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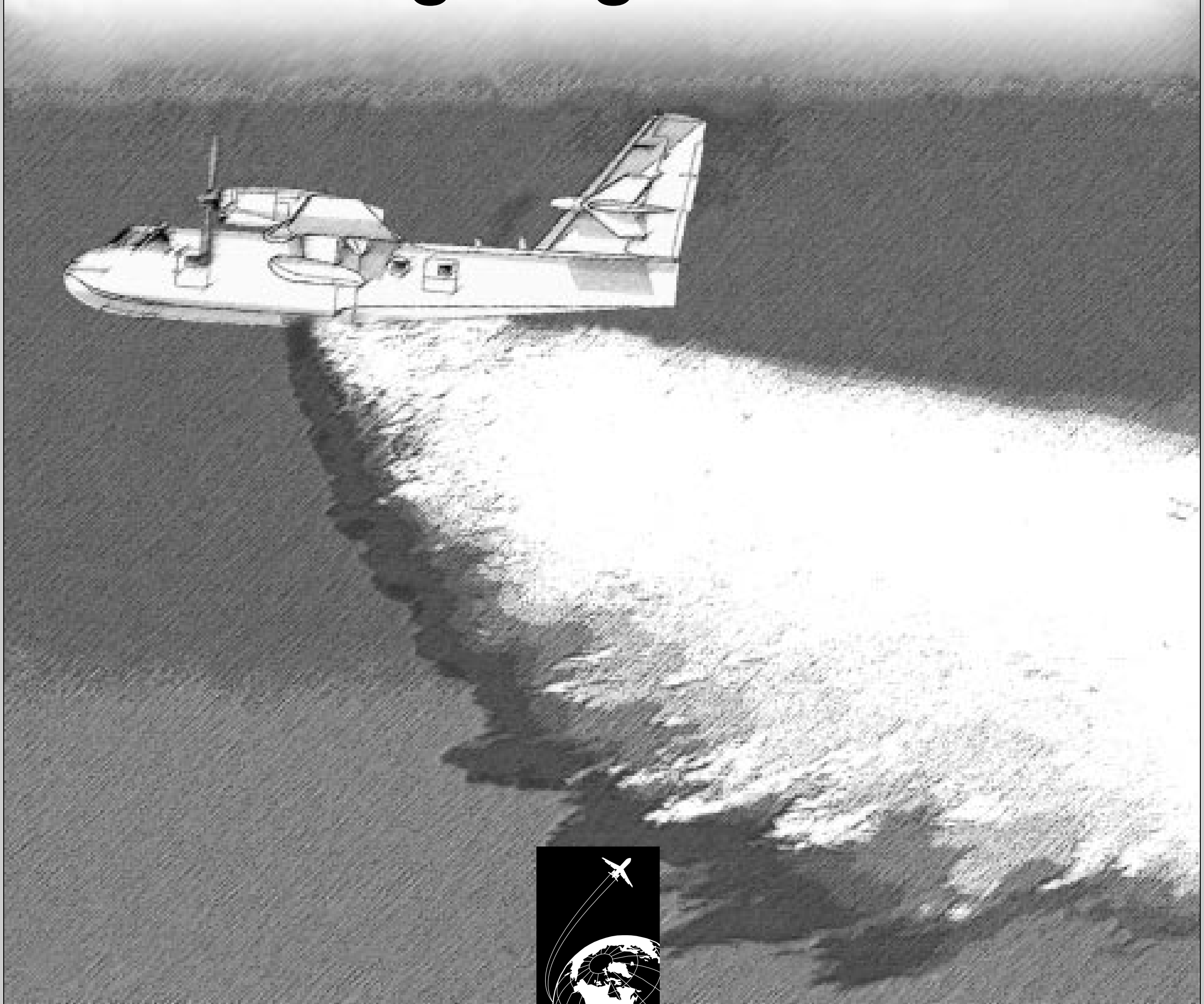
Crew Error Cited as Major Cause of U.S. Aerial Fire Fighting Accidents



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About the cover: A Canadair 415 air tanker discharges water. (Illustration by FSF Production Staff)

Flight Safety Foundation is an international membership organization dedicated to the continuous improvement of flight safety. Nonprofit and independent, the Foundation was launched in 1947 in response to the aviation industry's need for a neutral clearinghouse to disseminate objective safety information, and for a credible and knowledgeable body that would identify threats to safety, analyze the problems and recommend practical solutions to them. Since its beginning, the Foundation has acted in the public interest to produce positive influence on aviation safety. Today, the Foundation provides leadership to more than 700 member organizations in 80 countries.

Crew Error Cited as Major Cause of U.S. Aerial Fire Fighting Accidents

Errors in judgment and deficiencies in crew resource management and compliance with standard operating procedures were common causes of U.S. aerial fire fighting accidents involving fixed-wing aircraft in 1976–1998.

Patrick R. Veillette, Ph.D.

Unique features of aerial fire fighting, including flight in close proximity to rugged terrain, high-tempo operations, obscured visibility and high pilot workloads, combine to produce a very adverse environment for the aviator, and thus produce an accident pattern substantially different from other aviation sectors. From 1955 through 1997, fixed-wing aircraft engaged in such operations were involved in 124 accidents, in which 202 people were killed (Table 1, page 2).[1]

This report exclusively examines fixed-wing aerial fire fighting operations but recognizes that rotary-wing aircraft also play a major role in aerial fire fighting. To identify accident causes and potential methods of improving U.S. fixed-wing aerial fire fighting safety, the author conducted a study that included the following:

- Analysis of official reports on 61 fixed-wing-aircraft accidents that occurred in direct support of aerial fire fighting operations from January 1976 through December 1998 (see Appendix, page 14), with follow-up interviews of 40 accident investigators and some witnesses, and inspections of some accident sites;
- Examination of training documents and training courses;
- Examination of operating specifications and manuals;
- Inspection of fire bases; and,
- Survey of pilot attitudes regarding crew resource management (CRM).

The study produced the following major findings:

- Most accidents (48 percent) occurred during the "drop" phase of flight operations, which includes reconnaissance flights, the release of water or chemical retardant on the fire, and the delivery by parachute of firefighters ("smoke jumpers") and/or equipment and supplies ("paracargo") to the fire area. Human error was involved in 93 percent of the drop-phase accidents;
- The second-highest proportion of accidents (26 percent) occurred during approach and landing. Human error was involved in 50 percent of the approach-and-landing accidents (ALAs);
- Factors contributing to human error were deficiencies in pilot judgment, CRM, situational awareness, workload management, compliance with standard operating procedures (SOPs) and crew coordination;
- SOPs generally were documented inadequately and often were not followed by aerial firefighters;

Table 1
Airplane Accidents During U.S. Aerial Fire Fighting Operations, 1955–1997

Aircraft	Accidents	Fatalities
Air tanker	94	136
Lead plane	7	7
Others	23	59
Total	**124**	**202**

Source: Patrick R. Veillette, from Bushey, Chuck. “Wildland Fire/Aircraft Firefighter Fatalities in the United States Compared with Ground Based Firefighter Fatalities.” In *Proceedings of the First Canada/U.S. Wildland Fire Safety Summit, Rossland, British Columbia, Canada, 29 Sep.–2 Oct. 1997*. Fairfield, Washington, United States: International Association of Wildland Fire, 1997.

- Many aerial firefighters were skeptical of CRM concepts and practices; and,

- U.S. aerial fire fighting safety might be improved by better human-error management, SOP documentation and SOP compliance, crew training, management of risk in low-altitude flight operations, aircraft maintenance, aircraft flight deck design, and aircraft crashworthiness.[2]

The aircraft used in aerial fire fighting operations frequently are operated as “public aircraft” (commonly called public-use aircraft), which are exempt from some U.S. Federal Aviation Regulations (FARs).[3,4] Many regulations governing pilot certification, pilot training, aircraft operation and aircraft maintenance apply to “civil aircraft,” which by definition do not include public-use aircraft.

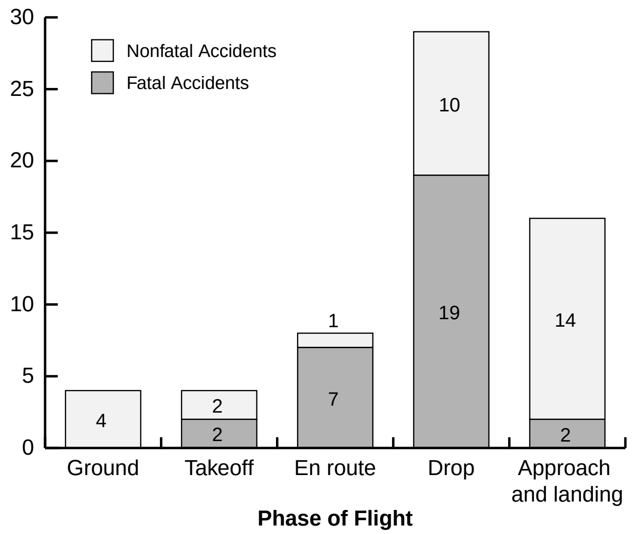
Before April 1995, many accidents and incidents involving public-use aircraft were investigated only by the agencies that operated the aircraft. U.S. regulations adopted in April 1995 require that the U.S. National Transportation Safety Board (NTSB) be notified of, and investigate, all public-aircraft accidents and incidents.

Reports on some accidents investigated only by the respective operating agencies were not available for analysis; thus, the exact number of aerial fire fighting accidents in 1976–1998 is unknown. Analysis of the 61 available reports shows that 30 accidents (49 percent) involved fatalities and that five accidents (8 percent) involved serious injuries. Sixty-six people were killed, seven people were seriously injured, and seven people received minor injuries.

Figure 1 shows that 29 accidents occurred during the drop phase of flight. Nineteen drop-phase accidents included 36 fatalities; two accidents involved serious injuries.

Figure 2 shows that human error was involved in 27 drop-phase accidents (93 percent) and that mechanical failure was involved in two drop-phase accidents (7 percent).

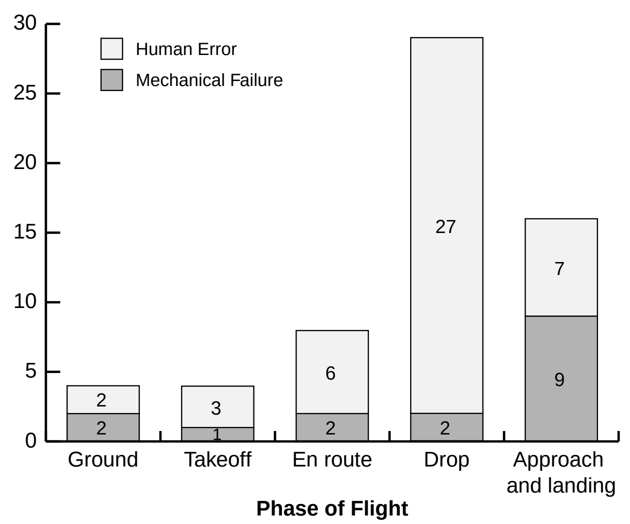
Phase of Flight for 61 U.S. Aerial Fire Fighting Airplane Accidents, 1976–1998



Source: Patrick R. Veillette

Figure 1

Involvement of Human Error and Mechanical Failure by Phase of Flight In 61 U.S. Aerial Fire Fighting Airplane Accidents, 1976–1998



Source: Patrick R. Veillette

Figure 2

Drop-phase flight operations typically are conducted at low altitudes in steep, mountainous terrain where there is limited room for aircraft maneuvering. The aircraft often are flown in smoke and gusty winds, and in close proximity to other aircraft. Density altitude often is high, which reduces aircraft performance.

The drop phase of flight is relatively brief. An air-tanker airplane (air tanker) or a smoke-jumper airplane flown for 90 minutes during a mission (from takeoff to landing) might be flown for only five minutes to 10 minutes during the drop phase. A lead airplane (lead plane) flown for four hours in a fire area might conduct 12 low-altitude passes over drop sites, with each pass comprising only 30 seconds (see "U.S. Aerial Fire Fighting Operations and Hazards Have Increased").

The drop-phase accidents involved 18 air tankers, six reconnaissance airplanes and five lead planes. Fifteen of the airplanes (14 air tankers and one reconnaissance airplane) had two pilots aboard; 14 airplanes had one pilot aboard. Twenty-seven of the airplanes had reciprocating engines; two aircraft had turboprop engines.

Crew-judgment deficiencies were contributing factors in 26 drop-phase accidents (90 percent). Twenty drop-phase accidents occurred when pilots flew airplanes too close to the ground and misjudged the airplanes' flight paths in relationship to terrain. Three airplanes struck objects (power lines, trees) that the flight crews did not see before the collisions occurred (no one was injured; the airplanes were substantially damaged but were landed safely at airports).

Several crew-related factors contributed to 12 drop-phase accidents involving air tankers with two-pilot crews. The factors included inadequate workload management, task saturation, loss of situational awareness and inadequate crew coordination.

After recognizing the necessity for terrain-avoidance maneuvers, the crews of 11 air tankers did not jettison their loads of retardant (water or chemicals) in sufficient time to avoid striking terrain. Large air tankers such as the Lockheed P-3 Orion and the Lockheed C-130 Hercules can carry approximately 3,000 gallons (11,355 liters) of retardant, which weighs from nine pounds to 12 pounds (4.1 kilograms to 5.4 kilograms) per U.S. gallon; thus, a full load of retardant weighs from 27,000 pounds to 36,000 pounds (12,247 kilograms to 16,330 kilograms). If a C-130 were to take off at its maximum gross takeoff weight of 120,000 pounds (54,432 kilograms), the release of 30,000 pounds (13,608 kilograms) of retardant would result in a 25 percent reduction of airplane gross weight and a commensurate increase in airplane performance capability.

The increase in airplane performance resulting from jettisoning retardant is especially important because of the high density altitudes and limited maneuvering areas that are common in aerial fire fighting operations. Several air tankers struck terrain close to the tops of ridges; the accidents might have been avoided if the crews had jettisoned promptly their loads of retardant when they recognized the necessity for terrain-avoidance maneuvers.

