FLIGHT SAFETY FOUNDATION

APRIL–MAY 2001

FLIGHT SAFETY DIGEST

SPECIAL DOUBLE ISSUE

Human Error Cited as Major Cause of U.S. Commercial EMS Helicopter Accidents

Data Show That More Than Half of EMS Airplane Accidents Occur During Approach and Landing

FLIGHT SAFETY FOUNDATION
SINCE 1947

Flight Safety Digest

Vol. 20 No. 4–5 April–May 2001

In This Issue

Flight Safety Foundation is an international membership organization dedicated to the continuous improvement of aviation safety. Nonprofit and independent, the Foundation was launched officially 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 830 member organizations in more than 150 countries.

Human Error Cited as Major Cause of U.S. Commercial EMS Helicopter Accidents

A study of 87 accidents from 1987 through 2000 found that human error was the primary causal factor in 76 percent. The greatest concentration of human error occurred during the en route phase of flight and often involved faulty in-flight planning and decision making or inadequate evaluation of weather information.

Patrick R. Veillette, Ph.D.

From January 1987 through December 2000, there were 87 accidents and 56 incidents involving commercial emergency medical services (EMS) helicopters in the United States (Figure 1, page 2). The accidents included 32 fatal accidents (37 percent of the total) and 17 serious-injury accidents (20 percent). Human error was associated with 66 accidents (76 percent) and 27 fatal accidents (84 percent); in some phases of flight, the percentage of accidents associated with human error was more than 90 percent. Of the 275 people aboard the helicopters, 96 people were killed, 33 people were seriously injured and 31 people received minor injuries. Thirty-six of the 87 aircraft were destroyed, and 51 were damaged substantially.[1,2]

EMS helicopters are flown day and night, in all types of weather, usually by a single pilot. EMS operations often involve flights scheduled with little advance notice to and from unimproved, confined landing areas surrounded by obstacles. The typical EMS flight involves a demanding pilot workload, substantial communication requirements, time pressure, distractions and stressful flight and duty conditions.

To identify the trends involved in the accidents, the author conducted an extensive 2001 study of EMS accidents, including an analysis of U.S. National Transportation Safety Board (NTSB) reports on the 87 accidents and U.S. Federal Aviation Administration (FAA) reports on the 56 incidents (see Appendix, page 27). Additional accidents or incidents might be included in other databases maintained by the helicopter industry; this 2001 study involves only official government accident reports and incident reports, along with the following:

- An analysis of reports submitted to the U.S. National Aeronautics and Space Administration (NASA) Aviation Safety Reporting System (ASRS) involving 218 EMS helicopter operations between January 1988 and December 1999;[3]

- Observations of more than 400 hundred EMS helicopter flights from 1995 to 2000;

- Interviews with accident investigators, accident witnesses, EMS pilots and EMS flight physicians, flight nurses and flight paramedics;

- Examinations of helicopter operating specifications and operating manuals;

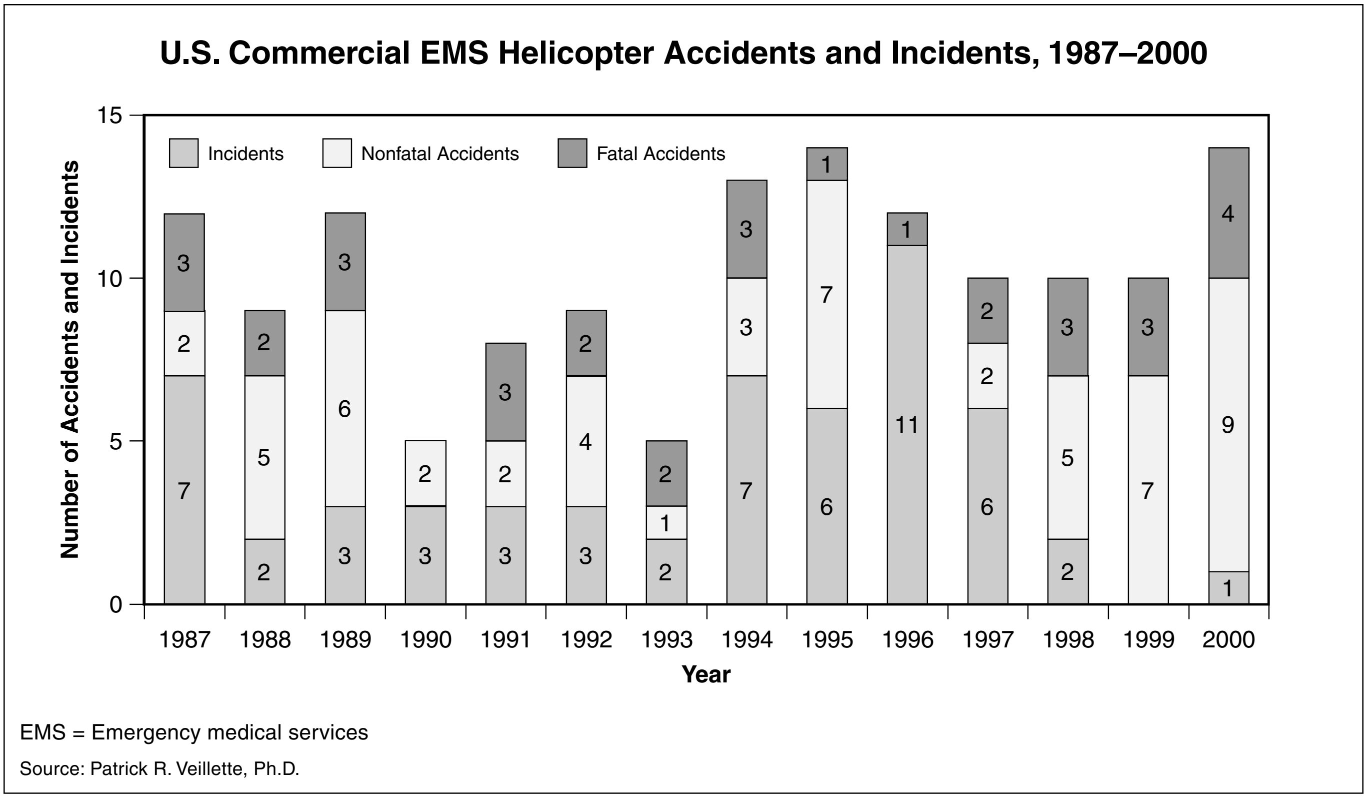

Figure 1

- Inspections of accident sites; and,
- Inspections of hospital heliports.

The 2001 study found that:

- Forty-one of the 87 accidents (47 percent), including 26 of the 32 fatal accidents (81 percent), and 25 of the 56 incidents (45 percent) occurred during the en route phase of flight (Figure 2, page 3). Of the en route accidents, 68 percent resulted from human error (Figure 3, page 3);
- Twenty-two accidents (25 percent), including three fatal accidents (9 percent), and 21 incidents (38 percent) occurred during approach and landing. Of the approach-and-landing accidents (ALAs), 91 percent resulted from human error, and 41 percent involved collisions with obstacles;
- Twenty-two accidents (25 percent), including three fatal accidents (9 percent), and six incidents (11 percent) occurred during takeoff. Of the takeoff accidents, 82 percent resulted from human error, and 50 percent involved collisions with obstacles;
- Twenty-six percent of the accidents — and 53 percent of the fatal accidents — occurred during low visibility or instrument meteorological conditions (IMC);
- Thirty-one percent of the accidents involved collisions with obstacles; and,
- Twenty-four percent of the accidents resulted from mechanical failure.

Of the 56 incidents, 38 incidents resulted in minor damage to the helicopter; 18 helicopters were undamaged. No injuries were reported among the 165 occupants of the incident helicopters.

The 2001 study used some of the parameters of a 1988 NTSB study of commercial EMS helicopter accidents and the parameters of several subsequent studies, which grouped EMS accidents into four categories: weather/low visibility or spatial disorientation accidents, mechanical malfunction accidents, obstacle-strike accidents and "other" accidents.[4] Figure 4 (page 4) shows the classification of the 87 accidents (and the 32 fatal accidents) into the four categories. A majority of the 32 fatal EMS accidents (22 accidents, or 69 percent) were weather/low visibility or spatial disorientation accidents.

In 23 accidents, including 12 fatal accidents, a patient was on board. Forty-nine accidents, including 18 fatal accidents, occurred during on-site responses; the 18 fatal accidents accounted for 56 percent of all fatal accidents studied (Table 1, page 4).

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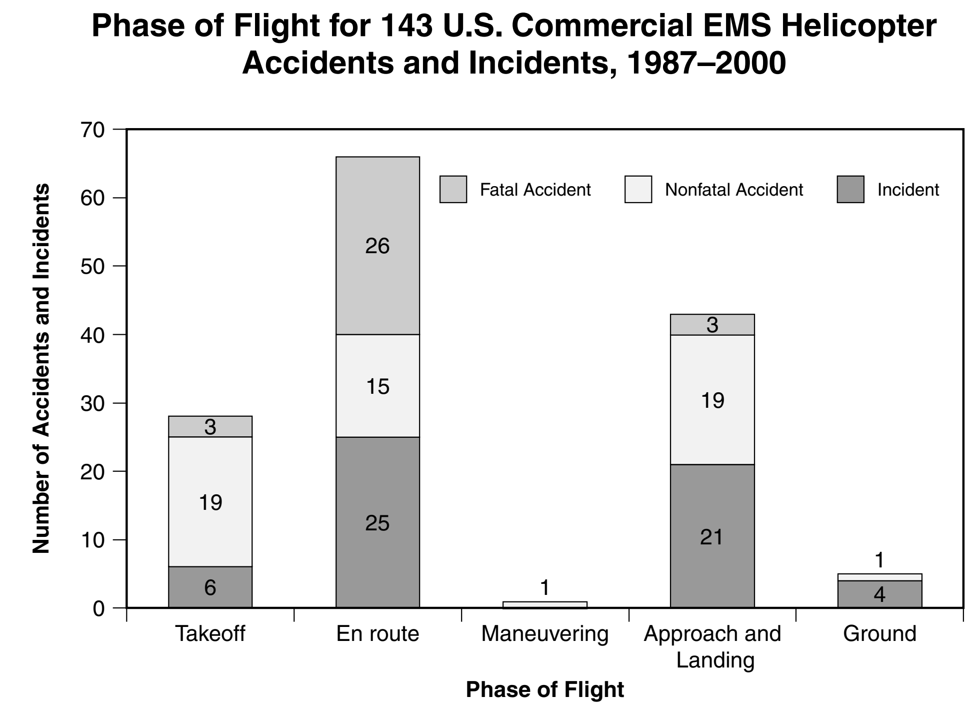
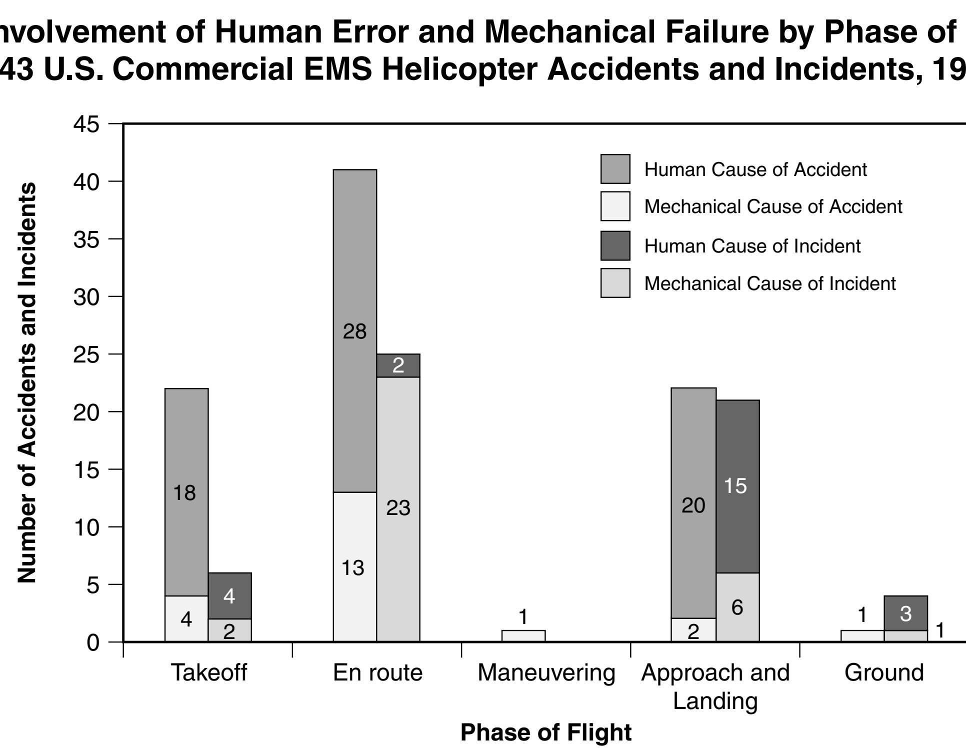


EMS = Emergency medical services

Source: Patrick R. Veillette, Ph.D.

Figure 2



EMS = Emergency medical services

Source: Patrick R. Veillette, Ph.D.

Figure 3

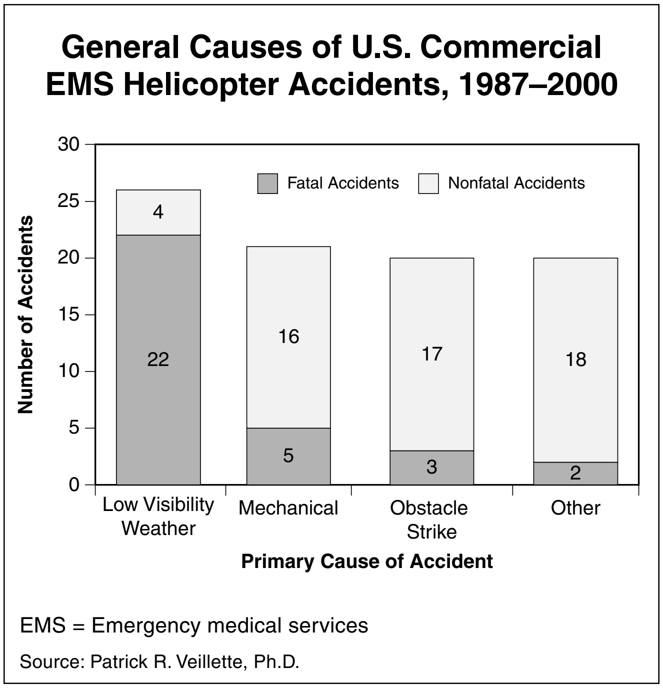


Figure 4

Table 1
Types of Flights Involving U.S. Commercial EMS Helicopter Accidents, 1987–2000

Type of Flight	All Accidents	Fatal Accidents
On-site	49	18
Positioning	22	7
Inter-hospital transfer	7	4
Maintenance	5	1
Public relations	3	2
Training	1	0
Total	**87**	**32**

EMS = Emergency medical services

Source: Patrick R. Veillette, Ph.D.

When surveyed in 1997 about the risks to flight safety in EMS operations, 59 percent of EMS pilots said that on-site operations constituted the greatest safety risk.[5] On-site responses historically account for about 30 percent of EMS helicopter flights, and inter-facility transports account for about 70 percent.[6]

Forty-seven Percent of Accidents Occurred En Route

Typically, 40 percent to 50 percent of all helicopter accidents occur during the en route phase of flight.[7] In the 2001 study, 47 percent of accidents occurred during en route flight. Sixty-three percent of the accidents in en route flight resulted in fatalities. Sixty-nine percent of those fatal accidents occurred in darkness, and 54 percent occurred in IMC.

Twenty-eight en route accidents were caused by human error, and 13 en route accidents were caused by mechanical malfunctions. Eighteen en route accidents involved IMC or low-visibility-related phenomena, such as spatial disorientation. Of the 18 accidents, 14 were fatal. Five en route accidents, including four fatal accidents, involved wire strikes; four of the wire strikes occurred in darkness and in IMC.

Two of the 25 en route incidents involved human error; the remainder involved mechanical malfunctions. Of the 23 en route mechanical incidents, 22 occurred in visual meteorological conditions (VMC), and 14 occurred in daylight; there were no injuries among occupants of those helicopters.

Typically, 14 percent to 20 percent of helicopter accidents occur during takeoff.[8] In the 2001 study, 22 accidents (25 percent) occurred during the takeoff phase. Eighteen takeoff accidents and four takeoff incidents resulted from human error. Eleven takeoff accidents, including one fatal accident, and four takeoff incidents involved collisions with obstacles. Seven accident aircraft and three incident aircraft struck wires; the remainder struck buildings, fences, lighting structures and trees. All but one obstacle strike occurred in VMC; eight obstacle strikes occurred in daylight, and six occurred in darkness.

ALAs typically account for 20 percent to 30 percent of accidents in helicopter operations.[9] In the 2001 study, 25 percent of accidents occurred during approach and landing. Twenty ALAs and 15 incidents resulted from human error. Seven ALAs — none of them fatal — involved hard landings and/or settling with power.[10] All of these accidents involved approaches into confined areas with high obstacles and a lack of suitable reference lights in unimproved landing zones. Ten ALAs and 18 incidents involved striking obstacles. Wire strikes occurred in three ALAs and eight incidents; in six ALAs and eight incidents, helicopters truck trees, lighting structures or fences; in one ALA, a helicopter struck terrain. VMC prevailed in nine obstacle-strike ALAs and 14 incidents. Four obstacle-strike ALAs and nine incidents occurred in daylight, and six obstacle-strikes ALAs and six incidents occurred in darkness.

One nonfatal accident occurred during maneuvering as a result of engine failure.

One nonfatal accident and four incidents occurred during ground operations. Two of the incidents involved collisions between the main-rotor system and ground vehicles in daylight VMC.

Faulty In-flight Decision Making Was Frequent Accident Cause

Human error was the primary causal factor in 66 of the 87 accidents (76 percent) in the 2001 study, including 27 fatal accidents (84 percent). Causal factors common throughout the accident database include in-flight decision making (17 accidents), preflight planning (15 accidents), risk-taking tendencies (14 accidents), inadequate crew coordination (eight accidents), failure to follow standard operating procedures (seven accidents), delayed remedial actions (seven accidents), and misinterpretation of environmental cues (seven accidents).

The following principle concentrations of human error were involved:

- The largest concentration of human error occurred during the en route phase of flight. Of the 41 en route accidents, 28 accidents (68 percent), including 21 fatal accidents, were a result of human error. Faulty in-flight planning and decision making were cited in 24 en route accidents, faulty in-flight weather evaluation was cited in 11 en route accidents, and spatial disorientation was cited in eight en route accidents (six of which occurred in darkness and six of which occurred because of a lack of visual cues). Four accidents resulted from a loss of control in IMC;

- The second-largest concentration of human error occurred during approach and landing. Of the 22 ALAs, 20 accidents (91 percent), including three fatal accidents, resulted from human error. Darkness, confined-space operations and obstacles were common in many ALAs. (Darkness prevailed in 45 percent of ALAs in this review, and confined areas and obstacles each were present in 85 percent. Other environmental factors also were common: Adverse winds were present in 22 percent of ALAs, and mountainous terrain was present in 33 percent.) Of the 21 approach-and-landing incidents, 15 resulted from human error; the environmental factors present were similar to those involved in ALAs. The environmental conditions present in the landing environment typically are conducive to sensory errors and perceptual errors and account for 93 percent of ALAs.

  Ten ALAs and 18 approach-and-landing incidents involved collisions with obstacles. Most of these involved the inability of the pilot to see wires, fences and lighting structures before the helicopter struck them. Three accidents and eight incidents involved wire strikes in the landing environment; six accidents and eight incidents involved fences, trees and lighting structures. About one-third of the obstacle strikes involved tail rotors that struck obstacles not in the pilots' view. Darkness prevailed in 60 percent of the obstacle-strike ALAs and 33 percent of incidents; other factors included the conspicuity of the wires, the lack of visual warning aids and the lack of contrast between the obstacles and the surrounding terrain.

  In eight accidents, the pilot was faulted for inadequate evaluation of the landing site. Many EMS operators attempt to solicit information about the landing zone from emergency response technicians at the site. In five accidents, the emergency response technicians gave the pilots incorrect information about obstacles near the landing zone.

  Inadequate crew coordination was cited in eight accidents, all of which occurred during landing or takeoff and resulted in collisions with obstacles. Other factors cited in these accidents included incorrect information, untimely information or distracting comments or movements by medical crewmembers during a critical phase of flight.

  Lack of visual cues (as a result of terrain, darkness, poor visibility or the absence of appropriate lighting) caused pilots in eight ALAs to misinterpret environmental cues. Five ALAs that resulted from human error involved hard landings, partly because of misinterpretation of environmental cues and subsequent delays in corrective actions; and,

- The third largest concentration of human error among accidents in the 2001 study occurred during takeoff. Of the 22 takeoff accidents, 18 accidents (82 percent), including three fatal accidents, resulted from human error. Combinations of adverse conditions such as inadequate visual cues, darkness, confined areas, poor visibility and obstacles were common throughout reports on takeoff accidents. Eleven accidents and four incidents involved obstacle strikes; six obstacle strikes involved the tail rotor in an area where the pilot was unable to see obstacles because of the viewing angle. Ten obstacle-strike accidents and four incidents occurred in VMC, and six obstacle-strike accidents (and no incidents) occurred in darkness. Unseen wires were involved in seven accidents and three incidents.

