A PILOT'S Accident Review

An in-depth look at high-profile accidents that shaped aviation rules and procedures

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Newcastle, Washington

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CONTENTS

FOREWORD

Once again, one of the most insightful, knowledgeable professional pilots in today's sphere of aviation has probed and poked the annals of aircraft accidents to unveil the causes of flyers killing themselves and others.

A long list of accidents spanning the spectrum of flight, from bug smashers to high-performance military and professional aviation, is examined in detail, providing solid foundations for drawing meaningful conclusions. Author John Lowery's research and experience as pilot, instructor, check airman and writer across that spectrum-of-wings are clearly evident, as he dissects an impressive array of incidents. That background is brought to bear in myriad subtle ways, such as avoiding temptations to zero-in on mechanical, training, decision making, weather, or other factor as *the* cause of a mishap. Lowery fully appreciates that most accidents are attributed to a cascade of equipment and/or human failures, and skillfully interweaves myriad elements, showing how they interact and contribute to a smoking hole.

Of particular interest to professionals, the author raises the intriguing probability that otherwise healthy pilots may suffer from an unrecognized degradation of cognitive abilities. Even experienced, proficient pilots can mentally "lose it," as they age. However, ego, complacency and a press-on proclivity that characterizes far too many aviators can lead to bad decisions and, ultimately, disaster.

Lowery addresses perennial topics associated with aircraft accidents, such as faulty training, poor judgment, fatigue, inadequate nutrition, compulsion (e.g., "get-home-itis"), and complacency. However, he also builds a compelling case for instructors and check pilots having to shoulder a portion of the blame for fatal accidents that kill innocent passengers and crew members. Time and again, training professionals in all sectors of aviation have identified deficiencies in a pilot's aptitude or cognitive capabilities, but were either reluctant to ground a career aviator, or were pressured into passing a pilot that they knew, on a gut level, was on a VFR-direct route to an accident. That, Lowery suggests, raises ethical concerns for everybody from individual at-risk pilots to training pros and Federal Aviation Administration regulators.

Aviation professionals, who've filled a pile of logbooks and think they've absorbed every tidbit written about aero-safety, will be impressed with Lowery's observations and insights. Real professionals will appreciate the author's discernment and incorporate this book's wisdom into their own flying.

— William B. Scott
Rocky Mountain Bureau Chief for *Aviation Week & Space Technology* (retired), author of *Space Wars, Counterspace* and *The Permit*.

INTRODUCTION

"He bears the seed of ruin in himself."
Matthew Arnold (1822-1888)

The intent of this book is to provide extra bits of knowledge to help the serious pilot in decision-making and thus enjoy a long flying career. Using the theory that we sometimes learn best by reviewing the mistakes of others, this book has been centered around aircraft accidents and why they occurred. In most cases the pilot or someone in his or her support team—mechanic, weather briefer, avionics technician, or in commercial flying, the pilot's management, even the manufacturer—made the accident inevitable. The pilot's personality too is frequently involved, with compulsion in decision-making a precipitating factor. To help understand the inherent problems, selected accidents have been analyzed in an effort to help prevent the predictable repetition that characterizes each year's record on file at the National Transportation Safety Board (NTSB).

The dictionary defines an accident as an "unexpected happening." Yet, when all factors are considered in most aircraft accidents, they cannot be called unexpected—simply because they were predictable. And, as you will note, many involve experienced pilots, which is by way of emphasizing that *it can* happen to you too.

Historically, about 80 percent of the annual general aviation accidents are attributed to pilot error. However, an in-depth analysis will usually show that a chain of errors, which included the pilot and one or more members of his or her extensive support team, culminated in an accident. It may have been the line-service person who refueled the piston-powered light twin with jet fuel instead of gasoline; or the flight instructor who signed off his student as fully trained before he/she was actually ready; or the FAA designated pilot examiner (DPE) who licensed a new pilot with a quick oral exam and short check flight that didn't adequately test the new pilot's knowledge or flying skill. Or perhaps it was the mechanic who repaired the engine and failed to properly torque the bolts holding the engine halves together, and the maintenance inspector who failed to catch the error. As a result, the engine fails over hostile terrain.