(continued on page 7)

U.S. Aerial Fire Fighting Operations and Hazards Have Increased

Aerial fire fighting operations in the United States began in the 1920s, when pilots and observers were dispatched in biplanes to detect fires in Idaho and Montana. The U.S. Forest Service (USFS) also used aircraft from 1925 to 1935 for aerial photography and to deliver cargo in the northern Rocky Mountain region. The U.S. Army and private fire fighting contractors in 1935 conducted experiments with airplanes dispersing water and chemical retardant on fires; the experiments led to the development of air-tanker aircraft. Smoke-jumper operations began in 1940, when firefighters parachuted from USFS Travel Air biplanes and three-engine Ford Trimotors to fight fires in Idaho, Montana and Washington.[1]

In the early 1950s, many surplus military single-engine airplanes — including Naval Aircraft Factory N-3Ns and Grumman TBM-1s — were used for air-tanker duties. The single-engine airplanes later were supplemented with surplus military multi-engine airplanes, including Boeing B-17s, Convair PBYs, Convair PB4Y-2s, Douglas C-54s and Lockheed P-2Vs. Many of the aircraft were procured from the U.S. military under the Federal Excess Property program and modified for aerial fire fighting.

Many retired commercial airliners — including Douglas DC-4s, DC-6s and DC-7s — were acquired and modified for aerial fire fighting.

By the mid-1960s, the USFS and the U.S. Department of the Interior Bureau of Land Management (BLM) were operating a diverse fleet of aerial fire fighting aircraft. The fleet comprised Aero Commanders, Beech Barons, Cessna 185s and 402s, de Havilland Twin Otters, Grumman Goose amphibians and Piper Aerostars.[2]

Table 1 (page 4) shows the variety of fixed-wing aircraft that were in use as of April 1999 in aerial fire fighting operations. Only the amphibious Canadair CL-215 and CL-415 were designed specifically for air-tanker operations; the other air-tanker airplanes were designed for different uses, and later were modified with equipment such as external tanks, internal tanks and hydraulic doors for retardant dispersal.

Some agencies are replacing World War II-era radial-engine airplanes with more modern turboprop airplanes. Some Douglas DC-3s and Grumman S-2s have been modified with turboprop powerplants.

Table 1
Fixed-wing Aircraft Typically Used in U.S. Aerial Fire Fighting Operations

Aircraft	User/Owner	Missions
Air Tractor 802	contractors	AT
Basler DC-3TP*	USFS	CT, PT, SMJ
Beech 55/58 Baron	USFS	CT, LP, PT
Beech King Air	BLM, contractors, USFS	CT, FR, IR, LP, PT
Canadair CL-215	contractors	AT
Canadair CL-415	contractors	AT
CASA C-212 Aviocar	contractors	SMJ
Convair PB4Y-2	contractors	AT
Convair PBY-4/5/6 Catalina	contractors	AT
de Havilland DHC-6 Twin Otter	BLM, contractors, USFS	CT, FR, PT, SMJ
Douglas DC-4	contractors	AT
Douglas DC-6	contractors	AT
Douglas DC-7	contractors	AT
Embraer EMB-110 Bandeirante	contractors	SMJ
Grumman S-2 Tracker	CDF	AT
Lockheed C-130 Hercules	ANG, contractors	AT
Lockheed P-2V Neptune	contractors	AT
Lockheed P-3 Orion	contractors	AT
Lockheed SP-2H	contractors	AT
Rockwell OV-10 Bronco	BLM, CDF, contractors	AA, LP
Shorts SD-3 Sherpa	BLM, USFS	CT, FR, PT, SMJ
(Various single-engine aircraft)	contractors	AA, CT, FR, PT

* Basler Turbo Conversions Douglas DC-3 turboprop conversion

AA = air attack ANG = Air National Guard AT = air tanker BLM = U.S. Bureau of Land Management
CASA = Construcciones Aeronáuticas CDF = California (U.S.) Department of Forestry CT = cargo transport
FR = fire reconnaissance IR = infrared photography LP = lead plane PT = personnel transport
SMJ = smoke jumper, parachute cargo delivery USFS = U.S. Forest Service

Source: Patrick R. Veillette

Several U.S. government studies have recommended that a fleet of air tankers for interdepartmental use be assembled from surplus military turboprop airplanes, including the Lockheed C-130 and the Lockheed P-3A.[3]

Rotary-wing aircraft also are used to deliver equipment to ground firefighters and to drop water and foam on fires. Nevertheless, this report discusses fixed-wing aerial fire fighting operations.

A typical wilderness fire fighting mission begins with a lightning strike that ignites vegetation. The smoke usually is detected by an observer stationed in a fire tower or the crew of a fire-reconnaissance aircraft.

The fire is reported to the local fire-management officer, who decides whether fire fighting forces are dispatched to suppress (extinguish) or manage (control) the fire. The decision is based on the area's fire-management plan and on resources available to fight the fire.

A wilderness fire might be allowed to burn if it does not threaten prime timber or other resources, and when weather conditions, vegetation moisture content and topography will keep the fire "cool." A cool fire remains close to the ground and has relatively small flame heights. A controlled fire sometimes benefits the environment by eliminating disease and pests (bark beetles, for example), returning nutrients to the soil, strengthening fire-resistant species and renewing grasses and shrubs that feed wildlife.

Fire-suppression efforts typically are initiated when the area is dry, the terrain is hilly, strong winds exist, and prime timber or other resources are threatened by the fire. Aerial fire fighting operations begin when a lead airplane (lead plane), air-tanker aircraft (air tankers), smoke-jumper aircraft and/or air-attack aircraft are dispatched to the fire area.

For the initial attack on a wilderness fire, aircraft speed has a high value. A fire can spread rapidly during the early stages, especially if the area has sloping terrain, dry vegetation, high ambient temperatures, low relative humidity, unstable atmospheric lapse rates (which might cause thermal activity) and/or strong winds.

Because the lead plane typically is faster than the other aircraft, it usually arrives first at the fire. The lead plane typically has only a pilot aboard. The pilot inspects the fire area, coordinates with ground forces and tells the air-tanker crews where to drop their loads of retardant. The lead-plane pilot also conducts reconnaissance flights over the planned air-tanker route to check for hazards, and might lead the air-tanker aircraft over the area where the retardant is dropped.

An air-tanker's load of retardant can be dropped either all at once or in stages. The retardant normally is dropped from 150 feet to 250 feet above ground level (AGL).

While the air tankers are dropping retardant on the fire, smoke-jumper aircraft circle the area, and the smoke jumpers (firefighters who parachute from the aircraft) formulate their strategy. When the air tankers vacate the fire area to reload water or chemical retardant, the smoke jumpers coordinate with the lead-plane pilot to keep the airspace clear for their jump.

Bureau of Land Management smoke jumpers normally exit the airplane at 3,000 feet AGL. Smoke-jumper airplanes also deliver "paracargo" — equipment and supplies needed to fight the fire — from 150 feet to 250 feet AGL.

If the fire is growing rapidly, and the potential exists for extreme fire conditions, an air-attack aircraft is dispatched to the area. Cessna 206, Cessna 337 and Rockwell OV-10 airplanes are among the most widely used air-attack aircraft.

The crew of an air-attack aircraft usually consists of a pilot and a professional wildland firefighter serving as the air tactical group supervisor (ATGS). The ATGS assumes the lead-plane pilot's task of coordinating the fire fighting efforts. As the pilot circles the airplane over the fire area, the ATGS directs and coordinates the aerial fire fighting operations and the ground fire fighting operations. The ATGS also coordinates with local law-enforcement agencies and emergency-medical-service personnel when people must be evacuated from the fire area or be treated for injuries.

The air-attack crew informs firefighters on the ground of the fire's location, current fire conditions, expected fire conditions, and the location of geographic features that might affect firefighter safety and fire fighting strategy.

Aerial fire fighting operations are conducted by federal, state, county and municipal agencies. These agencies often fight fires on multi-jurisdictional, government-owned lands and on private property. Interagency working agreements enable the agencies to borrow, exchange or mix their resources.

Federal agencies include the USFS, the BLM, the National Park Service, the Bureau of Indian Affairs and the U.S. Fish and Wildlife Service (USFWS). These agencies have staffs and resources devoted either full-time or part-time to fire fighting. Various armed services of the U.S. Department of Defense occasionally are used to supplement civilian fire fighting forces.

Several states maintain fleets of aircraft for fire fighting. The largest fleets are in Alaska, California and North Carolina. Air National Guard units in California, Idaho, North Carolina and Wyoming maintain Lockheed C-130s equipped with removable bladders to assist full-time fire fighting forces in air-tanker operations.

Numerous county and municipal agencies operate aircraft during emergency operations. For example, the County of Los Angeles (California) trains, equips and deploys its own aerial fire fighting force.

The involvement of many agencies in aerial fire fighting presents organizational challenges. The challenges have been further complicated by the increasing incidence of wildfires that threaten urban areas and require additional coordination with law-enforcement personnel and emergency-management personnel.

Several government agencies contract with private aviation companies for aircraft and crews. Contractor services and operations vary. Some contractors operate under exclusive-use contracts, which guarantee the availability of the contractors' aircraft and pilots. All private air-tanker aircraft and crews operate under exclusive-use contracts.

Other contractors operate only on call to supplement the full-time resources and part-time resources of the contracting agencies during increased fire activity.

Some pilots are full-time staff members of the aerial fire fighting agencies. Most pilots, however, are hired on a seasonal basis by the contractors and are paid a base salary plus compensation for flight time and overtime. In an active fire season, a contract captain might earn from $30,000 to $70,000.

Aerial firefighters must be able to adapt quickly to varying work assignments. When a dispatch arrives, the pilots must be airborne within minutes. Thus, flight crews usually conduct preflight inspections of their aircraft in the morning, so that they can proceed with the engine-start checklist when they are dispatched to a fire. Sometimes, however, several days pass between flights.

Fire fighting aircraft and crews often are dispatched to distant locations with little advance notice. Pilots commonly are away from their home bases for months at a time. During the active fire seasons that occurred in 1988, 1994 and 1996, pilots were involved in fire fighting operations from February through November.

The USFS and USFWS conduct performance evaluations of contractor pilots only when the pilots are to be assigned to special missions, such as retardant delivery and smoke-jumper delivery. Performance evaluations of contractor pilots generally are conducted by U.S. Federal Aviation Administration (FAA) inspectors and designated check airmen under U.S. Federal Aviation Regulations Part 135.

Aerial firefighters face many hazards and difficulties. The majority of aerial fire fighting operations are conducted over sparsely populated areas of the western United States, where communication with air traffic control (ATC) facilities and with flight service facilities is limited, and where relatively few weather-reporting facilities are available.

Aerial fire fighting operations also are conducted in densely populated areas such as the Los Angeles Basin, where the airspace is congested and the ATC environment is complex.

U.S. aerial fire fighting resources from the western United States also are used in other areas. These resources were used to fight wildfires in the eastern United States in 1995 and 1998, in Indonesia in 1997, and in Canada and Mexico in 1998.

Flight operations often are conducted in turbulence and in close proximity to steep and rugged terrain. Visibility is obstructed by smoke, haze, terrain and shadows. Visibility is further restricted by the size and location of the windows in some aircraft. Sloping terrain creates visual illusions that impair pilot perception.

Aircraft typically are operated at their maximum gross weights, which limits their maneuvering characteristics compared to operation at lower gross weights. Operations in narrow canyons also limit the extent to which the aircraft can be maneuvered, and increase airspace congestion.

An aerial fire fighting operation might involve a single aircraft, such as a smoke-jumper aircraft delivering smoke jumpers to a smoldering tree in the wilderness, or more than 20 aircraft used in suppressing a growing fire in a populated area.

Table 2 shows that a high proportion of fires from 1980 to 1995 required the use of two or more air tankers.[2] These fires also required a lead plane or an air-attack aircraft.

The concentration of initial attack aircraft over a fire creates control and coordination problems, and increases the risk of midair collision.

The FAA issues temporary flight restrictions (TFRs) that prevent unauthorized aircraft from being flown in fire areas and in disaster-relief areas. Nevertheless, the maximum altitudes established for some TFRs sometimes are relatively low. During the 1998 fire season in Florida, for example, the maximum TFR altitude was 2,500 feet.[4]

Communications workload and radio-frequency saturation often are problems. Lead-plane pilots, air-attack-aircraft pilots and smoke-jumper-aircraft pilots normally maintain radio contact with each other, with ground firefighters and with dispatchers. Radio frequencies can become saturated with the high volume of communications.

The communications workload is increased further by the necessity of pilots to communicate with crewmembers aboard their aircraft.

The pilots must make both flight-related decisions and tactical decisions about fire suppression or fire management. The decisions are based on information about the vegetation types and their characteristic burn patterns, prevailing winds, topography and weather forecasts. The information is used to develop a coordinated attack plan for aerial forces and ground forces. The pilots must make these decisions while conducting high-workload, and often high-risk, aviation tasks.[5]

Pilots also must adapt to, or compensate for, other factors that affect safety in their work environment. For example, they must cope with cockpit noise levels that are relatively

Table 2
U.S. Regional Aerial Fire Fighting Operations, 1980–1995

State or Area	Annual Number of Fires	Fires with at Least One Air Tanker	Fires with at Least Two Air Tankers	Fires with ATGS
Alaska	216	NA	NA	NA
California	3,082	987	427	1,639
Eastern U.S.	1,049	NA	NA	NA
Great Basin	2,322	786	444	1,635
Northern Rockies	1,950	263	87	933
Northwest U.S.	2,096	332	118	810
Central Rockies	1,645	747	275	116
Southern U.S.	2,098	NA	NA	NA
Southwest U.S.	3,657	730	1,349	1,095

ATGS = air tactical ground supervisor NA = not available

Notes: Eastern U.S. includes Connecticut, Delaware, Illinois, Indiana, Iowa, Maine, Maryland, Massachusetts, Michigan, Minnesota, New Hampshire, New Jersey, New York, Ohio, Pennsylvania, Rhode Island, Vermont and Wisconsin. Great Basin includes southern Idaho, Nevada and Utah. Northern Rockies includes northern Idaho, Montana, North Dakota and South Dakota. Northwest U.S. includes Oregon and Washington. Central Rockies includes Colorado and Wyoming. Southern U.S. includes Alabama, Arkansas, Florida, Georgia, Kentucky, Louisiana, Mississippi, Missouri, North Carolina, South Carolina, Tennessee, Texas and Virginia. Southwest U.S. includes Arizona and New Mexico.

Source: Patrick R. Veillette, from U.S. Department of Agriculture, Forest Service, and U.S. Department of the Interior, *National Study of Tactical Aerial Resource Management to Supprt Initial and Large Fire Supression*. April 1998.

high in many aerial fire fighting aircraft. Some aircraft are equipped with headsets and intercom systems; none of the aircraft are equipped with active noise-canceling systems.

Some aircraft have poor ventilation systems; few aircraft are air conditioned. Thus, cockpit temperature often is high. Many of the older aircraft with reciprocating engines also have excessive vibration levels compared to most modern commercial aircraft.

