds an aircraft's ability or performance to climb away from the terrain.
- Errors in pilot judgment and decision making.
- Diversion of pilot attention.
- Buzzing.
- Crew distractions or a breakdown in crew resource management.
- Operating in an unsafe manner.
- Failure to maintain control of the aircraft when taking off or landing.
- Failure to properly pre-plan the flight.
- Operating in unfamiliar areas or depending upon untrained people to provide important flight data.
- Not having an objective standard to make go/no-go decisions for launching.
- Failure to review all available data for the flight (particularly applicable to medical evacuation flights).
- Lack of terrain knowledge and elevation of the highest obstacles within your immediate operating area.
- Failure to properly plan your departure route when departing from unprepared areas. Such factors include weight and balance, aircraft performance, height of obstacles, wind direction, trees, density altitude, rising terrain, length of takeoff area, and safe abort areas.

Reducing CFIT Risks

Controlled flight into terrain normally occurs at speed, with the result that many such accidents are fatal. A common thread throughout this chapter is the importance of proper planning, good decision making, and being able to safely operate the aircraft throughout its entire operating range. Since CFIT implies that the aircraft is operating properly, the main reason for such accidents is what is commonly called "pilot error." Therefore it is the pilot's responsibility to ensure that he or she is qualified for the flight, that the aircraft is properly equipped, and that the flight is flown according to the appropriate regulations and aircraft operating limitations.

According to the CFIT Education and Training Aid, about 25.0 percent of all accidents occur during the takeoff and initial climb segment of flight. Approximately 7.0 percent of the accidents occur during the climb portion. About 4.5 percent occur during cruise. About 19.5 percent occur during descent and initial approach, but 41.4 percent of the accidents occur during final approach and landing. Takeoff, initial climb, final approach, and landing represent only about 6.0 percent of the total flight time of a given flight, but as these numbers point out, that 6.0 percent of a flight's total time can be deadly, since 65 percent of all accidents occur during this time.

Ground proximity warning systems and the newer terrain awareness and warning systems using GPS have the potential to reduce CFIT accidents on takeoff and landing. These systems provide one more tool for pilots to use to increase their safety margin when operating close to terrain and obstacles. However, every pilot must know the limitations of his or her database and what objects are included in the database.

The solution to combating CFIT accidents starts on the ground. Pilots need to properly prepare to safely execute the maneuvers required during takeoff, initial climb, final approach, and landing phases of flight. Whether VFR or IFR, each flight has critical flight segments. How the flight segments are planned for and handled determines, to a great extent, the safety of the flight. The Flight Safety Foundation's CFIT Checklist provides one example of how to calculate CFIT risk. It states, "Use the checklist to evaluate specific flight operations and to enhance pilot awareness of the CFIT risk." Page four of the checklist tells how pilots can obtain copies of the checklist or reproduce it.
Recommendations:

- Non-instrument rated VFR pilots should not attempt to fly in IMC.
- Know and fly above minimum published safe altitudes. VFR: Fly a minimum of 1,000 feet above the highest terrain in your immediate operating area in non-mountainous areas. Fly a minimum of 2,000 feet in mountainous areas.
- If IFR, fly published procedures. Fly the full published procedure at night, during minimum weather conditions, or when operating at an unfamiliar airport.
- Verify proper altitude, especially at night or over water, through use of a correctly set altimeter.
- Verify all ATC clearances. Question an ATC clearance that assigns a heading and/or altitude that, based upon your situational awareness, places the aircraft in a CFIT environment.
- Maintain situational awareness both vertically and horizontally.
- Comply with appropriate regulations for your specific operation.
- Don't operate below minimum safe altitudes if uncertain of position or ATC clearance.
- Be extra careful when operating outside the United States or in an area which you are not familiar.
- Use current charts and all available information.
- Use appropriate checklists.
- Know your aircraft and its equipment.

Related Links:
CFIT Checklist: http://bit.ly/glT2F7

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