Because many of the 87 EMS helicopter accidents were fatal and sufficient information about the accidents was not available (because the pilots were killed and the accident helicopters did not carry cockpit voice recorders or flight data recorders), the 2001 study examined the ASRS database for additional information about human factors in EMS operations.

Earlier studies of EMS operations showed that many factors can influence pilot judgment, such as the urgency of the mission, program competition and management pressure (real or perceived).[11] A 1995 NASA study that analyzed EMS reports submitted to ASRS between 1986 and 1991 said that EMS operations required pilots to cope with substantial communication requirements, time pressure, distractions, demanding workloads and stressful flight conditions and duty conditions.[12]

The 1995 NASA study said, "These demands can erode positive efforts towards good communication, thorough planning, cooperative teamwork and safe flight during patient transport. … Efforts need to be directed toward improving communication and transfer of information, decreasing distractions and decreasing time pressure to realistic levels and assisting in workload management, thereby increasing safety."[13]

James Reason's study of human error found that time shortages would increase by a factor of 11 the probability of human error; the probability of human error also would be increased by a factor of eight in circumstances involving poor human-system interface or the irreversibility of errors, by a factor of six in circumstances involving information overload and by a factor of four in circumstances involving misperception of the risk.[14] These critical error-causing factors are predominant in EMS operations, and their role in EMS helicopter accidents and incidents is apparent throughout the analysis of the events.

In the 1997 survey of EMS pilots, 43 percent said that program complacency was a significant risk to safety, 25 percent said that flight-related stress was a significant risk, and 21 percent said that pilot fatigue was a significant risk.[15]

Of the 218 ASRS reports analyzed for this study, most (62 percent) involved non-adherence to U.S. Federal Aviation Regulations (FARs) (Figure 5). Other reports involved unauthorized flight in controlled airspace (34 percent), near-midair collisions (24 percent), in-flight encounters with IMC (16 percent), violations of air traffic control clearances (16 percent), mechanical equipment malfunctions (15 percent) and violations of duty-time limits (6 percent). Eighty-six percent of the reports were submitted by pilots of single-pilot operations. Eighty percent of the reports involved incidents that occurred in twin-engine helicopters. Nearly 53 percent of the reports involved events that occurred during the en route phase of flight; 24 percent involved events that occurred during approach and landing.

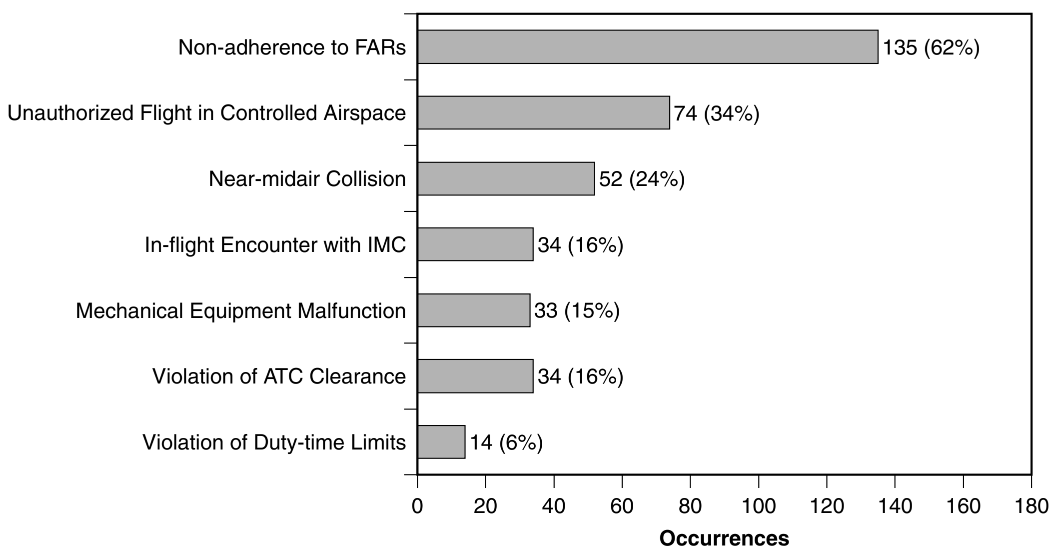
EMS Pilots Describe Workload as Substantial

Pilot workloads are substantial during EMS operations, and task saturation commonly is cited as a contributing factor in NTSB accident reports and ASRS reports (Figure 6, page 7).[16]

In one ASRS report, an EMS pilot described the flight as follows:

> I was flying an EMS helicopter dispatched from XYZ hospital, in City A, to recover a patient at the mall, City B. The coordinates provided were incorrect and took me five nautical miles [nine kilometers] south of the City B airport before I recognized the error and reversed course. I was coordinating with dispatcher, medic command (flight following/status reports) and emergency vehicle

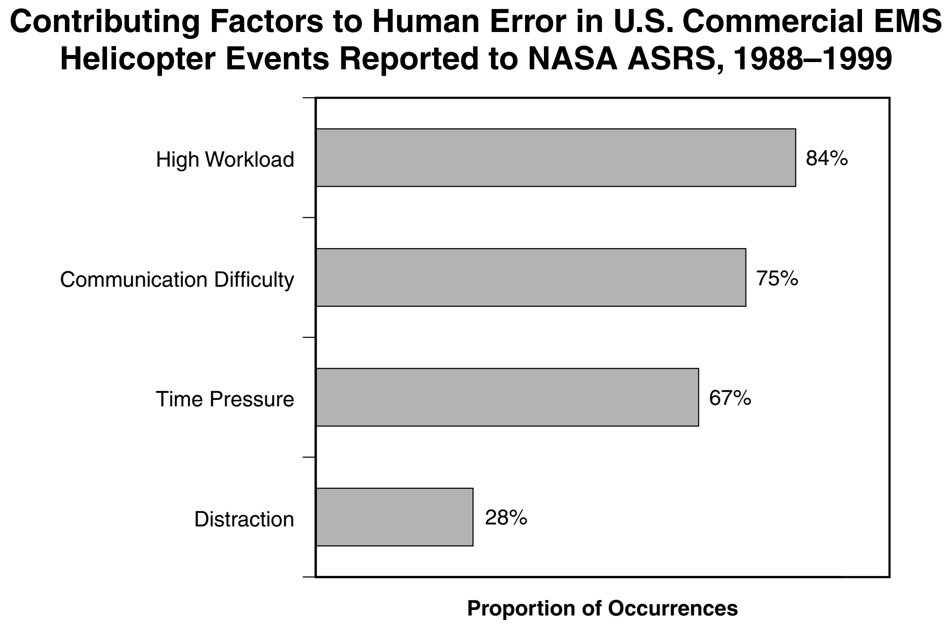
Subjects of 218 NASA ASRS Reports Involving U.S. Commercial EMS Helicopters, 1988–1999



NASA ASRS = U.S. National Aeronautics and Space Administration Aviation Safety Reporting System
EMS = Emergency medical services FARs = U.S. Federal Aviation Regulations
IMC = Instrument meteorological conditions ATC = Air traffic control

Source: Patrick R. Veillette, Ph.D.

Figure 5



Note: Some reports involved more than one contributing factor.
EMS = Emergency medical services
NASA ASRS = U.S. National Aeronautics and Space Administration Aviation Safety Reporting System

Source: Patrick R. Veillette, Ph.D.

Figure 6

> on scene and broadcasting position reports and intentions on Unicom. … [T]he Approach Supervisor advised me that I entered his airspace and did not properly coordinate with his controller. … I was working four frequencies and receiving conflicting coordinates from the ground while searching for the landing zone. I was aware of my close proximity to the airport traffic area. I was preoccupied with the traffic avoidance while coordinating with the ground vehicles during the search for and subsequent approach and landing at the landing zone.[17]

The ASRS reports showed indications of pilot multi-tasking (performing multiple tasks involving such actions as aircraft control, navigation and monitoring multiple radio frequencies) in 183 reports (84 percent). Of these, 97 percent were single-pilot operations. Pilots specifically mentioned overload in 35 reports.

Within the ASRS data, 74 reports indicated unauthorized flight in controlled airspace, all by pilots of single-pilot helicopters. The typical workload for the EMS helicopter pilot, especially when working as a single pilot, increases substantially when navigating near controlled airspace and attempting to obtain clearances for operating within adjacent sectors of controlled airspace. The pilot also must monitor hospital radio frequencies, must communicate with medical crewmembers and often must monitor the radio frequency of emergency medical services on the scene.

The multiple challenges facing EMS pilots are shown in the following narrative from an ASRS report:

> We received a request to fly to Hospital A to transfer a cardiac patient to Hospital B. We departed the home base hospital and headed towards Hospital A, which I had programmed into our Loran using information provided by our dispatchers and a directory. As I got closer to the metropolitan area, I relied more heavily on the Loran to keep me on track. Just as I started to realize that my nav was in error, I crossed over what turned about to be ZZZ [an airport] at 2,500 feet MSL [above mean sea level]. I was approximately five nm [nautical miles (nine kilometers)] from my destination, so I started my descent when I was well clear of the airport. I arrived at the coordinates and found nothing but a football field that had been listed as an alternate landing site for the hospital. I quickly discovered that I was 25 nm [46 kilometers] southeast of my destination. Very quickly, several VFR [visual flight rules] reporting points for the TCA [terminal control area, now called Class B airspace, which typically is the airspace from the surface to 10,000 feet MSL around the nation's busiest airports] came into view. I continued on to my destination and completed the mission without further incident. Several factors contributed to my situation. I am not as familiar with the area as I should be, and I had never been that close to the metropolitan area at night. I blindly trusted the information provided to me, and in my haste to get airborne, I failed to make an accurate

map study of the area. I should not have accepted the mission with as little information as I had when I initially took off. I was very fortunate that the weather was as good as it was and that there is not a lot of traffic that late on this night. Because there were so many flashing lights and Christmas decorations being displayed, I did not recognize the airport's beacon, and I had trouble picking out the hospital's beacon. It also made seeing normal VFR checkpoints difficult to see or even recognize."[18]

Fifty reports involved flights to or from hospitals that were adjacent to controlled airspace or beneath controlled airspace, and 32 reports involved flights to on-site responses that were beneath Class B airspace or adjacent to Class B airspace. In other instances, 29 reports discussed attempts to navigate around Class B airspace at the time of an airspace incursion, 24 reports said that pilots were distracted while monitoring multiple radio frequencies, and 20 reports indicated that pilots had difficulty obtaining clearances to penetrate the airspace. Eighteen reports were filed by pilots who were unfamiliar with airspace boundaries, and 16 reports were filed by pilots who lost positional awareness because of heavy workloads.

Fourteen pilots reported confusion caused by the navigational equipment and the location of data points, which conflicted with other information. Several reports indicated concerns by EMS pilots that some aeronautical charts did not include landmarks that would have helped them maintain positional awareness, especially near controlled airspace. Others cited darkness and a profusion of lights, which led to confusion as they attempted to navigate in controlled airspace.

Nineteen reports said that EMS pilots were unable to contact ATC from the helipad, even though the airspace above the helipad required a clearance. One ASRS report said:

After patient drop-off, which took 30 minutes, I was unable to contact ZZZ approach or tower from the hospital helipad. ([I]t is down in a hole surrounded by buildings.) I departed without clearance into … [controlled airspace surrounding a major airport] and immediately contacted ZZZ approach. I circled around the hospital while he gave me a transponder code and got me in radar contact. When he gave me the code, he told me to stay clear of the … [controlled airspace] until radar contact was established. The problem was that I was already in the … [controlled airspace] on the pad at the hospital.[19]

EMS pilots reported 52 near-midair collisions; 30 near-midair collisions occurred in high-traffic areas. Nineteen reports said that near-midair collisions occurred where an airport traffic pattern adjoined a hospital helipad, 12 near-midair collisions occurred at uncontrolled airports, and five near-midair collisions occurred above hospital helipads. Forty-five events occurred when neither aircraft was in contact with ATC, and 43 events occurred in daylight VFR conditions.

Noise, Heavy Workload Contribute to Communication Problems

Seventy-five ASRS reports directly indicated problems with communication, including 60 reports (80 percent) that involved difficulty in communication between a pilot and ATC. Of the 60 reports, 29 were filed by pilots who inadvertently violated an ATC clearance, including 23 pilots who misunderstood the clearance. Radio-frequency congestion was cited in nine reports.

Radio-monitoring responsibilities add to task saturation in EMS cockpits, especially in single-pilot operations. One ASRS report said:

History of U.S. Helicopter EMS

The U.S. military initiated the use of helicopters to move injured soldiers during the Korean War, when helicopters transported more than 20,000 wounded soldiers to emergency care facilities. During the Vietnam War, that number increased to more than 200,000.[1] The mortality rate was reduced from 2.5 deaths per 100 casualties during the Korean War to one death per 100 casualties during the Vietnam War.[2]

Public safety departments began to use helicopters in the 1960s and 1970s for multiple purposes, including emergency medical transportation. The early public-use systems were called "scoop-and-run" operations and provided only basic life support in the helicopter during transport.[3]

The Aviation Law Enforcement Association said in 1988 that about 25 percent of its members' 470 helicopters were involved in some type of emergency medical services (EMS) activity, but only a small portion conducted EMS operations full time.

Today, most U.S. EMS operators are commercial helicopter contractors, although some hospitals also own and operate EMS helicopters. The need for advanced life support (including administering medication, using cardiac defibrillators and establishing intravenous lines) while en route to the hospital led to the concept of present-day hospital-based EMS helicopter service.

The first U.S. commercial EMS helicopter service to offer advanced life support began in Denver, Colorado, in October 1972. The service was unique because it was affiliated with a hospital, received no special funding, was dedicated to patient transfer and was operated by the hospital in conjunction with a commercial helicopter operator.[4]

In 1980, 42 commercial EMS helicopter programs flew an estimated 20,750 flight hours in the United States.[5] By 1986, the number of commercial EMS helicopter programs had more than tripled, and about 95,000 patients were transported by commercial EMS helicopters.[6] By 1995, about 25 percent of the 5,000 acute care medical centers in the United States had a licensed heliport that satisfied regulatory criteria, and by 1997, 103 organizations — both commercial and public-use agencies — were listed by the Helicopter Association International as providers of EMS helicopter services.[7]

In the early years of commercial EMS helicopter operations, the accident rates were more than three times higher than the accident rates for other helicopter operations. In 1986, the U.S. commercial EMS helicopter accident rate was 17.08 accidents per 100,000 flight hours, and the fatal accident rate was 5.26 accidents per 100,000 flight hours. For all turbine-powered helicopters, the 1986 accident rate was 5.47 accidents per 100,000 flight hours, and the fatal accident rate was 1.55 fatal accidents per 100,000 flight hours.

A 1988 study by the U.S. National Transportation Safety Board (NTSB) found that, between May 11, 1978, and Dec. 3, 1986, there were 45 commercial EMS helicopter accidents during patient-transport flights.[8] During that period, the commercial EMS helicopter accident rate of 12.34 accidents per 100,000 flight hours was nearly twice as high as the accident rate of all U.S. Federal Aviation Regulations Part 135 unscheduled air taxi helicopter operations. The commercial EMS helicopter fatal accident rate was 5.40 fatal accidents per 100,000 flight hours, about 3.5 times higher than the fatal accident rate for Part 135 unscheduled air taxi helicopter operations.

Based on the study, NTSB recommended a review of pilot training requirements, pilot workloads, shift lengths and sleep requirements and other safety issues. The industry subsequently implemented stricter weather minimums, upgraded pilot training and reduced EMS duty-time requirements.

A 1994 Flight Safety Foundation study found that accident rates declined from Jan. 1, 1987, through Dec. 31, 1993, when the commercial EMS helicopter operations accident rate was 3.14 accidents per 100,000 flight hours, compared with 4.28 accidents per 100,000 flight hours for all turbine-powered helicopters.[9]

Accident rates have not been calculated for more recent years because data are not available for the number of hours flown by EMS helicopters. From 1998 through 2000, there were 31 commercial helicopter accidents, including 11 fatal accidents.♦

— Patrick R. Veillette, Ph.D.

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> I was returning to my hospital at 1,300 feet MSL (650 feet AGL [above ground level]). Approach control called with traffic. I never heard the call because I am also required to monitor my company frequency at all times. The second time he called, I heard him. He gave me traffic at 12 o'clock and one mile (1.6 kilometers) at 1,000 feet MSL and told me to climb to 1,500 feet immediately. The reason I didn't hear the first call was that my hospital's second aircraft was out on a flight, and our dispatcher was talking to them. That noise, plus my medical crew talking in the back cabin, made me miss the first call. Now I insist on a sterile cockpit in … [controlled airspace near an airport with an operating control tower]. I also inform dispatch that I will be turning them off while transitioning … [controlled airspace near an airport with an operating control tower] and tell them when I will re-establish contact."[20]

Delayed or missed communication between the pilot and ATC, as a result of interference from medical crew or dispatcher communication, was cited in 25 ASRS reports. Eighteen resulted from monitoring multiple frequencies, and seven resulted from the lack of a sterile cockpit.[21]

Problems with communication between pilots and FAA flight service stations (FSSs) were cited in eight ASRS reports involving obtaining updated weather information or an IFR clearance. Problems with communication between pilots and Unicom frequencies were cited in six reports, all involving near-midair collisions.

Patients' Conditions Add to Pilots' Sense of Urgency

The 2001 study found 146 ASRS reports of time pressure during EMS operations.

The 1988 NTSB study said that the urgency of the EMS flights, the critical medical conditions of the patients and the on-call nature of EMS operations contributed to time pressure and pilot fatigue. The 1995 NASA study said that time pressure involved four factors: the patient's condition, rapid flight preparation, flight to the patient pick-up location and low fuel.[22] That report said that the patient's condition was the most important factor in time pressure (cited by 44 percent of pilots surveyed) during EMS operations.

The following ASRS report describes how a patient's condition influenced the decision-making process:

> We were dispatched to an accident scene … to pick up a patient who was trapped underneath an overturned tractor. Once on the scene, an EMS person was injured and knocked unconscious. The medical personnel at the scene requested that I fly both people to the hospital. We do not carry a second litter normally. I asked the medical personnel if they felt it would be life-or-death situation, and they said yes. I elected to fly the second patient strapped to a backboard, and with the use of cargo straps, I fastened the backboard to the aircraft both front and rear. This is a non-approved litter device. We returned to the hospital without further event. Lessons learned: Have medical crew consider installing the second litter on the aircraft at all times. Although I do not regret having to be put in a situation such as this, it is another exercise in getting involved in the medical situation at the scene and how it can affect a pilot's judgment. We can never let the medical necessity override our good judgment and prevent us from being … safe.[23]

FARs Part 91.5 says that the pilot-in-command has full authority for aircraft operations. This includes the authority to refuse a flight or to cancel a flight because of weather conditions or any other factor that the pilot believes would adversely affect the safe operations of the aircraft. The National Flight Nurses Association (NFNA) *Practice Standards for Flight Nursing* says that "the flight nurse will make no attempt to influence the pilot's decision to accept or turn down a transport request."[24] Nevertheless, flight nurses are responsible for patient safety, and this responsibility inevitably leads to conflict and pressures.

In some instances, a patient's condition deteriorates so much that a pilot conducts a precautionary landing. Seven percent of those questioned in the 1997 survey of EMS pilots said that they conducted at least one forced landing or precautionary landing at a location other than their primary site during the previous year because of a change in patient condition.[25]

In the 2001 study, the patient's medical condition contributed to time pressure in 29 of the reports evaluated. One of the recommendations of the 1988 NTSB study was to develop procedures to isolate flight operation decisions from medical decisions. In the 1995 NASA study, EMS pilots indicated that they did not consider themselves isolated from medical decisions; nevertheless, the study said, isolation may not be realistic when a pilot is faced with anxiety and expressions of urgency, both in speech and nonverbal signs, from medical staff.[26]

NASA researchers suggested the application of crew resource management (CRM) principles, prevalent in air carrier operations, as an aid in EMS operations. In a 1999 survey of members of the National EMS Pilots Association (NEMSPA), 37 percent said that CRM training was useful, and 44 percent said that such training should be required. Nevertheless, 19 percent said that CRM training was not necessary or that they had not heard of CRM training.[27]

The 1988 NTSB study and the 1995 NASA study said that the second-most frequent cause of time pressure was rapid flight preparation, which was a contributing causal factor in 15 accidents and was cited in 18 ASRS reports. Many programs have self-imposed time limits to launch the aircraft. In several instances, these time limits have led to hasty preparations and time pressure.