The noise, heat and vibration contribute to pilots' physical stress and fatigue.

The piecemeal development of aerial fire fighting operations and procedures, the intense pace at which the operations are conducted, the high workload, the hazardous environmental conditions and the physical stresses create unique safety challenges for aerial firefighters.♦

— Patrick R. Veillette

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Air-tanker pilots sometimes take unnecessary risks to complete their missions. Insight into the pressures and motivational factors that air-tanker pilots encounter during the drop phase was provided by the following statements, which an investigator included in an accident report:[5]

> "Generally, I find that tanker pilots are very conscientious, take pride in their job [performance and] flying abilities, desire to do the best job possible and, in most cases, do not limit their drop altitudes to [a minimum of] 150 feet. Their desire is to please [their employers] and to place the retardant exactly on target. Many times, they take calculated risks in positioning the aircraft just right and flying lower in order to hit the spot. On occasions when pilots have missed the spot, they have been severely criticized over the radio, which is extremely embarrassing and degrading to the pilot. Because [people] on the ground who request and direct drops do not always realize the pilot/aircraft capabilities, the lay of the land as viewed from the air and [the] air-turbulence conditions, they sometimes request unreasonable or impossible drops."

Flying lower than the minimum altitudes authorized for drops was a factor in several air-tanker accidents and several lead-plane accidents.

Low-altitude flights also affect the safety of ground operations. Fire fighting incident reports show that aircraft-wake turbulence has caused erratic fire behavior that was hazardous to firefighters on the ground.[6] For example, one report said that a firefighter operating a bulldozer suddenly became encircled by flames that were spread by aircraft-wake turbulence; the firefighter escaped by driving the bulldozer through the flames.[7]

Among the tasks performed by lead-plane crews and air-tactical-group supervisors (ATGSs, who assume the tasks of lead-plane crews when fire activity becomes extreme) is to detect situations that could be hazardous to air-tanker crews, smoke-jumper crews and firefighters on the ground. When 11 air-tanker drop-phase accidents occurred, the air-tanker crews were being supervised by lead-plane crews or ATGSs. Several of the accidents occurred because air-tanker crews did not fly the drop routes that had been recommended by lead-plane crews; the air tankers struck terrain while being flown on routes that were different from the routes recommended by the lead-plane crews.

Five lead planes struck terrain while being maneuvered at low altitude to supervise air-tanker operations. Three of the five lead-plane drop-phase accidents were fatal. A report on one accident summarized the role of lead-plane crews as follows:[8]

> "The lead-plane mission has always been recognized as an extremely high-risk, dangerous, yet necessary mission. There is a wide variance of techniques, philosophy and opinions on how [a lead plane] should be flown. Some lead-plane pilots incur more Gs with steep pull-ups … and steep [climb] angles than is necessary."

Abrupt, steep pull-ups and steep climb angles were factors in the three of the five fatal lead-plane accidents that occurred during the drop phase.

A total of 11 accidents, including five fatal accidents, occurred during lead-plane operations. Six lead-plane accidents occurred during approach and landing, and five accidents occurred during the drop phase. Human error contributed to nine lead-plane accidents; mechanical failure caused two accidents.

Figure 1 (page 2) shows that 16 accidents occurred during approach and landing. Two ALAs were fatal and involved seven fatalities. One occurred when a personnel-transport airplane stalled on final approach and struck the ground; the four occupants were killed. The other was a midair collision between an air tanker and a lead plane; the collision resulted in three fatalities.

Figure 2 (page 2) shows that seven ALAs involved human error and nine ALAs involved mechanical failure.

Eight accidents occurred during the en route phase of flight. Seven of the eight en route accidents were fatal, with 21 fatalities. One en route accident was a midair collision between two air tankers that were being maneuvered for air-to-air photography. Human error was a factor in six of the eight en route accidents; mechanical failure was a factor in two en route accidents.

Table 2 shows the accident rates for air tankers in five-year periods from 1961 to 1995. The air-tanker accident rates are high compared with the accident rates for some other aircraft engaged in low-altitude operations. For example, air tankers in 1991 through 1995 were involved in 24.87 total accidents per 100,000 flight hours and 20.72 fatal accidents per 100,000 flight hours. During the same period, U.S. aerial-application (agricultural) aircraft were involved in an average of 11.34 accidents per 100,000 flight hours and 1.04 fatal accidents per 100,000 flight hours.[9]

The air-tanker fleet is relatively small. Some state fire fighting agencies own and operate their own air-tanker fleets, but most state agencies and all federal agencies contract for air tankers. The state and federal agencies contract for about 75 air tankers each year. Nevertheless, U.S. Department of Agriculture data show that, on average, two fatalities per year occur during air-tanker operations.[10]

In 1976–1998, air tankers were involved in 29 accidents, including 18 fatal accidents. Eighteen air-tanker accidents occurred during the drop phase of flight, six accidents occurred during the en route phase, and five accidents occurred during approach and landing. Six air tankers were involved in accidents after mechanical failures occurred.

Twenty-four air-tanker accidents involved human error. Pilot-judgment deficiencies contributed to 17 of the 24 air-tanker accidents; CRM deficiencies contributed to 15 of the accidents.

Two accidents occurred during smoke-jumper operations. CRM deficiencies were the primary causes of both smoke-jumper-airplane accidents. Although smoke-jumper airplanes often conduct paracargo missions, which involve low-altitude maneuvering to accurately deliver cargo, no smoke-jumper-airplane accidents in 1976–1998 occurred during the drop phase.

Reconnaissance airplanes were involved in 13 accidents, including six fatal accidents. Human error contributed to seven reconnaissance-airplane accidents; mechanical failure was involved in six accidents. Six reconnaissance-airplane accidents, including four fatal accidents, occurred during the drop phase.

Seven accidents, including three fatal accidents, occurred during personnel-transport operations. Human error contributed to four personnel-transport accidents; mechanical failure was involved in three personnel-transport accidents.

Neither of the midair collisions in 1976–1998 occurred during the drop phase, but incident reports show that the risk of midair collision in aerial fire fighting operations is high, especially during initial-attack operations over a rapidly growing fire. Initial-attack operations sometimes involve many fire fighting aircraft flying in close proximity. Fire fighting aircraft also risk colliding with other aircraft operated in the vicinity of the fire area.

Table 2
U.S. Fire Fighting Air-tanker Airplane Accidents, 1961–1995

Years	Hours Flown	Total Accidents	Fatal Accidents	Total Accident Rate*	Fatal Accident Rate*
1961–1965	21,000	15	NA	71.43	NA
1966–1970	25,000	22	NA	88.00	NA
1971–1975	27,000	11	NA	40.74	NA
1976–1980	23,000	4	3	17.39	13.04
1981–1985	19,000	5	3	26.32	15.79
1986–1990	21,529	5	3	23.22	13.94
1991–1995	24,130	6	5	24.87	20.72

* per 100,000 hours flown

NA = Not available

Source: Patrick R. Veillette, from U.S. Department of Agriculture. *Aviation Accident and Incident Trend Study. Letter to the Director, Fire and Aviation Management.* A special report prepared at the request of the U.S. Forest Service. March 1996.

Fifty-six near midair collisions (NMACs) were reported in 1992–1995.[11] (An NMAC is an incident involving less than 500 feet [153 meters] of separation between aircraft, or an incident perceived by a pilot as a collision hazard.)

Twenty-eight NMACs involved evasive actions taken by pilots to avoid collisions. Twenty-three NMACs occurred between fire fighting aircraft. Twenty NMACs occurred between fire fighting aircraft and general aviation aircraft. Thirteen NMACs occurred between fire fighting aircraft and military aircraft.

During the same period (1992–1995), 93 unauthorized aircraft were flown into fire areas in violation of temporary flight restrictions (TFRs) established by the U.S. Federal Aviation Administration.[11] Approximately 20 percent of the TFR violations resulted in NMACs.

The U.S. Forest Service (USFS) has installed traffic-alert and collision avoidance system (TCAS) equipment in all of its lead planes and has announced plans to equip its smoke-jumper aircraft with TCAS.

Figure 3 shows that 44 (72 percent) of the 61 aerial fire fighting accidents in 1976–1998 occurred in the months of June, July and August. This is the period in which the greatest fire activity occurs in the western U.S. The tempo of aerial fire fighting operations increases significantly during this time, thus increasing the risk of fatigue-related accidents and incidents.

Most aerial fire fighters are paid a base salary plus compensation for flight time and for overtime (duty time and flight time beyond limits specified in their contracts). Many of these aviators work on a seasonal contracts and welcome the opportunity to acquire overtime compensation.

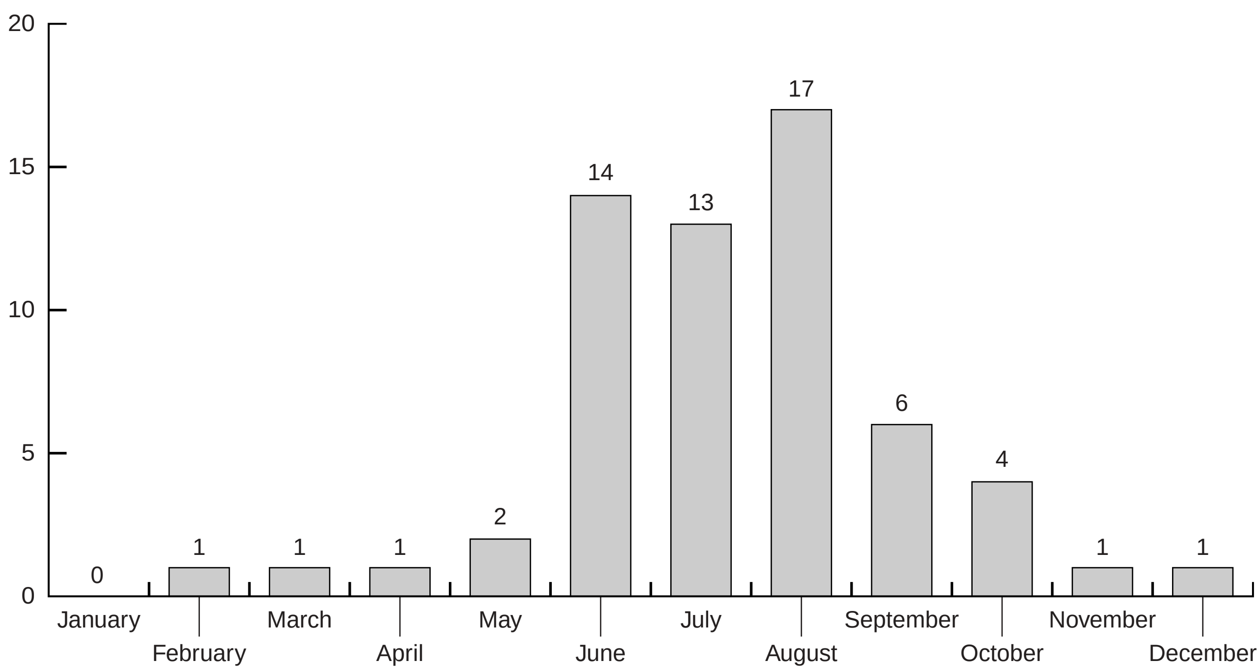
Nevertheless, the USFS and some other aerial fire fighting agencies have adopted FARs Part 135 duty-time restrictions and flight-time restrictions. The duty-time limit for aerial firefighters is 14 hours; during that time, they may fly a maximum of eight hours. A two-day rest period is required in any 14-day period. The USFS has provisions to further restrict duty time and flight time during periods of heightened fire activity.

A survey of aerial firefighters showed that short-term fatigue, long-term fatigue and heat-related stress sometimes are experienced during periods of intense fire fighting operations.

Seven reports on accidents in 1976–1998 said that crewmember fatigue was a possible factor. Five of the eight accidents were fatal. Nevertheless, studies have shown that fatigue typically is under-reported in accident reports and incident reports. An analysis of U.S. Aviation Safety Reporting System reports, for example, showed that fatigue specifically was cited in only 3.8 percent of the sample reports, *although evidence of fatigue appeared in 21.2 percent of the sample reports*.[12]

Of the seven reported fatigue-related accidents in 1976–1998, one occurred in June, two in July, two in August, one in

Distribution by Month of 61 U.S. Aerial Fire Fighting Airplane Accidents, 1976–1998



Source: Patrick R. Veillette

Figure 3

September, and one in October. Three fatigue-related accidents occurred in 1988, a year in which fire activity was especially high.

All of the fatigue-related accidents occurred during the hours of 1600–2000, that is, during the late afternoon and early evening. The reports did not say how many flights the crews had conducted during the morning or early afternoon on the days the accidents occurred. Because most aerial fire fighting operations are conducted during daylight and involve multiple flights, the possibility exists that the risk of fatigue was increased[12] (accident reports did not provide such details).

Air-tanker crews were involved in four of the seven fatigue-related accidents. Air tankers have no sound-proofing material, no vibration-damping systems and no environmental-control systems; thus, the crewmembers' risk of fatigue is relatively high.

High density altitude was common in the 1976–1998 accidents. Density altitudes of 5,000 feet or more were among the flight conditions in 42 accidents (68 percent). None of the accident reports cited density altitude as a probable cause. Nevertheless, reduced airplane performance resulting from high density altitude might have been a factor in some accidents.

Gusty winds and low-level turbulence were cited as environmental factors in all 29 of the drop-phase accidents and in six (38 percent) of the 16 ALAs. All of these accidents involved errors in judgment regarding the effects of the environmental factors on airplane performance.

Of the 63 airplanes involved in the 1976–1998 accidents, 33 airplanes (52 percent) were destroyed, 12 airplanes (19 percent) were substantially damaged, and 16 airplanes (25 percent) had minor damage.

A relatively large proportion of the accidents involved severe airplane damage and fatalities. Thirty-one airplanes (49 percent) struck mountainous and wooded terrain; 26 of the airplanes were destroyed. Twenty-five airplanes struck terrain that sloped more than 30 degrees; all the accidents involved fatalities.

Thirty-three accidents (54 percent) involved postaccident fires. Twenty-nine of the postaccident-fire accidents occurred in off-airport locations, where prompt response by aircraft rescue and fire fighting (ARFF) services was not possible. Personal-protection equipment — which typically includes fire-resistant Nomex flight suits, Nomex gloves and ankle-length leather boots — was ineffective because of the severe impact damage that was characteristic of the accidents.

Response by ARFF services to the 1976–1998 accidents varied. In 29 accidents, wildland firefighters were the first to arrive at the accident sites to extinguish postaccident fires and extract injured survivors. Smoke jumpers trained as emergency medical technicians parachuted to six accident sites in remote areas.

