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ACCIDENTS DURING FLIGHT INSTRUCTION:

A REVIEW

CONTENTS

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SUMMARY

The aviation industry has historically held that flight training is safer than non-instructional general aviation flight. The Air Safety Institute analyzed GA accident data to assess this claim. This analysis found that:

— Fatal accident rates during instructional flights were less than half of those during non-instructional flights.

While instructional flights have a much lower rate of fatal accidents, the rates of non-fatal accidents were similar. This is a useful finding in its own right, but other important points also emerged from the data review.

— In airplanes, accidents caused by fuel mismanagement, adverse weather, and mechanical failures were less common during instructional flights.

Just as in other GA flying, takeoffs, landings, and go-arounds accounted for a high percentage of training accidents in airplanes:

— Eighty percent of accidents on fixed-wing student solos occurred during takeoffs, landings, or go-arounds.

In both instructional and non-instructional flight, poor airmanship during these phases of flight caused the largest number of accidents but relatively few fatalities.

Accidents in helicopter training didn't follow the same patterns seen in fixed-wing aircraft. Perhaps this is because rotorcraft instructors wait longer before allowing students to fly solo, or perhaps it's due to reasons we haven't figured out yet. But there were differences.

— Two-thirds of primary training accidents in fixed-wing aircraft happened on student solo flights, while in helicopters these made up just one-quarter.

Just as in other GA flying, take-offs, landings, and go-arounds accounted for a high percentage of training accidents in airplanes...

> ...fatal accidents were more common during advanced instruction than in primary training...

In both categories, accidents were apparently both more frequent and more severe during advanced training.

- In both rotorcraft and airplanes, the majority of accidents on dual flights (with an instructor on board) occurred during advanced training (i.e., the student was already rated in the same category of aircraft).
- In both airplanes and helicopters, fatal accidents were more common during advanced instruction than in primary training, and happened more frequently during dual instruction than on solo flights by student pilots.
- More airplanes crashed during recurrent training and new-model transitions than in pursuit of additional ratings or certificates, but fatalities were most common during instrument training.

Additional details presented in the following pages offer further insights and suggest opportunities to make flight instruction safer.

INTRODUCTION

One of the most common questions of prospective students—and their families—is whether flight training is safe. The industry's traditional response has been that instructional flights have a better safety record than general aviation (GA) as a whole. While true as far as it goes, that answer ignores complexities in the accident records that characterize different aircraft and different stages of the training process. More detailed analysis can help illuminate the actual risks involved.

WHAT IS AN *ACCIDENT*?

While you might expect to know one when you see it, the actual definition of an aircraft accident is less straightforward. Inclusion in the official statistics isn't determined by the cost of repair or even entirely by the extent of the damage. An event that destroys an aircraft may not even qualify as an "accident" under the law.

While you might expect to know one when you see it, the actual definition of an aircraft accident is less straightforward.

The regulation that defines "aircraft accident" is 49 C.F.R. Part 830, which specifies which occurrences must be reported to the National Transportation Safety Board (NTSB). Two conditions must be met: The aircraft is occupied for the purpose of flight, and the event results in serious injury to a person, substantial damage to an aircraft, or both. Thus, if a pilot taxiing out to the runway hits a hangar and damages a wing spar, it would count as an accident, but if a mechanic does the same thing during a ground run, it would not.

"Serious injury" and "substantial damage" are likewise defined by the regulation. The former includes broken bones, injuries to internal organs, or hospitalization for more than 48 hours; the accident is considered fatal if the injuries cause death within 30 days. The latter essentially requires that damage to structural components of the aircraft make it unairworthy without major repair, but also provides a list of exclusions including damage to landing gear, propellers, engines, and skins. The result is that the majority of gear-up landings in retractable-gear airplanes, while expensive to fix, are not considered "accidents" for reporting or statistical purposes. Thus, accident statistics alone do not capture every event with safety implications, but do provide a fairly complete view of those causing significant injuries.

The relevant sections of 49 C.F.R. Part 830 are reprinted in the Appendix.

TYPES OF ACCIDENTS

To analyze their causes, it is useful to place each accident in exactly one category. The Air Safety Institute (ASI) reviews every probable-cause report issued by the NTSB before making an independent determination of the most important causal factor. In complex accident chains, this may be more a matter of emphasis than a clear choice. For instance, if a pilot successfully glides his tailwheel airplane back to the runway after an engine failure and touches down under control, then ground-loops during the landing roll, ASI would typically classify this as a landing accident rather than one caused by a mechanical problem.

The Air Safety Institute (ASI) reviews every probable-cause report issued by the NTSB before making an independent determination of the most important causal factor.

Some of the categories used in this report are less intuitive than others. Takeoff accidents are those involving loss of control between the start of the takeoff roll and beginning the crosswind turn or reaching pattern altitude; similarly, landing accidents are losses of control during the time between entering the final leg of the traffic pattern (or passing the final approach fix on IFR flights) and exiting the runway. Go-around accidents are those in which control is lost initiating the go-around prior to establishing a stable climb. Maneuvering accidents are all those precipitated by significant deliberate changes of aircraft attitude; these encompass everything from turns in the traffic pattern to aerobatic practice. When the failure of some part or component brings down the aircraft in circumstances that make a safe emergency landing unlikely, it's classified as a mechanical accident.

In helicopters, autorotation accidents include both intentional practice and those emergency autorotations where a pilot of ordinary skill could reasonably be expected to land without injury or damage. "Other rotorcraft aerodynamics" includes phenomena such as settling with power, dynamic rollovers, ground resonance, mast bumping, and losses of tail rotor effectiveness.

Complete definitions of all the accident categories used in this report are provided in the Appendix.

WHAT IS AN INSTRUCTIONAL FLIGHT?

While the first thing that comes to mind might be a student pilot working toward a recreational, sport, or private certificate, the field is considerably broader. Flight instruction includes not only initial pilot training, but also work toward advanced certificates or ratings, transitions into unfamiliar aircraft, and recurrent instruction such as flight reviews and instrument proficiency checks (IPCs). Practical tests administered by FAA inspectors or designated pilot examiners (aka "checkrides") are not considered dual instruction under the Federal Aviation Regulations, but are an essential step toward pilot certification and unavoidably part of the instructional process.

2401
INSTRUCTIONAL ACCIDENTS 2002–2011

410
INVOLVED HELICOPTERS

1995
INVOLVED AIRPLANES

In examining 10 years' worth of instructional accidents (calendar years 2002-2011, inclusive), ASI found it helpful to distinguish between the two basic levels of flight instruction:

Primary training: The pilot undergoing instruction (PUI) holds nothing higher than a student pilot certificate for that category of aircraft. Fixed-wing pilots learning to fly helicopters and helicopter pilots taking initial instruction in airplanes are also considered primary students.

Advanced training: The PUI holds at least a recreational, sport, or private pilot certificate in the same category of aircraft. He or she may be pursuing a more advanced certificate or rating, seeking an additional endorsement (e.g., tailwheel, complex, or high-performance), transitioning to an unfamiliar model of aircraft, or undergoing recurrent training such as a flight review or IPC. Dual instruction for the purpose of maintaining proficiency outside of flight reviews or IPCs also falls into this category.

IDENTIFYING INSTRUCTIONAL ACCIDENTS

Primary and advanced training include both dual and solo flights. Past analyses have relied on the NTSB's classification of the purpose of each accident flight; by their definition, instruction includes all "flying accomplished in supervised training under the direction of an accredited instructor." However, careful review discovered a predisposition to classify any single-pilot flight, including authorized student solos, as "personal." ASI was able to identify more than 300 instructional accidents that had been misclassified as personal flights, the vast majority of them student solos, as well as a small number of accidents labelled as "instructional" that were not. Unauthorized flights by student pilots, whether solo or carrying passengers, were not considered training flights.

Unfortunately, the purposes of solo flights by certificated pilots are often difficult to determine. Accidents can occur while accruing the required experience or practicing maneuvers in pursuit of commercial, flight instructor, or airline transport pilot certificates, but though these serve the same purposes as student solos, identifying them as training flights relies on statements from the pilots themselves, their instructors, or knowledgeable witnesses. Often none are available, making it likely that most solo accidents during advanced training are never identified as instructional. The extent of this undercount and its effects on calculated accident rates are difficult to estimate. ASI's review of a sample of accidents involving certificated pilots flying solo found that only about one percent could be conclusively determined to have occurred on training flights, but many more remained ambiguous.

THE RECORD

A total of 2,401 known instructional accidents between 2002 and 2011 involved 1,995 airplanes and 410 helicopters. (Four were mid-air collisions between two training aircraft.) These represent 16 and 31 percent, respectively, of all non-commercial accidents during that period. By FAA estimates, training made up 17 percent of non-commercial fixed-wing flight time and 26 percent of non-commercial helicopter activity.