In one ASRS report, the pilot said:

> I arrived at work for a shift change. After parking the car, I heard one of our hospital helicopter's [rotors] turning on the hospital helipad. I ran to the pad so I could relieve the night pilot and take the flight. The pilot at the controls was at the time looking over maps of the area while the aircraft turned at ground idle. We exchanged places with the [rotors] still turning. When I got into the helicopter cockpit, the aircraft was not ready for flight. The throttles were not out of ground idle, and I had to dial in a few radio frequencies applicable for the mission. We were responding to a multiple car accident with serious injuries incurred. I do remember pushing the throttles forward. I also remember glancing at my instrument gauges before liftoff. Everything looked good. I made the appropriate calls and began the takeoff process. I first came to a hover, turned on the spot and then began my transition to forward flight and climb. As we moved forward, my warning lights and horns for low-rotor rpm [revolutions per minute] came on. My rotor rpms began to drop, and the aircraft slowly began to settle. We were past the west end of the pad, over a very steep hill, which extended down to a commuter-hour freeway. My no. 1 concern was to reach the nearest spot to land, which was back at the helipad. I turned and was able to settle back on the pad and appeared to land without incident. I looked at the gauges and around the cockpit. Everything was normal again, except I noticed that my engine throttles were not full forward. I assumed

> that was the problem. I pushed the throttles forward completely, lifted off again and flew the flight to the accident scene as if everything was normal. Upon landing and shutting down at the scene, I discovered that approximately two [inches] to three [inches] [five centimeters to eight centimeters] of each tail-rotor blade … was chopped off. I gave the remaining rotors a detailed inspection, checked the drive train from the engines to the rotors and found everything in place. The patient was brought to the aircraft, dying, and placed inside. I made the decision that I could make the five-minute flight back to the hospital safely. The flight went back without incident. Problem areas: The quick EMS helicopter responses, the numerous interruptions of the EMS pilot during start-up and the pilot allowing this to happen. Plus, the added pressure of a dying person causing the pilot to make emotional decisions instead of safe ones.[28]

Another factor that contributed to time pressure was changing weather conditions, especially when pilots attempted to complete flights as the weather deteriorated.

In 60 of the 218 ASRS reports, pilots said that they had been distracted. Pilot performance was compromised in 57 of the 60 reports; in each instance, a single-pilot operation was involved. The most common causes of distractions were monitoring multiple radio frequencies (24 reports), aircraft equipment problems in flight (nine reports), radio-frequency congestion (nine reports), traffic-avoidance in high-density traffic areas (seven reports) and poor cockpit organization (seven reports). The relative contributions of each distraction may be under-reported, and other factors such as airspace complexity, communication, navigation and traffic avoidance may be more frequent than reported here.

Pilots Cite Fatigue, Stress as Safety Risks

Most pilots recognize that fatigue and stress jeopardize flight safety. In the 1997 survey of EMS pilots, 25 percent cited flight-related stress and 21 percent cited pilot fatigue as significant factors in EMS helicopter safety.[29] The 1988 NTSB study said that pilot fatigue could be a primary cause of the EMS industry's poor safety performance.[30]

EMS pilots are regulated by FARs Part 135, "Commuter and On-demand Operations," which says that a pilot must have a minimum of eight hours to 10 hours of uninterrupted rest within the previous 24-hour period. Flight nurses and other air medical crewmembers are not protected by this regulation, and the NFNA said that flight nurses who work 24-hour shifts frequently encounter difficulties in obtaining adequate rest.

The 1988 NTSB study found that, of 59 commercial EMS helicopter accidents, fatigue was cited as a factor in one. Nevertheless, NTSB said, "This does not mean that [fatigue] was not a factor in [other] accidents. It simply means that the evidence was not clear enough for the investigator to cite it [fatigue] as a causal factor."

The 2001 study found no accidents in which fatigue was a factor. Nevertheless, the ASRS reports included seven pilot references to fatigue, six references to fatigue caused by long duty cycles and 14 statements by pilots that they had violated duty-time limits because of unplanned delays. Patient medical conditions were responsible for five of the delays, and unforecast weather or changing weather conditions were responsible for five other delays.

The role of fatigue in previous accident analyses, as well as in the 2001 study, may be underestimated because of under-reporting. One previous analysis of the ASRS database found that 4 percent of reports were fatigue-related, but indirect references to fatigue were included in 21 percent of reports.[31] The latter figure may be more representative of the role of fatigue in aircraft mishaps. The analysis also found that fatigue-related incidents occurred most frequently between midnight and 0600.[32]

NEMSPA guidelines, cited in the 1988 NTSB study, say, "[F]atigue cannot always be self-determined, and in most cases, it may not be apparent until serious errors are made. It is necessary to avoid the environment that would promote these conditions.

NTSB said that EMS helicopter pilots, with their extended shifts and rotating shifts, "work in an environment and operate on a schedule … conducive to acute [fatigue] and chronic fatigue that can influence the pilot's ability to operate the aircraft safely."[33]

When NTSB interviewed pilots for the 1988 study, most pilots said that, other than combat flying, the EMS flight environment is the most stressful and most challenging.

The 2001 study found 14 ASRS reports of pilots who violated crew duty limits, six reports that complained about long duty shifts and seven reports that mentioned being fatigued. Some extended duty days were caused by patients whose medical conditions required unplanned delays while in transport.

Emergency medical services are provided 24 hours per day, 365 days per year — a factor that introduces fatigue into EMS operations. About 37 percent of commercial EMS helicopter flights take place in darkness,[34] and Table 2 (page 12) shows that 41 of 87 accidents and 21 of 32 fatal accidents in this study occurred in darkness. Figure 7 (page 13), which shows the approximate time of day of accidents and incidents, indicates that the proportion of fatal accidents increased during late-night operations and early-morning operations. Twenty-seven percent of the ASRS reports analyzed in this study were about events that occurred at night.

Because of management concerns about providing a fair distribution of various working hours, managers traditionally have rotated day shifts, evening shifts and night shifts among employees. Nevertheless, in many instances, rotating schedules have negative effects on individual performance.

Sleepiness also is influenced by the body's internal timing system. People tend to fall asleep most quickly at two distinct — but consistent — times in a 24-hour period.[35] Both long-haul pilots and short-haul pilots in sleep research studies exhibited a gradual increase in sleepiness throughout the day, reaching a maximum during the late afternoon, and followed by a gradual decline into the evening. Maximum daytime sleepiness occurs around 1530, and the body reaches peak alertness between 1930 and 2130. The body experiences another peak in alertness at 0930 after a night's sleep.[36] During the early morning hours (0400-0600), crewmembers in cruise flight displayed various brain wave patterns characteristic of sleep or extreme drowsiness.[37]

The stability of the sleepiness pattern suggests that some crewmembers may be able to use that information to predict when they could fall asleep more readily and thereby to develop better strategies for sleeping or napping.[38] Nevertheless, the changing schedules characteristic of most EMS operations limit the applicability of this option.

Research has found that the number of daily flight segments is consistently related to sleep quality. The intensity of the duty day has more influence on sleep quality than does the length of the duty day. As the number of daily flight hours — not duty hours — increased, the quality of sleep increased. Poorer sleep was associated with increases in the amount of en route stopover time. Less demanding duty days were followed by shorter periods of sleep and poorer sleep in the evenings.[39] The timing of trips — not necessarily the length of the duty day or the number of segments flown — appears to have contributed more to the development of fatigue. In EMS operations, pilots are unable to control the timing of trips and the number of segments flown, and the effectiveness of fatigue-prevention programs and stress-management programs is compromised.

Most Pilots Report Flying At Least 200 Hours a Year

The 1997 survey of EMS pilots found that the average lead pilot (chief pilot) in EMS helicopter operations has accumulated 6,530 flight hours in helicopters, 2,140 hours of twin-engine flight experience, 329 hours of instrument flight time and 1,305 hours of night flight time. The average line pilot has 5,894 hours of total helicopter flight experience, 2,071 hours of twin-engine flight time, 281 hours of instrument flight time and 1,120 hours of night flight time.[40] Of pilots responding to the 1999 NEMSPA survey, more than 44 percent had more than five years of experience flying helicopters in EMS operations.[41]

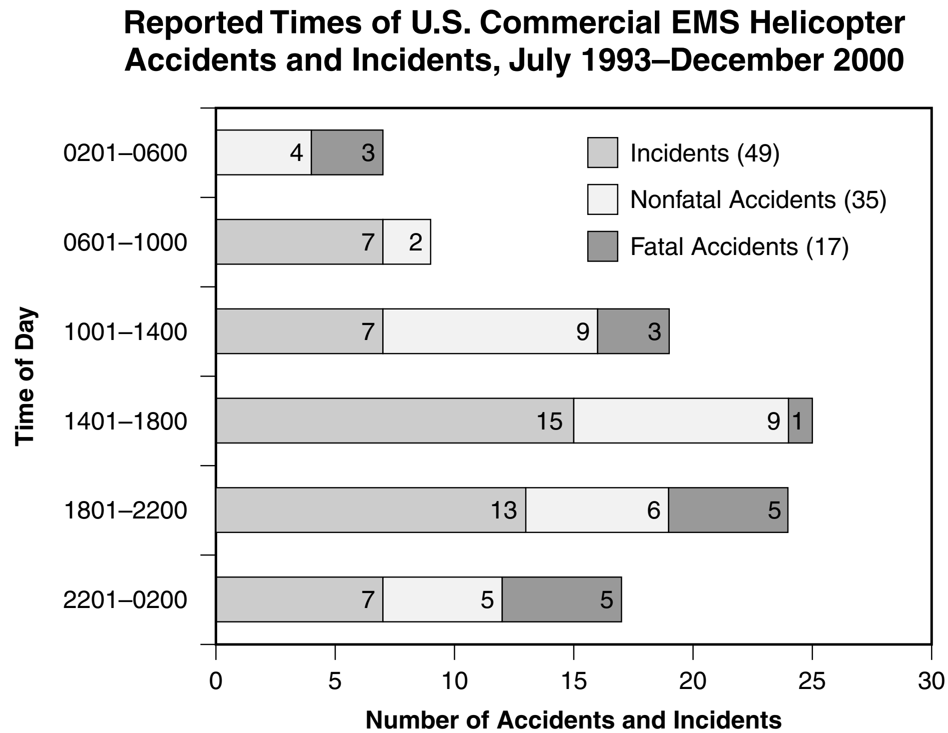
Of the commercial EMS pilots who submitted reports to ASRS, 50 percent held commercial pilot certificates, 24 percent held

Table 2
Lighting Conditions During U.S. Commercial EMS Helicopter Accidents and Incidents, 1987–2000

	Takeoff			En route			Approach and Landing			Others		
	All Accidents	Fatal Accidents	Incidents	All Accidents	Fatal Accidents	Incidents	All Accidents	Fatal Accidents	Incidents	All Accidents	Fatal Accidents	Incidents
Daylight	12	1	5	10	7	16	12	2	14	1	–	3
Darkness	9	2	1	22	18	9	10	1	7	–	–	1
Unspecified	1	–	–	9	1	–	–	–	–	1	–	–
Total	**22**	**3**	**6**	**41**	**26**	**25**	**22**	**3**	**21**	**2**	**0**	**4**

EMS = Emergency medical services

Source: Patrick R. Veillette, Ph.D.



Note: Some reports did not include the time of the accident or incident

Source: Patrick R. Veillette, Ph.D.

Figure 7

airline transport pilot certificates, and 26 percent held certified flight instructor certificates.

Nearly 60 percent of those questioned in the 1997 survey of EMS pilots reported flying a minimum of 200 hours per year in rotary-wing aircraft. More that 63 percent of lead pilots and 52 percent of line pilots had completed factory training school for the specific model of helicopter in which they were assigned.[42] Survey results indicate that 54 percent of the pilots received recurrent training annually, with an average of 22 hours of recurrent ground school and nine hours of recurrent flight training a year. Sixty-three percent of those surveyed said that other company pilots conducted their recurrent training; 19 percent said that the company's lead pilot conducted their recurrent training; and 12 percent said that their recurrent training was conducted at a factory school. Ninety-two percent said that instrument training and/or instrument refresher training would be advantageous for pilots if the training were funded by their company.

In the 1999 NEMSPA survey, 20 percent of pilots said that they received no inadvertent-VFR-into-IMC flight-recovery training during their recurrent training, 6 percent said that they performed unusual-attitude recoveries, 20 percent said that they performed unusual-attitude recoveries and air work, and 10 percent said that they performed IFR maneuvers and approaches in a simulator. Forty-four percent of the pilots said that a full approach to an airport was required.[43] In the 1997 survey of EMS pilots, 12 percent said that inadequate training was a risk to flight safety.[44]

Pilots Average Unplanned Entry Into IMC 1.3 Times a Year

The 1988 NTSB study said that the most common factor in fatal EMS helicopter accidents was unplanned entry into IMC and that most such accidents occurred in darkness. Spatial disorientation, weather information and interpretation of weather information, and pilot judgment frequently were associated factors in reduced-visibility accidents. That study said that, despite the high experience level of most EMS pilots, unplanned flight in IMC was common.

Another survey of EMS helicopter pilots, published in 1986, reported that they experienced unintentional flight into IMC an average of 1.3 times per year.[45] The 1997 survey of EMS pilots found that one-third of EMS pilots said that deteriorating weather was to blame for at least one forced landing or precautionary landing at a location other than their primary site during the previous year.[46]

The 2001 study's review of the NTSB database of EMS accidents between January 1987 and December 2000 (Table 3, page 14) shows that 23 accidents, including 17 fatal

Table 3
Weather Conditions During U.S. Commercial EMS Helicopter Accidents and Incidents, 1987–2000

	Takeoff			En route			Approach and Landing			Others		
	All Accidents	Fatal Accidents	Incidents	All Accidents	Fatal Accidents	Incidents	All Accidents	Fatal Accidents	Incidents	All Accidents	Fatal Accidents	Incidents
VMC	18	2	6	17	12	23	20	1	20	1	–	3
IMC, MVFR	3	1	–	18	14	2	2	2	1	–	–	1
Unspecified	1	–	–	6	–	–	–	–	–	1	–	–
Total	**22**	**3**	**6**	**41**	**26**	**25**	**22**	**3**	**21**	**2**	**0**	**4**

EMS = Emergency medical services VMC = Visual meteorological conditions IMC = Instrument meteorological conditions MVFR = Marginal visual flight rules weather conditions

Source: Patrick Veillette, Ph.D.

accidents, occurred in marginal VFR (MVFR) conditions or IMC.

The ASRS database includes 34 reports of inadvertent encounters with IMC by commercial EMS helicopter pilots. Thirty events occurred during flights in MVFR conditions, 22 events occurred in darkness, and 26 events occurred in weather conditions that had not been forecast. Twenty-nine pilots said that they were unable to safely continue VFR flight, 22 pilots flew their helicopters into IMC without an IFR clearance, 16 pilots climbed to avoid terrain, 22 pilots attempted to contact ATC for assistance (21 pilots made contact), and four pilots said that they temporarily lost control of their helicopters.

Flying into weather that obscures visibility is usually the first step in developing spatial disorientation. FAA's *Aeronautical Decision Making for Air Ambulance Helicopter Pilots* says, "The real killer lurking in the night sky is the unseen cloud. Clouds disappear easily in the dark, and you can fly into one without seeing it coming."[47]

One pilot who submitted an ASRS report about an unplanned flight into IMC said:

> Called for patient flight to ZZZ. Weather was marginal but acceptable. Landing at ZZZ with no problem. Upon departure and climb-out, flew into clouds at about 1,000 feet MSL. Due to rising terrain in vicinity and limited visual references anyway, I performed a maximum-performance climb and came to a heading that would avoid terrain. Just as I was calling ZZZ approach for an IFR clearance, I broke out at 1,800 feet MSL. Continued flight with no further incident. Contributing factors to entering IMC were the darkness, low-light illumination and ragged ceiling."[48]

FAA testing found that, even when the pilot is qualified for instrument flight, some pilots took as long as 35 seconds after loss of visual contact with the ground to establish full control of the aircraft by reference to instruments. (FAA said that the tests were conducted with fixed-wing aircraft, which are inherently more stable than helicopters.)[49]

FAA's *Aeronautical Decision Making for Air Ambulance Helicopter Pilots* says that, "even on the clearest night with VFR conditions, a pilot can come close to IFR (instrument flight rules, i.e. inadvertent IMC) operations if there is no moon and/or no ground lights to establish a horizon reference. Or, on the other hand, a profusion of ground lights below and stars above can merge into a continuous sweep of pinpoints that deprive a pilot of any horizon reference."[50]

FAA's *Spatial Disorientation* advisory circular says, "Surface references and the natural horizon may at times be obscured, although visibility may be above VFR minimums. Lack of natural horizon or surface reference is common on overwater flights, at night, and especially at night in extremely sparsely populated areas or in low visibility conditions."[51]

The 1988 NTSB study said, "Tests and experience have shown that non-instrument-trained pilots or nonproficient pilots are rarely successful in overcoming spatial disorientation. Most helicopters require some form of autopilot system in addition to appropriate navigation equipment and instrumentation in order to be approved and certificated for single-pilot flight into instrument conditions. Without this help, even if the helicopter has appropriate instrumentation, pilots will have a difficult time controlling the helicopter if they lose visual reference, since helicopters are unstable in flight and require constant input from the pilot to remain under control."[52]

In the 1999 NEMSPA survey, when pilots were asked which technologies would help them most, 50 percent said that they wanted equipment to aid them in IFR operations: Twenty-nine percent said that a fully coupled autopilot would be the greatest aid, and 21 percent said that global positioning system (GPS) approaches and improved access to the IFR en route structure would be most helpful. Thirty-four percent of EMS pilots said that night-vision goggles would be the greatest technological aid to their work.[53]

Official Weather Reports Often Are Unavailable

Commercial EMS helicopter operators are subject to the rules contained in FARs Part 135 and FARs Part 91, "General Operating and Flight Rules." When only the flight crew and EMS medical personnel are on board, the flight may be conducted under Part 91 rules; when a patient is on board, Part 135 rules apply. Under Part 91, the flight may be conducted without a flight plan and in weather that does not comply with Part 135 takeoff minimums and landing minimums. Under Part 135, a pilot may not begin an instrument approach unless there is an approved weather-reporting source, and the reported ceiling and visibility are higher than IFR landing minimums.

NTSB said, in its 1988 study, that there was a need for better weather information and additional training for pilots in interpreting weather information. Of the 15 pilots in the 1988 NTSB study who were involved in reduced-visibility accidents, 13 pilots had received some form of weather briefing before the accident.[54]

"[I]n some cases," the 1988 NTSB study said, "the pilots did not wait to receive a full weather briefing, and departed in haste, further increasing their chances of encountering poor weather, especially at night."

In the 2001 study, pilots in 14 of the IMC-related accidents had obtained a weather briefing. In 11 of the 14 accidents, NTSB faulted the pilot's weather evaluation. (Eight NTSB accident reports did not say whether the pilot had obtained a weather briefing.) Pilots in five of the seven inter-hospital transport accidents and seven of the 22 positioning flights used terminal area forecasts and routine aviation weather reports from nearby airports.

The 2001 study found that official weather reports for the destination were unavailable in some instances and that pilots relied on area forecasts, which may not reflect localized weather conditions.

Weather briefings typically include qualifiers such as "chance of IMC" or "occasional MVFR." The words "chance of" or "occasional" IMC or MVFR were used in weather briefings in 11 of the 14 accidents in which pilots obtained weather briefings.

In 34 ASRS reports of inadvertent encounters with IMC, 30 reports involved mixed weather conditions or MVFR, and 26 involved unforecast weather.