Aerial fire fighting dispatch centers and coordination centers were notified within 30 minutes of the occurrence of 45 (74 percent) of the accidents. Notification of the centers of the occurrence of three accidents was delayed for two hours or more because the flight crews of the accident airplanes had not complied with interagency mobilization guidelines for position reporting.[13]

ARFF personnel and/or emergency-medical-service (EMS) personnel arrived at the accident sites within 30 minutes of the occurrence of 32 accidents, and within 31 minutes to 60 minutes of four accidents. ARFF/EMS response times were more than one hour in 11 accidents; darkness and rugged terrain delayed ARFF/EMS personnel from reaching five accident sites for 24 hours or more.

Several accident reports said that postaccident fires were made worse by improperly labeled and improperly secured cargo that either ignited, added combustible material to a fire or impeded occupant evacuation from the airplanes.

Smoke-jumper airplanes, which are used to transport fire fighters and equipment to the fire area, also often carry flares, explosives and containers of flammable liquids and gases. Although reference material regarding the transportation of hazardous materials (HAZMAT) was found in several accident airplanes, there was no documented evidence that flight crewmembers had received initial training or recurrent training on HAZMAT.

Human error was the most common cause of the 1976–1998 accidents. Human error was involved in 47 (77 percent) of the 61 accidents. In descending order of frequency, pilot judgment, CRM and situational awareness were the primary factors.

Pilot-judgment deficiencies were involved in all 47 human-error accidents. Crews were maneuvering aircraft too close to terrain when several of the accidents occurred. Because most of the accidents were fatal, and because none of the aircraft was equipped with a cockpit voice recorder, investigators did not find evidence that indicated why the crews maneuvered the aircraft too close to terrain. Possible factors include sensory problems (difficulty seeing the terrain or obstacles), perceptual difficulties (visual illusions) and crew motivation (willingness to accept greater risk to complete the mission).

CRM deficiencies were involved in 45 of the 47 human-error accidents. CRM deficiencies included inadequate crew decision making, loss of situational awareness, inadequate conflict resolution, inadequate workload management, task saturation, inadequate error detection and resolution, inadequate crew coordination, and inadequate communication. The crews of several accident airplanes included first officers who previously had shown nonassertive behavior and captains who often conducted all flying and communications.

In summing up the instructor's observations regarding the performance of three USFS senior check airmen during flight-simulator training by FlightSafety Canada in 1996, the chief check airman for the USFS Intermountain Region said, “Our stick-and-rudder skills are above average, and it would be those skills alone that would enable us to survive an emergency situation. [Our] cockpit resource management skills were poor and below industry standards.”[14]

In a letter to the USFS, the FlightSafety Canada instructor said, “I found all three pilots to have above-average piloting abilities.” The instructor said that he also found a “lack of application of the crew concept … no crew briefings, ineffective departure briefings, poor communications procedures, inconsistent checklist procedures [and an] inability to create a synergistic cockpit environment for problem solving.”[15]

A 1996 survey of aerial firefighters who had attended a four-hour, interactive CRM seminar in Boise, Idaho, showed that many firefighters were skeptical of CRM concepts and practices.[16] The survey included 23 air-tanker captains, 13 air-tanker first officers, 20 ATGSs and 11 lead-plane pilots. The following observations were among the survey results:

- Some air-tanker pilots and lead-plane pilots had conflicting beliefs regarding their respective roles in fighting fires;
- The majority of air-tanker first officers were reluctant to identify mistakes made by captains;
- Some aerial firefighters were unwilling to make comments over the radio that might be perceived as criticism of other aerial firefighters;
- Some aerial firefighters did not know how to handle confrontations that arose in radio communications; and,
- Some aerial firefighters were unwilling to listen to comments from other aerial firefighters regarding their performance.

Situational awareness was a factor in 37 of the 47 human-error accidents. Twenty-one loss-of-situational-awareness accidents involved distractions. Pilots involved in 16 of the accidents were distracted by fire fighting duties. Pilots involved in five of the accidents were distracted by mechanical failures.

Failure to comply with SOPs was involved in 29 (48 percent) of the 61 accidents. These accidents occurred when flight crews flew airplanes into box canyons without guidance from crews of reconnaissance airplanes, failed to use checklists, and improperly configured airplanes for approach and landing.

Improper conduct of emergency procedures was involved in 15 (25 percent) of the 61 accidents.

Noncompliance with SOPs was cited in 46 percent of 397 reported fixed-wing aerial fire fighting incidents from 1992–1995.[11] The incident reports cited violations of duty-time requirements, use of unauthorized aircraft, improper transportation of cargo and passengers, flying below authorized minimum altitudes, deviation from operating plans, and improper engine-control manipulation.

Among the SOP-related incidents involving improper engine-control manipulation were one incident in which a crewmember attempted to use a condition lever to lean a Pratt & Whitney PT-6 turboprop engine (the purpose of a PT-6 condition lever is to set engine-idle speed when the power lever is at idle; unlike reciprocating engines, turboprop engines do not require manual leaning of their fuel-air mixture), and one incident in which a crewmember feathered the propellers on a multi-engine airplane during short-final approach to a wilderness airstrip.

The accident data and the incident data suggest inadequate standardization of procedures and noncompliance with SOPs in aerial fire fighting operations.

During the flight-simulator training of three USFS senior check airmen, FlightSafety Canada also identified that the senior check airmen did not comply with SOPs. The instructor’s report to the USFS on the training said that “each pilot ‘did it their own way.’”[15]

The report said, “Effective SOPs, CRM and recurrent training are essential to maintaining crew proficiency. This is especially true given your highly specialized type of operation.”

The accident data and the incident data suggest inadequate standardization of procedures and noncompliance with SOPs in aerial fire fighting operations. Among the challenges to standardization of procedures are the various agencies and contractors involved in aerial fire fighting, and the diverse backgrounds of the crewmembers.

Reports on the 1976–1998 accidents included flight-time data for 50 pilots. None of the pilots had fewer than 2,000 flight hours. One pilot had between 2,000 flight hours and 3,000 flight hours. One pilot had between 3,000 flight hours and 4,000 flight hours. Three pilots had between 4,000 flight hours and 5,000 flight hours. Thirty-five pilots had between 5,000 flight hours and 10,000 flight hours. Ten pilots had more than 10,000 flight hours.

Five pilots were involved in more than one accident; one was involved in three accidents. All of the accidents involving these pilots were caused by pilot-judgment errors.

The 1996 survey of aerial firefighters showed that their backgrounds included aerial application, flight instruction, charter flying, airline flying and military flying.

The aerial firefighters who participated in the survey were highly experienced. The average flight time among lead-plane pilots was 4,650 hours (ranging from 2,200 hours to 16,000 hours). The average flight time among air-tanker captains was 16,800 hours (ranging from 5,000 hours to 26,000 hours). The average flight time among air-tanker first officers was 7,650 hours (ranging from 2,000 hours to 11,000 hours).

Aerial fire fighting agencies use flight simulators to train pilots and to check pilots in the following airplanes: Beech 58P Baron, Beech King Air 200, de Havilland DHC-6 Twin Otter and Shorts SD-3 Sherpa. Flight-simulator training currently is not available in other airplanes used in aerial fire fighting. Thus, the pilots who fly these airplanes do not receive flight-simulator training in emergency procedures or use flight simulators to practice CRM skills such as workload management, situational awareness, error detection and error resolution.

Aerial fire fighting aircraft operated by private contractors are maintained and inspected according to FARs Part 135 standards. Public-use aircraft operated by government agencies are maintained and inspected according to programs established by the agencies. C-23 airplanes (U.S. military Shorts SD-3 Sherpas) procured under the Federal Excess Property program are maintained according to a program designed and used by the U.S. Air Force.

Mechanical malfunctions and mechanical failures led to 21 accidents (34 percent) in 1976–1998. The accidents included eight engine failures, seven landing-gear malfunctions, four structural failures, one tire failure and one electrical-system failure. All four structural failures occurred in airplanes that were built more than 20 years before the accidents occurred; three structural failures were induced by operator error.

Deficient maintenance was a factor in six of the 21 accidents. Maintenance deficiencies included improper installation of components and improper selection of electrical-circuit protection.

Mechanical malfunctions, mechanical failures and maintenance deficiencies were cited in 394 incident reports in 1992–1995.[11] The incidents included 35 reciprocating-engine failures and five turbine-engine failures. Twenty-two reciprocating-engine failures were caused by cylinder failures.

Based on the findings of this study, the author recommends the following actions to improve the safety of aerial fire fighting operations:

- The physical, organizational and management environments in which aerial firefighters operate should be studied to identify methods for improvement of crewmember judgment, situational awareness, CRM, stress management, attention management and risk management. Compliance with SOPs should be emphasized during crewmember selection and crewmember training;

- The agencies involved in aerial fire fighting should develop a common set of SOPs and an integrated program for crewmember selection and training. Aircraft types and aircraft equipment also should be standardized;

- Agencies should accelerate their efforts to replace aging, reciprocating-engine air tankers with turboprop air tankers. Until the aging airplanes are replaced, rigorous maintenance-and-inspection procedures, with special attention to powerplants and landing gear, should be established and used;

- Crewmember initial training and recurrent training should make maximum use of flight simulators. Compliance with SOPs and CRM should be emphasized during flight-simulator training;

- Airspace management should be improved to provide maximum protection of aerial firefighters and to reduce congestion of communications frequencies. Communications should be structured to ensure that all crewmembers understand the mission objectives;

- Studies should be conducted on the combined effects on crewmember performance of fatigue, stress, noise, vibration, heat, turbulence and sustained low-altitude flight operations. Findings should be used to improve the selection of crewmember equipment and facilities, SOPs, scheduling-and-dispatch policies, and training;

- The survivability of aerial fire fighting airplane accidents should be examined, and the findings should be used in selecting appropriate personal-protection equipment. Flight-crew training should include methods of minimizing airplane impact damage; and,

- EMS training of aerial firefighters should be expanded to include training in accident-site hazards such as hazardous materials, potential explosions and biological hazards.♦

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About the Author

Patrick R. Veillette, a professional pilot with more than 11,000 flight hours, flies de Havilland DHC-6 Twin Otter and Shorts SD-3 Sherpa airplanes in aerial fire fighting operations. Veillette earned a bachelor's degree in aeronautical engineering at the U.S. Air Force Academy and a doctorate in civil engineering at the University of Utah. He has conducted several research projects on cockpit automation and human error in high-risk environments. Veillette has an air transport pilot certificate and is a former U.S. Federal Aviation Administration designated pilot examiner.

Appendix

Fixed-wing Aircraft Accidents During U.S. Aerial Fire Fighting Operations, 1976–1998

Date	Location	Aircraft	Aircraft Damage	Injuries
July 16, 1976	Grand Valley, Colorado	Douglas B-26	destroyed	1 fatal
The air-tanker pilot was following a lead airplane (lead plane) to the drop site. The lead plane began a left turn, and the air tanker overshot the turn. The air-tanker pilot released the load of fire retardant just before the air tanker struck a mountain ridge.				
Aug. 2, 1976	McCall, Idaho	Douglas B-26	substantial	none
The air tanker was returning to reload fire retardant. The landing gear collapsed soon after the airplane touched down on the runway. The hydraulic-actuator seal on the left retardant-tank door had ruptured. Hydraulic-system pressure was not sufficient to hold the gear in the down-and-locked position.				
Aug. 8, 1976	Grand Junction, Colorado	Douglas B-26	destroyed	1 fatal
The air tanker dropped one tank of retardant on the fire and was in a steep left turn when the accident occurred in a box canyon. The failure of the pilot to maintain flying speed was cited as a cause of the accident; high density altitude was cited as a contributing factor.				
June 11, 1979	Selway River, Idaho	Douglas DC-3	destroyed	10 fatal; 2 serious
The airplane's left engine failed in flight. The crew secured the engine, feathered the left propeller and increased power on the right engine. Witnesses saw vapor trailing from the right engine before the engine burst into flame and separated from the wing. The airplane then struck canyon walls and a river. The cause of the left-engine failure was undetermined. The no. 8 cylinder in the right engine had failed. Investigators found that critical components of the oil-transfer pipe had been omitted during previous assembly of the nose case and right engine.				
July 21, 1979	Superior, Montana	Boeing B-17	destroyed	2 fatal
The air-tanker crew decided to approach the drop site from a direction that was different from the direction they had used on the previous approach, which terminated with a turn over lower terrain. The crew conducted the approach but dropped no retardant on the fire. The airplane stalled while being maneuvered at a low airspeed and at low altitude in a confined area.				
Aug. 5, 1980	Salmon, Idaho	Aero Commander 500B	destroyed	1 fatal; 1 serious
The reconnaissance airplane departed from Salmon at 1515 local time to fly to McCall, Idaho. Witnesses saw the airplane enter a canyon at an abnormally low altitude. The airplane did not arrive at the destination. Discrepancies in flight-plan filing and follow-up procedures contributed significantly to a delay in initiating a search for the airplane. The wreckage was found at 1120 the next day. Severe turbulence and downdrafts exceeding 1,500 feet (458 meters) per minute were reported in the area at the time of the accident. The accident was attributed to the pilot's misjudgment of distance, speed and altitude while flying in a blind canyon; high density altitude and downdrafts; and the pilot's inexperience in flying multi-engine airplanes over mountainous terrain.				
Dec. 2, 1980	Indio, California	Douglas DC-4	destroyed	2 fatal
After conducting air-tanker operations, two DC-4s were being flown to their home base in Tucson, Arizona. The crew of one airplane began to photograph the other airplane. During maneuvers for the aerial photography, one airplane's vertical stabilizer struck the other airplane's right-wing flaps. The vertical stabilizer separated on impact, the tail section then separated, and the airplane descended out of control. The other airplane was substantially damaged but was landed without further incident.				
May 11, 1981	Redding, California	Beech 58P	destroyed	4 fatal
The airplane was being used to transport an air-tanker inspection team to Chico, California. After takeoff, the pilot said that he was returning to the airport. The airplane stalled during final approach and struck a building. An engine exhaust stack was found on a taxiway, but inspection of the engines revealed no mechanical failure that would have affected engine operation prior to the accident.				
June 27, 1981	Bettles, Alaska	Fairchild C-119	substantial	none
The airplane was being flown on a paracargo mission when the no. 5 cylinder in the right engine failed, resulting in an engine failure and engine fire. The fire spread along the length of the right tail boom. The passengers and the first officer parachuted from the airplane. The captain landed the airplane on a gravel bar. Inadequate maintenance procedures and inadequate record keeping by the airplane operator were cited as factors contributing to the accident.				
Aug. 8, 1981	Bear Hollow, Utah	Lockheed P2V	substantial	none
The air tanker was climbing after dropping the sixth load of retardant on a fire in steep terrain when the first officer saw a tall tree in the airplane's flight path and attempted to warn the captain. The first officer said "watch the tree" just as the airplane's right wing struck the tree. The crew landed the airplane at an airport without further incident.				
Aug. 30, 1981	Hoopa Valley, California	Beech C55	substantial	none
The airplane was dispatched to an airstrip with a runway that was only 98 feet (30 meters) longer than the required landing distance shown in the airplane flight manual. During the landing rollout, the pilot told the passengers that the rudder system had failed and that the brakes had failed. The passengers braced for impact. The airplane traveled off the end of the runway and struck rocks and gravel. The nose section and landing gear separated from the airplane.				
Oct. 26, 1981	Bishop, California	Aero Commander 500	destroyed	1 serious
The reconnaissance airplane was being used to transport management personnel to a meeting and was slightly behind schedule on arrival. The pilot did not monitor the airplane's refueling; the piston-engine airplane was misfueled with Jet-A turbine fuel. When the airplane later departed, both engines failed approximately five miles (nine kilometers) from the runway. The airplane came to rest inverted during the gear-up forced landing in rugged terrain.				