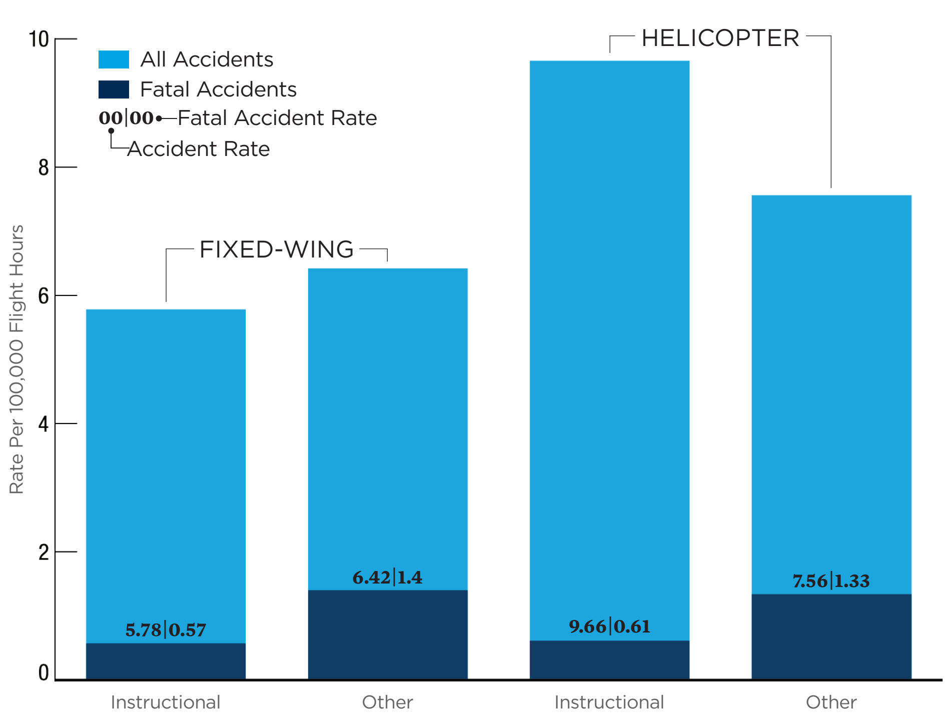
18%
HIGHER, HELICOPTER ACCIDENT RATE VS FIXED-WING RATE SINCE 2006

In both categories, instructional accidents were less than half as likely to be fatal as non-instructional; 194 of the fixed-wing accidents (10 percent) and 24 of the helicopter (6 percent) caused fatalities compared to 22 percent of non-instructional fixed-wing and 18 percent of non-instructional helicopter accidents. Fatal accident rates were likewise less than half of those on all other non-commercial flights. Overall accident rates were much more similar.

The rate of fixed-wing training accidents changed little during this decade, but the helicopter accident rate dropped dramatically...

The rate of fixed-wing training accidents changed little during this decade, but the helicopter accident rate dropped dramatically: from more than 25 per 100,000 flight hours in 2002 to just 5 in 2006. The decrease owes less to reductions in the numbers of accidents (44 in 2002 compared to 35 in 2006) than to sharp increases in FAA-estimated training time, which quadrupled over the same period from less than 175,000 hours to nearly 700,000. It's possible that this reflects improvements

Accident Rates: Instructional Vs. Non-Instructional Flights



Note: At the time of publication, the FAA had not released the results of the 2011 General Aviation and Part 135 Activity Survey. Estimated rates are based on accidents and flight times from 2002-2010.

in the methods used to conduct the annual GA activity survey more than an actual increase in instructional flying. Since 2006, the rate of helicopter training accidents has been 18 percent higher than the fixed-wing rate (7.00 vs. 5.92).

TYPES OF INSTRUCTION: FIXED-WING VS. HELICOPTER

In airplanes, almost two-thirds of all accidents occurred during primary training, but more than 60 percent of fatal accidents came in advanced instruction. Two-thirds of all primary accidents were on student solos, but two-thirds of fatal primary accidents took place during dual instruction. In helicopters, advanced instruction accounted for nearly 60 percent of all accidents, fatal and non-fatal alike, and student solos only made up one quarter of all primary training accidents.

Two-thirds of all primary accidents were on student solos, but two-thirds of fatal primary accidents took place during dual instruction.

63% OF FATAL ACCIDENTS DURING ADV. TRAINING

Because of the strong likelihood that most solo accidents during advanced training have not been identified, and with no reason to assume those that have are representative of the rest, discussion of advanced instructional accidents will be confined to those on dual flights.

Instructional Accidents, 2002-2011

	ALL ACCIDENTS		FATAL ACCIDENTS	
FIXED-WING	1995		194	
Primary	1306	65%	72	37%
Dual	436	33%	47	65%
Solo	870	67%	25	35%
Advanced	687	35%	122	63%
Dual	615	90%	115	94%
Solo*	72	10%	7	6%
HELICOPTER	409		24	
Primary	180	44%	11	46%
Dual	135	75%	7	64%
Solo	45	25%	4	36%
Advanced	229	56%	13	54%
Dual	210	92%	11	85%
Solo*	19	8%	2	15%

**Probably undercounted*

FIXED-WING

Mishaps during takeoffs, landings, and go-arounds (TLGs) made up half of all accidents in both primary and advanced dual instruction and more than 80 percent of those on student solos.

RELATIVE RISKS

Two-thirds of primary accidents, including 35 percent of fatal accidents, were on student solos. Unfortunately, there is no reliable data on the total amount of solo flight time logged by student pilots, but there is little doubt that it is a small fraction of the time spent in dual instruction. If 80 percent of a typical student's training time is dual, it would follow that the risk of an accident during a solo is eight times higher than on a dual flight. The risk of fatality would be about twice as high during solos, though still very low.

Looking only at dual instruction, the number of accidents during advanced training was more than 40 percent higher than the number in primary training, and included two and a half times as many fatal accidents. Differences in the respective amounts of CFI time devoted to the two are likewise difficult to estimate. Those without instrument or multiengine instructor privileges presumably devote almost all their time to primary instruction, while senior instructors in larger schools may be able to use the majority of theirs providing instrument, commercial, and multiengine training. Long-time CFIs often describe this kind of career progression.

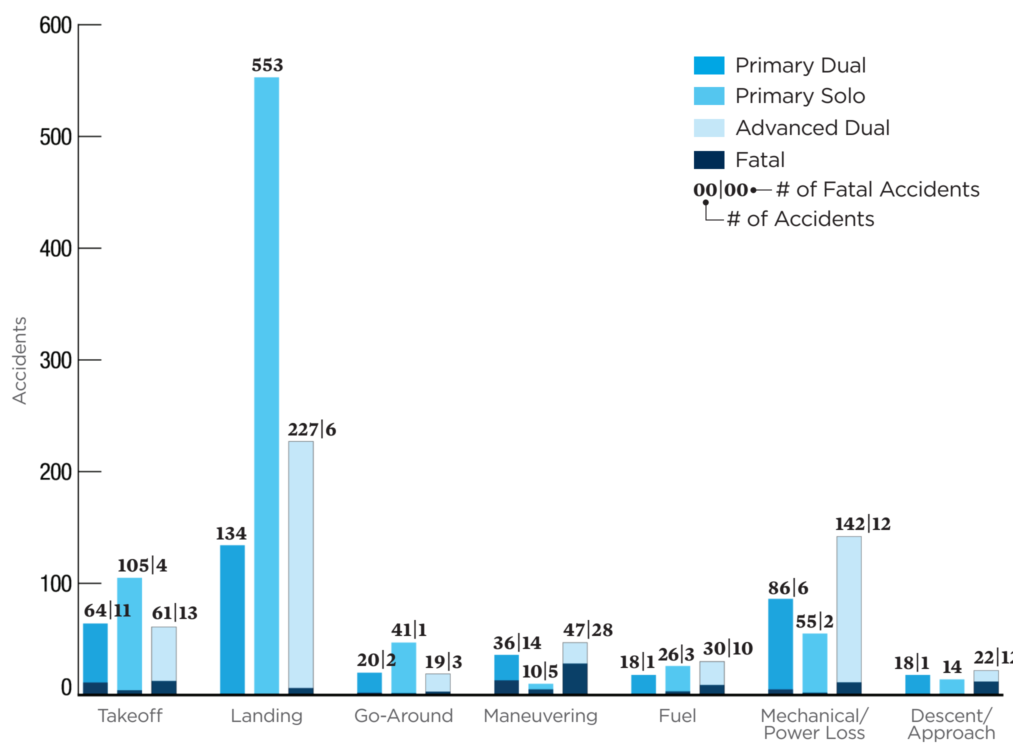
It seems clear that advanced instruction carries a greater accident risk and a much higher risk of fatality than primary instruction. How much greater depends on the amount of CFI time devoted to each. If, for example, two-thirds of all teaching time was spent with primary students, the overall accident rate during advanced instruction would be almost three times higher, and the fatal accident rate five times as high. If primary training made up 80 percent of all fixed-wing instruction, advanced training would carry five and a half times the risk of any accident and nearly 10 times the risk of fatality.

ACCIDENT CAUSES

As in all fixed-wing GA, the greatest hazards are near the ground. Mishaps during takeoffs, landings, and go-arounds (TLGs) made up half of all accidents in both primary and advanced dual instruction and more than 80 percent of those on student solos. Landing accidents were most common but least dangerous; while they accounted for 64 percent of student solo accidents, 31 percent of primary dual, and 37 percent in advanced training, only six were fatal (all on advanced flights). Takeoffs ranked a distant second in primary training at 15 percent of dual and 12 percent of solo accidents; in advanced instruction, they accounted for 10 percent, ranking third behind mechanical failures (17 percent).