One ASRS report described the following inadvertent encounter with IMC:

> Departed the hospital in town. … The weather was thin scattered, with about six-mile [10-kilometer] visibility, and my base was reporting clear and five-mile [eight-kilometer] visibility, temperature 16 degrees C [Celsius, 61 degrees Fahrenheit (F)], dew point 15 degrees C [59 degrees F], and wind 200 degrees at 10 knots. My initial plan was to stay below the scattered layer, which was about 1,500 feet MSL, and return to my base. I expected the weather to improve as we flew east. It did not, so I turned south to follow lower terrain out of the town's area. I began to encounter thin scattered clouds at 1,200 feet MSL. With the weather at my base still reporting clear, I elected to climb through the thin scattered layer of clouds rather than continue low-level. The scattered layer bases were at 1,500 feet and tops at 1,800 feet. I climbed to 3,500 feet MSL and flew east towards my base and continued to check on the weather below. It was thin scattered, with lights visible through it. At about 22 nm [41 kilometers] out, the level below turned solid to broken. I looked behind me, and that was solid, too. I called approach, and the tower said my base was still clear. At eight miles [13 kilometers] out, I asked for the weather again, because I could only see a glow and occasionally some ground lights. The tower reported the weather was still clear, then stopped and said that weather was moving in from the west rapidly. The weather then went to 700 feet broken and five miles in mist. I continued to occasionally see ground lights through the layer. I was concerned the weather would deteriorate further. I declared an emergency and was cleared for an ILS [instrument landing system approach] to runway 4R. After requesting approach information, I asked to be vectored back out to reintercept the localizer due to high ground speed and not comfortable with the approach. I entered the cloud layer at about 1,800 feet and broke out at about 800 feet MSL. The cabin crew

> reported ground lights visible throughout the descent. I stayed on the instruments in order to not become disoriented or get vertigo. In retrospect, I should have stayed below the cloud layer and continued to my base, even though the reported and forecasted weather there indicated the climb would be a better course of action.[55]

A report in the *American Journal of Emergency Medicine* said that a two-year study found that 3.5 percent of all EMS flights were conducted on IFR flight plans.[56] Nevertheless, ASRS reports from EMS pilots indicate that the ATC system sometimes is unable to allow pilots of EMS helicopters to enter the IFR system easily. EMS helicopters frequently depart from off-airport sites such as hospitals or on-site locations and seldom proceed to their destination via the federal airway system, as this ASRS report illustrates:

> IFR flight plan was filed by operations to depart a hospital helipad and proceed IFR to my destination. I called XYZ FSS to pick up my IFR clearance. XYZ FSS Radio requested a clarification of my departure location. I informed XYZ Radio that I would be departing from a hospital helipad located in ZZZ, and the geographical location was filed in the form of latitude/longitude coordinates in the flight plan. Also, I gave an estimate of the … [distance] and direction from AB County Airport. XYZ FSS relayed the following short-range clearance: 'ATC clears EMS helicopter direct to XXX NDB, climb and maintain 4,000 feet. Contact XXZ Approach on 119.2, squawk XXXX, clearance void if not off by AB40.' I repeated the clearance to XYZ Radio. I contacted XXZ Approach on departure and was immediately queried on my departure point. IFR was completed without incident. Upon landing, I received phone calls from XYZ Radio and XXZ Approach concerning confusion over my departure point. Evidently, the clearance was obtained and issued based upon an IFR departure from ZB County Airport, which is controlled by XXZ Approach. The actual departure point was ZZZ, which is controlled by center. My clearance never mentioned a departure location. I should have clarified the missing departure point in my readback. The ability of helicopters to depart from locations other than airports seems to have created a source of confusion among various ATC facilities. With an increasing number of GPS approaches [being] approved into hospital helipads and the ability of helicopters to depart remote locations would indicate a strong need for the aviation community to address this issue.[57]

In uncontrolled airspace, usually found below 1,200 feet AGL, FARs Part 135.205(b) and Part 205(b) say that helicopters may be operated VFR if visibility is at least 0.5 statute mile (805 meters) during the day and at least one mile at night. FARs Part 135.203 says that the helicopter must remain above congested areas by 300 feet; FARs Part 135.207 says that the helicopter pilot must maintain visual reference with the surface (or with surface lights at night).

In the 2001 study, 25 of the 27 low-visibility accidents occurred at low altitudes and in uncontrolled airspace.

Speed Is Often a Factor In Low-visibility Accidents

In the 2001 study, 17 commercial EMS helicopter accidents in low-visibility conditions, including 14 fatal accidents, occurred at cruise speeds, and nine accidents, including three fatal accidents, occurred at approach speeds.

NTSB, in its 1988 study, quoted a study that found that the average helicopter pilot required five seconds to recognize a hazard, to determine that corrective action was needed and to respond.[58] For example, if a pilot began a 30-degree banked turn away from an obstacle, a helicopter traveling at 120 knots would continue 3,220 feet (982 meters) toward the obstacle before moving away. A 30-degree banked turn in marginal visibility could induce spatial disorientation if a pilot relied on outside visual cues to control the aircraft. NTSB said that a helicopter being flown at cruise speed in marginal weather conditions could overfly the pilot's ability to see and avoid obstacles or deteriorating weather.

One EMS pilot described such a situation in the following ASRS report:

> I departed medical center and picked up a patient to be transferred to a hospital. We left with a ceiling of 700 feet and visibility of four miles [6.4 kilometers]. About 23 miles [37 kilometers] from XYZ airport, I monitored ATIS [automatic terminal information service] and found the ceiling and visibility at the airport to be 600 feet and two miles [3.2 kilometers]. I discussed getting an IFR clearance with the medical crew, but decided I could make it VFR. I then contacted approach control and they had me squawk and ident 20 miles [32 kilometers] south of the airport. After another two minutes, I contacted the hospital and let them know we were about five minutes out at nine miles [14 kilometers]. I slowed the aircraft to 90 knots, and, as I was slowing, medcom called for a position report. I told them I didn't have time right now and looked down to set my selector switch back to approach control. While I looked up again, all I saw was a cloud for one [second] or two seconds. As I was getting ready to transmit for an IFR clearance, I broke out of the cloud to see a tower to my right front at approximately 500 feet to 1,000 feet [153 meters to 305 meters]. I immediately turned 20 degrees to the left and momentarily heard the main rotor strike one of the guy wires. I felt a slight lateral vibration and continued a left descending turn into a 10-knot southerly wind. I found an open field, and, after verifying my rotor [speed] was still in the green, did a power-on approach to the field. As I was landing, I gave a mayday call to approach. After landing and finding all passengers safe, I executed an

emergency shutdown. I knew the weather was marginal when I departed, so I reviewed my options from our company ops manual. These include land immediately, divert to another location, turn around and go home, go IFR. In retrospect I know I waited too long to [select] one of the four options. I should have either landed or asked for an IFR clearance. I let my attention divert to making radio calls instead of flying the aircraft. In the future, I will not hesitate to land or ask for a clearance much sooner in a deteriorating situation.[59]

Obstacle Strikes Involved in 27 Accidents

Table 4 shows the number of collisions with obstacles that occurred during each phase of flight and in different lighting conditions and visibility conditions. Twenty-seven accidents in the 2001 study, including eight fatal accidents, and 23 incidents involved collisions with obstacles. Fifteen accidents and 12 incidents involved wire strikes, and 10 accidents and nine incidents involved collisions with fences, trees or lights in the takeoff zone and the landing zone.

Table 4
Obstacle Strikes Involved in U.S. Commercial EMS Helicopter Accidents and Incidents, 1987–2000

	Takeoff	En route	Approach and Landing	Ground
Type of Obstacle				
Wire				
Incidents	3	1	8	–
Nonfatal accidents	6	1	2	–
Fatal accidents	1	4	1	–
Fence, tree, light				
Incidents	1	–	8	–
Nonfatal accidents	4	–	6	–
Fatal accidents	–	–	–	–
Vehicle				
Incidents	–	–	2	–
Nonfatal accidents	–	–	–	–
Fatal accidents	–	–	–	–
Terrain				
Incidents	–	–	–	–
Nonfatal accidents	–	–	–	–
Fatal accidents	–	1	1	–
Lighting Condition				
Daylight				
Incidents	4	1	9	2
Nonfatal accidents	4	1	3	–
Fatal accidents	–	1	1	–
Darkness				
Incidents	–	–	6	–
Nonfatal accidents	5	–	5	–
Fatal accidents	1	4	1	–
Visibility Condition				
VMC				
Incidents	4	2	14	2
Nonfatal accidents	9	–	7	–
Fatal accidents	1	1	2	–
IMC, MVFR				
Incidents	–	1	1	–
Nonfatal accidents	1	1	1	–
Fatal accidents	–	4	–	–

EMS = Emergency medical services VMC = Visual meteorological conditions
IMC= Instrument meteorological conditions MVFR = Marginal visual flight rules weather conditions

Source: Patrick R. Veillette, Ph.D.

Five of the six obstacle-strike accidents during the en route phase of flight involved MVFR conditions or IMC conditions. Four obstacle strikes during en route flight in IMC conditions resulted in fatalities. Three of the five en route wire strikes involved electrical transmission wires that were less than 100 feet above the ground; the other two en route wire strikes involved telecommunications towers. NTSB accident reports said that none of the helicopters was equipped with wire-strike detection equipment. (This gyroscopically stabilized equipment consists of a 35-gigahertz radar with a range of 40 nautical miles [74 kilometers].)[60]

One EMS pilot described his concern about unlighted towers in this report to ASRS:

> Is there anything you can do about the quickly growing problem of unlit towers? Current Florida NOTAMS [notices to airmen] show 25 unlighted towers, including 11 over 500 feet AGL and three over 1,000 feet AGL. ([One tower at] 1,574 feet AGL is the highest.) This only includes towers that are reported. There also is a problem with cell phone towers. From what I've heard, they are below the height that either the FAA or FCC [U.S. Federal Communications Commission] requires lights, but low-flying aircraft such as EMS, law enforcement and media are operating around them. Is there any way to convince tower operators of the potential hazard? I've got to assume there is electrical power to all these towers, and it wouldn't be that hard to put lights on them. I've gotten closer than I would have liked. I saw the tower as I did a reconnaissance orbit over a landing zone at an accident scene. It was unlighted and painted dark gray. Thanks for anything you can do.[61]

Another EMS pilot wrote:

> On takeoff from a night landing on an EMS scene, I swept my … [light] along my flight path during the climb. My light … fortunately illuminated a recently erected telephone tower. A nearby water tower, which was only slightly taller, was well illuminated. I suspect the cell phone towers were intentionally erected to less than 200 feet to avoid the FAA regulation requiring paint and hazard-illumination [on towers taller than 200 feet]. There are several now in the local area, all near roads on which we land, so they pose a particular hazard to EMS helicopters.[62]

Telecommunications industry specialists estimated that about 100,000 new towers were being constructed from 1997 to 2002, with more than 50,000 of them expected to be more than 200 feet AGL. The U.S. Federal Communications Commission requires FAA to review the safety of any tower that would be more than 200 feet tall, but helicopter industry officials say that some new towers are not being included on aeronautical charts and that some do not have proper lighting and proper marking.[63]

The 2001 study found that seven EMS helicopters struck obstacles while taking off from or landing at hospital heliports. One helicopter was destroyed, three helicopters were substantially damaged, and three helicopters received minor damage. Light structures were involved in four of the obstacle strikes; the other obstacle strikes involved an adjacent building structure, a fence and wires.

On-site landing zones typically are obstructed by vehicles and people, including both trained emergency response personnel and bystanders. During on-site takeoff operations and landing operations, pilots must assess the effects of adverse winds, debris on the heliport, obstacles and congestion from vehicles and bystanders.

In the following ASRS report, the pilot described a wire strike that occurred during on-site congestion:

> An EMS helicopter landed on a dirt road near a seafood processing plant. [The pilot] was to pick up a worker who had suffered a major back injury from a falling 500-pound [227-kilogram] block of ice. His takeoff path was obstructed by telephone wires. He elected to take off beneath the wires rather than to try to climb over them. He had 35 hours in this particular model aircraft. He misjudged the height of his tail rotor, which cut the lowest of three phone wires. A 1/4[-inch] by 1/8[-inch] [6.4-millimeter by 3.2-millimeter] nick was made in one tail rotor blade.[64]

Twenty-one of the 27 obstacle-strike accidents in the 2001 study occurred during takeoff or landing, including seven that occurred at the operator's hospital helipad and 14 that occurred during on-site responses. In 11 of the 14 on-site accidents, pilots had attempted to obtain information regarding obstacles near the operating sites. In eight of the accidents, the pilots were warned about the existence of wires, but six of the eight warnings were vague, inadequate or nonspecific. The pilots had been warned of the obstacles in all seven hospital-helipad accidents. In five accidents, the pilot's attention was diverted to other aviation tasks (such as monitoring the aircraft instruments). Inadequate crew coordination was cited in five obstacle-strike accidents in the landing area. Inadequate visual lookout was cited in five accidents.

EMS pilots submitted 11 ASRS reports about events in which the rotor blades were damaged during on-site operations. Factors most common to these events included confined-area operations and night conditions. Rotor damage was caused not only by wires but also by debris and objects that were moved by the rotor's downwash.

The following ASRS report involved damage caused by debris:

> My EMS helicopter, as well as another helicopter, were dispatched to the scene of an auto [accident on] the side of a highway embankment. The [other] helicopter landed

first in a confined area next to the road. The [other] helicopter left the scene and, upon leaving, disturbed a large amount of debris. When my helicopter was landed in the same location shortly after the other helicopter, the debris was once again disturbed. This is not unusual in EMS helicopter operations, as we almost always are required to land adjacent to roadways where debris collects. After arrival at the hospital … a post-flight [inspection] was conducted, and a one-inch (2.54-centimeter) void in the main-rotor blade tip cap was discovered. This void required temporarily grounding the helicopter and subsequent maintenance action. The blade sustained enough damage to require its removal and replacement.[65]

Pilots See Risks in 'Hot Loading'

During helicopter ground operations, turning rotors can cause serious injuries to personnel operating beneath the main rotors or near the tail rotors. When the main rotor is turning at sufficient speed, the pilot has considerable control of the rotor position through the cyclic control; the pilot can lift the rotor or tilt the rotor away from people who are moving beneath it.[66]

When the rotor turns at slower-than-normal operating speeds, however, such as when pilots are shutting down the rotor or when the rotor is accelerating during startup, the pilot has less control of the rotor position.

Personnel sometimes walk underneath rotors or near rotors without obtaining the pilot's attention and acknowledgment.

Some operators require helicopter rotors to be stopped during loading operations. This is termed "cold loading." Other operators allow "hot loading" while the rotors are turning, because hot loading can save time during an emergency response.

A study by Samaritan Air Evac in Phoenix, Arizona, U.S., showed that 73 percent of the 87 air medical programs surveyed conducted hot loading and hot unloading of patients under some circumstances. Eight percent of the programs surveyed had written policies for conducting the procedure safely.[67] Ninety percent of the surveyed pilots said that hot loading and hot unloading procedures should be conducted. Forty-five percent of the pilots said that hot loading and hot unloading are risky, but that, in certain situations, the benefits outweigh the risks. Nine percent of pilots said that they conduct hot loading and hot unloading only when the severity of the patient's condition warrants the procedure and when all safety requirements are met. Thirty-six percent said that the procedures create no additional risk.[68]

Preliminary studies have shown that hot loading a typical EMS helicopter requires an average of 3.59 minutes; cold loading the same helicopter requires an average of 5.45 minutes. The total on-site time decreases from 15 minutes for cold loading the helicopter to 14.25 minutes for hot loading.[69]

NFNA said that safety would be improved if every EMS program that conducts hot loading operations had formal written policies and procedures. NFNA also said that safety would be enhanced if hot loading and hot unloading were not used routinely and if all personnel involved were required to receive initial training and recurrent training on correct performance of the procedures. Because ground personnel at on-site operations or at other hospitals may not be familiar with hot loading procedures, consideration should be given to limiting hot loading and hot unloading to those hospitals and crewmembers who are trained in the procedures, NFNA said.[70]

Mechanical Failures Cited in 26 Accidents

In the 1997 survey of EMS pilots, 18 percent reported at least one forced landing or a precautionary landing at a location other than their primary site during the previous year because of a mechanical malfunction.[71]

Of the 87 commercial EMS helicopter accidents in the 2001 study, 26 accidents involved mechanical failures. Thirty-four of the 56 EMS incident reports involved mechanical failures. Nine mechanical-failure accidents resulted in fatalities, and one mechanical-failure accident resulted in serious injuries. The nine mechanical-failure fatal accidents constituted 28 percent of all fatal EMS helicopter accidents in the sample.

Table 5 (page 20) shows the distribution of mechanical-failure accidents and mechanical-failure incidents to the component system and the phase of flight. Of the 26 mechanical-failure accidents, six were attributed to improper maintenance procedures. Seven accidents and 13 incidents were caused by engine failure. Six accidents occurred because of tail-rotor failure. Six accidents and five incidents were attributed to failure of the transmission system.

Twenty-two of the 23 en route mechanical incidents occurred in VMC. Fourteen of these occurred during daylight. Thirteen incidents resulted in precautionary landings or emergency landings with no further damage to the aircraft. None of the mechanical incidents involved injury to the aircraft occupants.

Cowlings and loose panels that separated from helicopters caused four accidents and six incidents. In five of these events, the cowlings had been closed improperly by medical crewmembers during preparation for the flight. In three events, worn latches were discovered.

Thirty-three ASRS reports involved mechanical problems. Successful precautionary landings were conducted in 20 of these events, all of which occurred in multi-engine helicopters. In six events, helicopters unintentionally were operated beyond mandatory inspection periods, and in eight events, pilots attempted flight with known mechanical discrepancies.

Table 5
Mechanical Failures Involved in U.S. Commercial EMS Helicopter Accidents and Incidents, 1987–2000

	Takeoff	En route	Maneuvering	Approach and Landing	Ground
Engine					
Incidents	–	11	–	2	–
Nonfatal accidents	2	2	–	1	–
Fatal accidents	–	2	–	–	–
Cowlings, doors					
Incidents	1	3	–	2	–
Nonfatal accidents	1	–	–	1	–
Fatal accidents	1	–	–	1	–
Flight control					
Incidents	–	4	–	2	1
Nonfatal accidents	1	2	–	2	–
Fatal accidents	–	1	–	–	–
Transmission					
Incidents	–	5	–	–	–
Nonfatal accidents	–	3	1	–	–
Fatal accidents	–	2	–	–	–
Other					
Incidents	1	2	–	–	–
Nonfatal accidents	–	–	–	1	–
Fatal accidents	–	2	–	–	–

EMS = Emergency medical services

Source: Patrick R. Veillette, Ph.D.

Helicopters used for EMS transport are complex, in part because they are modified for installation of medical components for advanced life support. During the modification process, the helicopter is stripped of all unnecessary furnishings, carpeting and equipment, then equipped with new seats for medical personnel, patient litters and medical equipment. Medical equipment includes such items as oxygen bottles, cardiac cylinders and hooks to support intravenous bottles. The modifications usually are conducted according to the contracting hospital's specifications and often are based primarily on the need for compatibility with other hospital equipment.[72]

Sometimes the modification of helicopters for EMS operations includes the addition of medical equipment that may interfere with the functioning of the helicopter, as shown by the following ASRS report:

> In our EMS helicopter, we have been getting interference on 130.0 (VHF AM [amplitude modulation]), while using a patient heart monitor. The interference has been in the form of … [a] tone received over the VHF radios. (We have two VHF radios in the aircraft.) During a short flight from a hospital just north of XXX, to our hospital 13 nm [24 kilometers] west, the interfering tone was practically continuous and quite distracting to pilot's thinking, as well to his reception of tower transmissions. Just after takeoff, I contacted XXX tower, received instructions to squawk XXXX and clearance to depart the TCA at or below 2,400 feet, which I acknowledged and complied with. Now, however, the interference was so loud on tower frequencies (135.0 and 120.0) that I inadvertently turned my tower volume control so low that I could not hear the tower at all.[73]

Study Finds Crashworthiness at Risk

In the 1988 study, NTSB said that the crashworthiness of EMS helicopters was jeopardized by interior modifications. (*Crashworthiness* is the ability of an aircraft design to withstand impact forces with minimal structural damage to living space and adequate absorption of impact energy so that occupants survive.) NTSB found that, in some EMS helicopters, the interior was not modified according to applicable FAA standards for crashworthiness or to sound engineering practices. NTSB found a scarcity of shoulder harnesses, seats that were attached improperly to the floor, seats that were constructed from unapproved materials, medical equipment that was not properly restrained, intravenous-bottle hooks that projected from helicopter interiors, and equipment — some of substantial weight — that was stored loosely or mounted improperly.[74]

Those factors may be considerations in the fatality rates in EMS helicopter accidents, compared with accidents involving helicopters that have not been modified for EMS operations. One study found that occupants of EMS helicopters were nearly three times more likely to be seriously injured in a survivable accident than occupants of non-EMS turbine helicopters involved in survivable accidents.[75]

In the 2001 study, 35 percent of occupants of the EMS accident helicopters received fatal injuries, 12 percent were seriously injured, 11 percent received minor injuries, and 42 percent were uninjured.

Four accidents in the 2001 study were caused by in-flight fires, which fatally injured four people. Patients were on board in one of these accidents. Three of the four in-flight-fire accidents involved engine fires, all of which occurred in multi-engine aircraft. Engine-fire warning systems activated in each of the three accidents and were accompanied by visible smoke and fire. In each accident, the pilot completed a single-engine autorotation without significant damage to the fuselage structure, enabling the medical crewmembers to exit the burning aircraft quickly.

Five accidents in this report involved post-crash fires, in which seven people were injured fatally. The ignition sources in four post-crash fires were not identified; exposure of the patient oxygen system to oil or grease was the cause of the other fire. In three of the five post-crash fires, EMS crews were unable to extricate themselves from the wreckage.

Escape from EMS helicopter wreckage is complicated by the position and condition of the stretcher and by debris from unsecured medical equipment. These factors explain, in part, the higher incidence of severe injuries resulting from EMS accidents. The injuries hinder the ability of EMS crews to extricate themselves and injured patients who are strapped to medical stretchers for in-flight transport.