Sometimes it's the weather briefer who provided incomplete information, or the airport manager who failed to adequately maintain the runway surface and allowed an excessive rubber buildup from the landing traffic. As a result, it becomes slick during a rain, and when a pilot lands on the slick surface the airplane hydroplanes off the end of the runway resulting in major damage and serious injuries to passengers or crew.

Occasionally, it's a misunderstood clearance from the control tower—possibly combined with the pilot's inattention—that culminates in catastrophe. This is especially true with runway incursions, wherein a clearance was misunderstood; or while taxing for takeoff, the pilot was chatting with a friend in the right seat.

Conflicting information too is sometimes a factor. For example, there's the pilot who crashes on final approach due to wing and tail ice that accumulated during cruise flight. Although his airplane was certified for flight in known icing conditions, he didn't realize that icing certification doesn't allow continuous flight within it.

Important information is available in Advisory Circular 91-74A concerning reports of "mixed-icing, freezing drizzle or rain." The circular shows that moisture droplet size is much larger than the icing certification requirements, which typically constitute severe icing. Yet, in the Pilot's Operating Handbook/Airplane Flight Manual (POH/AFM), pilots are not clearly told that the aircraft they are flying is not equipped for flight in severe icing conditions.

This book has been designed to analyze selected accidents in the statistically most vulnerable areas. Organized according to the sequence of flight, the first chapter is an overall look at general aviation's historical accident record to see what can be learned from it. Also discussed is the increasing prevalence in GA aircraft of electronic flight instrumentation systems (EFIS), typically referred to as *glass cockpits*. While EFIS instrumentation has resulted in a decrease in the number of accidents in aircraft so equipped, NTSB records show an increase in fatalities when they are involved in accidents. This implies inadequate training or improper utilization by pilots of the remarkable EFIS capabilities.

In the hazardous environment of Alaska, the FAA's introduction of the GPS-based Capstone Program in 1999 immediately proved effective in reducing accidents—particularly those classed as controlled flight into terrain (CFIT).

About 20 percent of our annual accidents happen during departure. Chapters 2 and 3 cover preflight, takeoff, and climb accidents. Chapter 4 is a special look at the Air France Concorde crash, simply because it's a classic example of an integrated chain of errors that led to a tragic accident. This included the aircraft manufacturer, Air France management, their dispatch operation, and both the line service and cockpit crews. It was ultimately precipitated by a gross maintenance error, yet the French government ignored these failures, and to protect national pride blamed a metal strip dropped a few minutes earlier from the engine of a departing Continental Airlines DC-10.

Chapter 5 covers the enroute phase, which accounts for a major share of the fatalities. With 60 percent of the accidents occurring during descent, approach and landing, Chapter 6 is especially important. Chapter 7 concerns safety problems unique to flying by instrument flight rules.

Chapter 8 discusses maintenance error and material failure. The first event discussed involves a Cessna P210 that experienced engine failure due to improper engine maintenance by a mechanic and inadequate inspection by his supervisor. The second accident concerns a Cessna Citation CJ-1 whose pilot/owner was forced to ditch in Puget Sound because of a runaway nose-down elevator trim. Cause of the trim problem was either carelessness or inadequate training of a company electronics technician. He had used pliers to install or remove a printed circuit board in the aircraft's autopilot/trim system, and unknowingly had damaged the delicate printed circuit. This led to a runaway nose-down trim during climb, which overpowered the elevator controls. Fortunately, the pilot was able to successfully ditch the aircraft without injury or loss of life.

The third accident involved an MU-2 in which eight people were killed, one of whom was the governor of South Dakota. In this case, the NTSB accident report clearly showed the cause was failure of the FAA to require the manufacturer to abide by an earlier NTSB recommendation for a one-time fleet-wide inspection of the propeller governor hubs. The Board's recommendations were based on an in-depth analysis of a previous MU-2 accident that involved propeller hub failure. Yet 30 days after the governor was killed, the inspection was suddenly accomplished.