(continued)

Appendix

Fixed-wing Aircraft Accidents During U.S. Aerial Fire Fighting Operations, 1976–1998

Date	Location	Aircraft	Aircraft Damage	Injuries
Aug. 6, 1982	Mackay Bar, Idaho	Cessna 207	substantial	none

The airplane had five crewmembers aboard when it departed from a short, unimproved airstrip in high-density-altitude conditions. The airplane was approximately 50 feet above a river when it encountered a downdraft. The pilot said that full power did not arrest the airplane's sink rate. The airplane struck a river bank. The airplane was loaded beyond the maximum certified gross weight, and the cargo was not secured.

Date	Location	Aircraft	Aircraft Damage	Injuries
March 5, 1983	Hubbards Fork, Kentucky	Douglas B-26C	destroyed	1 fatal

The air-tanker pilot followed a lead plane while dropping two loads of retardant on the fire. The pilot then made another approach to the drop site without guidance from the lead plane. The tanker struck trees near the top of a ridge.

Date	Location	Aircraft	Aircraft Damage	Injuries
June 8, 1983	Weaverville, California	Beech 58	substantial	none

The airplane was dispatched to an airport that has mountainous terrain on three sides and tall trees obstructing the approach. The runway has a significant slope that can cause visual illusions. The pilot was not given an adequate briefing on the hazards and approach procedures. The airplane developed a high sink rate on final approach, then stalled and struck the ground 44 feet (13 meters) from the runway.

Date	Location	Aircraft	Aircraft Damage	Injuries
June 9, 1983	West Yellowstone, Montana	Douglas DC-7	substantial	1 serious

The air tanker was being refueled when the fuel hose fell to the ground and created a large puddle of aviation-grade gasoline on the ramp. The fuel began to flow toward several electrical extension cords used to power fuel pumps. The fuel-truck driver ran to the cords and disconnected the plugs from their sockets. This created an electric arc that ignited the fuel. The driver was engulfed in flames, which were extinguished by a nearby smoke jumper. During this time, the fire spread to the fuel truck and to the wing of the airplane. The smoke jumper entered the burning truck and drove it away from the airplane, then began suppressing the fire on the wing of the airplane. Aircraft rescue and fire fighting personnel arrived within three minutes and extinguished the fire.

Date	Location	Aircraft	Aircraft Damage	Injuries
Aug. 27, 1983	Carson City, Nevada	Lockheed P2V	none	2 serious

The air-tanker captain chose to operate in flight conditions that did not allow him to see the drop site or to determine the airplane's height above the ground. The air tanker approached the drop site without guidance from a lead plane. The retardant dropped by the airplane struck two firefighters and two trucks on the ground. Inadequate communication and coordination among the various personnel involved in fighting the fire were cited as factors in the accident.

Date	Location	Aircraft	Aircraft Damage	Injuries
Sept. 9, 1983	Big Horn National Forest, Wyoming	Cessna 210	destroyed	2 fatal

The crew flew the fire-reconnaissance airplane into a narrow box canyon where the ridges were obscured by clouds and fog. The pilot apparently realized that the airplane could not climb out of the canyon and attempted to turn around. The canyon was only 1,200 feet (366 meters) wide at this location. The airplane stalled and spun into a steep slope.

Date	Location	Aircraft	Aircraft Damage	Injuries
Sept. 18, 1983	San Gabriel National Forest, California	Beech 58P	substantial	none

The pilot was flying the lead plane at a low altitude in a canyon. Visibility was reduced by a low sun position, haze and smoke. The pilot saw power lines too late to avoid colliding with them, but was able to continue flying and land the airplane without further incident. Investigators found that the power lines were not adequately depicted on hazard maps available to aircrews, and that helicopter pilots operating in the area did not inform the lead-plane pilot about the power lines.

Date	Location	Aircraft	Aircraft Damage	Injuries
July 23, 1984	Ruidoso, New Mexico	Cessna P-337	destroyed	2 fatal

The crew was conducting a forest survey when the airplane struck steep and rugged terrain at 9,500 feet. Density altitude was approximately 12,000 feet. Investigators found that the front-engine turbocharger had been inoperative prior to the accident flight and during the accident flight. Diminished airplane performance and the pilot's limited experience with low-level flying in mountainous terrain were cited as factors that contributed to the accident.

Date	Location	Aircraft	Aircraft Damage	Injuries
July 6, 1985	Battle Mountain, Nevada	Fairchild C-119G	substantial	none

During initial climb, left-engine oil temperature increased and oil pressure decreased. The crew turned back to the airport and reduced power on the left engine. The crew did not jettison an 18,250-pound (8,278-kilogram) load of fire retardant. The airplane was not aligned properly for landing on the runway, and the crew attempted to maneuver for landing on another runway. The airplane again was not aligned properly for landing, and the crew attempted to go around. The airplane then struck rough desert terrain adjacent to the runway. Investigators found that the abnormal left-engine oil indications were caused by the crew's mismanagement of the engine oil-cooler door.

Date	Location	Aircraft	Aircraft Damage	Injuries
July 29, 1985	Northport, Washington	Convair PBY-6A	destroyed	2 fatal

While preparing to land on a lake to reload the air-tanker's water tanks, the crew inadvertently engaged the dump-door locks before they closed the dump doors. The dump doors remained partially open, and this resulted in an accident during the landing. The investigation determined that the failure of the pilot-in-command (PIC) to follow the checklist caused the accident, and that the PIC's chronic fatigue and psychological pressure to conduct the mission were contributing factors.

Date	Location	Aircraft	Aircraft Damage	Injuries
Sept. 3, 1985	Boise, Idaho	Cessna 337	substantial	none

During a routine preflight inspection four days before the accident occurred, a large puddle of hydraulic fluid was found under the airplane's front engine. An inspector was not on duty when repairs were conducted. The accident occurred on the next flight; the landing gear failed to extend fully and lock, and the airplane was landed with the gear retracted. The investigation determined that a hydraulic-fluid leak had been caused by a loose nut on the nose-gear-door hydraulic line.

Date	Location	Aircraft	Aircraft Damage	Injuries
Aug. 21, 1986	Frenchglen, Oregon	Cessna T207A	destroyed	6 fatal

The airplane was near maximum gross weight when it took off for a reconnaissance flight over a wilderness area. Witnesses saw the airplane flying below canyon rim-rock level toward rising terrain. The airplane was in a near-vertical attitude when it struck the ground approximately 900 feet (275 meters) below the canyon rim. The pilot did not have authorization for low-level flight operations.

(continued)

Appendix

Fixed-wing Aircraft Accidents During U.S. Aerial Fire Fighting Operations, 1976–1998

Date	Location	Aircraft	Aircraft Damage	Injuries
July 29, 1987	Minden, Nevada	Fairchild C-119	substantial	none

The right-main-landing-gear warning indicator illuminated during takeoff, but visual inspection by the crew showed that the landing gear was retracted. After dropping retardant on a fire and returning to the airport, the crew was not able to extend the right-main gear. The crew landed the airplane with the landing gear retracted. A broken jackscrew on the right-main gear had been detected but not repaired during a previous maintenance inspection.

Sept. 16, 1987	Montague, California	Fairchild C-119G	destroyed	3 fatal

The air tanker was dropping retardant on a fire when both wing outer sections separated from the booms. The right-wing section traveled over the fuselage, struck the left tail boom and severed the horizontal stabilizer. No evidence was found of material fatigue, corrosion or flutter. The investigation determined that excessive airspeed and unapproved maneuvering at this airspeed created aerodynamic loads that caused catastrophic structural failure of the wings.

Nov. 9, 1987	Birmingham, Alabama	Beech 200	substantial	none

After a late-night landing, the infrared-photography airplane was being taxied to the ramp. The crew taxied the airplane past the turn-off for the ramp and then inadvertently taxied the airplane into a drainage ditch adjacent to the taxiway. Both propellers struck the ground. The investigation determined that the taxiway turn-off was poorly marked and lighted, and that two other airplanes in the past two years had been involved in similar accidents at the same location.

June 24, 1988	McCall, Idaho	Beech 99	substantial	none

The smoke-jumper airplane was being used to conduct multiple practice jumps. Before the first flight, the pilot pulled the landing-gear-warning-horn circuit breaker to eliminate continuous activation of the horn during slow-speed jump operations. During the last flight, the pilot neglected to lower the landing gear on approach.

July 14, 1988	John Day, Oregon	de Havilland DHC-6	destroyed	1 fatal

The smoke-jumper airplane struck the ground after departing from a fire base to pick up passengers at another base. The investigation found no mechanical anomalies and determined that the accident probably occurred because the pilot fell asleep.

Aug. 11, 1988	Jackson, Wyoming	Beech 200	destroyed	1 fatal

After conducting several flights during the day, the pilot departed on a very dark night with a 2,000-foot overcast and no visible horizon. Witnesses saw the airplane rapidly climb and dive several times before it struck the ground in a vertical dive. The investigation determined that the pilot's poor planning, fatigue, improper use of the flight controls and spatial disorientation were the probable causes of the accident.

Aug. 12, 1988	Sequoia National Forest, California	Beech 58P	destroyed	1 fatal

The pilot flew the lead plane to guide an air tanker on descent to the drop site. The pilot then increased the pitch attitude and steeply banked the airplane. The airplane stalled and spun to the ground. The investigation determined that the probable cause of the accident was a mechanical failure or malfunction of the left engine while the airplane was in the climbing turn.

Aug. 22, 1988	Hells Canyon, Oregon/Idaho	Beech 58P	substantial	1 minor

While taxiing for takeoff, the pilot was distracted by a radio call from a dispatcher and did not reposition the right fuel-selector valve from the crossfeed position. During the flight, the pilot used aileron trim to correct a right-rolling tendency. The pilot did not determine that both engines were drawing fuel from the left-wing reserve tank. After two hours of flight, both engines failed because of fuel starvation. The pilot attempted a gear-up landing on a gravel bar in a river, but the airplane struck a sand bar and sank in 10 feet (three meters) of water.

Sept. 2, 1988	Deer Lodge National Forest, Montana	Lockheed C-130B	substantial	none

The air-tanker crew had just dropped retardant on a fire when the airplane encountered turbulence. The airplane then struck trees, causing damage to the bottom of the fuselage and left horizontal stabilizer, but continued flying.

July 27, 1989	Hamilton, Montana	Cessna TU-206	substantial	none

The airplane was on a fire-reconnaissance mission when the engine crankshaft gear failed catastrophically. The pilot landed the airplane on a sloping field covered with tall weeds but was unable to stop the airplane before it struck a ditch and came to rest inverted.

July 10, 1989	Denver, Colorado	Convair PB4Y-2	none	1 serious

After performing maintenance on the airplane, a maintenance technician accompanied the crew on an air-tanker mission for orientation and to monitor the engine gauges. While dropping retardant on the fire, the airplane encountered strong turbulence. The maintenance technician, who was standing in the cockpit aisle between the pilots, fell and suffered a fracture of his right leg.

June 28, 1990	Albuquerque, New Mexico	Beech 58P	substantial	none

Upon arriving at the fire, the pilot attempted to extend the landing gear to help slow the airplane. He heard a loud snapping noise and saw the landing-gear-unsafe warning light. The pilot of another lead plane confirmed that the landing gear was only partially extended. After several unsuccessful attempts to fully extend or retract the gear, the pilot made an emergency landing at an airport. The gear collapsed upon touchdown. The investigation determined that the gear teeth were worn.

Aug. 10, 1990	Missoula, Montana	Beech 200	minor	none

After departing with five passengers at 0350 local time, the pilot heard an unusual noise and saw the landing-gear-unsafe warning light. The pilot continued the flight to the destination and attempted to lower the landing gear. The left main gear did not extend fully. The pilot diverted the flight to the Missoula airport, where emergency equipment was available. Emergency landing-gear-extension procedures failed. The pilot continued flying the airplane to reduce the fuel load and requested that the runway be foamed. He landed the airplane with the left main gear in the foam. The upper torque knee and lower torque knee on the left main gear had separated. The investigation determined that incorrectly sized washers had been installed in the gear-extension system and that the airplane maintenance manual did not provide clear instructions for washer installation.

(continued)

Appendix

Fixed-wing Aircraft Accidents During U.S. Aerial Fire Fighting Operations, 1976–1998

Date	Location	Aircraft	Aircraft Damage	Injuries
Sept. 30, 1990	Olympic National Forest, Washington	Lockheed P2V	destroyed	2 fatal

A lead-plane pilot told the crew of the P2V air tanker to drop the retardant from a relatively high altitude because of steep terrain. The air-tanker crew extended the flaps, which is the normal procedure; the crew also extended the landing gear to prevent airspeed from increasing while descending into the canyon. During the pull-up from the drop, the air tanker collided with terrain. Photographs show that the flaps and landing gear were in transit when the accident occurred. The investigation determined that the two turbojet engines — which usually are used to supplement power produced by the two radial-piston engines during pull-up — were at idle when the accident occurred, and that the first officer, who was responsible for controlling the turbojet engines, was inexperienced in the airplane.

Date	Location	Aircraft	Aircraft Damage	Injuries
June 21, 1991	Cibola National Forest, New Mexico	Beech 58P	destroyed	1 fatal

The lead-plane pilot had been engaged in fire fighting operations for more than four hours. He led an air tanker to the retardant-drop site, wagged the airplane's wings to mark the point of release and then initiated a steep climbing left turn to observe the air-tanker's drop. The air-tanker pilot saw the lead plane pitch up approximately 30 degrees, roll inverted and descend to the ground. The investigation did not determine the cause of the accident.