Accidents blamed on known mechanical failures or unexplained losses of engine power were the next most common, accounting for 20 percent of all accidents during primary dual, 23 percent during advanced, and 7 percent of accidents on student solos. Maneuvering—including flight in the traffic pattern as well as maneuver practice per se—led to the largest numbers of fatal accidents, including 30 percent of all those in primary dual, 20 percent of those on student solos, and one-quarter of those during advanced dual. Forty percent of maneuvering accidents on dual primary flights, 50 percent of those on student solos, and 60 percent of those during advanced lessons were fatal.

Leading Accident Causes During Fixed-Wing Instruction



Advanced training flights suffered nine mid-air collisions, all fatal, including two between two training aircraft. There were six, two of them fatal, on student solos, and five (three fatal) during primary dual lessons. Unlike fixed-wing GA in general, adverse weather was not a significant hazard, causing less than 1 percent of all instructional accidents.

Unlike fixed-wing GA in general, adverse weather was not a significant hazard, causing less than 1 percent of all instructional accidents.

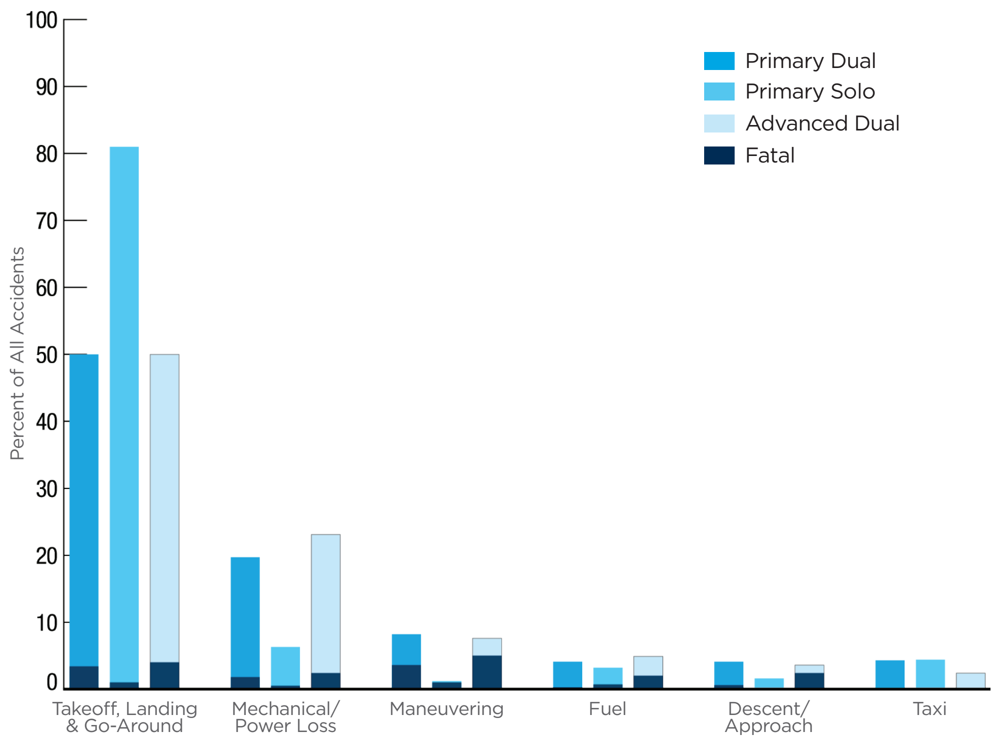
In dual instruction, most types of accidents were both more frequent and more severe during advanced training, but the percentages due to various causes were almost identical. Half occurred during takeoffs, landings, or go-arounds. A little more than 20 percent were caused by unexplained power losses or proven mechanical problems, and 8 percent of each were losses of control or collisions with obstacles while maneuvering. Fuel mismanagement led to 4 percent of primary and 5 percent of advanced dual accidents and another 4 percent came during descent and approach. Only accidents while taxiing were less common during advanced training, where they made up only 2 percent of the total compared to 4 percent in both levels of primary training.

50%

PRIMARY DUAL AND ADVANCED DUAL ACCIDENTS ARE DURING TAKEOFFS, LANDINGS, AND GO-AROUNDS

On student solos, TLG accidents were almost evenly divided between losses of directional control and hard landings or stalls...

Percent of Accidents by Cause During Fixed-Wing Instruction



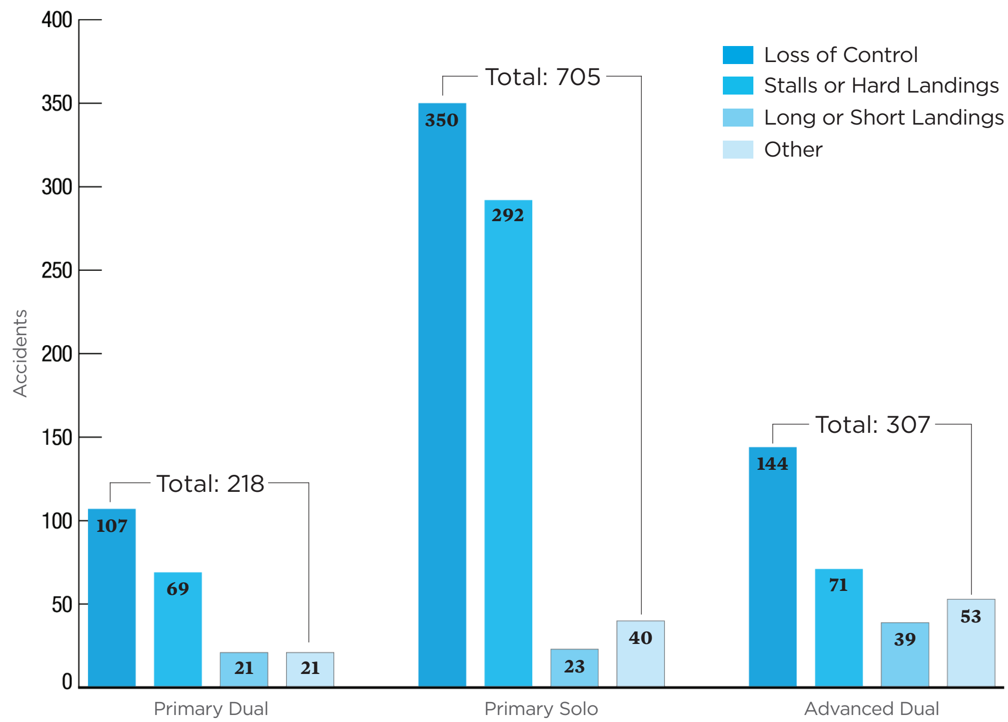
TAKEOFFS, LANDINGS, AND GO-AROUNDS

The specific causes of TLG accidents did vary with type of instruction. Almost half involved losses of directional control (including ground loops and cartwheels) in primary dual, solo, and advanced training alike, but the raw counts differed considerably. Primary and advanced dual saw almost identical numbers of stalls and hard landings, but advanced lessons suffered 35 percent more losses of control, almost twice as many undershoots or overruns, and two and a half times as many TLG accidents of other types (including accidents attributed to density altitude, excess weight, runway conditions, and errors operating retractable landing gear). Collectively, these led to 40 percent more TLG accidents during advanced training. Student solo accidents were almost evenly divided between losses of directional control and hard landings or stalls; only 3 percent were landing attempts that came up either long or short.

Stall accidents on instructional flights rarely occur while actually practicing stalls.

90% OF STALLS ON STUDENT SOLOS CAME WHILE LANDING

Takeoff, Landing, and Go-Around Accidents During Fixed-Wing Instruction



STALLS

Unintended stalls (including spins) have been an area of concern for many years; all levels of fixed-wing instruction devote considerable attention to stall recognition, prevention, and recovery. Despite that emphasis, stalls continue to cause significant numbers of accidents both during and outside training. Notably, stall accidents on instructional flights rarely occur while actually practicing stalls. Almost 90 percent of those on student solos happened during landing attempts, while the single largest share in both levels of dual instruction occurred while practicing other maneuvers. Maneuvering stalls were also the most deadly in every phase of instruction: Five of seven on student solos, 12 of 25 during dual primary instruction, and 20 of 33 during advanced dual were fatal. These made up two-thirds of all fatal stall accidents during dual instruction and more than 70 percent of those on student solos.