Chapter 9 concerns human factors involved in safe flying. This includes management and design error, the pilot's personality, emotional involvement, and ethical considerations involving the pilot's physical fitness. Chapter 10 is all about flying operations unique to the special features of seaplanes and ski-planes. If you enjoy outdoor adventure, then you must be a seaplane or ski-plane pilot. In these airplanes you have almost unlimited landing capability, but you are operating continuously in an unpredictable and potentially hazardous, off-airport environment. Thus, special knowledge is needed to use them safely.

Chapter 11 concerns flying after scuba diving, with an in-depth look at the unique physiological considerations involved. And finally, Chapter 12 considers the flight instructor, FAA designated pilot examiner, and aeromedical examiner as they relate to aircraft accidents. After all, they have the last word in aviation safety.

Someone once said, "life is a group effort." And the teamwork required to make aviation safe is the embodiment of that saying; from the manufacturer's design and production teams, the mechanics, avionics technicians, weather briefers, the line service crewmen, to the company that manufactures the fuel—even the fuel truck and its driver.

Should you become interested in researching a particular accident, the preliminary accident reports or synopses of completed accident investigations can be found at http://www.ntsb.gov/_layouts/ntsb.aviation/index.aspx. Or you can get the complete report of an accident from Public Inquiries, National Transportation Safety Board, Washington D. C. 20592-2000.

To Colonel Joe Shriber (USAFR Retired), I owe a special thanks for his detailed editing and proof reading. Your sharp eye for detail has been invaluable in rewriting this book. And I am especially indebted to retired FAA Inspector Ray C. Steinkraus, for reviewing the book's content for both technical accuracy and the author's recommendations for compliance with the FAR regulations.

To quote from the late German General Adolf Galland, "Flying is more than a sport, more than a job. Flying is pure passion and desire, which fills a lifetime." The intent of this book is to provide some additional knowledge that will help you enjoy a safe flying career for your lifetime. Meanwhile, fly safe and fly smart.

— John Lowery

CHAPTER 1

The General Aviation Safety Record

The question is often asked, "is private flying safe?" The continually improving accident record shows that it certainly is. Since an unbelievable high of 4,494 accidents in 1978, of which 793 were fatal, AOPA's 24th Nall Report covering 2012 shows GA experienced 1,029 non-commercial and commercial fixed-wing aircraft accidents with 224 being fatal—the lowest number since the end of World War II. Yet, it's regrettable to note the regularity with which pilots, or members of their support team, fail to learn from the mistakes of others, and year after year continue making almost identical errors.

Two specific areas that consistently account for a high percentage of the fatalities include *maneuvering flight* and *weather*. As for maneuvering accidents, buzzing is often involved. Many weather related mishaps are what is called *controlled flight into terrain* (CFIT): the pilot flew VFR into clouds that masked high terrain. This type of accident usually involves non-instrument rated pilots who inadvertently fly into *instrument meteorological conditions* (IMC) and hit an obstruction or high terrain. Fuel starvation or fuel exhaustion is yet another regular player that continues to cause accidents and fatalities every year.

As for maneuvering flight, how many times have you read about the pilot who buzzed his buddies or relatives and flew into the ground at high speed, simply because he didn't know that control pressures increase significantly as airspeed builds toward the redline—the maximum indicated airspeed (V_{NE})? This is a typical characteristic with cable-and-pulley flight controls, and as a by-product it helps prevent structural overstress from sudden pitch control inputs. But it also reduces controllability.

There are instances too of pilots buzzing the calm surface of a lake and flying into the water. Without seaplane training they didn't know that *mirror effect* on a glassy water surface robs you of your depth perception.

One fatal accident involved the pilot of a Cessna 185 who was attempting to drop a message to his river-rafting friends who were camped on a sand bar. To keep them in sight in the narrow river canyon he got low and slow and began banking the airplane steeply. But in his zeal to communicate, he forgot that a 60-degree angle of bank increases stall speed by 70 percent, and a 70-degree bank essentially doubles the stall speed. Thus, with a wings-level stall speed of 55 knots indicated airspeed (KIAS), a 60-degree bank would have increased the aircraft's stall speed to about 94 knots; with a 70-degree bank the aircraft would have stalled at an indicated airspeed of about 110 knots. And unfortunately that's what he did: stalled out and spun-in before his horrified friends.