Date	Location	Aircraft	Aircraft Damage	Injuries
Oct. 16, 1991	Florence, Montana	Lockheed P3	destroyed	2 fatal

The air tanker was dispatched to an airport that had instrument meteorological conditions. The crew did not have the applicable instrument-approach charts aboard the airplane. The crew requested and received verbal instructions from air traffic control for a VOR/DME (very-high-frequency omnidirectional radio/distance-measuring equipment) approach. The crew apparently misunderstood the instructions and turned the airplane in the wrong direction to intercept a DME arc that is part of the approach procedure. The airplane then struck high terrain.

Date	Location	Aircraft	Aircraft Damage	Injuries
Feb. 8, 1992	Dixon, Wyoming	Lockheed P2V-7	destroyed	2 fatal

The airplane was being ferried from Tucson, Arizona, to Greybull, Wyoming. The airplane was not equipped for instrument flight operations. The crew was told that visual flight operations were not recommended because of low ceilings and snow in Wyoming. The airplane was in a steep nose-down attitude when it struck snow-covered terrain.

Date	Location	Aircraft	Aircraft Damage	Injuries
Oct. 1, 1992	Kyburz, California	Douglas DC-7B	destroyed	2 fatal

The air-tanker captain aborted an approach to a drop site because of an engine problem. The air-attack supervisor asked the captain if he needed to jettison his load of retardant; the captain said that he might have to jettison the retardant if he couldn't solve the engine problem. Witnesses saw the airplane flying low over the ground, then pitch up sharply before striking trees. The horizontal stabilizers and elevators separated, and the airplane descended steeply to the ground. The cause of the accident was not determined because of extensive airplane impact damage and fire damage.

Date	Location	Aircraft	Aircraft Damage	Injuries
June 17, 1994	Springerville, Arizona	Basler DC-3TP	substantial	none

The crew was accomplishing the taxi checklist while taxiing the airplane (a Douglas DC-3 modified with turboprop powerplants) in a confined area. Neither of the pilots was aware that a wing had struck a fence until they were notified by radio.

Date	Location	Aircraft	Aircraft Damage	Injuries
June 29, 1994	Silver City, New Mexico	Beech 58P	substantial	none

While landing to refuel, the airplane settled onto the runway and slid on the landing gear doors, left cabin step and flap trailing edges for a distance of nearly 1,100 feet (336 meters). The investigation determined that the landing-gear switch was worn.

Date	Location	Aircraft	Aircraft Damage	Injuries
July 25, 1994	Cottonwood, Arizona	Cessna T210	substantial	3 minor

The airplane was on approach to land when the pilot heard a loud "pop." While attempting to determine what had caused the noise, the pilot extended the landing gear and the first increment of flaps to prepare for an emergency landing. The pilot observed no abnormal gauge indications. The airplane was about a quarter mile (one-half kilometer) from the runway when the pilot attempted to increase power. The engine did not respond, and the airplane struck terrain short of the runway.

Date	Location	Aircraft	Aircraft Damage	Injuries
July 29, 1994	Squaw Peak, Montana	Lockheed P2V	destroyed	2 fatal

The air-tanker crew was preparing to drop retardant on a fire when the retardant-release doors malfunctioned. The crew apparently became fixated on the malfunction and did not realize that the airplane was entering a narrow box canyon. The airplane struck steeply rising terrain 350 feet (107 meters) below the ridge top.

Date	Location	Aircraft	Aircraft Damage	Injuries
Aug. 13, 1994	Pearblossum, California	Lockheed C-130A	destroyed	3 fatal

Witnesses said that the air tanker was in level flight when a bright orange flash was emitted near the wing root. Shortly thereafter, a large dark-orange fireball was emitted, and the right wing separated. The investigation determined that an explosion probably occurred when fuel leaking from pressurized fuel lines was ignited by electrical arcing or by hot surfaces of the no. 3 engine.

Date	Location	Aircraft	Aircraft Damage	Injuries
Aug. 19, 1994	Wenatchee, Washington	Lockheed P2V	substantial	none

The crew was attempting to drop retardant on a fire when they detected smoke from the motor that drives the retardant-delivery hydraulic pump. The captain was not able to shut off the pump's electric-power supply. The crew removed a portion of the cockpit canopy for smoke removal and attempted to suppress the smoke source with a handheld fire extinguisher. When the captain landed the airplane at an airport, the first officer was in the hydraulic bay trying to suppress the smoke. Because of cockpit ergonomics, the captain was unable to reverse the propellers without the first officer's assistance. The left brake locked, and the left tire ruptured before the airplane was stopped on the runway. The investigation determined that the capacity of the pump's current limiter was too high to properly protect the motor and wiring.

Date	Location	Aircraft	Aircraft Damage	Injuries
Aug. 22, 1994	McCall, Idaho	de Havilland DHC-6-300	substantial	1 minor

The airplane touched down for landing, veered to the left, exited the runway and stopped in a marsh 375 feet (114 meters) from the runway. The nose-wheel-steering tiller was fully deflected.

(continued)

Appendix

Fixed-wing Aircraft Accidents During U.S. Aerial Fire Fighting Operations, 1976–1998

Date	Location	Aircraft	Aircraft Damage	Injuries
June 21, 1995	Ramona, California	Beech 58; Douglas C-54G	destroyed	3 fatal

The BE-58 lead plane and the C-54 (military DC-4) air tanker were being flown to their base after a fire-suppression mission. The lead plane departed from the fire area five minutes before the air tanker. For undetermined reasons, however, the lead plane was not flown at its normal cruising speed. Witnesses saw the lead plane being flown above and to the left of the air tanker. The lead plane then appeared to accelerate on approach to the airport, enter a nonstandard and unpublished overhead traffic pattern, and collide with the air tanker. The tail sections on both airplanes separated, and the airplanes descended to the ground.

Date	Location	Aircraft	Aircraft Damage	Injuries
Aug. 23, 1995	Auberry, California	Douglas C-54G	substantial	none

The air-tanker crew was told that there were power lines on the approach to the drop site. The crew said that they were aware of the power lines. The air tanker was descending for the drop when the first officer saw power lines ahead and called for increased engine power. The captain elected to fly under the power lines, rather than over them, because the airplane was flying at a low airspeed with the flaps extended. Impact with the power lines damaged three propeller blades on the no. 4 engine and severed the top one-third of the vertical stabilizer. The crew maintained control of the airplane and landed at an airport without further incident.

Date	Location	Aircraft	Aircraft Damage	Injuries
May 1, 1996	Albuquerque, New Mexico	Rockwell Sabreliner 80	substantial	none

Takeoff was initiated on a runway that was 10,000 feet (3,050 meters) long and 150 feet (46 meters) wide. The airplane was halfway down the runway and traveling at approximately 120 knots when the crew detected a loud noise and a severe vibration. The captain initiated rejected-takeoff procedures by applying brakes and reverse thrust. The airplane was stopped 300 feet (92 meters) beyond the departure end of the runway. The investigation determined that the tires on the left-main gear failed because they were overdeflected. The report said, "Overdeflection is caused by operating the tire overloaded or underinflated."

Date	Location	Aircraft	Aircraft Damage	Injuries
April 20, 1997	Blandburg, Pennsylvania	Lockheed P2V	destroyed	2 fatal

Winds were gusting to 18 knots when the air-tanker crew dropped water on a fire on a steep slope. The airplane then encountered dense smoke. One wing struck trees, and the airplane descended onto the slope.

Date	Location	Aircraft	Aircraft Damage	Injuries
June 3, 1997	San Carlos, New Mexico	Beech B55	destroyed	2 fatal

Ground personnel did not receive a position report from the crew of the fire-reconnaissance airplane within a required 15-minute interval, and a column of smoke was reported where the airplane had been flying. A helicopter was dispatched to the area, and the airplane wreckage was found in a deep ravine. The investigation found no evidence that a mechanical failure had occurred.

Date	Location	Aircraft	Aircraft Damage	Injuries
June 10, 1997	Hollister, California	Rockwell OV-10A	destroyed	1 fatal

Witnesses at a fire station saw the airplane fly by at approximately 200 feet and roll right to a near-inverted attitude. The airplane then began to roll left and struck the ground in a 90-degree right-wing-down attitude. The investigation determined that the probable cause of the accident was the pilot's failure to maintain ground clearance, and that contributing factors were the aerobatic maneuver and the pilot's lack of experience in the airplane.

Date	Location	Aircraft	Aircraft Damage	Injuries
Aug. 1, 1997	Moreno, California	Convair PBY-5A	destroyed	2 serious

After conducting three water-bombing runs, the crew flew the air tanker to a reservoir to load more water. This is conducted by landing the airplane and loading water through scoops on the bottom of the airplane. The surface of the reservoir appeared smooth but showed some indications of wind gusts. Soon after touching down, the crew applied takeoff power. The airplane pitched forward and struck the water. The cockpit separated and sank. Both crewmembers extricated themselves from the cockpit and swam to the surface. The investigation determined that the left nose-gear locking pin had separated from the hydraulic actuator, and that both nose-gear doors had separated from the hull.

Date	Location	Aircraft	Aircraft Damage	Injuries
June 25, 1998	Morganton, North Carolina	Cessna L-19	substantial	none

The fire-reconnaissance airplane was being flown near a ridge when turbulence was encountered. The pilot increased altitude to approximately 1,600 feet to 1,800 feet above the ridge. The airplane was on the lee side of the ridge when it began to lose altitude rapidly. The pilot applied full power and leveled the wings, but the airplane continued to descend at more than 500 feet (153 meters) per minute, and airspeed decreased below 80 miles per hour (129 kilometers per hour). The flight controls became mushy and unresponsive. The pilot extended full flaps and attempted to maintain control of the airplane as it descended to the ground. Neither occupant was injured.

Date	Location	Aircraft	Aircraft Damage	Injuries
June 27, 1998	Reserve, New Mexico	Lockheed SP-2H	destroyed	2 fatal

The first officer was receiving training to become an air-tanker captain. The air tanker made a dry pass over the drop site, then circled for a second pass. The airplane was in a nose-low, right-wing-low attitude when it struck a tree at 55 feet and descended to the ground.

Date	Location	Aircraft	Aircraft Damage	Injuries
July 28, 1998	Ely, Nevada	Aero Commander 690	substantial	none

The airplane was being taxied for takeoff when the left main wheel separated from the axle.

Date	Location	Aircraft	Aircraft Damage	Injuries
July 29, 1998	Burns, Oregon	Cessna TU-206G	substantial	1 minor

The fire-reconnaissance airplane had been in flight for two hours when the engine failed. The pilot was not able to restart the engine and attempted to land the airplane on a dirt road. The airplane touched down short of the road and struck sagebrush and a barbed-wire fence. The investigation determined that the engine crankshaft had failed because of a fatigue crack in the no. 2 main bearing.

Date	Location	Aircraft	Aircraft Damage	Injuries
Oct. 5, 1998	Banning, California	Grumman TS-2A	destroyed	1 fatal

The air tanker was in a 60-degree left bank during a turn to approach the drop site. The bank angle suddenly increased to 90 degrees, and the airplane struck the ground. Other pilots reported strong winds and turbulence in the area of the accident.♦

Sources: Patrick R. Veillette, from reports by the U.S. Bureau of Land Management, U.S. Forest Service and U.S. National Transportation Safety Board

Accident Rate for FARs Part 121 Operators Declines from 1997 to 1998, but Remains Higher Than Any Other Year Since 1982

Based on definitions used by the U.S. National Transportation Safety Board, no major accidents occurred in 1998 and three were identified as serious accidents.

FSF Editorial Staff

The U.S. Federal Aviation Administration (FAA) has published 1998 accident data for U.S. air carriers operating under U.S. Federal Aviation Regulations (FARs) Part 121 in a report of 24 aviation-system indicators and 12 aviation-environmental indicators for the 1992–1998 period.[1] A total of 48 accidents[2] occurred among FARs Part 121 operators in 1998, said the report. Nevertheless, none of the accidents was identified by the U.S. National Transportation Safety Board as a major accident[3] and three were identified as serious accidents, said the report. Of the other accidents, 21 were identified as injury accidents and 24 were damage accidents.

"The large air carrier accident rate was 0.465 accidents per 100,000 departures [rounded to 0.47 in Table 1], lower than that for 1997 (0.476) but higher than the rate for any other year since at least 1982," said the report (Table 1, Figure 1, page 20).

As of April 1997, because of FAA regulatory changes known collectively as the "commuter rule," many operations formerly conducted under commuter air carrier rules (FARs Part 135) were conducted under large air carrier rules (FARs Part 121). Thus, in addition to normal annual fluctuation in operations among large air carriers, the 1998 data represent a different group of carriers compared to the 1992–1996 period, when the year-to-year change in total departures varied from an increase of 2.7 percent to a decrease of 2.7 percent. By comparison, the total departures used to calculate this system indicator increased 25.2 percent from 1996 to 1997.

FAA's accident-rate system indicators compare the number of accidents involving all FARs Part 121 air carriers to the number of flight hours and departures for these carriers. The FAA calculates the "per departures" rate, for example, by dividing the number of accidents by the number of departures in one year, then multiplying the result by 100,000.

The report said, "Because most accidents occur during arrival or departure, the number of departures is considered to be the best normalizing variable. However, because departure data are not available for all operator types, rates based on flight hours also are calculated."

A new compliance measure — airport-certification indicator rate — is under development, said the report. Together, the FAA indicators provide information about aviation-system performance over time. No single system indicator adequately or accurately shows the status of safety. The statistically small numbers of accidents among large air carriers, for example, alone do not provide enough data for analysis other than general observations.♦

Notes and References

1. U.S. Federal Aviation Administration. *FAA System Indicators: 1998 Annual Report.* Washington, D.C., U.S.: May 7, 1999.

2. The U.S. National Transportation Board (NTSB) has defined an aircraft accident as "an occurrence associated with the operation of an aircraft that 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."

3. A *major* accident involves any of the following conditions: a FARs Part 121 aircraft was destroyed, multiple fatalities occurred, or one fatality occurred and a FARs Part 121 aircraft was substantially damaged. A *serious* accident involves at least one of the following conditions: one fatality occurred without substantial damage to a FARs Part 121 aircraft, or at least one serious injury occurred and a FARs Part 121 aircraft was substantially damaged. An *injury* accident involves a nonfatal accident with at least one serious injury and without substantial damage to a FARs Part 121 aircraft. A *damage* accident involves no person killed or seriously injured, but in which any aircraft was substantially damaged.