3/4

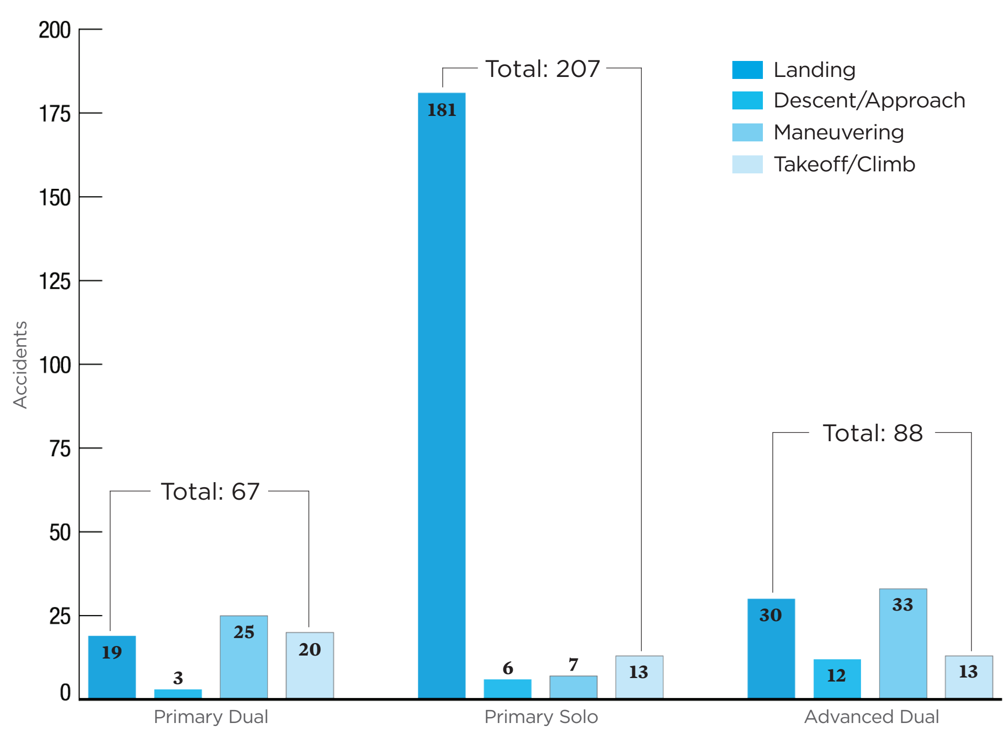
OF FUEL MGMT. ACCIDENTS DURING ADVANCED TRAINING WERE DUE TO INCORRECT OPERATION OF FUEL SYSTEMS

Only 5 percent of those in primary dual instruction and 10 percent of those on student solos were fatal compared to 33 percent of the fuel-management accidents during advanced training...

Student pilots flying solo occasionally succumb to temptation and attempt unauthorized maneuvers. Four of the seven maneuvering stalls on student solos happened during sharp pull-ups after low-altitude passes, and two were fatal. During dual instruction, the leading cause of stall accidents in maneuvering flight was practicing emergency procedures, particularly simulated engine failures. More than half of all maneuvering stalls in both primary (14 of 25) and advanced training (17 of 33) were the result of emergency training gone wrong, including 14 of a combined 32 fatal accidents.

All the remaining fatal stalls during primary training were takeoff accidents, six on dual lessons and two on student solos. Stalls during descent and approach were especially lethal in advanced instruction, where seven of 12 were fatal. Only one occurred during an instrument approach, and it was the result of an unauthorized low-altitude circling attempt in IMC. All the rest took place in visual conditions in daylight. Ten of the 12, including all seven fatal accidents, were in single-engine airplanes. Both stalls in twins occurred in the traffic pattern while simulating single-engine flight.

Stall Accidents During Fixed-Wing Instruction



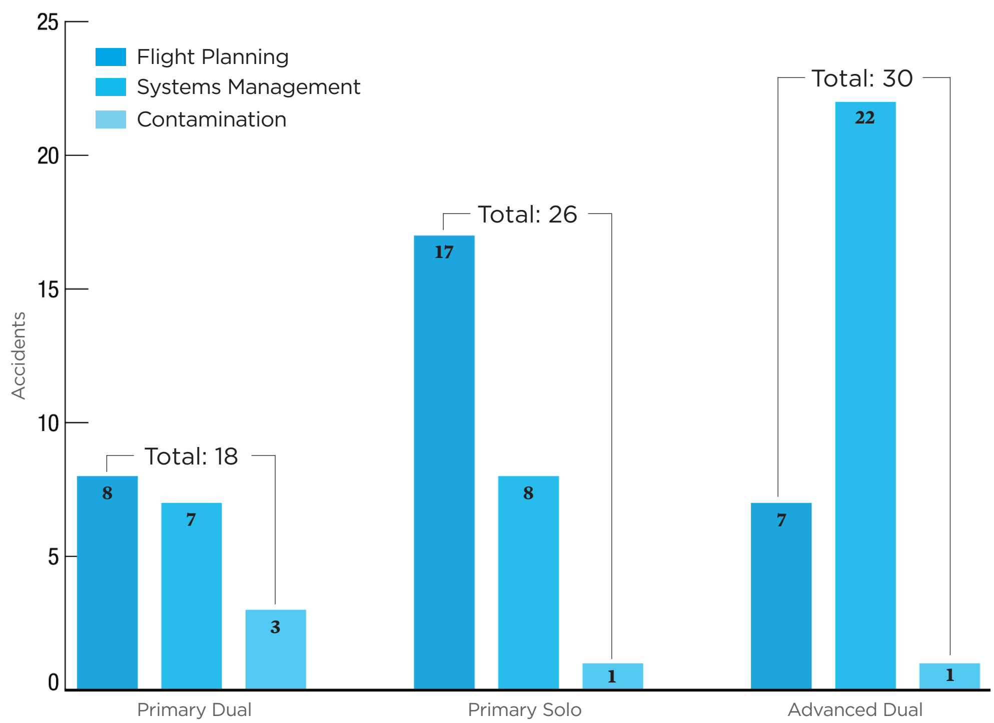
FUEL MISMANAGEMENT

Because it is entirely preventable, fuel mismanagement remains of concern even though it caused less than 4 percent of all instructional accidents. The record of these suggests the interaction between pilot experience and aircraft speed and complexity. Two-thirds of those on student solos were complete fuel exhaustion, the result of poor flight planning or unwillingness to adapt to unexpected circumstances such as stronger-than-forecast headwinds or fuel not being available at a planned stop.

Three-quarters of those during advanced instruction, on the other hand, resulted from incorrect operation of the aircraft's fuel systems, either starvation due to a failure to switch tanks at an appropriate time or misuse of boost or transfer pumps. Primary dual instruction saw both types of accidents in essentially equal numbers. Both pilot experience and the speed and weight of the accident aircraft helped determine these accidents' survivability. Only 5 percent of those in primary dual instruction and 10 percent of those on student solos were fatal compared to 33 percent of the fuel-management accidents during advanced training, where 20 of the 30 accident aircraft were high-performance, complex, or both; these included seven of the 10 fatal accidents. Fuel mismanagement was particularly hazardous in twin-engine airplanes, where five of eight accidents were fatal.

The record of these suggests the interaction between pilot experience and aircraft speed and complexity.

Fuel Mismanagement Accidents During Fixed-Wing Instruction



6%

OF ACCIDENTS ON STUDENT SOLOS DUE TO ENGINE STOPPAGES OR MECHANICAL FAILURE

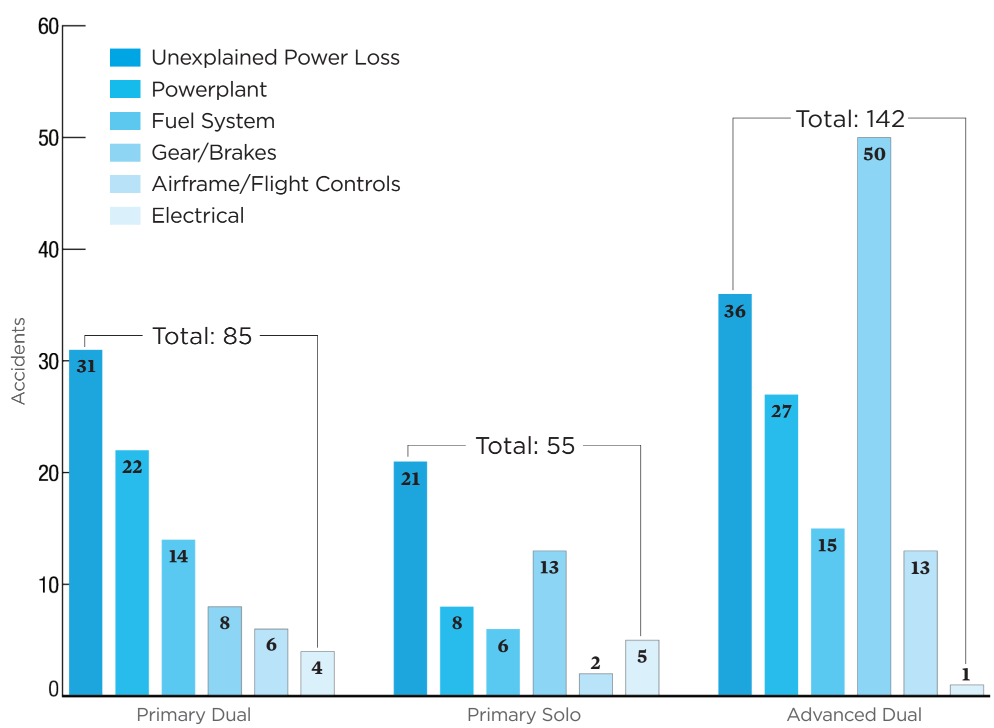
In primary training, unexplained losses of engine power caused more accidents on both dual and solo flights than proven failures...

MECHANICAL FAILURES AND UNEXPLAINED ENGINE STOPPAGES

About 22 percent of all accidents during dual instruction were the result of either confirmed mechanical problems or losses of engine power for reasons that were never satisfactorily explained: adequate fuel was available, and inspection found no evidence of pre-impact abnormalities. This is comparable to non-instructional flights, where they caused about 25 percent of fixed-wing accidents. Only 6 percent of accidents on student solos were attributed to engine stoppages or mechanical failures. (This does not mean that solo students are less likely to break their airplanes; rather, the overall number of accidents on their flights is inflated by the large number caused by lapses in basic airmanship.) Standardized by hours flown, the rate of mechanical and power-failure accidents on instructional flights was only half that on non-instructional (0.81 vs. 1.62 per 100,000 hours), and those that did occur were only about half as likely to be fatal, with 7 percent lethality compared to 13 percent in all other types of flights.