Have you heard about the pilot who ran out of fuel a mile or so short of the runway? It doesn't matter what year; it happens every year. The 22nd Nall Report covering 2010 shows that after decreasing for five straight years, the number of fuel management accidents in non-commercial fixed-wing aircraft increased by 20 percent in 2009 and 2010 even as the total number of accidents has decreased.

Some accidents occur when the pilot flies an instrument approach, and as the aircraft begins breaking out of the clouds, he abandons the approach procedure and attempts to find the airport visually. A classic example occurred on a dark and foggy night when a private pilot and flight instructor in a Piper Saratoga flew a VOR/DME approach to runway 13 at Beaumont Municipal Airport (BMT), Texas. While still four miles from the airport, they began breaking out of the clouds. They quickly cancelled their IFR clearance and abandoned the approach procedure, then at a very low altitude began searching for the runway visually: *scud running*, it's called.

They found the runway, but ignored the additional protection provided by the runway's visual glide slope—a PVASI. Unfortunately, they flew into power lines near the runway and were killed. Yet adherence to the VOR procedure and use of the PVASI would have prevented this fatal accident.

Figure 1-1. ILS minimums.

Accident Defined

NTSB regulation 49 CFR §830.2 defines an accident (*mishap* is used interchangeably throughout this book) as an occurrence associated with the operation of an aircraft that takes place after the aircraft has been boarded with the intention of flight and before all occupants are deplaned. In addition, it must have resulted in substantial aircraft damage, or the death of or serious injury to someone on board. An *incident* means "an occurrence, other than an accident, that's associated with the operation of an aircraft, which affects or could affect, the safety of operations."

A *serious injury* is one requiring hospitalization for more than 48 hours within seven days of the date of injury; or one that results in fracture of any bone (except simple fractures of fingers, toes, or nose); causes severe hemorrhage; damages a nerve, muscle, or tendon; injures an internal organ; causes second and third-degree burns; or any burn that affects more than five percent of the body. If death occurs within 30 days of an injury due to an aircraft accident, it is classed as a *fatality*.

Accident Trends

NTSB data for the years 1975 to 1978 shows there were more than 4,000 accidents each year, with the previously mentioned spike in 1978 to 4,494 accidents. This is more than four times the 1,160 non-commercial, fixed-wing accidents for 2012. The alarming accident rate in the 1970s was due to a soaring economy, favorable tax laws, and limited regulation and supervision by the FAA.

With about 80 percent of each year's accidents classed as pilot error, it became painfully obvious that the FAA's lax training and proficiency standards were a major part of the problem. Accordingly, more stringent regulations were implemented, along with aggressive safety programs. For example, 14 CFR §61.56 mandated the biennial flight review for all non-commercial pilots. And for aircraft requiring two crewmembers, §61.58 mandated an annual proficiency check for the pilot-in-command. Essentially, this amounts to a re-validation of his or her type rating.

Still, the biennial flight review had inherent flaws. The pilot of a turboprop King Air could (and still can) take his flight review in a Cessna 152. And unbelievably, such a review keeps him current under §61.56 for two more years in the much more sophisticated light twins and turboprops. Although single-pilot accidents in these more sophisticated aircraft continue to be problematic, the insurance companies stepped into the breach by requiring *annual* recurrency training in these aircraft. This, and the availability of sophisticated simulators, has helped improve our accident history.

Attempting to fly VFR into IMC continues to be a major cause of accidents. The 2010 Nall Report states that at night IMC "*was one of the most deadly accident environments.*" More than 30 percent of the accidents occurring at night involved fatalities; and if the flight was in IMC, then the chance of fatalities doubled to 60 percent.

Because of the additional hazards of night flying, a night-current pilot with an instrument rating flying IFR greatly improves the odds for a safe flight. Although some disagree, the accident record shows that you simply cannot routinely fly cross-country at night safely without an instrument rating. Because sooner or later you'll encounter inky-blackness in reduced visibility due to smoke or haze, unexpected clouds, featureless terrain, or a combination of all three at once. Then spatial disorientation seals your doom. To buffer this recommendation, countries belonging to the International Civil Aviation Organization (ICAO) require that all flights after sunset must be on an IFR flight plan.