U.S. Army research has shown that the degree and extent of thermal injuries received during escape from burning helicopter wreckage depends upon the thermal protection provided by clothing. The Army study found that an aviator wearing a standard, military-issue, summer-weight, cotton flight uniform must escape from the fire within 10 seconds of fuel-tank ignition for a reasonable chance of survival. After 20 seconds, the aviator would be exposed to temperatures greater than 927 degrees C (1,701 degrees F).[76]

Proper Seating Credited With Limiting Injuries

Because of their in-flight medical duties, medical crewmembers frequently are not seated in energy-absorbing seats with their seat belts and shoulder harnesses fastened.

Table 6 shows the results of field observations of on-site and positioning EMS flights. During takeoffs from on-site operations, 11 percent of EMS crewmembers were seated with a seat belt fastened, and 4 percent were wearing a shoulder harness. In every instance, the flight nurses and paramedics were busy with patient care. Results during patient transfer from a fixed-wing air ambulance to a rotary-wing EMS helicopter were similar: 10 percent of EMS crewmembers were seated with seat belts fastened and 3 percent were wearing shoulder harnesses. During repositioning flights without a patient on board, all EMS crewmembers were seated with seat belts fastened, and 45 percent wore shoulder harnesses.

A U.S. Department of Transportation analysis of injuries sustained in civil helicopter accidents found that 18 percent of

Table 6
Use of Protective Clothing by U.S. Commercial EMS Helicopter Crews, 1995–2000

	Accident Scene	Repositioning	Inter-hospital Transfer
Events observed	128	247	58
Pilot wearing flight helmet	75%	69%	70%
Medical crew wearing flight helmet	0%	0%	0%
Pilot wearing flight suit	77%	75%	72%
Medical crew wearing flight suit	100%	100%	100%
Pilot wearing gloves	85%	86%	70%
Medical crew wearing gloves	27%	9%	7%
Medical crew wearing seat belt during takeoff	11%	100%	6%
Medical crew wearing shoulder harness during takeoff	4%	45%	4%

EMS = Emergency medical services

Source: Patrick R. Veillette, Ph.D.

fatal injuries and major injuries were head injuries and that 9 percent were attributed to face injuries and neck injuries.[77,78]

Military studies have found that a helmet that remained in place throughout an accident sequence was associated with a significant reduction of both the number of injuries and the severity of injuries, compared with individuals whose helmets came off.[79,80,81] Flight helmets specifically designed for use in helicopters provide greater sound protection, crash attenuation, increased movement, broader field of vision and increased comfort.

To determine the effectiveness of visor-equipped helmets, the U.S. Army Aeromedical Research Laboratory studied data from 1,035 U.S. Army helicopter accidents from October 1989 through September 1996. The study found that visors were used in 459 of the accidents and that visors prevented injury in 102 accidents and reduced the severity of injury in 13 accidents.[82] In some instances, the visors contributed to minor facial injuries, but data showed 18.2 percent fatalities among crewmembers who wore their visors down, compared with 53.5 percent fatalities among those who kept the visors up.[83]

Despite these advantages, flight-helmet use among EMS crewmembers varies. One earlier study found that 23 percent of the passengers injured in EMS helicopter accidents experienced serious head injuries, a level twice as high as that of other group in the study.[84]

During field observations for the 2001 study of more than 400 EMS helicopter crews at work, none of the EMS crewmembers was observed wearing the equivalent of an aviation flight helmet. Seventy percent to 75 percent of the EMS pilots, however, wore the equivalent of a military-aviation flight helmet. Because more than 75 percent of EMS pilots received their initial flight training in the military, most were familiar with the uses of aviation helmets.

Optimal clothing for EMS crews should be determined by the fabric's flammability, heat-transfer characteristics, comfort, launderability, abrasion resistance, fabric strength and durability, colorfastness, and predicted useful service length. No fabric has all of these desired qualities.

The U.S. Army, which compared protection available from 100-percent cotton, cotton/polyester blends and Nomex, found a significant reduction in thermal injury with the use of Nomex. (Nomex is a flame-resistant, heat-resistant material made from aramid fiber, which is similar to nylon but does not melt or drip when exposed to high heat.) Nomex does not prevent thermal injury to the skin, but may reduce the risk or severity of tissue damage.[85]

Nomex can withstand temperatures of up to 800 degrees F (427 degrees C). Nevertheless, some military aviators have been burned through Nomex flight suits because they were not wearing undergarments made of suitable fabrics and the heat was transferred through the Nomex to the skin. Undergarments made of all-natural fibers can reduce the amount of heat transferred to the skin.[86]

EMS crews are exposed to sharp metals, broken glass and other hazards at on-site locations. Hazards from punctures, moving equipment, falling objects and slips are present at nearly every site. In the 1988 study, NTSB said that use of helmets, flame-resistant uniforms and protective footwear could reduce or could prevent serious injuries and deaths of EMS pilots and medical personnel in survivable accidents.[87]

Requirements for personal protective clothing vary throughout the industry. In the 1999 NEMSPA survey, 70 percent of EMS pilots said that they wore Nomex flight suits, and 60 percent said that they wore flight helmets and high-top leather boots. Forty-two percent of EMS pilots said that helmets, Nomex flight suits, leather boots and gloves should be mandatory safety equipment; 12 percent said that helmets and Nomex flight suits should be satisfactory; and 20 percent said that no safety protective clothing should be mandatory.[88]

In field observations for the 2001 study of more than 400 EMS flight crews at work, 72 percent to 77 percent of the pilots were observed wearing Nomex flight suits, and 70 percent to 85 percent were observed wearing flight gloves. All EMS medical crewmembers were observed wearing loose-fitting, long-sleeved flight suits with unit identifications, and 7 percent to 27 percent of EMS medical crewmembers were observed wearing gloves.

One aspect of EMS operations is the risk to flight safety posed by combative patients or potentially combative patients, including those with head injuries, patients under the influence of alcohol and/or drugs, patients with psychiatric disturbances, patients with a potential for seizure activity, patients with a potential for brain-tissue hypoxia, and patients who are prisoners.[89]

NFNA said that safe transport would be improved if a flight nurse was responsible for evaluating each patient for potential combativeness prior to transport. NFNA also said that patients with a potential for combativeness should have full-extremity restraints applied before being loaded on board an aircraft and that each program should have a formal policy on searches by law enforcement personnel for weapons on prisoners.[90]

Typical EMS Helicopters Have Three-member Crews

The typical EMS helicopter crew has a single pilot and two medical care professionals: a critical-care flight nurse and a paramedic. In most EMS programs, the flight nurse and paramedic are permanently assigned to the EMS helicopter unit. Some EMS flights are conducted with a physician, but this is less common.

In some instances, medical care specialists from hospital neonatal units, respiratory units or burn units become the emergency medical care providers on flights. These specialists work with the helicopter operation in an adjunct status. In one study, briefings were instituted for all crewmembers to increase their knowledge of aircraft safety and emergency procedures. During a three-year period, variations of the briefings were used and their effectiveness was evaluated. The program did not increase the proficiency of nonpermanent crewmembers, and the study said that nonpermanent crewmembers may require extra attention and be less prepared to respond, particularly in an aircraft emergency.[91]

In contrast, flight crewmembers with previous safety training demonstrated increased confidence in describing and performing safety procedures in emergencies.[92]

Assessments of EMS Effectiveness Vary

Studies of the effectiveness of EMS helicopter operations have produced varying results, but estimates are that patients who receive medical treatment within 10 minutes of an accident have about an 80 percent chance of survival.[93]

The demanding conditions of EMS operations present pilots with an array of challenges and risks. Foremost among them are the frequent flights to makeshift landing areas, operations in marginal weather and often at night, and a workload that is complicated by time pressure and sensitivity to the medical needs of their passengers.♦

Terry Brown, M.D, M.P.H., and Matthew McNamara, first officer, Canadair Regional Jet CL-65, contributed to the research and preparation of this report.

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Appendix
Commercial EMS Helicopter Accidents and Incidents In the United States, 1987–2000

Date	Location	Helicopter Type	Helicopter Damage	Injuries
Jan. 8, 1987	Pollockville, North Carolina	Bell 206L-1	destroyed	4 fatal

In night visual meteorological conditions (VMC), the pilot told air traffic control (ATC) that the helicopter was level at 3,000 feet, then said that he was going to conduct an emergency landing. The flight nurse said on the hospital radio frequency that the helicopter was on fire and was going down. Radar contact and radio contact were lost, and the helicopter struck terrain in a nose-down right bank and burned. An investigation revealed a high-velocity impact with little forward movement or no forward movement. The source of the in-flight fire was not determined.

Date	Location	Helicopter Type	Helicopter Damage	Injuries
Feb. 6, 1987	Sioux Falls, South Dakota	Agusta A109	none	2 uninjured

While in cruise flight in night VMC, excessive oil temperature was observed on one engine of the twin-engine helicopter. The pilot shut down the engine and returned the helicopter to the airport. A defective thermal relief valve was found.

Date	Location	Helicopter Type	Helicopter Damage	Injuries
April 27, 1987	Pittsburgh, Pennsylvania	Bolkow BO 105S	none	1 uninjured

While the helicopter was being repositioned in night VMC, the magnetic chip-detector light illuminated. The pilot conducted a precautionary landing. Maintenance technicians found one metal sliver on the detector. There was no engine damage.

Date	Location	Helicopter Type	Helicopter Damage	Injuries
May 15, 1987	Phoenix, Arizona	MBB BK 117A-3	minor	3 uninjured

While the pilot shut down the helicopter engine in day VMC, another helicopter flew overhead. The other helicopter's downwash caused the accident helicopter's main rotors to strike the vertical fins.

Date	Location	Helicopter Type	Helicopter Damage	Injuries
May 30, 1987	Austin, Texas	Bell 206L-3	none	4 uninjured

The helicopter's engine temperature exceeded limits, and the pilot conducted a successful autorotation in day VMC. The report said that the fuel control had malfunctioned.

Date	Location	Helicopter Type	Helicopter Damage	Injuries
June 5, 1987	Choteau, Montana	Bell 206L-1	destroyed	4 fatal

The helicopter struck terrain while being flown to Great Falls, Montana, in day VMC. A videotape recovered from the wreckage showed that, while being flown at treetop level up a 7,000-foot mountain slope, the helicopter suddenly yawed to the right. The helicopter was being flown at a high gross weight, at a high density altitude and with a tail wind.

Date	Location	Helicopter Type	Helicopter Damage	Injuries
June 7, 1987	Bay City, Michigan	MBB BO 105 CBS	destroyed	2 fatal, 1 minor

The pilot attempted a steep downwind turn at low altitude in day VMC. Reported winds were 250 degrees at 18 knots, with gusts to 23 knots. An investigation showed that the right skid and main-rotor blades contacted the ground during the turn, causing loss of control.

Date	Location	Helicopter Type	Helicopter Damage	Injuries
July 8, 1987	Cupertino, California	MBB BK 117A-3	substantial	3 uninjured

The helicopter struck wires on final approach in night VMC to an asphalt road near a traffic accident. The report said that the pilot had not seen the wires and had not realized that there had been a collision until ground personnel told him. The pilot had made numerous orbits before beginning his descent for landing and said that his vision was hampered by blowing dust from rotor wash and a spotlight on a law-enforcement vehicle.

Date	Location	Helicopter Type	Helicopter Damage	Injuries
July 22, 1987	Louisville, Colorado	Aerospatiale SA 315	minor	1 uninjured

The pilot was landing the helicopter in night VMC at the scene of an accident and trying to avoid contact with a car. As the helicopter engine was being shut down, the rotor struck a road sign.

Date	Location	Helicopter Type	Helicopter Damage	Injuries
Sept. 1, 1987	Charleston, West Virginia	MBB BK 117A-3	none	5 uninjured

During cruise flight in night VMC, the no. 2 engine revolutions per minute (rpm) declined, and a low-power light illuminated. The pilot conducted a safe landing. An inspection found that the indicator was improperly connected.

Date	Location	Helicopter Type	Helicopter Damage	Injuries
Dec. 10, 1987	Little Rock, Arkansas	Bell 206L-3	destroyed	2 minor

The helicopter was consumed by fire while parked at a heliport after a medevac (medical evacuation) flight. The on-board patient-oxygen pressure was low, and two respiratory therapists refilled the system, which is serviced through a rear baggage compartment accessible from outside the aircraft. The attendants indicated that, after the connection was made and the valve was partially opened, a fire erupted near the connection. One therapist remembered that there was oil above the baggage door.

Date	Location	Helicopter Type	Helicopter Damage	Injuries
Dec. 24, 1987	St. Louis, Missouri	Bell 206L	none	3 uninjured

During flight in day instrument meteorological conditions (IMC), the helicopter windscreen developed fogging. The pilot activated the windscreen defogger, but the windscreen remained fogged. A precautionary landing was performed.

Date	Location	Helicopter Type	Helicopter Damage	Injuries
April 1, 1988	Springfield, Missouri	Bell 206L-1	substantial	3 serious

The pilot obtained a weather briefing before the night takeoff. The forecast predicted marginal visual flight rules (VFR) weather, with periods of IMC. While en route to a motor vehicle accident, the pilot flew into fog and turned on the night-scanner light, then experienced spatial disorientation and failed to maintain aircraft control. During a precautionary landing, the helicopter struck a large row of hay bales.

Appendix
Commercial EMS Helicopter Accidents and Incidents In the United States, 1987–2000 *(continued)*

Date	Location	Helicopter Type	Helicopter Damage	Injuries
April 2, 1988	Silver Plume, Colorado	Aerospatiale SA 316B	substantial	4 uninjured

The pilot was transporting a patient over mountainous terrain when a part from the flight-control mixing unit failed because of fatigue. Without collective control, the pilot executed an emergency, run-on landing on a small road. During the landing, the nose landing gear and right strut failed.

Date	Location	Helicopter Type	Helicopter Damage	Injuries
April 9, 1988	Sioux Falls, South Dakota	Agusta A109A	substantial	3 uninjured

On approach to an airport, the pilot heard a loud snap and experienced an uncommanded right yaw. The helicopter touched down on one landing wheel. The yaw continued, and the left landing gear collapsed. An investigation showed that the no. 3 hangar bearing had failed from lack of lubrication and separated the tail-rotor drive shaft at the bearing race. All hangar bearings showed evidence of lack of lubrication.

Date	Location	Helicopter Type	Helicopter Damage	Injuries
April 17, 1988	Cajon, California	Aerospatiale AS 355F	destroyed	2 fatal, 1 serious

During a flight in IMC with a nurse and a patient aboard, the helicopter struck power lines 36 feet (11 meters) above a road. The helicopter then struck a retaining wall, clipped the tops off several trees and plunged into a 70-foot-deep (21-meter-deep) ravine. The only survivor was the patient, who was strapped into a full-body board.

Date	Location	Helicopter Type	Helicopter Damage	Injuries
May 12, 1988	Reidsville, North Carolina	Aerospatiale AS 355	substantial	4 uninjured

During cruise in day VMC, a tail-rotor blade separated from the helicopter because of fatigue failure of the composite-material spar. The tail-rotor drive shaft then separated at the tail-rotor gearbox. The fatigue failure had developed over about 500 flight hours. Bonding separation of a spar-reinforcement pad had been noted during an overhaul inspection. The operator said in maintenance records that there had been continuous problems with balancing the tail rotor. Contrary to maintenance instructions, the tail rotor was left in service.

Date	Location	Helicopter Type	Helicopter Damage	Injuries
May 14, 1988	Montegut, Louisiana	MBB BO 105C	minor	3 uninjured

The pilot was unaware that the helicopter had struck a telephone wire during takeoff in day VMC. One rotor blade was gouged.

Date	Location	Helicopter Type	Helicopter Damage	Injuries
June 18, 1988	Saint Joseph, Michigan	Aerospatiale SA 365N	minor	3 uninjured

The helicopter struck a light pole during a night VMC landing in a parking lot.

Date	Location	Helicopter Type	Helicopter Damage	Injuries
Dec. 18, 1988	Linwood, Kansas	Bell 206L-1	substantial	4 minor

The helicopter was being flown to the home base in day VMC. The pilot observed smoke on the ground and descended to make a visual inspection. The helicopter struck power lines about 60 feet (18 meters) above ground level (AGL). Autorotation was attempted, and the pilot conducted a hard landing in a shallow river.

Date	Location	Helicopter Type	Helicopter Damage	Injuries
Dec. 22, 1988	Cape Girardeau, Missouri	Bell 206L-1	destroyed	3 fatal, 1 serious

After the helicopter departed on a VFR flight, the weather deteriorated, and the pilot was unable to land at the destination hospital. In night IMC, the pilot navigated to the airport on the instrument landing system (ILS) course to determine whether the airport lighting would help him to "let down." He said that, while flying inbound at about 300 feet AGL, he experienced flicker vertigo. The helicopter struck a power line and came to rest in a field.

Date	Location	Helicopter Type	Helicopter Damage	Injuries
Jan. 8, 1989	Park City, Utah	Bell 206B III	substantial	1 uninjured

The pilot flew a rescue team to a mountain avalanche area in day VMC. The team deplaned, and the helicopter settled backward into loose snow. The pilot added collective pitch and attempted to hover. As the helicopter left the ground, an uncommanded right spin began. The pilot performed a hovering autorotation, and, at touchdown, the tail boom entered deep snow, and the aircraft came to rest nose-high. The pilot discovered that the tail-rotor drive shaft had broken forward of the tail-rotor gearbox because of the rapid deceleration into the snow.

Date	Location	Helicopter Type	Helicopter Damage	Injuries
Feb. 13, 1989	Tyler, Texas	MBB BK 117A-1	destroyed	3 fatal

The aircraft struck 70-foot-tall (21-meter-tall) high-tension power lines during a night flight. Weather was IMC, with low-overcast ceilings, visibility of 0.25 mile to one mile (402 meters to 1,610 meters) and rain, fog and thunderstorms. The pilot obtained three briefings from a U.S. Federal Aviation Administration flight service station and knew of the conditions. The pilot did not comply with hospital procedures for inadvertent flight into instrument flight rules. Records did not indicate that the pilot received instrument training during his one-month employment.

Date	Location	Helicopter Type	Helicopter Damage	Injuries
March 26, 1989	Bear Valley, California	Aerospatiale AS 355F	substantial	3 uninjured

During the slow-speed approach to a stolport (short-takeoff-and-landing airport) at 7,073 feet in day VMC, the helicopter began to yaw to the left. The pilot applied right pedal and lowered the nose to begin a go-around, but the yaw intensified. The pilot shut down both engines and conducted an autorotation. Before landing, loose snow was blown up, and whiteout conditions occurred. During touchdown, the helicopter pitched forward into a snow bank. A sheriff's deputy said that the wind was from the south-southwest at five knots to 10 knots.

Date	Location	Helicopter Type	Helicopter Damage	Injuries
April 9, 1989	Houston, Texas	MBB BK 117A-4	destroyed	3 serious

The helicopter was being operated from a temporary landing zone in a parking lot. As the pilot prepared to take off in night IMC, he observed people near the landing zone and advised the dispatcher. During a vertical takeoff, the helicopter encountered turbulence. Witnesses saw the helicopter drift backward. The tail rotor struck the top of a garage, and the helicopter began an uncontrolled spin and struck terrain.

Appendix
Commercial EMS Helicopter Accidents and Incidents In the United States, 1987–2000 *(continued)*

Date	Location	Helicopter Type	Helicopter Damage	Injuries
June 1, 1989	Big Timber, Montana	Bell 206L III	destroyed	4 fatal

The pilot told ATC that he would be conducting approaches to the hospital in VMC for night currency. Nine minutes later, he said that he was being dispatched. He was told about terrain conditions. The helicopter lifted off quickly and was flown across a hill, then struck terrain at high speed in a slight nose-low, right bank. The pilot recently was hired; his previous job involved day VFR flights of a dissimilar helicopter in the Gulf of Mexico. His last recorded night flight was before June 1984. No record was found of area familiarization training.

July 1, 1989	Des Moines, Iowa	Bell 222U	none	5 uninjured

En route in night VMC, the helicopter's no. 1 hydraulic system failed. The pilot diverted to Des Moines. A hydraulic line had chafed through contact with the cowling.

July 6, 1989	Chiefland, Florida	Bell 206L-1	substantial	3 uninjured

In day VMC, the flight was on final approach to the designated pick-up area at about 300 feet AGL when a noise was heard from the engine section. The pilot conducted an autorotation into a field. An inspection of the turbine section revealed that it was "locked up." Disassembly of the turbine module revealed that a piece of the first-stage turbine disk had separated.

July 6, 1989	Lubbock, Texas	Aerospatiale AS 355F1	minor	3 uninjured

The helicopter pilot was responding to an emergency in day VMC when the helicopter struck four power lines. The pilot conducted a forced landing.

July 24, 1989	Seattle, Washington	Agusta A109	minor	3 uninjured

The helicopter settled back onto the heliport because of low-rotor rpm and struck a fence in day VMC. An inspection found damage to the tail rotor.