In primary training, unexplained losses of engine power caused more accidents on both dual and solo flights than proven failures of any individual type of aircraft system or component. In these cases, physical examination of the aircraft's engines and accessories failed to detect any anomalies beyond impact damage; adequate fuel was available and the fuel system was configured correctly. Those

Mechanical and Power Loss Accidents During Fixed-Wing Instruction



engines that escaped serious damage generally ran normally after the accidents. Some were probably due to fuel starvation or carburetor ice, but neither these nor any other causes could be confirmed. Add in powerplant and fuel-system malfunctions, and conditions causing complete or partial losses of engine power were responsible for nearly 80 percent of all accidents of mechanical origin in primary dual instruction (67 of 85) and almost two-thirds of those on student solos (35 of 55).

Landing gear and brake problems were the most prevalent type of failure during advanced instruction.

Landing gear and brake problems were the most prevalent type of failure during advanced instruction. Three-fourths of the airplanes involved (37 of 50) had retractable gear, including 21 twins. Gear collapses were also the second leading category on student solos, where they made up almost one-quarter of the total (13 of 55), though all of those aircraft were fixed-gear singles. Unexplained power losses and confirmed breakdowns of powerplant or fuel-system components were responsible for just over half of mechanically related accidents during advanced training. Failures of flight controls, other airframe elements, or electrical equipment rarely led to accidents in any level of flight instruction, causing a combined total of just 11 percent (31 of 282).

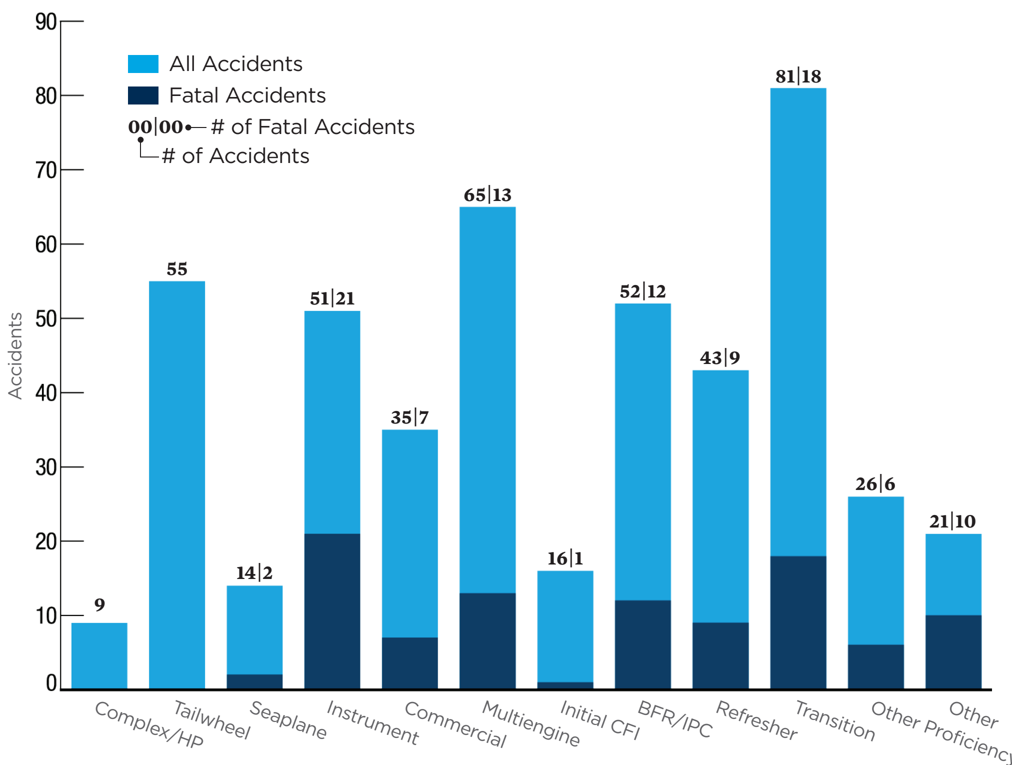
LESS THAN **40%** OF ADVANCED DUAL ACCIDENTS OCCURRED IN PURSUIT OF CHECKRIDE-REQUIRED CERTIFICATES OR RATINGS

TYPES OF ADVANCED TRAINING

The elements of primary instruction are well defined, but "advanced training" is a catch-all category including everything from complex and high-performance endorsements to standardization training for newly hired instructors and the proficiency checks required by commercial and government flight departments. Detailed review of the 615 accidents during advanced dual instruction identified the type of training being conducted in 468 (76 percent), including 99 of the 115 fatal accidents (86 percent). They cannot be assumed representative of the remaining 147, so the results should be interpreted with some caution. However, accidents on flights for which the type of instruction was not specified were predominantly minor, with only half the lethality of those on flights whose purposes were identified.

Few accidents occurred while training for complex and high-performance endorsements, and though aircraft were frequently damaged during tailwheel instruction, serious injuries were rare. During the study period, there were no fatalities during instruction toward any of these logbook endorsements. In all, less than 40 percent of advanced dual accidents occurred in pursuit of certificates or ratings requiring a checkride. The majority took place during recurrent training, new-model transitions, instruction in specialized techniques such as crop-dusting, mountain flying, or aerobatics, and training toward the logbook endorsements mentioned above.

Types of Advanced Fixed-Wing Instruction Conducted on Accident Flights



The number of accidents during multiengine training, which ranked second overall, was disproportionate to the number of aircraft and amount of flight time involved.

Fatal accidents were most frequent during instrument training, including recurrent practice approaches as well as initial instruction; 41 percent were fatal, almost double the lethality of accidents during flight reviews, IPCs, or transition training. However, only three of the 21 fatal accidents were ascribed to deficiencies in flying instrument procedures. Five were the result of mid-air collisions, including one between two airplanes engaged in hood work. Since there were only nine fatal mid-airs in all types of advanced training, the perception of excess risk of collisions during instrument practice seems well founded.

Of the remaining 12, three were takeoff or landing stalls in visual conditions and three more were the result of fuel mismanagement (two cases of starvation and one of complete fuel exhaustion). One was a low-altitude stall attempting an unauthorized circling approach after breaking out long and four were CFIT or losses of control during the visual portions of the flights. One instructor was killed by a prop strike after leaving the cockpit with the engine running.

The number of accidents during multiengine training, which ranked second overall, was disproportionate to the number of aircraft and amount of flight time involved. As might be expected, the majority occurred during real or simulated engine failures (which make up much of the multiengine curriculum). Nine of 13 fatal accidents involved losses of control in flight, and at least seven of those were in single-engine flight (including two which lost engine power due to fuel starvation). One loss of control was precipitated when the instructor suffered a seizure; there were also two mid-air collisions, a bird strike at night, and one case of complete fuel exhaustion without loss of control.

The greatest number of accidents overall occurred during transitions to unfamiliar aircraft, which also resulted in the second-largest number of fatalities.

The greatest number of accidents overall occurred during transitions to unfamiliar aircraft, which also resulted in the second-largest number of fatalities. More than a third, including six of 18 fatal accidents, were in either antique or experimental aircraft. Non-fatal accidents were predominantly takeoffs, landings, or go-arounds (35 of 63, or 56 percent, combined), while mechanical failures and unexplained engine stoppages accounted for another 17 (28 percent) combined. The largest share of fatal accidents (7 of 18) was attributed to unduly aggressive maneuvering, including attempted aerobatics in unapproved airplanes, aggravated stalls in low-altitude pull-ups, and unrecoverable stalls while practicing emergency procedures. Losses of control while attempting to take off or go around led to another five, while fuel mismanagement, adverse weather, unexplained power loss, inadequate preflight, and mechanical failure were each blamed for one.

MORE THAN **1/3** WERE IN EITHER ANTIQUE OR EXPERIMENTAL AIRCRAFT

Flight reviews and instrument proficiency checks ranked just ahead of refresher training not targeted toward specific currency requirements; together they produced just over 20 percent of advanced training accidents, fatal and non-fatal alike. The "Other proficiency" category includes scheduled recurrent training and check flights required by Part 135 operators, government entities, and organizations like the Civil Air Patrol, while "Other" captures specialized programs including aerial application, mountain flying, aerobatic, and upset recovery training.

AIRCRAFT AND FLIGHT CONDITIONS

Primary training is conducted almost exclusively in single-engine fixed-gear airplanes (SEF), and the accident record shows it. Advanced instruction, by contrast, is far more likely to involve retractable-gear, multiengine, or turbine aircraft. SEF airplanes were involved in 94 percent of primary dual accidents and 98 percent of accidents on student solos but just 54 percent of those during advanced instruction, where 25 percent of all accidents involved retractable piston singles, 18 percent were in piston twins, and 3 percent were in turbine-powered models. The small number of accidents in turboprops probably reflects the wide availability of simulator training for higher-end aircraft, the characteristically greater experience of the pilots who fly them, and more stringent apprenticeship requirements imposed by operators or their insurance underwriters.