Simulators have been a major contributor to improved pilot proficiency and the reduction in accidents—especially in the sophisticated cabin-class twins and turboprop aircraft. During the seventies and early eighties, accidental spins that occurred during engine-out training and minimum control speed (V_{MC}) demonstrations were taking a heavy toll on multi-engine students and flight instructors. Now, sophisticated simulators allow multi-engine pilots to gain and maintain proficiency in these hazardous events, particularly during the takeoff and climb phases of flight. In addition, they eliminate the risk of de-tuning or thermal shock damage to engines.

Phase of Flight

For many years, accident investigators have referred to the "critical eight minutes of flight." This comprises the first two minutes of takeoff and climb and the final six minutes of flight, encompassing descent, approach, and landing. The rule of thumb is that about 20 percent of accidents occur during departure and around 60 percent during the approach and landing phase.

Loss-of-control accidents that occur on takeoff and landing often involve crosswinds which exceed the "demonstrated" figure published in the POH and/or AFM. Unfortunately, what many pilots fail to realize is that the manufacturer's published demonstrated crosswind is established from *a dry, paved runway*, and with aircraft equipped with new tires. This crosswind velocity represents the aerodynamic limit of the flight controls to maintain a straight ground track during takeoff or landing.

To illustrate the problem, on February 10, 2004, the pilot of a turboprop Cessna 208B Caravan was departing from a runway with patches of packed snow and ice on the surface. The airplane has a demonstrated crosswind of 20 knots, and in this case the surface wind was a right-crosswind of 15 gusting to 25 knots. Predictably, during takeoff roll at between 30 to 50 knots, the pilot lost control and ran off the downwind side of the runway, then nosed over.

Although slick patches of snow and ice were also involved in this accident, the record shows that the demonstrated crosswind in the manufacturer's handbook should be considered a limitation—just as it is with transport category aircraft. Because realistically, that demonstrated crosswind figure is the manufacturer's way of telling you that beyond that number there are no guarantees. Left unsaid is that snow, ice, or a wet runway surface and worn tires causes a reduction in the demonstrated crosswind figure, simply because of the reduced tire/runway surface traction.

Fatalities

Fatal accidents are most prevalent during maneuvering flight, takeoff and climb, weather, and during descent and approach—in that order. AOPA's 23rd Nall Report also shows an ever-improving trend with only 214 non-commercial fixed-wing mishaps being fatal in 2010, compared to 233 in 2009. The report for 2002 shows that of 122 maneuvering flight accidents, 66 (54 percent) were fatal. Hitting wires, terrain, trees, or the water accounted for 25 of these; more than half occurred during personal flights where the pilot was buzzing, or attempting low-level aerobatics. As in previous years, the takeoff and climb phase was responsible for about 21 percent of the fatalities, 51 of 249 mishaps. And this is a fairly consistent annual percentage.

The 2010 Nall Report shows there were 385 landing accidents, or 35.3 percent of the total, but only 4 (1.8 percent) involved fatalities. Meanwhile weather—usually VFR into IMC—accounted for 15 percent of accidents by non-instrument rated pilots. Of these, 60 percent, or 33 of 55 accidents, were fatal. Maintenance or material failure was involved in 15.5 percent of all GA accidents, with 10.4 percent resulting in fatalities.

Electronic Flight Instrumentation Systems

Aircraft equipped with electronic flight instrumentation systems (EFIS) show a major improvement in flying safety. With EFIS, the ship's instrument panel provides electronic information rather than electromechanical indications (analog, or round dial). Basically, an EFIS equipped cockpit has a primary flight display (PFD), which includes attitude and airspeed, a multifunction display (MFD), showing navigation, and an engine indicating and crew alerting system (EICAS). Originally, only the attitude director indicator (ADI) and horizontal situation indicator (HSI) were replaced. Today, however, there are few flight instruments that aren't presented electronically. (Yet the EFIS must always be backed by the critical emergency analog instruments—airspeed, attitude indicator and altimeter.) Two notable EFIS systems for GA aircraft are the Garmin G-1000 and Chelton Flight Systems EFIS-SV (synthetic vision).