Aug. 27, 1989	Blanchard, Idaho	Aerospatiale AS 350D	destroyed	4 fatal

The helicopter was being flown in day VMC to transport to a hospital a handcuffed prisoner with a gunshot wound. The pilot reported a problem with the patient and requested police assistance when they arrived at the hospital. The pilot transmitted an expletive, and radar contact was lost. Wreckage was found over a one-mile (1.6-kilometer) area, with evidence of an in-flight breakup and main-rotor contact with the cockpit and tail cone. An investigation found evidence of a swash plate bearing seizure, which led to the in-flight breakup.

Sept. 9, 1989	White Plains, Maryland	Bell 206B III	substantial	1 serious, 3 minor, 2 uninjured

During a night VMC takeoff from a field that had been established to pick up a patient, the pilot flew the helicopter west across a field but climbed no higher than wires until the helicopter was about 20 feet (six meters) from the wires. Then the helicopter nosed up to a 45-degree angle, climbed over the wires and descended to the ground. The pilot was faulted for delaying his climb during a night takeoff from a confined area.

Nov. 2, 1989	St. Paul, Minnesota	Bell 206L III	substantial	3 uninjured

The pilot encountered stronger-than-expected head winds in night VMC. After delivering the patient, he estimated that the helicopter had 12 minutes of fuel remaining. Because the flight to the home base would take about six minutes, he decided to return without refueling. Abeam the destination, the fuel-boost-pump light illuminated. The helicopter lost power from fuel exhaustion at about 50 feet AGL, and the pilot conducted a night autorotative landing.

March 6, 1990	Benton, Alabama	MBB BO 105S	substantial	4 uninjured

After the patient was loaded into the helicopter at a remote site, the pilot conducted a hover turn and departed in night VMC, flying back on the same route on which he had arrived. About 538 feet (164 meters) east of the takeoff site and about 40 feet AGL, the helicopter struck a wire above a highway. The wire snapped and struck the main-rotor system. The pilot landed the helicopter straight ahead. The highway patrol reported that there were no wires crossing the road.

March 23, 1990	Jackson, Mississippi	Bell 206L-3	minor	3 uninjured

During takeoff from an accident site in day VMC, the helicopter struck a wire. The helicopter then was landed safely.

Nov. 2, 1990	Knoxville, Tennessee	Bell 412	substantial	4 uninjured

The night VMC flight was dispatched to a site on an interstate highway to pick up a patient. The searchlight was used to inspect the landing zone for obstructions, and ground personnel inspected the area. No obstructions were observed. After landing, the pilot walked along the departure corridor with a flashlight. Shortly after takeoff, the helicopter struck four wires strung across the highway. The wires were black, and the poles were hidden by buildings and trees.

Nov. 10, 1990	Denver, Colorado	Aerospatiale SA 316	minor	3 uninjured

In day VMC, the pedal jammed when a snap ring popped off, and the pivot pin dislodged. The aircraft yawed right, and the right pedal became inoperative.

Dec. 9, 1990	Cape Girardeau, Missouri	Bell 206L-1	minor	3 uninjured

The crew heard a noise after takeoff and conducted a precautionary landing in day VMC. The right engine cowling had separated from the aircraft.

Appendix
Commercial EMS Helicopter Accidents and Incidents In the United States, 1987–2000 *(continued)*

Date	Location	Helicopter Type	Helicopter Damage	Injuries
Jan. 26, 1991	Sonestown, Pennsylvania	MBB BK 117B-1	destroyed	4 fatal
The pilot was flying a direct course in night IMC from one hospital to another hospital. The helicopter struck terrain 80 feet (24 meters) below the crest of a hill. A witness said that there was a heavy snowstorm.				
Feb. 10, 1991	Valdez, Alaska	MBB BO 105 CBS	substantial	1 minor, 3 uninjured
About 30 minutes after takeoff, one engine lost power. The pilot conducted an emergency landing in the water. The pilot had not turned on the four fuel pumps before takeoff, as required by the aircraft flight manual.				
May 30, 1991	Draper, Utah	Bell 222U	minor	3 uninjured
The helicopter was landed on a road in night VMC. Emergency vehicles provided landing lights for the rescue operation. The helicopter struck a sign and damaged the tail rotor.				
June 8, 1991	Houston, Texas	MBB BK 117A-4	none	3 uninjured
After an engine bearing failed in flight in day VMC, the helicopter was landed in a field.				
Oct. 28, 1991	Billings, Montana	Aerospatiale AS 355F1	substantial	3 uninjured
Shortly after the flight was curtailed, the flight crew felt a shudder, which they attributed to gusty winds. A portion of the left-rear engine cowl door had separated, and the main-rotor blades were damaged. The crew previously had told company personnel of a cowl-latch problem. The manufacturer had issued a relevant service bulletin that had not been implemented on the accident aircraft.				
Nov. 27, 1991	Bridgeport, California	Aerospatiale SA 316B	destroyed	4 fatal
During a flight in night VMC, the pilot interrupted a normal position report, broadcast “mayday” three times and told a company dispatcher the helicopter’s position. He did not explain the nature of the emergency. Witnesses said that the helicopter’s fuselage rotated counter-clockwise, then the helicopter veered to the west, disappeared from sight and crashed. The tail-rotor drive shaft and drive-shaft bearing had failed for undetermined reasons.				
Dec. 9, 1991	DeRuyter, New York	MBB BO 105 CBS	substantial	3 fatal
The helicopter was cruising at 2,700 feet (700 feet AGL), when it turned right 95 degrees in 15 seconds, then entered a descending left turn of 60 degrees. The helicopter struck terrain in a skids-level, nose-down pitch attitude. The accident occurred in night IMC over an unlighted area with overcast clouds. Interviews and company correspondence revealed that the pilot had a documented problem with night flying and navigation.				
Dec. 29, 1991	Bedford, Michigan	Aerospatiale AS 365	minor	4 uninjured
The helicopter was being landed in day, VMC at the scene of an automobile accident. Downwash from the rotor blades caused a plastic sheet to enter the rotor system and tail-rotor shroud, causing damage to the rotor blades.				
March 4, 1992	Fort Grant, Arizona	Aerospatiale AS 350	destroyed	2 fatal, 1 serious
After takeoff in day VMC, ATC told the pilot that there was “weather [on his route of flight], but the intensity is unknown.” Radar service was terminated, and the crew continued the flight. The surviving crewmember said that everything got “black”; about five minutes before the accident, the pilot said that the helicopter was flying into IMC.				
March 4, 1992	Arlington, Texas	Bell 222U	minor	4 uninjured
The hydraulic-system-failure light illuminated during a flight in day IMC. The pilot executed a precautionary low-speed run-on landing in a field. During the landing, the helicopter struck a concealed hump in the ground.				
May 29, 1992	Winnsboro, South Carolina	Aerospatiale AS 350	substantial	3 serious
The pilot said that, while en route to a roadside emergency in night VMC, he encountered ground fog and entered IMC. He said that he attempted to conduct a 180-degree turn to fly out of the fog, but the aircraft struck trees and then terrain.				
June 7, 1992	Mariposa, California	Bell 222	destroyed	1 minor
The previous flight had been terminated because of sparks from the right engine. After takeoff in day VMC for a ferry flight, the right-engine temperature increased quickly, and the pilot shut down the right engine. The helicopter descended, struck a tree, then struck terrain. Examination of the right engine revealed extensive heat damage to the gas-turbine wheel with 20 percent to 30 percent deterioration of all blades.				
June 15, 1992	Fort Bragg, North Carolina	Aerospatiale AS 355F	substantial	4 uninjured
The pilot observed the engine-fire light and smoke in the cabin and conducted an emergency landing at a nearby airport. Inspection revealed that the oil-supply line for the bearing was blocked with carbon and that the rear bearing in the no. 3 module had failed. The engine-start fuel valve, located above the engine starter/generator, began leaking fuel because of a loss of torque on connecting bolts caused by engine vibration. Inspection showed that there had been a fire in the no. 1 engine compartment that originated near the starter/generator.				

Appendix
Commercial EMS Helicopter Accidents and Incidents In the United States, 1987–2000 *(continued)*

Date	Location	Helicopter Type	Helicopter Damage	Injuries
June 20, 1992	Middletown, Connecticut	MBB BK 117	destroyed	1 fatal, 3 serious
The helicopter struck an unmarked static wire 105 feet above the ground, 0.25 mile (0.4 kilometer) south of the landing area. Witnesses said that the night was dark and fog was forming. The pilot had not made a reconnaissance flight and had not said that he had identified the landing area, which was filled with numerous emergency vehicles with red and blue flashing lights. Neither the pilot nor the hospital communication coordinator had requested hazard information about the area.				
June 28, 1992	Scipio, Utah	Bell 222UT	substantial	3 uninjured
The helicopter encountered clear air turbulence while en route to pick up a patient. The helicopter's nose pitched up rapidly to about 20 degrees, activating the emergency locator transmitter (ELT). The pilot felt feedback through the controls and landed to reset the ELT. Later, the pilot observed mast-torque fluctuations and a zero reading on the gauge. A post-flight inspection showed that the transmission had contacted its mounts, severing several electrical leads, including the torque sensor.				
Sept. 2, 1992	Bayfield, Colorado	Bell 206L-3	substantial	3 serious
While attempting to land in day VMC in rough, rocky mountainous terrain at a pressure altitude of 9,803 feet, loss of tail-rotor effectiveness occurred, and the helicopter descended rapidly and struck rocks. The helicopter was being operated in a performance-limited portion of the hover-performance chart.				
Sept. 19, 1992	Phoenix, Arizona	MBB BK 117B-1	minor	3 uninjured
The aircraft began settling rapidly during landing in day VMC. The pilot noticed the N_2 (engine high-pressure rotor) unwinding. A hard landing resulted.				
Dec. 11, 1992	Aguila, Arizona	MBB BK 117B-1	minor	1 uninjured
In day VMC, a medical ambulance was driven under the helicopter to unload a patient. The helicopter rotor blade struck the antenna on the ambulance.				
Jan. 31, 1993	Chino, California	Bell 412	minor	5 uninjured
On climb-out in night VMC, the helicopter struck an electrical power line. The pilot conducted a precautionary landing, and the patients were transferred to another helicopter.				
May 27, 1993	Cameron, Missouri	Aerospatiale AS 350B	destroyed	2 fatal, 2 serious
The helicopter was en route in day VMC with a patient when the nurse heard a loud "pop," followed by a clattering and a horn alarm. The helicopter struck terrain in a field. Witnesses said that the wind was strong and gusty from the south. The engine had lost power because of failure of the labyrinth seal in the second-stage turbine-nozzle guide vane.				
June 6, 1993	Saint Mary's, Pennsylvania	Aerospatiale SA 365	minor	4 uninjured
The helicopter began an uncontrolled turn to the left after engine start, then lifted off the platform in night VMC. The pilot returned the helicopter to the pad and shut down the engines.				
June 20, 1993	West Monroe, Louisiana	Bell 206L-3	substantial	3 minor
The helicopter struck high-tension power lines in day IMC while on initial climb from the median of an interstate highway after picking up a patient who had been in an automobile accident. The weather was reported as 500 feet overcast, with four miles (6.5 kilometers) visibility in fog and rain showers.				
Nov. 19, 1993	Portland, Maine	Bell 206L-1	destroyed	3 fatal, 1 serious
The pilot departed on a night flight with 310 pounds (141 kilograms) of fuel. He said that fuel consumption was about 200 pounds to 220 pounds (91 kilograms to 100 kilograms) per hour and that the 97-nautical mile (180-kilometer) flight normally took less than one hour. The pilot encountered IMC and a 40-knot to 60-knot head wind. As the pilot was being vectored to the airport, the engine lost power. He ditched the helicopter into rough seas seven miles (11 kilometers) east of the airport. The company operations manual says, "The minimum acceptable weather is in VFR conditions."				
Feb. 1, 1994	Caro, Michigan	MBB BO 105S	minor	2 uninjured
The hospital recently had designated part of a circular driveway area for helicopter landings; this flight was to be the first to use the new site. Before touchdown in night IMC, the pilot was told to land elsewhere. He established a hover about 10 feet AGL at the original landing site while assessing the alternate site. The rotors blew snow, which partially obscured the pilot's view, and a paramedic crewmember grabbed his arm and told him to watch out for a light pole. The pilot was distracted; the helicopter struck a light assembly, damaging the rotor blades.				
March 4, 1994	Indianapolis, Indiana	MBB BK 117A-3	minor	1 uninjured
On a positioning flight in night VMC, the helicopter lost an engine cowling after the latches opened in flight.				

Appendix
Commercial EMS Helicopter Accidents and Incidents In the United States, 1987–2000 *(continued)*

Date	Location	Helicopter Type	Helicopter Damage	Injuries
April 22, 1994	Bluefield, Virginia	Bell 412	destroyed	4 fatal

The pilot was told to maintain 7,000 feet until established on an ILS approach in day IMC. Recorded radar data show that the helicopter did not intercept the localizer and that the last recorded position was about five miles (eight kilometers) southwest of the airport at 4,100 feet. The accident site was on a mountain 7.5 miles (12 kilometers) southwest of the airport at 3,400 feet. A witness said that the mountain was obscured by fog.

June 23, 1994	Amarillo, Texas	Aerospatiale AS 350B	minor	4 uninjured

The helicopter struck a wire during takeoff from a highway in day VMC. The pilot landed the helicopter immediately. Damage was found on the main rotors.

July 9, 1994	Granite, Colorado	Aerospatiale AS 350B	destroyed	2 fatal, 3 minor

The helicopter was dispatched in day VMC to pick up an injured hiker on a 14,000-foot mountain. Terrain at the pickup point was about 12,200 feet with a 35-degree slope. Ground rescue personnel said that the pilot told them that he would place the helicopter's right skid on the mountain slope to allow them to load the patient on the downhill side. As the helicopter hovered above them, the main-rotor blades struck rocks, and the helicopter tumbled 800 feet (244 meters) down the mountain.

Aug. 9, 1994	Stateline, Nevada	Aerospatiale SA 316B	substantial	3 minor

The helicopter was en route in dark-night VMC to pick up an auto-accident victim. The pilot terminated the approach about 200 feet AGL (7,400 feet), lowered the collective and descended vertically. A rapid rate of descent developed, which the pilot was unable to arrest, and the helicopter landed hard. Density altitude was 9,500 feet.

Aug. 19, 1994	Albert Lea, Minnesota	Bell 230	substantial	4 uninjured

The pilot was maneuvering the helicopter in day VMC to land on the airport ramp to pick up a patient from a waiting ambulance. To avoid overflying trees, a hangar and an untied airplane, the pilot conducted a steep approach at low airspeed while side-slipping the helicopter to maintain alignment on a track of 175 degrees. When the pilot adjusted the collective to slow the rate of descent and the rate of closure, the revolutions per minute (rpm) dropped, the helicopter made an unusual noise and the airframe shuddered. The pilot attempted to conduct a running landing to a grassy area next to the intended landing site. The helicopter landed hard and bounced twice. A fire consumed the top of the cabin. Winds were from 310 degrees at 15 knots, gusting to 20 knots.

Aug. 30, 1994	Fitchburg, Wisconsin	Bell 206L-1	minor	4 uninjured

The pilot continued flight into deteriorating day IMC conditions, and the helicopter struck an object.

Nov. 22, 1994	Lincoln, Nebraska	MBB BK 117	none	4 uninjured

After the chip-detector light illuminated in flight in day VMC, the pilot landed the helicopter at the nearest airport.

Dec. 1, 1994	Ann Arbor, Michigan	Agusta A109	destroyed	3 fatal

The helicopter had been airborne in day VMC for two minutes when the pilot requested landing permission, saying, "I'd like to proceed inbound ... single-engine landing, please." He immediately canceled the request and said, "I'm going down at this time." He told the dispatcher his intended landing position and, about 25 seconds later, said that impact with terrain was imminent. Investigation revealed that neither engine was operating; no mechanical reason for the loss of engine power or the need for an engine shutdown was determined. Damage to the rotor indicated that rpm was low at the time of impact.

Dec. 13, 1994	Topeka, Kansas	Bell 206L-1	none	3 uninjured

The helicopter experienced rotor problems and hydraulic problems after departure in night VMC. The pilot conducted a precautionary landing in a field.

Dec. 20, 1994	Pittsburgh, Pennsylvania	Aerospatiale AS 355	none	4 uninjured

The pilot heard a loud bang en route in night VMC and diverted. The cargo doors had separated from the helicopter. The doors were not secured prior to flight.

March 7, 1995	Portland, Oregon	Bell 230	substantial	2 uninjured

The pilot said that, while landing in day VMC at the hospital heliport, about three feet to four feet above touchdown, he felt an impact from the tail area and severe vibrations. He rolled both throttles off and completed a landing from a low hover. The tail rotor had struck a heliport perimeter fence. The pilot said that the fence had an approximate four-inch (10-centimeter) gap at mid-span. The tail-rotor guard had slipped into the gap, resulting in contact between the tail rotor and the fence.

April 10, 1995	Glastonbury, Connecticut	MBB MK 117A-1	none	4 uninjured

In day VMC, while practicing confined-area landings in conjunction with flight-nurse training, the aircraft sustained a puncture in the rear fuel bladder from an unseen object. Everyone on board smelled fuel. The pilot began a shallow approach to an open field. During the approach, the flight nurse reported fuel on the back window and smoke trailing the helicopter. During the landing, the pilot observed fuel drops on the windshield. The pilot landed the helicopter and everyone on board evacuated.

Appendix
Commercial EMS Helicopter Accidents and Incidents In the United States, 1987–2000 *(continued)*

Date	Location	Helicopter Type	Helicopter Damage	Injuries
May 31, 1995	Lost Hills, California	Eurocopter AS 355F1	substantial	3 uninjured

On a dark, moonless night in VMC, the helicopter was being flown to a sparsely populated area without ground-reference lights to pick up a patient. Fire department personnel had illuminated a landing site with two fire trucks. The pilot said that he flew over the area and began the approach from 300 feet. He said that he became spatially disoriented and lost visual reference with the ground while looking at his instruments to correct a high rate of descent and low airspeed. The helicopter pitched nose-down, but the pilot stabilized the helicopter just before touching down hard. The aircraft bounced 20 feet to 30 feet, rolled to the left and struck terrain.

Date	Location	Helicopter Type	Helicopter Damage	Injuries
June 21, 1995	Des Moines, Iowa	Bell 222UT	substantial	3 uninjured

The pilot said that after takeoff in night VMC, the helicopter yawed. The nurse and paramedic said that they heard a pop, and the no. 1 engine-out indicator light illuminated. The pilot reduced the throttle to flight idle and turned the helicopter toward the airport to land. The pilot said that the no. 1 engine-fire indicator light illuminated, and he discharged the fire-extinguisher bottle. The pilot conducted an emergency landing. The engine-air-inlet duct on the left engine had collapsed internally because of delamination.

Date	Location	Helicopter Type	Helicopter Damage	Injuries
July 12, 1995	Fordland, Missouri	Bell 206L-1	none	3 uninjured

During an emergency medical services (EMS) ferry flight in day VMC, the bendix shaft failed, causing a loss of torque. The pilot conducted an off-field landing.

Date	Location	Helicopter Type	Helicopter Damage	Injuries
Aug. 7, 1995	Montgomery, Alabama	Bell UH-1H	substantial	6 uninjured

The pilot was conducting an approach in day VMC when the main-rotor blades contacted trees.

Date	Location	Helicopter Type	Helicopter Damage	Injuries
Aug. 26, 1995	Pittsford, New York	Bell 206L-1	none	3 uninjured

The chip-detector light illuminated during the flight in day VMC, and the pilot diverted to the nearest airport. The patient was transported by ground ambulance.

Date	Location	Helicopter Type	Helicopter Damage	Injuries
Aug. 27, 1995	Oklahoma City, Oklahoma	Bell 206L-1	substantial	4 uninjured

After landing the helicopter in day VMC on the roof helipad, the pilot was told that the hospital elevator was inoperative, and the stairway would not accommodate the medical equipment. During the subsequent takeoff, the engine lost power, and the pilot began an autorotation. Below the helicopter were a full parking lot, a street and trees. The pilot said that he flared the helicopter over the trees, lowered the pitch and applied forward cyclic in an attempt to regain rpm and airspeed. The helicopter touched down in an uneven field and skidded 30 yards (27 meters). The company reported a low-side governor failure as the cause of the power loss.

Date	Location	Helicopter Type	Helicopter Damage	Injuries
Sept. 11, 1995	Winslow, Washington	Agusta A109A II	destroyed	3 fatal

Witnesses said that the helicopter was flying low over the ground, and over water in night IMC toward a nearby island. The helicopter struck the water and sank. Some witnesses said that the engines sounded normal before the accident, but others reported a popping sound from the engines.