More than half (55 percent) of all accidents involving tailwheel airplanes took place during advanced instruction, and 45 percent of all SEF aircraft in advanced training accidents had conventional gear. In primary training, they made up only 14 percent of SEF aircraft in dual accidents and 8 percent of those that suffered accidents on student solos. The ratio of solo to dual primary training accidents was actually higher in tricycle-gear airplanes, where there were 2.20 accidents on student solos for every one during dual instruction. In taildraggers, the ratio was 1.25 to one. The difference in the risk of landing accidents—widely believed to be a particular hazard to students and tailwheel pilots alike—was even more pronounced: In tailwheel airplanes, there were 1.91 times as many landing accidents on student solos as in dual lessons compared to 4.63 times as many in airplanes with tricycle gear. The extent to which this represents more thorough pre-solo training of tailwheel students versus less ability of their instructors to prevent accidents on dual flights isn't clear.

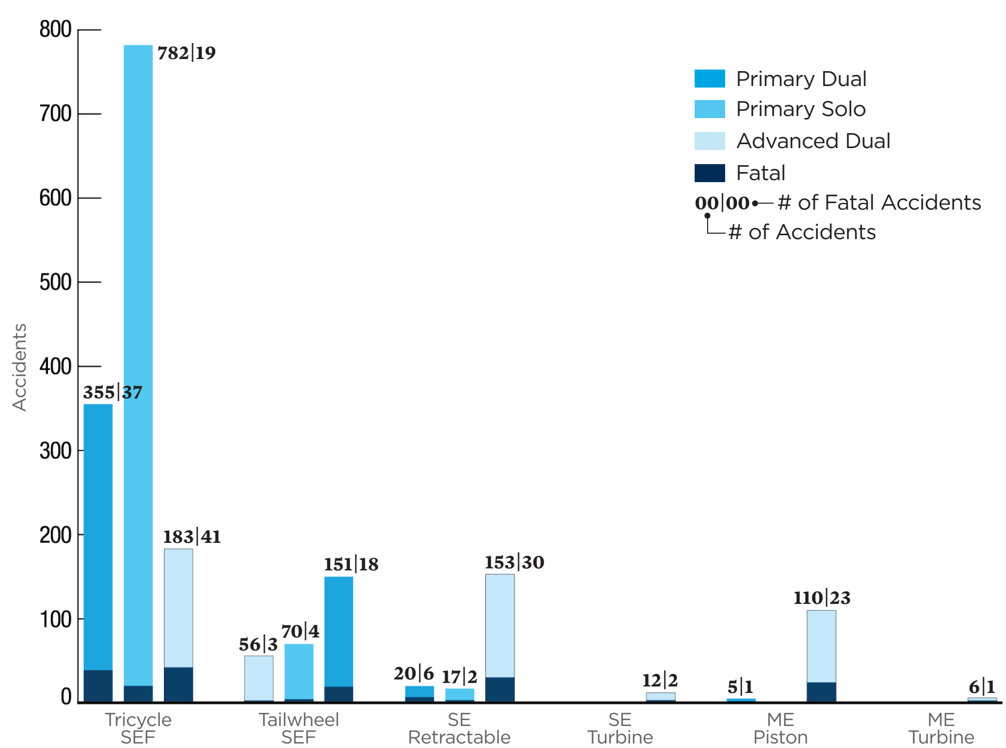
In tailwheel airplanes, there were 1.91 times as many landing accidents on student solos as in dual lessons...

Even for pilots pursuing an instrument rating, flight training remains primarily a fair-weather activity. Only 3 percent of all accidents in advanced training took place in instrument meteorological conditions (IMC), and adverse weather was the principal cause of only 15 of the 1,993 accidents in all three types of instruction combined. The vast majority of training flights are made in daytime, and 91 percent of primary dual accidents, 98 percent of accidents on student solos, and 90 percent of those during advanced dual took place in visual meteorological conditions (VMC) during daylight hours. Night VMC was the setting in 7 percent of accidents during primary dual instruction, 8 percent during advanced dual, and just 2 percent of those on student solos.

15

OF 1,993 ACCIDENTS WERE ATTRIBUTED TO HAZARDOUS WEATHER

Accidents By Aircraft Type During Fixed-Wing Instruction



HELICOPTER

1/4

OF PRIMARY TRAINING ACCIDENTS IN HELICOPTERS WERE DURING SOLOS

[In helicopters] fatal accidents were almost evenly divided between primary and advanced training...

RELATIVE RISKS

Accidents on solo flights by student pilots were much rarer in helicopters, accounting for only about one-quarter of primary training accidents compared to two-thirds of those in airplanes. While reliable data on time to first solo aren't available, anecdotal accounts suggest that helicopter students routinely receive more dual instruction (perhaps 25-30 hours) and complete a larger portion of the curriculum before receiving their solo endorsements than fixed-wing students, for whom 15-20 hours might be more typical. Students flying Robinson R22 and R44 helicopters, which comprise a substantial share of the training fleet, are required by Special Federal Aviation Regulation (SFAR) 73 to log a minimum of 20 hours of dual before becoming eligible to solo, and among those without prior rotorcraft experience, solos at the 20-hour mark are rare.

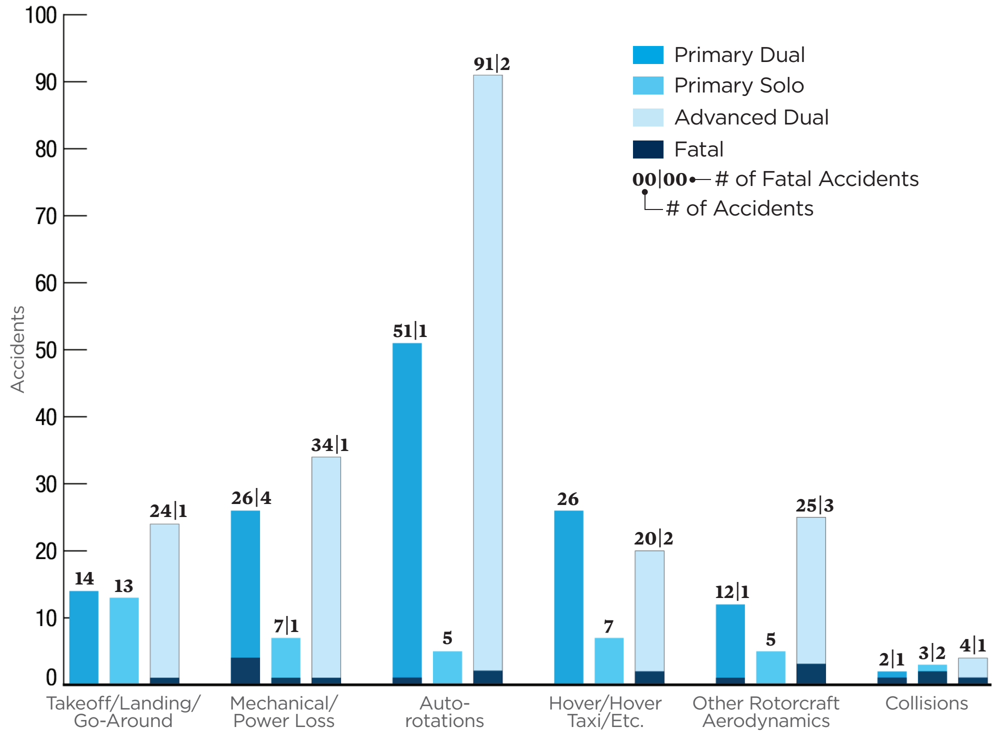
Not only did student solos comprise a much smaller share of primary training accidents in helicopters, but primary instruction as a whole accounted for only 44 percent of all rotorcraft training accidents compared to two-thirds of those in fixed-wing aircraft. As a result, student solos made up less than 12 percent of all instructional accidents in helicopters. In airplanes, they accounted for 45 percent.

Fatal accidents were almost evenly divided between primary and advanced training, another contrast with the fixed-wing record where more than 60 percent occurred during advanced instruction. The highest proportion of fatalities occurred on solo flights, which had the lowest proportion of fatal fixed-wing accidents. A lower risk of relatively minor landing accidents appears to be the principal factor; a much greater proportion of solo helicopter crashes were the result of genuine emergencies such as mechanical problems.