The Garmin-1000 consists of an integrated flight instrument system composed of two display units. One serves as the PFD and the other as the MFD. Additional features are found in the newer and larger G-1000 units used in the business jets. This includes a copilot's PFD combined with an alphanumeric keyboard and integrated flight director/autopilot.

The Capstone Program, implemented successfully in Alaska in 1999 to 2006, utilized the Chelton Flight Systems PFD and MFD. The PFD provided the attitude, heading, airspeed, and vertical speed information. The MFD provides a satellite based GPS visual representation of the terrain. In addition, it had the additional feature of a terrain awareness and warning system (TAWS) that alerted the pilot of an impending close encounter with the ground.

In an effort to reduce airborne collisions, the system used the new Automatic Dependent Surveillance-Broadcast (ADS-B) technology to continuously show similarly equipped aircraft on the MFD. And in the Anchorage area, a system called Traffic Information Service-Broadcast (TIS-B) depicted non-ADS-B aircraft on the MFD.

Phase I of the Capstone Program implemented in the Yukon-Kuskokwim (Y-K) Delta of southwestern Alaska, was an immediate success. The Y-K Delta area encompasses an area of about 100,000 square miles with no roads to connect more than 50 villages—the largest settlement being

Figure 1-2. The Garmin G-1000 EFIS cockpit displays a multitude of information.
(Courtesy of Garmin International)

Figure 1-3. The Chelton Flight System, introduced in Alaska in 1999, was an immediate success in reducing accidents. (Courtesy of Chelton Flight Systems)

Bethel. Consequently, aviation is the primary means of transportation. Because the Capstone Program involved professional pilots with lots of flying experience, during its first year of operation Phase I saw a 40 percent reduction in aircraft accidents. In 2002, Phase II became operational in the challenging terrain and weather of the southeast area of the state, around Juneau. From 2000 to 2004 FAA data show the Capstone Program reduced accidents by 47 percent.

Phase III which covered the entire state was activated in 2006, but in December that year the Capstone Program was incorporated into the FAA's nationwide ADS-B program. As the Capstone Program shows, the increased use of this modern-day technology has continued to significantly improve the safety of both private and commercial flying operations.

An NTSB statistical analysis for the period 2002 to 2008 of accidents involving light single-engine aircraft equipped with EFIS, found that "light single-engine aircraft, equipped with glass cockpit displays, experienced lower total accident rates, but higher fatal accident rates, than the same type equipped with conventional analog instrumentation." Accidents in the glass cockpit equipped aircraft typically involved pilots with a higher level of certification and with more total flight time than pilots flying with older analog instrumentation. Mishaps in glass cockpit aircraft were typically associated with personal/business flights, longer flights, instrument flight plans, and single-pilot operations. Accidents in airplanes equipped with conventional analog instrumentation occurred on shorter two-pilot instructional flights, and the pilots involved had less flight time than those flying with EFIS.

Age Groupings

Safety educators talk of the 18-through-23-year age group as most prone to risky flight behavior. But youth as an accident cause is not supported by the general aviation accident history. For example, statistics from a June 27, 2003 FAA study showed pilots aged 40 to 49 years had the most accidents, with the 50 to 59 year-olds in second place. Rather than being caused by high-risk behavior this probably reflects inadequate training and proficiency.

The original mandatory retirement of airline pilots at age 60 (14 CFR §121.383(c)) was a hot topic after its adoption in 1959. This rule was the result of several well-publicized incidents of in-flight incapacitation due to heart attack or stroke by airline pilots at the controls during the 1950s. The precipitating event involved the captain of a Lockheed Electra who after completing an ILS in bad weather had a fatal heart attack on short final. The copilot failed to recognize the problem in time and the aircraft crashed short of the runway, killing all aboard.