Date	Location	Helicopter Type	Helicopter Damage	Injuries
Sept. 14, 1995	Houston, Texas	MBB BO 105C	destroyed	3 uninjured

The pilot said that, during cruise flight at 800 feet in day VMC, he heard an unusual whine from the engines and then a loud snap and felt severe vibrations. After determining that a dual engine failure had occurred, the pilot observed the no. 1 engine-fire warning light illuminate and smelled smoke. The pilot began an autorotation to a shopping mall parking lot. The helicopter touched down and slid 200 feet (61 meters) to a stop. When the nurse opened the door, smoke billowed into the cabin from the tunnel area. Examination of the helicopter revealed that the drive shaft for the left engine had separated from the transmission-input-shaft flange. Examination of the main-transmission lower housing revealed debris partially blocking the oil channel for the left side input pinion. Both engines experienced internal thermal damage and foreign object damage.

Date	Location	Helicopter Type	Helicopter Damage	Injuries
Sept. 20, 1995	Ware, Illinois	Bell 206L	substantial	2 minor, 1 uninjured

At the time of departure, the ceiling was 1,900 feet and visibility was four miles (6.4 kilometers). The destination was an automobile-accident scene 25 miles (40 kilometers) away. The pilot said that, after the night takeoff, the helicopter flew through small clouds, and he decided to terminate the flight. He initiated a left turn and encountered IMC. The pilot said that he tried to transition to instruments but that he was unable to make the transition before he lost control of the helicopter. The pilot was unable to regain control before ground impact.

Date	Location	Helicopter Type	Helicopter Damage	Injuries
Oct. 29, 1995	Tampa, Florida	MBB BO 105A	minor	2 uninjured

The helicopter was on approach to a hospital helipad in night VMC when the pilot smelled fuel. A post-flight investigation revealed that a supply-fuel-tank hose clamp had failed.

Date	Location	Helicopter Type	Helicopter Damage	Injuries
Dec. 7, 1995	Carlsbad, Texas	Aerospatiale AS 365	minor	3 uninjured

The helicopter departed in day VMC to pick up a patient involved in an accident. After landing at the scene, the tail rotor struck a mesquite tree.

Date	Location	Helicopter Type	Helicopter Damage	Injuries
Dec. 28, 1995	Chicago, Illinois	Aerospatiale AS 365	none	4 uninjured

The no. 2 engine gas-generator gauge fluctuated during flight in day VMC. The pilot declared an emergency and conducted a precautionary landing.

Appendix
Commercial EMS Helicopter Accidents and Incidents In the United States, 1987–2000 *(continued)*

Date	Location	Helicopter Type	Helicopter Damage	Injuries
Feb. 19, 1996	Surprise, Arizona	MBB BO 105C	minor	3 uninjured

While the pilot attempted to land in night VMC to pick up an accident victim, the helicopter tail rotor struck a wire. A police officer on the ground had advised that there were no wires.

March 25, 1996	Springtown, Texas	Bell 222U	minor	3 uninjured

The pilot was attempting to land the helicopter on a highway in day VMC when the main rotors struck an electrical power line.

May 14, 1996	Oklahoma City, Oklahoma	Bell 206L-1	none	1 uninjured

The transmission chip light prompted the pilot to conduct two precautionary landings in day VMC. No foreign material was found on the plug.

June 12, 1996	Pittsburgh, Pennsylvania	MBB BK 117B-1	minor	3 uninjured

The pilot was flying a shallow approach to a hospital heliport in night VMC. The pilot decreased the approach angle, and as the helicopter neared the landing pad, the pilot flared and felt the heels of the skids touch first and slide slightly. The pilot found damage to the tail stinger and vertical end plate, which had grazed a pole near the helipad.

June 13, 1996	Madison, South Dakota	Bell 206L-1	none	3 uninjured

The engine was replaced because of metal particles found on the chip detector. A maintenance flight check was conducted and the aircraft was returned to service. On the next flight, in day VMC, the oil fluctuated and a chip light illuminated. The pilot made a precautionary landing and shut down the engine.

June 21, 1996	Cleveland, Ohio	Sikorsky S-76	none	3 uninjured

The no. 2 engine failed during flight in day VMC. The pilot diverted the helicopter to the nearest airport and landed. The starter generator's drive seal was leaking.

July 28, 1996	Oceanside, California	Bell 222U	minor	3 uninjured

In day VMC, the main-rotor blades struck the upper deflector of the helicopter's wire-strike protection system.

Oct. 20, 1996	Rockwall, Texas	Bell 222U	minor	4 uninjured

An unauthorized vehicle struck the tail stinger at an on-scene operation while the helicopter was being prepared for takeoff in day VMC.

Nov. 7, 1996	Jersey Shore, Pennsylvania	Aerospatiale SA 365	minor	3 uninjured

On approach in day VMC to an approved landing site to pick up an aeromedical patient, the right engine cowling separated from the aircraft and struck a rotor blade and the upper fenestron (a type of tail rotor). An investigation revealed a worn latch.

Nov. 13, 1996	Rock Rapids, Iowa	Bell 222U	minor	5 uninjured

During cruise flight in night VMC at 2,500 feet, the left engine failed. The right engine would not produce sufficient power to continue flight, so an autorotation was made into a farm field.

Nov. 22, 1996	Tampa, Florida	MBB BO-105-A	minor	3 uninjured

During hover takeoff in day VMC, the no. 2 engine failed, and parts from the engine separated from the helicopter. The helicopter was landed safely. The first-stage turbine wheel had failed.

Dec. 12, 1996	Penn Yan, New York	MBB BO 105 CBS	destroyed	3 fatal

After takeoff in night IMC from an open field, the pilot radioed the company dispatcher that the helicopter was airborne and to stand by for his report on time and distance to the destination. The distance was to be obtained from a global positioning system (GPS) receiver on the rear of the helicopter's center console. Two minutes later, the helicopter struck terrain in a secluded wooded area on rising ground about 1.1 miles (1.8 kilometers) northwest of the departure point. Witnesses said that no horizon was discernable in the night darkness. Winds were strong and gusty. The area was near rising terrain with peaks at 2,700 feet; the accident occurred at 1,740 feet, with cloud cover between 1,900 feet and 2,000 feet.

Feb. 20, 1997	Medina, Ohio	Sikorsky S-76	none	2 uninjured

During cruise flight in day VMC, the no. 2 engine oil pressure fluctuated. The engine was slowed to flight idle, and the oil pressure continued to decrease into the yellow arc. The engine was secured, and shutdown was completed. A precautionary landing was conducted at the nearest airport.

March 5, 1997	Washington, Pennsylvania	Aerospatiale AS 355	substantial	1 minor

The pilot conducted a test flight after a maintenance technician changed the cyclic lateral servo. After completing the flight, the pilot began a takeoff to reposition the helicopter to the hospital helipad. The helicopter was in a three-foot to four-foot hover in day VMC when it began to roll left. The pilot attempted to correct for a perceived crosswind, but the left roll continued. The helicopter struck the ground on its left side. The accident report said that the hydraulic servos apparently had undergone maintenance and did not meet manufacturer's specifications.

Appendix
Commercial EMS Helicopter Accidents and Incidents In the United States, 1987–2000 *(continued)*

Date	Location	Helicopter Type	Helicopter Damage	Injuries
March 14, 1997	Lena, Louisiana	MBB BO 105S	destroyed	1 fatal, 1 serious

During a dark-night flight, the pilot descended to 500 feet because of weather and followed a highway. The pilot slowed the helicopter to 70 knots. The medical crewmember said that he felt "a shudder, like the shudder as the helicopter decelerates through effective translational lift." He heard the pilot say an expletive and felt the helicopter turn left as he saw sparks overhead and felt Plexiglas hit him. The helicopter struck the ground. The company operations manual says that the cross-country VFR minimum ceiling at night is 1,000 feet and minimum visibility is three miles (five kilometers). The medical crewmember said that the ceiling was about 550 feet to 600 feet, and visibility was about two miles (3.2 kilometers).

Date	Location	Helicopter Type	Helicopter Damage	Injuries
April 30, 1997	Kane, Pennsylvania	MBB BK 117A-1	substantial	4 uninjured

The helicopter struck the ground during landing at a hospital helipad in day VMC. The windsock indicated winds of three knots to five knots from the west/southwest. Because of obstacles, the pilot descended vertically to the helipad. As the pilot attempted to stop the descent rate at 50 feet AGL, the helicopter shuddered with the application of additional power. The helicopter yawed right. Additional collective pitch did not slow the rate of descent; instead, the rate of descent increased, and the pilot said, "We're settling in, guys." At touchdown, all remaining collective pitch was applied. The pilot said that he reduced the collective to stop the yaw rate; the helicopter stopped after turning 180 degrees.

Date	Location	Helicopter Type	Helicopter Damage	Injuries
May 9, 1997	Reno, Nevada	MDD MD-900	minor	3 uninjured

During an approach in day VMC to a medical-center heliport, the pilot observed that the helicopter hovered nose-low. A post-flight inspection revealed that the adjustable collective-drive-link assembly had failed. Subsequently, a service bulletin and an airworthiness directive were issued.

Date	Location	Helicopter Type	Helicopter Damage	Injuries
June 4, 1997	Clay, New York	Bell 206L-1	minor	2 uninjured

The helicopter cut a cable-television wire while being flown in day VMC.

Date	Location	Helicopter Type	Helicopter Damage	Injuries
Aug. 19, 1997	Florence, South Carolina	MBB BK 117A-3	minor	1 uninjured

In day VMC, the aircraft struck a bird, which shattered the aft greenhouse after penetrating the windscreen.

Date	Location	Helicopter Type	Helicopter Damage	Injuries
Aug. 26, 1997	Hawley, Minnesota	Bell 222U	minor	2 uninjured

The helicopter struck a wire in day VMC while on approach to an automobile-accident site. A medical crewmember shouted "wire," and the pilot initiated a go-around. The pilot did not know whether the helicopter actually struck the wire; nevertheless, he flew the helicopter back to the hospital pad.

Date	Location	Helicopter Type	Helicopter Damage	Injuries
Sept. 15, 1997	Salt Lake City, Utah	Bell 206L-3	minor	4 uninjured

In day VMC, while the helicopter was lifting off from a helipad in a right turn, the tail rotor struck a parked ambulance. The pilot immediately returned the helicopter to the pad.

Date	Location	Helicopter Type	Helicopter Damage	Injuries
Dec. 14, 1997	Littleton, Colorado	Bell 407	destroyed	4 fatal

The helicopter arrived from the northeast at the scene of an automobile accident and circled the site clockwise before landing. After a takeoff in night VMC with the patient on board, the pilot began a right turn. The helicopter struck power lines. Company landing-zone departure procedures were to climb straight ahead in a near-vertical climb to a minimum of 300 feet AGL before turning.

Date	Location	Helicopter Type	Helicopter Damage	Injuries
Jan. 11, 1998	Sandy, Utah	Bell 222UT	destroyed	4 fatal

The helicopter was dispatched in night IMC to transport a skier injured in an avalanche. Snow was not falling when the helicopter departed the hospital, but there were gusty winds and snow when the helicopter arrived at the landing zone. The dispatcher telephoned the pilot to advise him that hospital weather conditions had deteriorated. A sheriff's deputy said that the helicopter took off from the landing zone in blizzard conditions and circled, then turned and disappeared from view. Seconds later, a deputy heard "a slight muffled boom." The wreckage was found on mountainous terrain.

Date	Location	Helicopter Type	Helicopter Damage	Injuries
April 25, 1998	Wellsboro, Pennsylvania	Aerospatiale SA 365	minor	3 uninjured

The belly panel separated from the helicopter during flight in day VMC. The panel was never found.

Date	Location	Helicopter Type	Helicopter Damage	Injuries
May 10, 1998	Jackson, Ohio	MBB BK 117A-1	minor	4 uninjured

In night VMC, the left-side engine cover separated from the aircraft and struck the rotor blades.

Date	Location	Helicopter Type	Helicopter Damage	Injuries
May 24, 1998	Springdale, Arkansas	Bell 206L-3	substantial	3 serious

Shortly after the helicopter lifted off in day VMC from a hospital helipad to pick up a patient, the engine lost power. The helicopter descended into a parking lot, landed hard and rolled onto its right side. Disassembly of the engine revealed that both the N_1 (low-pressure rotor) and the N_2 shafts had separated. Coke deposits were found on the inside diameter of the N_2 shaft. Metallurgical examination of the shafts determined that coke buildup consistent with reduced oil flow led to friction between the shafts. The friction produced heat that resulted in softening and failure of the shafts. The report said that maintenance personnel failed to assemble properly the engine's accessory gearbox; that failure resulted in a partial blockage of the main oil passage by an O-ring.

Date	Location	Helicopter Type	Helicopter Damage	Injuries
June 5, 1998	La Gloria, Texas	Eurocopter AS 350BA	destroyed	3 fatal

The helicopter was being flown in dark-night IMC to pick up a traffic-accident victim. The aircraft was observed on radar at 1,800 feet, about two miles from the traffic-accident site. The helicopter struck trees while in a left turn, with a nose-low attitude. A witness said that visibility was less than one mile (1.6 kilometers) because of smoke from forest fires.

Appendix
Commercial EMS Helicopter Accidents and Incidents In the United States, 1987–2000 *(continued)*

Date	Location	Helicopter Type	Helicopter Damage	Injuries
July 29, 1998	Tranquility, California	Bell 222B	substantial	3 uninjured

The helicopter was dispatched in night VMC to pick up two victims of an automobile accident. The pilot made three high orbits of the landing site before the approach. Before touchdown, the helicopter was engulfed in dust. While the pilot was climbing the helicopter out of the dust, the right wheel touched down, and the helicopter rolled over.

Aug. 20, 1998	Spencer, Iowa	Bell 222	destroyed	3 fatal

The helicopter was en route in night VMC for a patient transfer. The pilot maintained 130 knots airspeed on a direct course at 2,500 feet to 3,000 feet. While in cruise descent, the aircraft experienced an in-flight break-up. Examination of the swash plate outer-ring assembly revealed that the flats of the swash plate pinheads were causing wear on the inside surface of the swash plate ring. The maintenance manual says that no wear or movement of the pin should be permitted.

Aug. 28, 1998	Topeka, Kansas	MBB BK 117	substantial	3 uninjured

The helicopter was being flown in day VMC to obtain engine-matching-adjustment measurements after installation of a new no. 1 engine. The pilot said that there was a severe bump when the helicopter was about two miles from the airport, followed by a bang, a yaw and violent oscillations. The helicopter rotated to the right, descended and struck terrain. An investigation showed that the no. 1 engine cowling had separated during flight, damaging the main-rotor blades and resulting in an imbalance and in the loss of the tail-rotor gear box. A service bulletin had addressed removing and modifying latches of the access doors, but the actions were not incorporated on the accident helicopter.

Nov. 29, 1998	Idaho City, Idaho	MDD MD-900	substantial	4 uninjured

The helicopter was dispatched in dark-night VMC to pick up a traffic-accident victim in a remote canyon. Before landing, the pilot asked ground crewmembers about wires and was told that there were none. After landing, the pilot used a flashlight to check for obstructions in the direction of takeoff. The pilot observed no obstructions except trees and then conducted a vertical takeoff because of the narrowness of the canyon. At about 150 feet, the pilot rotated the helicopter forward and at approximately 20 knots, the crew heard a loud noise and saw a bright white light. The helicopter had struck unmarked transmission lines. Because of risks in attempting to land again at the scene, the pilot completed the flight and conducted a normal landing at the hospital with the patient and crew.

Dec. 13, 1998	San Angelo, Texas	Aerospatiale AS 350BA	substantial	2 uninjured

On the previous flight, the director of operations had conducted a check ride; the last maneuver was a hydraulics-off maneuver. On the accident flight in night VMC, a newly hired pilot conducted a hydraulic-system-off landing, then the pilot-in-command took the controls for a normal takeoff. The helicopter rolled left, and the main rotors struck the ground. The pilot rolled the engine throttles off and righted the helicopter on its skids before the helicopter stopped. The new-hire pilot said that he saw the hydraulic light flicker, and the pilot-in-command said that a hydraulic hardover had caused the helicopter to roll. Maintenance records showed that the hydraulic-drive-belt assembly had been replaced Dec. 10, 1998.

Feb. 12, 1999	Toledo, Ohio	Aerospatiale AS 355	substantial	3 serious

While the helicopter was being flown at night to a hospital, dispatch told the pilot that snow prevented seeing across the ramp. A company pilot suggested that he climb and execute a very-high-frequency omnidirectional radio (VOR) approach, but — without an autopilot and with only a basic instrument package — the accident pilot rejected that option. Instead, the pilot initiated a descent to land in an open area. Between 300 feet AGL and 75 feet AGL, the helicopter entered IMC. The pilot declared an emergency and continued to descend. At about 60 feet AGL, the pilot saw a 50-foot to 60-foot tree. The pilot applied aft cyclic, and the helicopter impacted the tree, continued to descend and struck a house. The helicopter came to rest upright and partially in the house.

Feb. 13, 1999	Hockley, Texas	Eurocopter BK 117B-1	substantial	5 uninjured

Two helicopters were dispatched in day VMC to the scene of an automobile accident. During the approach, the accident pilot observed power lines parallel to the road. After the patients were loaded, the pilot of the other helicopter conducted a "safety walk-around" for the departing helicopter. He watched the helicopter lift up and drift toward the power lines, where the main-rotor blades contacted the wires. The accident pilot said that, during the takeoff, he observed "trash blowing around" and "the sun … shining directly into the windscreen." The pilot felt a slight shudder but no loss of control and set the helicopter back down in a field adjacent to the road.

April 4, 1999	Indian Springs, Nevada	MBB BO 105	destroyed	3 fatal

Night IMC prevailed for the helicopter's repositioning flight after delivering a patient to a hospital. The weather had deteriorated, with freezing rain that turned to wet snow and freezing sleet. The helicopter was seen using its spotlight to follow the highway at about 150 feet to 200 feet. Visibility had decreased to about 50 feet when witnesses heard the sound of the impact. The aircraft was not certified for instrument flight. The pilot had completed inadvertent-IMC training within the previous 90 days.

April 11, 1999	Sarasota, Florida	MBB BK 117	substantial	3 uninjured

The pilot lifted the helicopter into a hover facing south in day VMC and called ATC for departure clearance. The controller asked the pilot to hold for landing traffic, then asked the pilot if he could see the landing traffic. The pilot moved the helicopter to the east looking for traffic. He then heard a thud and felt a thud, followed a second later by three more thuds. The helicopter drifted back, and the tail rotor contacted a hangar.

May 15, 1999	Rockton, Illinois	Bell 222	substantial	3 uninjured

The pilot flew the helicopter to a temporary landing zone in a freshly plowed field for a landing in night VMC. The pilot oriented his approach angle off the bright lights from the emergency vehicles and a ground guide with two light wands. The helicopter landed hard, damaging the nose cowl, landing skids and tail boom.

Appendix
Commercial EMS Helicopter Accidents and Incidents In the United States, 1987–2000 *(continued)*

Date	Location	Helicopter Type	Helicopter Damage	Injuries
June 14, 1999	Jackson, Kentucky	Sikorsky S-76A	destroyed	4 fatal

Soon after the pilot reported leaving 1,600 feet for 4,000 feet in night IMC, ATC asked the pilot to report altitude, but this transmission and subsequent transmissions were not answered. Visibility was reported as less than 0.25 mile (403 meters). Another witness heard the helicopter flying behind a hill and then heard a pop from that direction. The helicopter struck rising terrain on a tree-covered slope.

July 17, 1999	Fresno, Texas	MBB BK-117	destroyed	3 fatal

The helicopter was being flown in day VMC to pick up a patient for transfer to a hospital when it struck terrain about 40 miles (64 kilometers) from the hospital. Witnesses said that the helicopter was being flown parallel to a highway and appeared to begin a left turn when pieces “shot out” from the top of the helicopter. The helicopter descended in a nose-low attitude behind trees and struck terrain. All four main-rotor blades separated from the main-rotor hub.

Aug. 10, 1999	Cape Girardeau, Missouri	Bell 206L	substantial	3 uninjured

The auxiliary-power cord was attached to the helicopter when the pilot began to take off in day VMC from a hospital helipad. The helicopter yawed left and pitched down at the edge of the fourth-floor helipad. The pilot landed the helicopter on a street, and the tail boom struck a brick wall.

Sept. 10, 1999	Kenansville, Florida	MBB BO 105	substantial	3 serious

The helicopter was flown at night to a motor-vehicle accident on a highway. The crew encountered ground fog en route but saw lights of the emergency vehicles and descended from 1,000 feet to 700 feet to fly over the accident scene. About 300 feet above the ground, the pilot applied collective control and engine power, but the helicopter continued to descend. The helicopter struck trees and rolled onto its right side. The pilot observed no warning lights or anomalies before the accident.

Nov. 17, 1999	Neihart, Montana	Bell 206L-1	substantial	4 uninjured

The helicopter was flown in day VMC to a ski resort to pick up a patient. After the patient was loaded and weight and balance were calculated, the pilot prepared for departure. The pilot observed periodic wind gusts of five knots to 15 knots. He said that, because of trees, he turned the nose of the helicopter 45 degrees to 50 degrees to the left, hovered to an open area and departed downslope, building speed and altitude. After the helicopter moved about 20 feet to 30 feet, the pilot felt the tail of the helicopter abruptly rotate left. The pilot applied left pedal, but that did not stop the rotation. The pilot applied cyclic control to return to the landing zone. During the maneuver, the tail rotor struck a ski-lift tower. The pilot closed the throttle and used collective to cushion the landing. The helicopter landed hard.