ACCIDENT CAUSES

Takeoffs and landings also posed the greatest risk to helicopter students on solo flights, though to a much lower extent than in fixed-wing training. Eight of 45 solo accidents occurred while trying to lift off, and five more when trying to set back down. Together they accounted for 29 percent of student solo accidents—a far cry from the 80 percent share of student solo accidents attributed to TLGs during fixed-wing instruction. Seven each were attributed to mechanical failures and to losses of control during either stationary hovering (three) or pedal turns (four). The remaining accidents were too scattered to reveal much of a pattern; there were three while attempting practice autorotations (a practice most flight

Leading Accident Causes During Helicopter Instruction



40% OF HELICOPTER DUAL INSTRUCTION ACCIDENTS OCCURRED DURING AUTOROTATIONS

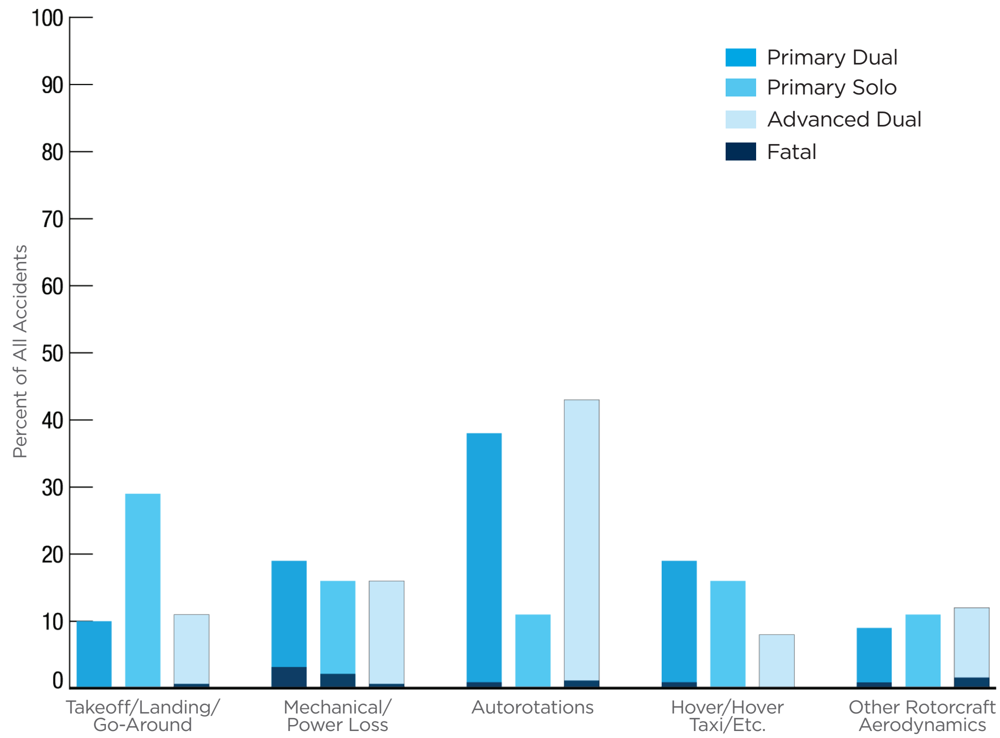
...primary students were more susceptible to losses of control while hovering, hover taxiing, or doing other low-altitude exercises...

schools discourage on student solos) and two more in full-down autorotations in response to perceived in-flight abnormalities. Fuel exhaustion, dynamic rollover, and loss of tail rotor effectiveness caused two apiece, while one was attributed to settling with power. The four fatal accidents on student solos were similarly random; an unexplained loss of engine power, controlled flight into terrain in visual conditions, continuing VFR flight into IMC, and a mid-air collision each caused one.

Autorotations were the major problem in dual instruction; they led to about 40 percent of all accidents in primary and advanced dual alike. Ninety-six percent of these happened while practicing autorotations; only six of 147 (less than 4 percent) involved actual emergency landings. Known mechanical failures and unexplained losses of engine power, the next largest category, caused less than half as many (67). Sixteen of the 26 accidents of this type in primary training were either unexplained or proven engine failures (nine and seven, respectively). Mechanical problems led to four of the seven fatal accidents in primary dual. These included three of the four accidents involving failures of rotor blades or pitch-change mechanisms.

Eleven of 26 mechanically related accidents in advanced instruction were powerplant failures or stoppages, while 11 more were caused by anomalies in main or tail rotor systems. Airframe or landing gear problems made up the rest. As might be expected, primary students were more susceptible to losses of

Percent of Accidents By Cause During Helicopter Instruction



Solo students were most vulnerable to losses of control during takeoffs and landings but suffered far fewer accidents during autorotations, most likely because they rarely attempted them.

control while hovering, hover taxiing, or doing other low-altitude exercises such as pedal turns, but advanced students suffered more accidents due to phenomena like settling with power (12 vs. two), ground resonance, and dynamic rollover (three vs. two in both cases). Advanced instruction also saw seven losses of control (none fatal) while practicing simulated hydraulic failures as well as the only fatal accident attributed to mast bumping.

As in fixed-wing training, the relative frequencies of different accident types were very similar at the primary and advanced states of dual instruction, both of which were quite distinct from the patterns that characterized student solos. Solo students were most vulnerable to losses of control during takeoffs and landings (no solo helicopter accidents were specifically attributed to piloting technique while attempting go-arounds) but suffered far fewer accidents during autorotations, most likely because they rarely attempted them. The share of accidents precipitated by mechanical failures or losses of engine power was very similar at all three levels, accounting for 19 percent in primary dual and 16 percent in both advanced instruction and student solos. Hovering, hover taxiing, and other low-altitude maneuvers such as pedal turns or practicing sideways or backwards flight posed the greatest hazard during dual primary instruction, where 19 percent of all accidents occurred during those maneuvers compared to 16 percent on student solos and just 6 percent in advanced training. In each case, less than 10 percent were blamed on aerodynamic phenomena peculiar to rotorcraft such as dynamic rollover, settling with power, or failures to recover from a loss of main rotor RPM.

Some accident causes that were rare during fixed-wing instruction were even more so in helicopters. Only 2 percent were due to fuel mismanagement, and only five accidents in 10 years were blamed on adverse weather. There was also one bird strike, three wire strikes, and three mid-air collisions.

6 OF 180
PRIMARY TRAINING ACCIDENTS WERE IN TURBINE HELICOPTERS

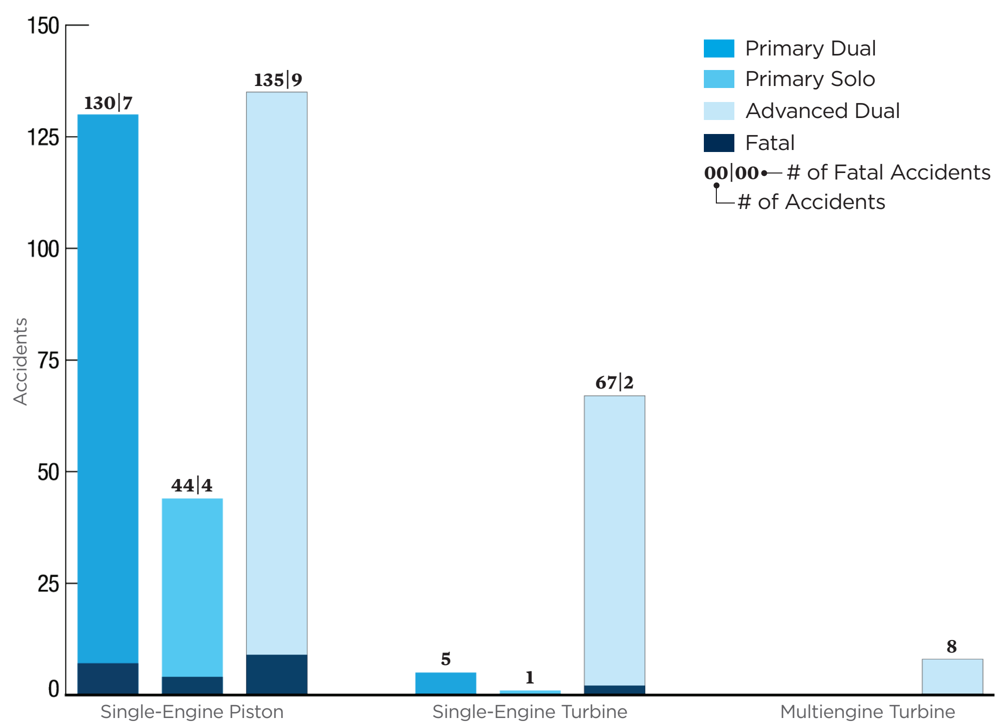
75 OF 211
ACCIDENTS DURING ADV. TRAINING WERE IN TURBINE HELICOPTERS

AIRCRAFT AND FLIGHT CONDITIONS

The accident record suggests that helicopter primary training is conducted almost exclusively in single-engine piston models; only six of 180 (3 percent) were in turbine helicopters, and none in multiengine turbines. More than one-third of the accidents during advanced instruction (75 of 211) occurred in turbine models, almost all of them (67) single-engine. Fatal accidents were likewise concentrated in piston aircraft; there were only two in turbine-powered helicopters, both in North Carolina during the first few weeks of 2009. One occurred while practicing powerline inspections, the other during a simulated shipboard landing.

Except for two fatal accidents arising from attempted VFR flight in instrument meteorological conditions, all instructional helicopter accidents during this decade took place in visual conditions, and 96 percent were during daylight hours. Of the 14 accidents at night, 10 were during advanced instruction and two each during dual and solo primary lessons.

Accidents by Aircraft Type During Helicopter Instruction



CONCLUSION

While overall accident rates are similar, the rates of fatal accidents during flight instruction are less than half those on non-instructional flights. These facts back up the familiar assertion that flight training is safer than general aviation as a whole.

Fixed-wing training is characterized by a pattern suggesting a high but rapidly diminishing early risk of low-impact, low-injury "fender-benders." Two-thirds of all fixed-wing training accidents come during primary instruction, and two-thirds of those are during the relatively few hours of solo flight by student pilots. However, fatalities on student solos are extremely rare. Accidents during primary dual instruction are three times as likely to be fatal as solo accidents. This should not be interpreted as evidence that an instructor's presence increases risk; rather, it reflects their success in preventing the less serious mishaps that dog student pilots. These dual accidents are still fatal less than half as often as non-instructional airplane crashes. Accidents during takeoffs, landings, and go-arounds—when maneuvering room and reaction time are both in short supply—make up 80 percent of all those on student solos and half in both levels of dual instruction.