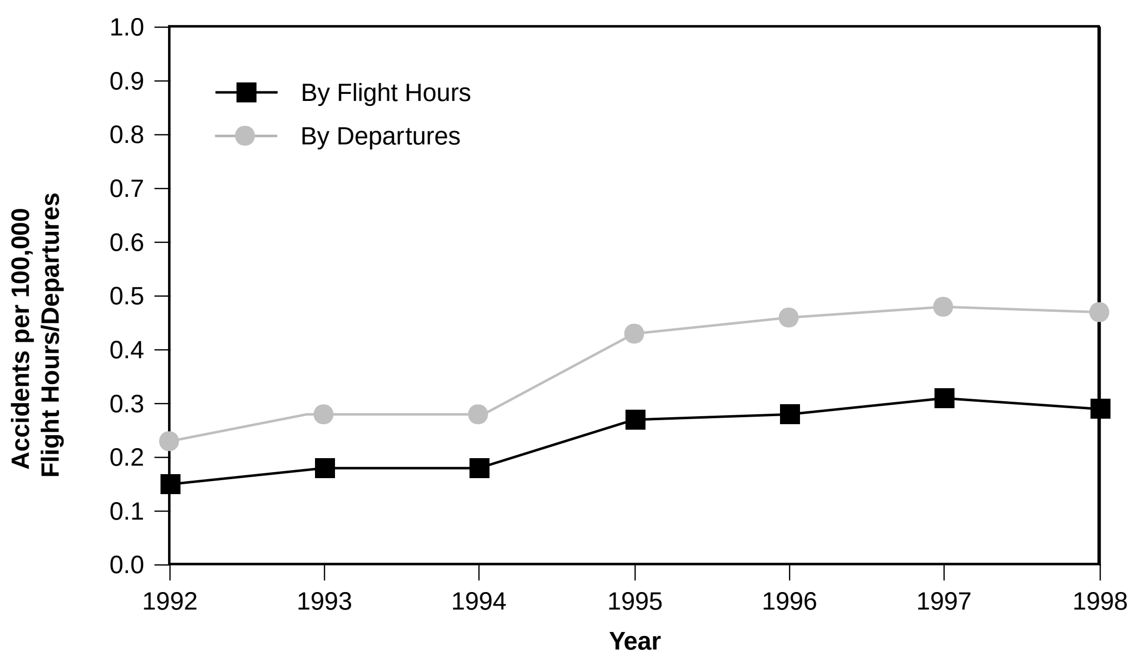
Table 1
U.S. Air Carrier Accident Data

Year	Accidents	Flight Hours	Rate/100,000 Flight Hours	Departures	Rate/100,000 Departures
1992	18	12,359,715	0.15	7,880,707	0.23
1993	23	12,706,206	0.18	8,073,173	0.28
1994	23	13,124,315	0.18	8,238,306	0.28
1995	36	13,505,257	0.27	8,457,465	0.43
1996	38	13,746,112	0.28	8,228,810	0.46
1997	49	15,829,408	0.31	10,300,040	0.48
1998	48	16,508,000	0.29	10,318,000	0.47

Note: Accident data are from the U.S. National Transportation Safety Board for operations under U.S. Federal Aviation Regulations (FARs) Part 121. Many commuter operations formerly conducted under FARs Part 135 are conducted under air carrier rules (FARs Part 121) as of April 1997. Flight-hour data and departure data are from the U.S. Federal Aviation Administration.

Source: U.S. Federal Aviation Administration

U.S. Air Carrier Accident Rates



Note: Accident data are from the U.S. National Transportation Safety Board for operations under U.S. Federal Aviation Regulations (FARs) Part 121. Many commuter operations formerly conducted under FARs Part 135 are conducted under air carrier rules (FARs Part 121) as of April 1997. Flight-hour data and departure data are from the U.S. Federal Aviation Administration.

Source: U.S. Federal Aviation Administration

Figure 1

Publications Received at FSF Jerry Lederer Aviation Safety Library

FAA Commercial-pilot Practical-test Standards for Glider Available in Print and Electronic Formats

Document will be useful to flight instructors, students and applicants.

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FSF Library Staff

Advisory Circulars (ACs)

Announcement of Availability: FAA-S-8081-23, Commercial Pilot Practical Test Standards for Glider. U.S. Federal Aviation Administration (FAA) Advisory Circular (AC) 61-132. April 26, 1999. 1 p. Available through GPO.*

FAA has published FAA-S-8081-23 to establish standards for commercial-pilot practical tests for glider. Practical tests conducted by FAA inspectors, designated pilot examiners and check airmen (examiners) must comply with these standards. These standards also will be helpful to flight instructors and applicants preparing for the tests.

This advisory circular (AC) announces the availability of FAA-S-8081-23, *Commercial Pilot Practical Test Standards for Glider*, and provides information on obtaining both electronic and printed copies. [Adapted from AC.]

Announcement of Availability: FAA-S-8081-22, Private Pilot Practical Test Standards for Glider. U.S. Federal Aviation Administration (FAA) Advisory Circular (AC) 61-131. April 26, 1999. 1 p. Available through GPO.*

FAA has published FAA-S-8081-22 to establish standards for private pilot practical tests for glider. Practical tests conducted by FAA inspectors, designated pilot examiners and check airmen (examiners) must comply with these standards. These standards also will be helpful to flight instructors and applicants preparing for the tests.

This AC announces the availability of FAA-S-8081-22, *Private Pilot Practical Test Standards for Glider,* and provides information on obtaining both electronic and printed copies. [Adapted from AC.]

Reports

Optimizing Blink Parameters For Highlighting an Air Traffic Control Situation Display. Milburn, Nelda J.; Mertens, Henry W. U.S. Federal Aviation Administration (FAA) Office of Aviation Medicine. Report DOT/FAA/AM-99/8. March 1999. 26 pp. Available through NTIS.**

<u>Keywords:</u>

1. Attention-getting
2. Text Size
3. Target
4. Flashing CRT Display
5. Frequency
6. Air Traffic Control
7. Amplitude
8. Blink

When computers are used to deliver information, presenting the information in a way that is concise and can be interpreted quickly and easily is of primary importance. Research has demonstrated that blinking is beneficial in reducing search time in monitoring tasks. Other factors such as blink rate, amplitude, duration and target size can provide added benefits for attracting attention.

This report examined the effectiveness of blinking or flashing of text as a method of gaining the user's attention. Results showed that amplitudes of 75 percent or greater, with frequencies from 2 hertz to 4 hertz and text size 0.15 inch or greater, were optimum for visual-search tasks. [Adapted from Introduction and Conclusions.]

A Usability Survey of GPS Avionics Equipment: Some Preliminary Findings. Joseph, Kurt M.; Jahns, Dieter W.; Nendick, Michael D.; St. George, Ross. U.S. Federal Aviation Administration (FAA) Office of Aviation Medicine. Report DOT/FAA/AM-99/9. March 1999. 10 pp. Available through NTIS.**

Keywords:
1. GPS
2. Certification
3. Human Factors
4. TSO C129 A1
5. Pilot Experience
6. General Aviation
7. Aviation Safety

The rapid development and introduction of global positioning system (GPS) receivers for use in airborne navigation has outpaced the capacity of international aviation authorities to fully implement regulations and guidance for the safe and efficient use of such devices. Accepted certification technical standards appear to have had little influence on standardizing receiver architecture, interfaces, and operating manuals.

Recent FAA research illustrates that some features of GPS-receiver interfaces may even undermine safety. This report contains research intended to complement existing human factors data by providing baseline measures of pilot perceptions and experiences with GPS receivers. A GPS user survey identified human factors–related issues such as receiver displays and controls, operating procedures, navigation performance and training. The human factors data collected in this survey should help ensure usability through basic standardization guidelines without prohibiting GPS receiver manufacturers from adding new features to their devices. [Adapted from Introduction and Discussion.]

Aircraft Evacuations onto Escape Slides and Platforms II: Effects of Exit Size. McLean, Garner A.; George, Mark H.; Funkhouser, Gordon E.; Chittum, Charles B. U.S. Federal Aviation Administration (FAA) Office of Aviation Medicine. Report DOT/FAA/AM-99/10. April 1999. 11 pp. Available through NTIS.**

Keywords:
1. Aircraft Evacuation
2. Motivation
3. Escape Slide
4. Competitive Behavior

This research was designed to study the effects of differences in exit size (height of the opening) on egress using both inflatable escape slides and doorsill-height platform escape routes. The experiment used 174 adult participants ranging in age from 18 to 40 years. A single-aisle aircraft simulator was equipped with 30-inch-wide rectangular floor-level exits variously configured with exit heights of 48 inches, 60 inches, and 72 inches (1.2 meters, 1.5 meters, and 1.8 meters).

Results showed that the effect of egress route on evacuation rates was significant. Evacuations using the doorsill-height platform allowed much faster egress than the inflatable slide. Egress using the platform was equivalent to going unimpeded, but using the slide required a sitting position and a downward leap onto the slide surface. This research indicates that specific details of the egress route used in any aircraft-evacuation study are important contributors to the final results. Physical and psychological demands must be taken into account when interpreting results. [Adapted from Introduction and Discussion.]

The First Seven Years (1991-1998) of the FAA's Postmortem Forensic Toxicology Proficiency-Testing Program. Chaturvedi, Arvind K. U.S. Federal Aviation Administration (FAA) Office of Aviation Medicine. Report DOT/FAA/AM-99/11. April 1999. 15 pp. Available through NTIS.**

Keywords:
1. Quality Assurance/Quality Control
2. Proficiency Testing
3. Postmortem Forensic Toxicology
4. Aircraft Accident Investigation

When fatal aircraft accidents are being investigated, postmortem tissue samples collected from the victims at autopsy are submitted to the FAA Civil Aeromedical Institute (CAMI) for forensic toxicological evaluation. The goal is to acquire accurate analytical data to identify the chemical basis for the cause of an accident or death. Strict adherence to quality assurance/quality control (QA/QC) procedures is essential to the achievement of that objective, and proficiency-testing (PT) programs authenticate such QA/QC procedures.

A suitable PT program that could handle the complexity of forensic toxicology was lacking. Therefore, in 1991, CAMI initiated such a PT program. This report summarizes details of FAA's CAMI postmortem forensic toxicology PT program along with findings of seven years of PT surveys.

In the field of postmortem toxicology, the CAMI PT program is a timely, suitable program accepted and recommended by the American Board of Forensic Toxicology. Laboratories may participate for accreditation. The CAMI PT plays a critical role in supporting the QA/QC component of forensic toxicology. [Adapted from Introduction and Discussion.]

Book

The International Directory of Civil Aircraft 1999/2000. Frawley, Gerard. Fyshwick, Australia: Aerospace Publications, 1999. 233 pp.

This new, expanded and revised third edition provides a comprehensive, worldwide catalog of civil aircraft, both in service and under serious development. The number of entries has increased to 388, with almost 20 new types appearing for the first time. For each aircraft, the directory provides details on powerplant(s), performance, weights, dimensions, capacities, production figures and history including development. Entries from previous editions have been updated to reflect recent changes. Many new photographs also have been added. Aircraft are listed in alphabetical order by manufacturer and are usually sorted by model number or chronological order of appearance. Contains a civil aircraft index. [Adapted from Introduction.]♦

Sources

* Superintendent of Documents
U.S. Government Printing Office (GPO)
Washington, DC 20402 U.S.

** National Technical Information Service (NTIS)
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Updated U.S. Federal Aviation Administration (FAA) Regulations and Reference Materials

Advisory Circulars (ACs)

AC No.	Date	Title
147-2EE	March 12, 1999	*Directory of FAA Certificated Aviation Maintenance Technician Schools.*(Cancels AC 147-2DD, *Directory of FAA Certificated Aviation Maintenance Technician Schools,* dated March 26, 1997).
23.1311-1A	March 12, 1999	*Installation of Electronic Displays in Part 23 Airplanes.* (Cancels AC 23.1311-1, *Installation of Electronic Displays in Part 23 Airplanes,* dated June 11, 1993).
23.1309-1C	March 12, 1999	*Equipment, Systems, and Installations in Part 23 Airplanes.* (Cancels AC 23.1309-1B, *Equipment, Systems, and Installations in Part 23 Airplanes,* dated July 28, 1995).

International Reference Updates

Airclaims

Supplement No.	Date	
113	March 24, 1999	Updates "Major Loss Record."

Aeronautical Information Publication (A.I.P.) Canada

Amendment No.	Date	
2/99	April 22, 1999	Updates the General, Meteorology, Rules of the Air and Air Traffic Services, Search and Rescue, Aeronautical Charts and Publications, Licensing, Registration and Airworthiness, and Airmanship sections of the A.I.P.

Accident/Incident Briefs

Over-rotation Causes Boeing 747 Tail Strike

The following information provides an awareness of problems through which such occurrences may be prevented in the future. Some accident/incident briefs are based on preliminary information from government agencies, aviation organizations, press information and other sources. The information may not be entirely accurate.

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FSF Editorial Staff

Air Carrier

Anomalous Airspeed Indication Causes Over-rotation, Tail Strike

Boeing 747-400. Substantial damage. No injuries.

Flight conditions included rain showers and gusty winds when the flight crew conducted a takeoff from an airport in England with 314 passengers and 22 crewmembers aboard the airplane. The report said that the first officer (the pilot flying) was relatively inexperienced in conducting takeoffs during line operations. The first officer began rotating the airplane at 168 knots, the precomputed rotation speed. The captain saw that the airspeed was increasing to 197 knots (20 knots higher than the precomputed takeoff safety speed, V_2) as the first officer continued the rotation. The report said, "To assist the first officer in achieving the correct speed for the initial climb, the [captain] made an additional rearward control-column input."

The captain's action increased the airplane's pitch attitude, and the tail struck the runway as the airplane lifted off. "The stick shaker [stall warning] activated momentarily, and a forward control-column input was made to reduce the pitch attitude," said the report. The flight crew conducted the emergency checklist, jettisoned some fuel, returned to the airport and landed the airplane without further incident.

The report said that the Boeing 747-400 Flight Crew Training Manual recommends that the airplane be rotated smoothly at an average pitch rate of two degrees per second to three degrees per second to a pitch attitude of 10 degrees. "The actual pitch rate achieved in this case was 3.6 [degrees per second] initially, which then increased to about 5.5 [degrees per second] during the additional rearward movement of the control column," the report said. "The tail strike occurred at a pitch attitude of 12.5 degrees nose up."