Although these tragic events appeared to justify the mandatory age-60 retirement rule, later events showed the underlying reason was economic rather than safety. Prior to deregulation, airline growth was sluggish because the now defunct Civil Aeronautics Board tightly controlled competition and profitability. Consequently in the large airlines, the senior captains were making all the money and preventing the younger first-officers from progressing. In addition, many of the old-timers were having trouble converting to jet flying.

In 1992, the FAA granted a 21-month exemption from the age 60 rule for 18 pilots employed by two foreign carriers, Icelandic Air and Corse Air. In addition, there was no age limitation for copilots flying for foreign airlines into the United States.

In 1995, the commuter airlines were placed under Part 121, and their pilots were also hit by the age-60 retirement rule. Yet NTSB records for

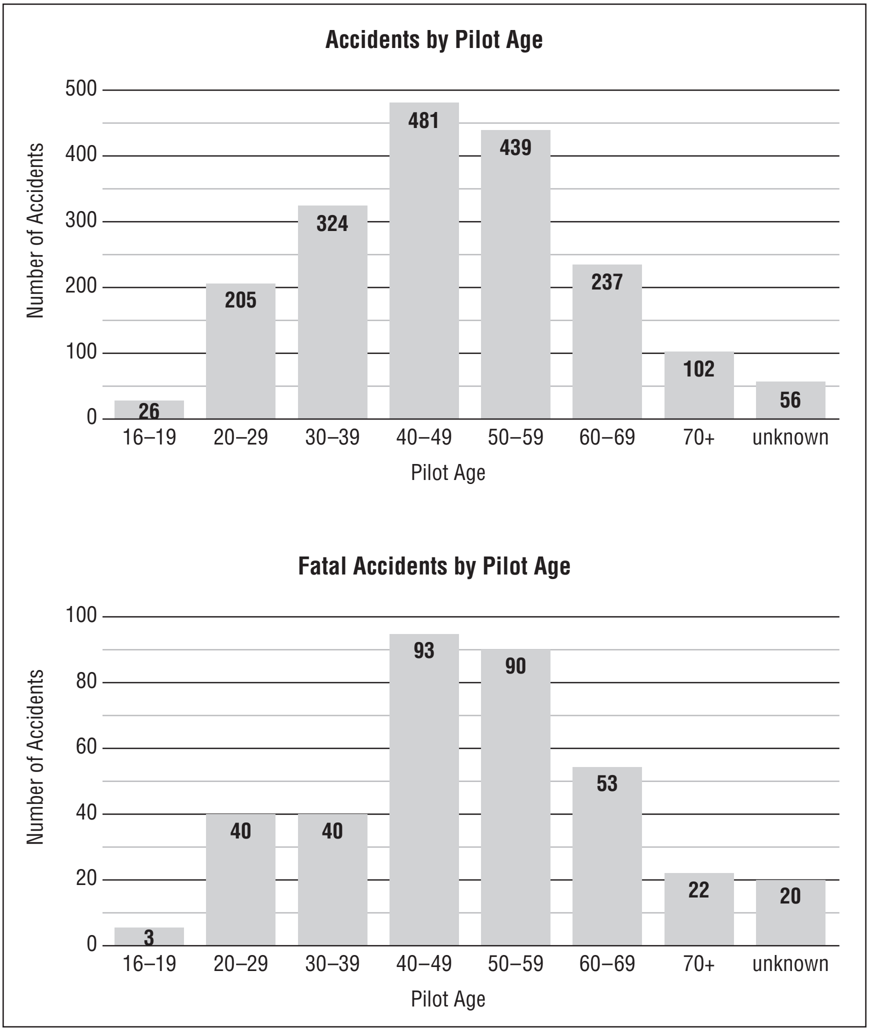

Figure 1-4. All accidents by pilot age (from a 1999 U.S. study).

these younger, erstwhile Part 135 pilots showed a higher accident rate. Consequently, the FAA delayed application of the age-60 rule to commuter crews for four years until December 20, 1999. However, during that period there were no incidents of in-flight incapacitation.

Although the Airline Pilots Association was initially against the age-60 rule, feeling the influence of a younger membership, the union reversed itself in 1980 and supported the mandatory age-60 retirement. Despite arguments to the contrary, the reasons were *strictly* economic.