These facts back up the familiar assertion that flight training is safer than general aviation as a whole.

Two-thirds of all fatal fixed-wing accidents occurred during advanced instruction, less than half of them while pursuing a specific certificate, rating, or endorsement. Transition training, flight reviews, generic refresher training, and specialized instruction in areas such as mountain flying, aerobatics, and crop-dusting collectively accounted for over 60 percent of all advanced dual accidents, including more than half the fatal accidents. Of the programs directed toward higher ratings, instrument and multiengine instruction were the most lethal; initial tailwheel instruction saw a large number of accidents but no fatalities.

Helicopter students were insulated from much of the excess risk of TLG crashes that afflicted fixed-wing students; these were no more common than accidents caused by mechanical problems. Probably because they rarely attempted them, helicopter students also suffered few accidents during autorotation practice, the leading cause of accidents in all levels of dual instruction. Practice autos were actually a greater factor in advanced instruction than in primary. This reflects both a reduced risk of spills while practicing hovering, hover taxiing, and other low-altitude maneuvers and the more challenging aircraft and maneuver profiles flown at the advanced level. (The latter include specialties like zero-airspeed and 360-degree autorotations and maximum-performance glides at low rotor rpm, while far more autos are continued to full-down landings.) In contrast with the fixed-wing record, more than half of all helicopter accidents came during advanced instruction. (This is partly explained by data published by the FAA which shows that in calendar year 2012, 78 percent of helicopter pilots held advanced ratings compared to 70 percent of airplane pilots.) Fatalities were proportional to the total number of accidents in all three phases of instruction.

The competence of unfamiliar pilots should be demonstrated, not assumed, even when those pilots own the aircraft they fly.

This record suggests that the most promising areas for risk mitigation are:

Fixed-Wing Student Solos: The first solo is a crucial step for any pilot, but the traditional approach of focusing the first phase of instruction on readying the student for solo flight may merit re-examination. The need to manage the aircraft at speeds of 50 knots or more while control authority is near its minimum makes takeoffs and landings in airplanes challenging for student pilots. Helicopter students, by contrast, benefit from extensive time spent learning to hover the aircraft and control it precisely in low-altitude maneuvers, with the result that actual takeoffs and landings involve only small changes in altitude and airspeed, and low airspeed does not reduce a helicopter's control effectiveness. A conscious decision to postpone fixed-wing solo endorsements to allow students to gain more experience with aircraft performance, low-speed handling including stalls and stall recoveries, and crosswind control might substantially reduce their susceptibility to solo accidents.

Flight Reviews, Make-and-Model Transitions, and Other Informal Training: The prevalence of accidents during transition and refresher training of certificated fixed-wing pilots suggests that the hazards of these types of instruction have not been fully appreciated. CFIs undertaking them should be wary, especially with pilots they haven't flown with frequently or recently, and should be realistic in assessing their own ability to maintain an adequate margin of safety, particularly in aircraft they don't know well. The competence of unfamiliar pilots should be demonstrated, not assumed, even (perhaps particularly) when those pilots own the aircraft they fly. Instructors should also insist both parties agree on who will act as pilot-in-command before they get into the aircraft.

Autorotation Practice: Since autorotation is the most crucial emergency maneuver, frequent practice is essential. That practice is also the leading cause of helicopter training accidents, however, suggesting room for improvement in developing techniques for teaching it safely. CFIs should not wait to intervene until the safe completion of the maneuver is in real doubt.

Training is an essential part of all aviation, and while flight instruction enjoys one of the better safety records in GA, there are lessons to be learned...

HOW SAFE IS FLIGHT TRAINING?

It's safer than most other types of general aviation, but there's still room for improvement. A prospective pilot with a realistic understanding of real-world GA may fairly see this as "safe enough," while nervous friends and family members might be less sanguine. As in personal flying, though, most of the risk is under the pilot's control. For student and CFI alike, combining a clear understanding of their own abilities and those of the aircraft with a consistent conscious effort to maintain a healthy margin of safety can substantially reduce the risks. The keys to minimizing risk include practicing as much as necessary, expanding the envelope gradually, and taking the time to learn to do things right rather than trying to do them fast. Becoming a bad pilot isn't worth the effort.

Training is an essential part of all aviation, and while flight instruction enjoys one of the better safety records in GA, there are lessons to be learned from its accident history. Identifying problem areas and developing strategies to address them is the first step in making it safer still—and regular, rigorous training helps make all other flying more enjoyable as well as safer.

APPENDIX

ACCIDENT DEFINITION AND TYPES

49 C.F.R. Part 830, the regulation that covers mandatory reporting to the National Transportation Safety Board, defines “aircraft accident” for the purposes of both official statistics and the Air Safety Institute’s reports. The relevant sections of the full definition follow:

Aircraft accident means an occurrence associated with the operation of an aircraft which takes place between the time any person boards the aircraft with the intention of flight and all such persons have disembarked, and in which any person suffers death or serious injury, or in which the aircraft receives substantial damage. For purposes of this part, the definition of “aircraft accident” includes “unmanned aircraft accident” as defined herein.

— **Fatal injury** means any injury which results in death within 30 days of the accident.

— **Serious injury** means any injury which:

(1) Requires hospitalization for more than 48 hours, commencing within seven days from the date the injury was received;

(2) Results in a fracture of any bone (except simple fractures of fingers, toes, or nose);

(3) Causes severe hemorrhages, nerve, muscle, or tendon damage;

(4) Involves any internal organ; or

(5) Involves second- or third-degree burns, or any burns affecting more than five percent of the body surface.

— **Substantial damage** means damage or structural failure which adversely affects the structural strength, performance, or flight characteristics of the aircraft, and which would normally require major repair or replacement of the affected component. Engine failure or damage limited to an engine if only one engine fails or is damaged, bent fairings or cowling, dented skin, small punctured holes in the skin or fabric, ground damage to rotor or propeller blades, and damage to landing gear, wheels, tires, flaps, engine accessories, brakes, or wing tips are not considered "substantial damage" for the purpose of this part.

- **Unmanned aircraft accident** means an occurrence associated with the operation of any public or civil unmanned aircraft system that takes place between the time that the system is activated with the purpose of flight and the time that the system is deactivated at the conclusion of its mission, in which

  (1) Any person suffers death or serious injury; or

  (2) The aircraft has a maximum gross takeoff weight of 300 pounds or greater and suffers substantial damage.

- **Civil aircraft** means any aircraft other than a public aircraft.

- **Public aircraft** means an aircraft used only for the United States Government, or an aircraft owned and operated (except for commercial purposes) or exclusively leased for at least 90 continuous days by a government other than the United States Government, including a State, the District of Columbia, a territory or possession of the United States, or a political subdivision of that government. "Public aircraft" does not include a government-owned aircraft transporting property for commercial purposes and does not include a government-owned aircraft transporting passengers other than: transporting (for other than commercial purposes) crewmembers or other persons aboard the aircraft whose presence is required to perform, or is associated with the performance of, a governmental function such as firefighting, search and rescue, law enforcement, aeronautical research, or biological or geological resource management; or transporting (for other than commercial purposes) persons aboard the aircraft if the aircraft is operated by the Armed Forces or an intelligence agency of the United States. Notwithstanding any limitation relating to use of the aircraft for commercial purposes, an aircraft shall be considered to be a public aircraft without regard to whether it is operated by a unit of government on behalf of another unit of government pursuant to a cost reimbursement agreement, if the unit of government on whose behalf the operation is conducted certifies to the Administrator of the Federal Aviation Administration that the operation was necessary to respond to a significant and imminent threat to life or property (including natural resources) and that no service by a private operator was reasonably available to meet the threat.

For analytic purposes, this report classified accidents into broad categories defined as follows:

Mechanical: Accidents caused by the failure of some aircraft part or component in circumstances where a pilot of ordinary skill couldn't be expected to land the aircraft without damage (including failures due to improper or neglected maintenance)

Unexplained Power Loss: Partial or total loss of engine power during flight for reasons that could not be determined afterwards; adequate fuel was available and the engines showed no evidence of mechanical failure

Takeoff: Losses of control between the beginning of the takeoff roll and turning crosswind or reaching pattern altitude

Landing: Losses of control between passing the final approach fix (IFR) or entering the final leg of the traffic pattern (VFR) and exiting the runway

Go-Around: Losses of control while attempting to initiate a go-around and prior to attaining a stable climb

Maneuvering: Losses of control or collisions caused by deliberate and significant changes of aircraft attitude; includes everything from deliberate stalls to attempted aerobatics to turns in the traffic pattern

Fuel Mismanagement: Fuel exhaustion (no usable fuel remains aboard the aircraft), starvation (engine stops due to lack of fuel although usable fuel is available), or contamination

Descent and Approach: Losses of control or collisions between the end of the en route portion of the flight and entry to the traffic pattern (VFR) or the initial approach fix (IFR)

Autorotations: Includes both practice autorotations and those emergency autorotations that a pilot of ordinary skill could reasonably be expected to complete without damage to the aircraft

Hovering, Hover Taxi, Etc.: Also includes low-altitude maneuvers such as pedal turns, box patterns, point turns, etc.

Other Rotorcraft Aerodynamics: Phenomena peculiar to rotorcraft, including settling with power, loss of tail rotor effectiveness, dynamic rollover, ground resonance, and mast bumping.