The report said that indicated airspeeds had fluctuated during rotation. The airspeed fluctuations included a 16-knot increase in one second to V_2 and then an 11-knot decrease. "Based on the motion of the aircraft following liftoff, there appeared to be some atmospheric disturbance (wind shear or gusts) which could have lead to the fluctuation in airspeed indication," said the report.

Check-valve Failure Prompts Emergency Evacuation

Airbus A300-B4. Minor damage. Two serious injuries; 32 minor injuries.

The airplane was pushed back from the gate at a U.S. airport, and the flight crew started the engines and changed the pneumatic system from auxiliary power to engine power. The crew then saw smoke in the cockpit; smoke also was reported in the cabin. The flight crew donned smoke masks, and the captain told the cabin crew to conduct an emergency evacuation of the airplane. Among the 163 occupants, two passengers were seriously injured, and 32 passengers sustained minor injuries during the evacuation.

The report said that the smoke was caused by a hydraulic check-valve failure, which allowed hydraulic fluid to enter the engine pneumatic duct. "Investigation also noted that the 3R door [did not fully open and the] evacuation slide did not deploy," said the report. "[Nevertheless,] when manually pushed during the investigation, the door went fully open, and the slide deployed and inflated." The report said that "improper evacuation of the passengers" was the probable cause of the accident.

Crew Loses Control when Visibility Decreases to Zero

Boeing 737-200. Substantial damage. No injuries.

The flight crew conducted a nonprecision instrument approach to Runway 5 at an airport in Cuba. Weather conditions at the airport included thunderstorms, one-quarter mile (0.4 kilometer) visibility, heavy rain and surface winds from 240 degrees at 25 knots, gusting to 30 knots.

The airplane was eight nautical miles (15 kilometers) from the airport when the flight crew reported the runway in sight. Air traffic control cleared the crew to land. During the landing roll, the airplane traveled off the runway surface and was substantially damaged. None of the six crewmembers and 63 passengers was injured.

In a statement to investigators, the captain said, "After landing … with 15,000 pounds [6,804 kilograms] of fuel, we found bad weather conditions which caused a total loss of visibility, resulting in a loss of directional control, which at the same time caused the aircraft to exit the right side of the runway."

Air Taxi
Commuter

Lightning Strike Causes False Flight-control Warning

Fokker 100. Minor damage. No injuries.

After conducting a takeoff from an airport in the Netherlands, the flight crew encountered instrument meteorological conditions. The airplane was being flown at 6,000 feet with the autopilot disengaged when small hailstones were encountered. The report said that the onboard weather-radar system showed no significant precipitation within five nautical miles (nine kilometers). Nevertheless, the airplane was struck by lightning. "The cabin crew observed what they described as fireballs in the cabin, originating at the front [of the cabin] and appearing to exit in the region of the overwing emergency doors," said the report.

Cockpit master caution lights indicated decreased elevator-control-system hydraulic pressure. The flight crew conducted the emergency checklists, reverted to manual (unboosted) elevator control, returned to the departure airport and landed the airplane without further incident.

The report said that the lightning strike had damaged both elevator-boost-system bypass switches and apparently had caused the flight warning computer to falsely indicate a loss of elevator-control-system hydraulic pressure. The bypass switches, however, had remained open, and hydraulic pressure was being supplied to the elevator control system. When the crew reverted to manual elevator control, the bypass switches were closed, and hydraulic pressure was removed from the elevator control system. "Thus, correct crew response to a false warning resulted in a serviceable boost system being switched off," said the report.

Neglected Parking Brake Causes Four Burst Tires

British Aerospace ATP. Substantial damage. No injuries.

While conducting checklist procedures during an approach to an airport in Ireland, the flight crew checked the wheel brakes and saw the "brake-low-pressure" warning light illuminate. The crew activated a hydraulic pump to restore accumulator pressure. When the "brake-low-pressure" warning light extinguished, the crew checked the wheel brakes and the parking brake. The checks revealed no anomalies, but the crew neglected to disengage the parking brake.

The airplane was landed with the parking brake engaged, and all four main-landing-gear tires burst. The crew stopped the airplane on the runway and, after determining that there was no fire and that an emergency evacuation was not warranted, told the flight attendants to use the airplane's stairs to disembark the passengers.

"Black-hole" Effect Cited in Airplane's Descent into Sea

Cessna 402. Destroyed. Two fatalities; three minor injuries.

The airplane was being flown on a dark night to an airport on a Caribbean island. The report said, "The absence of visual cues caused by the combination of dark sky and darkness over the water produced a 'black-hole' effect in which the pilot lost a visual sense of the airplane's height above [the] water." The pilot was adjusting navigation equipment when the airplane struck the water approximately three nautical miles (six kilometers) from shore. Two passengers were killed; two other passengers and the pilot sustained minor injuries.

The report said, "Because the flight was conducted under [visual flight rules], the pilot had no assistance from air traffic control (ATC) regarding proximity to the [water] surface, despite the approach path being within an area of ATC radar coverage. Had the pilot operated under instrument flight rules, radar would have enabled [ATC] to monitor the flight's altitude, as well as its position."

Corporate Executive

Tailwind, Low Visibility Cited in Runway Over-run

Beech King Air 300. Substantial damage. No injuries.

Weather conditions at the U.S. airport included an obscured ceiling at 200 feet, visibility of one-eighth statute mile (0.2 kilometer) in fog and surface winds from 160 degrees at 10 knots. The pilots of two airplanes that preceded the King Air on the instrument landing system (ILS) approach to Runway 35 had missed the approach and diverted to alternate airports. The King Air pilot missed the first ILS approach and received clearance from the air traffic controller to conduct another ILS approach.

The pilot said that he saw the runway at decision height, continued the approach and landed the airplane. The controller said that the airplane was still at approximately 200 feet when it crossed the midpoint of the 6,500-foot (1,983-meter) runway. The report said, "The pilot used brakes and reverse thrust upon seeing … the end of the runway, but the airplane continued beyond the end of the runway."

The airplane was substantially damaged when its landing gear collapsed; the pilot and his 10 passengers were not injured. The report said that the pilot's misjudgment of speed and distance was the probable cause of the accident, and that "pressure to land at the airport" was a contributing factor. "There was interest by the pilot and his employer to land [at the airport to attend a local college] basketball game," said the report.

Severe Weather Cited in Loss-of-control Accident

Aero Commander Jet Commander. Destroyed. Four fatalities.

The airplane was at Flight Level (FL) 370, en route to an airport in Mexico, when the flight crew requested clearance to climb to FL 410 because of thunderstorm activity. The report said that the flight crew then lost control of the airplane during cruise flight. The airplane was approximately 237 nautical miles (439 kilometers) from the destination when its radar target disappeared from air traffic control radar screens.

The report said, "The wreckage of the airplane was located by local residents in a remote semiarid, hilly area. The residents reported hearing the sound of impact in the early hours of the evening but were unable to initiate a search due to the severity of the weather in the vicinity of the accident site."

Sunlight Falsely Accused Of Engine Fire Warning

Beech King Air. No damage. No injuries.

The flight crew conducted a takeoff from an airport in Australia and was flying the airplane at 700 feet above ground level toward the rising sun. The master-warning light and the left-engine fire-warning light illuminated. The crew looked at the left engine and saw no evidence of fire. Nevertheless, they shut down the left engine and feathered the propeller. The crew then flew the airplane back to the airport and landed without further incident. The report said that maintenance technicians found no evidence of fire in the left engine and concluded that the fire warning had been caused by sunlight. "It is a known fact, though rare in occurrence, that the King Air fire detectors can be activated by sunlight," said the report.

During a flight on the day after this incident, the crew again saw the master-warning light and the left-engine fire-warning light illuminate. The crew looked at the engine and saw no evidence of fire. The report said, “The captain decided that this was a false indication and decided not to shut the engine down, but to monitor it.” The crew flew the airplane back to the airport and landed without further incident. This time, maintenance technicians determined that the left-engine forward fire detector was faulty; the detector could be activated by movement of the wiring leading to the detector.

The report said, “Despite the captain’s well-founded thoughts on [illumination of the left-engine fire-warning light] being a spurious warning, the engine still should have been shut down. All fire lights should be treated as real.”

Other General Aviation

Go-around from Wet Runway Terminates in Grove of Trees

Cessna Citation I. Substantial damage. No injuries.

Visual meteorological conditions prevailed, but rain was falling when the airplane was landed at a Caribbean airport. The pilot said that the airplane touched down on the runway at the precomputed landing-reference airspeed and with the flaps extended fully. The pilot then deployed the speedbrakes and applied the wheel brakes. He said that the antiskid braking system appeared to be functioning, but the airplane did not decelerate.

The report said, “With unsuitable obstructions ahead, [the pilot] elected to go around. [He] applied full thrust to both engines but doesn’t recall if he partially retracted the flaps. The airplane failed to clear a grove of trees past the departure end of the runway and came to rest upright.” The airplane was substantially damaged; the pilot and his seven passengers were not injured.

Pilot Loses Control After Landing in a Sideslip

de Havilland Chipmunk. Substantial damage. One serious injury.

The pilot realized during final approach that the airplane was too high to land on the wet-grass airstrip. He then flew the airplane in a sideslip to increase the descent rate. The report said, “The pilot … held that attitude until [the airplane was] a few feet above the runway and at the point of flare. The pilot stated that the airplane continued to descend in the flare and touched down while still in the slip attitude.”

The airplane contacted the airstrip and bounced back into the air. The pilot increased power but was not able to maintain directional control of the airplane. The airplane traveled off the side of the runway. The pilot reduced power and applied the wheel brakes, but was unable to stop the airplane before it struck a hangar.

Airplane Stalls During Steep Turn at Low Airspeed

Cessna T303. Substantial damage. One serious injury.

The pilot was flying the airplane at 1,000 feet over a friend’s house in England. The report said, “While orbiting the house, the pilot felt a moderate ‘bumping’ sensation that he attributed to thermal activity rather than prestall buffet.” The airplane then rolled inverted and began to descend rapidly. The pilot said that he rolled the airplane to an upright attitude and attempted to increase power to arrest the descent, but the engines did not develop full power.

The pilot decided to land the airplane in a field with the landing gear retracted. The airplane struck a telegraph pole on approach and landed hard in the field. The report said, “The pilot was unable to evacuate the aircraft because of his injuries but was rescued by local people who were quickly on the scene.”

The pilot told investigators that before the airplane rolled inverted, he was flying at approximately 100 knots and with 60 degrees of bank. The report said, “The basic stalling speed of the aircraft in the configuration at the time was about 70 knots. Application of the correction for load factor in the turn would have given a stalling speed of 100 knots.”

Overweight Airplane Stalls During Soft-field Takeoff

Bellanca 7GCBC. Destroyed. Two fatalities.

Witnesses said the airplane lifted off the runway in a nose-high attitude at low airspeed and then stalled and struck the ground. The report said, “The pilot had been admonished for regularly making soft-field takeoffs — that is, holding full-aft control stick, lifting off in a nose-high attitude and then climbing at a steep angle-of-attack. [The pilot’s] son, a student pilot, who was in the front seat, had previously expressed his apprehension in using this takeoff technique, especially in high-density-altitude conditions. At the time of the accident, the airplane was … 219 pounds [99 kilograms] over the maximum certificated gross weight, [and] density altitude was … 10,920 feet.”

Rotorcraft

High Density Altitude Thwarts Takeoff from Mountain Lake

Bell UH-1H. Substantial damage. One minor injury.

The helicopter was being used to transport six firefighters to a forest fire in a mountainous region of the United States. The pilot said that he had determined before the flight that the load would be within the helicopter's weight-and-balance limits for the "hottest time of the day."

The pilot flew the helicopter to a small lake near the fire area. Although the approach to the lake was obstructed by trees that were 50 feet (15 meters) tall, the pilot determined that the lake was large enough to enable him to conduct an approach and landing on the beach. The pilot landed the helicopter on the beach without incident, but then was told that the firefighters were not needed there. When the pilot attempted to take off from the beach, he found that the helicopter's climb performance was insufficient to clear trees in the flight path. He reversed course, and the helicopter descended into the lake, rolled over and sank.

The report said that the density altitude was approximately 9,500 feet and that the gross weight of the helicopter was 800 pounds (363 kilograms) over the maximum allowable weight for hover out of ground effect.

Contaminated Fuel Causes In-flight Engine Failure

Schweizer 269C. Substantial damage. No injuries.

The helicopter was being used to conduct an airborne seismic survey in the United States. The pilot said that he was flying the helicopter at approximately 150 feet above ground level when the engine suddenly lost power. The pilot turned the helicopter into the wind and conducted an autorotative landing.

The report said, "During the flare for [the] landing, the rotor [speed] decayed, and the helicopter touched down hard." The helicopter was substantially damaged, but the two occupants were not injured.

The report said that a "substantial" amount of water was found in a fuel sample taken from the engine fuel-filter sump. "[U.S. Federal Aviation Administration] inspectors, accompanied by the operator of the helicopter, inspected the fuel-storage tank that was being used to refuel the helicopter," the report said. "Examination of the fuel filter in the trailer-mounted tank revealed the presence of water and rust."

The report said that fuel contamination and the pilot's inadequate preflight inspection of the helicopter were the probable causes of the accident.

False Fuel-quantity Indication Prompts Emergency Landing

Aerospatiale SA-315. Substantial damage. No injuries.

The helicopter was on an aerial-application flight when the low-fuel warning light illuminated. The report said that the aircraft flight manual recommends that the helicopter be flown no longer than 10 minutes after the low-fuel warning light illuminates. The pilot began timing with his stopwatch after the warning light illuminated and flew the helicopter toward a refueling facility. The engine failed six minutes later because of fuel exhaustion. The helicopter was substantially damaged during the emergency landing, but the pilot was not injured.

Postaccident tests showed that the fuel-quantity indicator registered full with the fuel tanks empty because the fuel-quantity transmitter was immobile. The report said that the fuel-quantity transmitter would dislodge when the side of the fuel tank was struck. "The pilot stated that he had brought the stuck-fuel-transmitter problem to the attention of the operator, but review of the maintenance records revealed no record of the transmitter being repaired or replaced," said the report.

Engine Seizes after Dumping Oil Through Loose Line

Bell 206B. No damage. No injuries.

After routine maintenance was performed, the helicopter was being repositioned from the company helipad to a forestry base on the other side of the Canadian airport. The engine-chip warning light illuminated, and the engine failed. The pilot made a safe emergency landing near a runway threshold. The report said that an engine-oil-line fitting was loose and that all of the engine oil had leaked through the loose fitting. The engine seized as a result of the absence of lubrication.♦

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