Jan. 2, 2000	Kalispel, Montana	Bell 206L-3	minor	2 uninjured

In day VMC, the pilot began a takeoff from a landing zone after picking up a victim of a skiing accident. Minor damage to the tip cap resulted when the rotor blade struck a tree.

Feb. 26, 2000	Knoxville, Tennessee	Bell 412	substantial	3 uninjured

The pilot landed in night VMC at a roadside landing zone to pick up an injured patient. The slope of the terrain was steep, so he attempted to reposition the helicopter. He was looking out the left side of the helicopter at wires when he turned the tail to the right; the tail rotor struck a tree. The pilot reduced collective, and the helicopter came to rest on the skids. After contact, the tail rotor and tail-rotor gearbox separated from the helicopter. Flying debris from the separating components caused further damage to the fuselage.

March 10, 2000	Near Dalhart, Texas	Eurocopter BO 105	destroyed	4 fatal

The helicopter was met by a ground ambulance crew at a landing site in a farm field, where the patient, who was suffering from respiratory distress, was transferred. The helicopter took off for the 120-mile (193-kilometer) return flight about 0600 in dark-night IMC. Witnesses observed patchy fog in the area. About 0.25 inch (6.4 millimeters) of ice had formed on vehicle mirrors and antennas. When the helicopter was late arriving, another crew was dispatched in the hospital’s other helicopter to search. The crew observed wreckage in a field about 1045, as police arrived at the scene.

April 14, 2000	St. Paul, Minnesota	Bell 222	substantial	2 uninjured

The helicopter was being flown in day VMC to a downtown airport after a patient drop-off. The pilot said that about halfway to the airport, he felt two thuds in the cyclic control in the aft direction. He turned for a downwind traffic-pattern entry. At 800 feet to 900 feet, the helicopter pitched into a severe nose-high attitude. The cyclic stick “harded over” to the full-aft position, and the pilot was unable to move any flight controls except the pedals. The helicopter climbed and dived, and the cyclic moved on its own. The pilot struggled to keep the controls centered. He realized that the helicopter would not clear the power lines, so he applied full-left pedal and placed the helicopter on the roof of a two-story building.

April 25, 2000	St. Petersburg, Florida	MBB BK 117	destroyed	3 fatal

After transporting a patient to a medical center, the helicopter was being flown in day VMC on an eight-minute flight to the hospital operating base. The pilot flew a newly established route, developed in response to noise complaints from residents along the previous, more direct, route. A witness said that the helicopter was being flown at about 500 feet AGL when it collided with a radio transmission tower guy wire. The helicopter continued flying several hundred feet before striking a mangrove tree.

Appendix
Commercial EMS Helicopter Accidents and Incidents In the United States, 1987–2000 *(continued)*

Date	Location	Helicopter Type	Helicopter Damage	Injuries
May 6, 2000	Cincinnati, Ohio	Eurocopter BK 117A-4	substantial	1 serious

The pilot was completing his sixth flight of the night in VMC. He had refueled and was returning the helicopter to the hospital without the medical crew on board. He initiated his approach to the west side landing area from the southwest and observed the windsock indicating a light wind from the southwest. The pilot said that, after the helicopter crossed the edge of the landing area and was almost in a hover, he heard a loud noise from the rear, the left rudder pedal pushed rearward and the nose moved to the right. The pilot recognized a loss of tail-rotor thrust and closed the power levers. The helicopter struck the ground upright with both engines running. Examination of the windsock revealed that the end was caught on a crossbar attached to the windsock support structure. When the windsock was freed, it extended straight out.

July 16, 2000	Allen, Texas	MBB BK 117A-3	substantial	3 uninjured

While hovering in ground effect during an approach in night VMC, the pilot attempted to move away from obstacles surrounding the landing location. When the pilot began a pedal turn to face EMS units behind the helicopter, the tail rotor struck trees. As the helicopter began to spin, the pilot lowered the collective and landed hard.

July 24, 2000	Sumner, Georgia	Eurocopter AS 350B	destroyed	3 fatal

The helicopter was being flown in night VMC back to a hospital after transporting a patient to another hospital. About 0227, the pilot established radio contact with the dispatcher and reported a GPS location. No further transmissions were received from the pilot. When the flight failed to arrive at its final destination, a search was initiated; the helicopter was found at 0850 in a swampy, wooded area. The helicopter had struck trees.

July 28, 2000	Minneapolis, Minnesota	Bell 222U	substantial	1 uninjured

At 1140, the helicopter lifted off from a hospital helipad in VMC for a repositioning flight, and the tail rotor struck a light. The pilot landed on the helipad and shut down the engines.

Oct. 14, 2000	Grand Canyon, Arizona	Bell 206L-1	substantial	1 minor

The helicopter was departing in day VMC from an accident scene with a patient who had been injured in a fall. The pilot said that the helicopter rotated to the right at 80 feet AGL to 100 feet AGL and that he applied full left pedal to stop the rotation. The helicopter continued to rotate and descended into trees.

Oct. 16, 2000	Burlington, North Carolina	Aerospatiale AS 355	destroyed	1 fatal

The main transmission had been installed after overhaul three days before the accident. About four minutes before landing at a medical center in night VMC, the main-transmission oil-pressure warning light illuminated. The pilot landed the helicopter. A maintenance technician found no excessive oil leaks and disconnected the wire from the transmission-oil-pressure switch; the warning light extinguished. The crew performed a ground run and hover check, then departed. Witnesses heard the helicopter flying at what appeared to be a low altitude. The helicopter made a steady drone and a low-velocity thumping noise. The helicopter struck trees, and a fire erupted. A post-accident inspection showed that the gears in the combiner gearbox were damaged and that the transmission-oil-pump drive shaft was separated near the midspan.

Nov. 13, 2000	Parumph, Nevada	MBB BO 105	substantial	3 uninjured

The helicopter had been flown in night VMC to a landing site on a rural road to pick up a patient. Ground personnel had illuminated the site with headlights from an ambulance and told the helicopter crew by radio that there was no wind and that there were no wires obstructing the site. While on the downwind leg for landing, the pilot observed a car moving toward the site and told the flight nurse to inform ground personnel. When the helicopter was on short final, the pilot observed that the car had stopped in the landing site. The pilot began a go-around at a low altitude. He observed power lines in his peripheral vision and attempted to make a climbing right turn. During the turn, the right skid contacted the ground, and the helicopter rolled onto its side.

Dec. 18, 2000	West Mifflin, Pennsylvania	Aerospatiale SA 365	substantial	2 serious, 1 uninjured

The helicopter was undergoing a 500-hour inspection after replacement of major tail-rotor components. A post-maintenance operational flight check, the fifth one, was being conducted in day VMC when a maintenance technician heard a bang, and the pilot experienced a loss of tail-rotor control. About 10 attempts were made to land. The pilot then attempted a running landing. The helicopter began a left spin with up-and-down nose oscillations and impacted the ground. The tail boom and main-rotor system broke away from the main fuselage, and the main fuselage broke in half. A post-flight inspection revealed that the fenestron and pitch-change servo-actuating-rod end were not connected to the actuating bell crank.

Dec. 22, 2000	Wilcox, Arizona	Bell 206L-3	substantial	3 minor

The helicopter departed from a medical center after delivering a patient and was being flown to its base in night VMC. The pilot felt uncomfortable when he detected an aftertaste from something he had tried to drink about two hours earlier. About five minutes from the base hospital, nausea, sweating and cramps suddenly overcame him. He said that the night was dark and moonless and that rough terrain was below him. The airport was at his 12 o'clock position at five miles, so he decided to fly there rather than to attempt an off-airport landing. About 20 feet above the touchdown point, the pilot doubled over because of severe cramping. This moved the cyclic forward and to the right. The main-rotor blades contacted the ground, and the helicopter came to rest on its side.

MBB = Messerschmitt-Bolkow-Blohm MDD = McDonnell Douglas

Source: Patrick R. Veillette, Ph.D., from reports by the U.S. National Transportation Safety Board and the U.S. Federal Aviation Administration.

Data Show That More Than Half of EMS Airplane Accidents Occur During Approach and Landing

From 1983 through 2000, 42 accidents occurred involving U.S. commercial EMS airplanes; of these, 23 occurred during approach and landing.

Patrick R. Veillette, Ph.D.

Airplanes, as well as helicopters, are used for the rapid transportation of critically ill patients to major trauma centers and the time-critical transportation of human organs and blood.

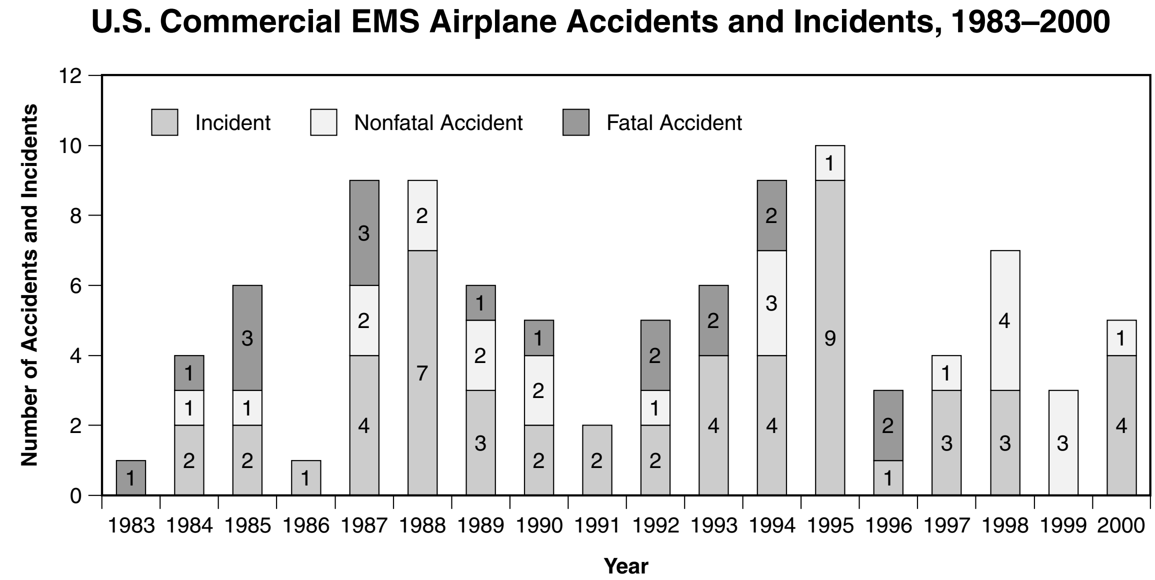
Emergency medical services (EMS) airplane operations involve many of the same challenges presented by EMS helicopter operations: Pilots often fly into remote locations surrounded by mountainous terrain, using limited navigational aids and instrument approach aids. Landings sometimes are made on unimproved surfaces, during adverse weather and/or in darkness.

From 1983 to 2000, there were 42 accidents and 53 incidents involving U.S.-registered airplanes on EMS flights within the United States. The 42 accidents included 18 fatal accidents and six serious-injury accidents. Of 153 occupants of the aircraft, 54 people were killed, 11 people were seriously injured, and 12 people received minor injuries. Nineteen aircraft were destroyed, and 20 aircraft received substantial damage (Figure 1, page 40).

To identify accident trends, the author conducted an extensive 2001 study of EMS accidents, including an analysis of U.S. National Transportation Safety Board (NTSB) reports on the 42 accidents and U.S. Federal Aviation Administration (FAA) reports on the 53 incidents (see Appendix, page 48). The study also included an analysis of 103 U.S. National Aeronautics and Space Administration Aviation Safety Reporting System (ASRS) reports on EMS airplane operations from January 1988 through December 1999; direct observation of 278 commercial EMS airplane flights for 12 months in 1998, including 122 flights as a crewmember; interviews with accident investigators, witnesses, EMS pilots, flight physicians, flight nurses and flight paramedics; on-site inspections of 50 accident sites or incident sites; and examinations of operating specifications and operating manuals.[1]

The study found that:

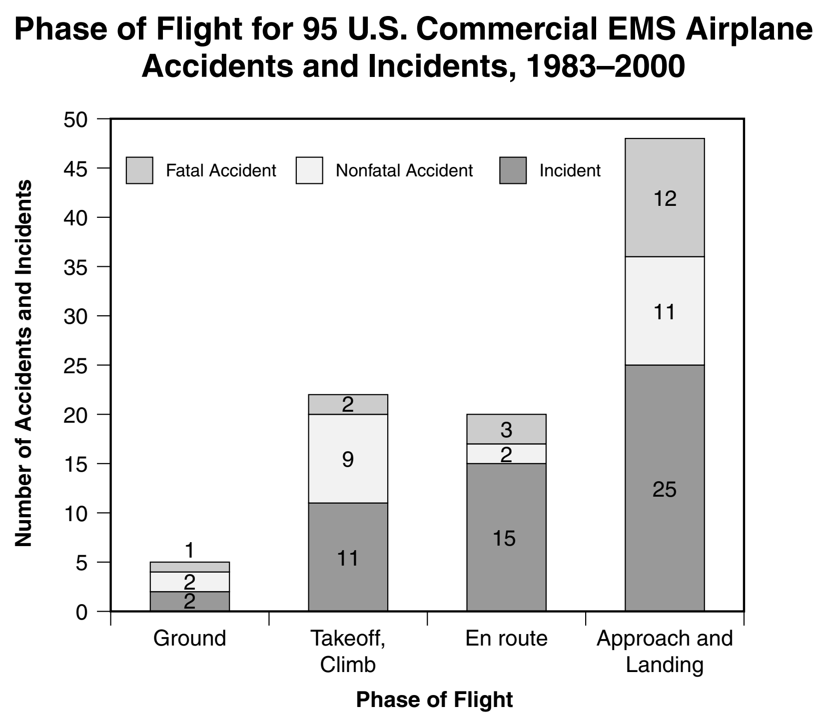
- Twenty-three of the 42 accidents (55 percent) occurred during approach and landing (Figure 2, page 40);
- Eleven accidents (26 percent) occurred during takeoff;
- Mountainous terrain was a contributing factor in 25 accidents (60 percent), including 11 fatal accidents. Sixty-one percent of all fatal accidents involved mountainous terrain;



EMS = Emergency medical services

Source: Patrick R. Veillette, Ph.D.

Figure 1



EMS = Emergency medical services

Source: Patrick R. Veillette, Ph.D.

Figure 2

- Darkness contributed to 20 accidents (48 percent), including eight fatal accidents. Forty-four percent of all fatal accidents involved darkness (Table 1, page 41);
- Twenty accidents (48 percent) involved operations from adverse runway surfaces, including surfaces that were contaminated by snow or rain and those that were occupied by uncontrolled grazing animals; and,

Table 1
Lighting Conditions During U.S. Commercial EMS Airplane Accidents and Incidents, 1983–2000

	Ground			Takeoff			En route			Approach and Landing		
	All Accidents	Fatal Accidents	Incidents	All Accidents	Fatal Accidents	Incidents	All Accidents	Fatal Accidents	Incidents	All Accidents	Fatal Accidents	Incidents
Daylight	–	–	–	3	1	6	–	–	10	6	2	17
Darkness	1	–	2	5	1	5	2	1	5	12	6	8
Unspecified	2	1	–	3	–	–	3	2	–	5	4	–
Total	**3**	**1**	**2**	**11**	**2**	**11**	**5**	**3**	**15**	**23**	**12**	**25**

EMS = Emergency medical services

Source: Patrick R. Veillette, Ph.D.

- Adverse weather (heavy snow, heavy rain or thunderstorms) contributed to 13 of the 42 accidents (31 percent), including 12 fatal accidents. Two-thirds of all fatal accidents occurred in adverse weather.

Among the 53 incidents, 35 incidents resulted in minor damage to the aircraft, and 18 incidents resulted in no damage. None of the 195 occupants was injured.

Twenty-three of the 42 accidents (55 percent), including 12 of the 18 fatal accidents (67 percent), and 25 incidents occurred during approach and landing. The 12 fatal accidents resulted in 37 fatalities (69 percent of all fatalities in EMS airplane accidents). Human error was involved in 20 of the 23 approach-and-landing accidents (ALAs [87 percent]) and in 14 of the 25 approach-and-landing incidents (56 percent) (Figure 3, page 42).

Mountainous terrain contributed to 13 ALAs and five approach-and-landing incidents. Darkness contributed to 12 ALAs and eight approach-and-landing incidents. Adverse runway conditions contributed to 11 ALAs and eight approach-and-landing incidents. (One airstrip was the scene of four ALAs and one landing incident.) Instrument meteorological conditions (IMC) contributed to 10 ALAs and four approach-and-landing incidents, and adverse weather contributed to nine ALAs (all of them fatal) and seven approach-and-landing incidents (Table 2, page 43).

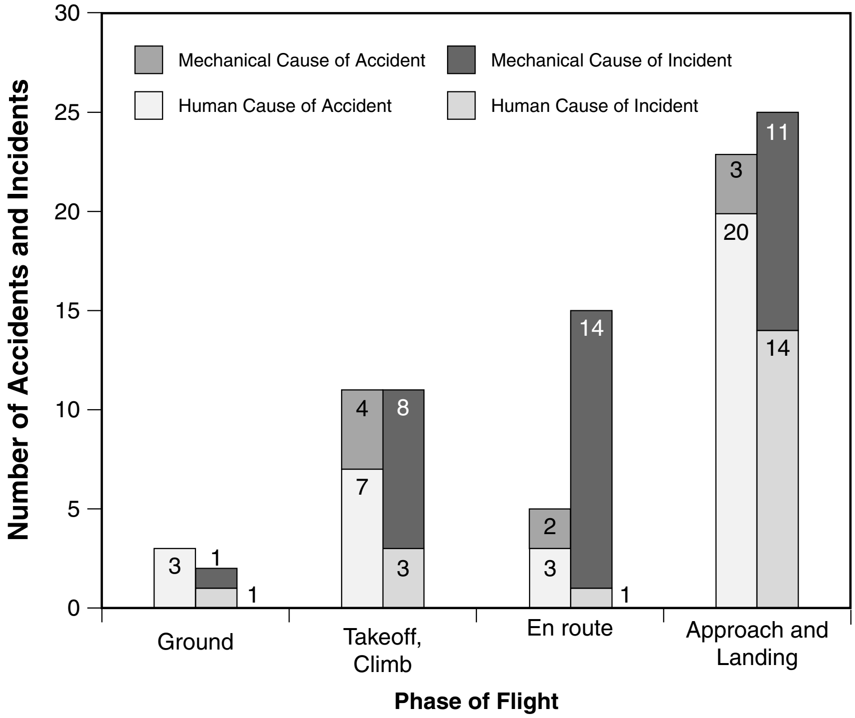
In nine of the 11 ALAs and six of the eight approach-and-landing incidents that involved adverse runway conditions, the runway surface was contaminated by rain or snow; in each instance, the conditions were reported inaccurately to the EMS pilot. Six accidents and five incidents involving adverse runway conditions occurred in darkness. Five ALAs involved inadequate runway lighting or airport lighting; five other ALAs involved uncontrolled wildlife grazing on marginally lighted, unimproved runways.

Mechanical failure caused three ALAs and 11 approach-and-landing incidents (Table 3, page 44). Nine approach-and-landing incidents involved failure of the landing-gear systems.

Eleven accidents, including two fatal accidents, and 11 incidents occurred during takeoff and initial climb. The two fatal accidents resulted in five fatalities. Seven of the takeoff accidents and three takeoff incidents resulted from human error.

Mechanical failures caused four takeoff accidents and eight takeoff incidents. Engine malfunctions occurred in three of the four takeoff accidents and three of the eight takeoff incidents. (Two takeoff accidents and two takeoff incidents were caused by engine failures during takeoff.) One takeoff accident and three takeoff incidents were caused by landing-gear malfunctions. Two incidents occurred because of flight

Involvement of Human Error and Mechanical Failure by Phase of Flight In 95 U.S. Commercial EMS Airplane Accidents and Incidents, 1983–2000



EMS = Emergency medical services

Source: Patrick R. Veillette, Ph.D.

Figure 3

control problems encountered during takeoff; both occurred after maintenance.

Other factors contributing to the takeoff accidents included mountainous terrain (seven accidents), marginal runway conditions (five accidents) and darkness (five accidents).

Five accidents and 15 incidents occurred during cruise. Two cruise accidents and 14 cruise incidents were caused by mechanical failures; all but one were without injury. The injury accident was complicated by darkness, IMC, adverse weather and mountainous terrain; three of those aboard the airplane received serious injuries, one received minor injuries, and one was uninjured. Twelve of the mechanical incidents occurred in visual meteorological conditions, and 10 occurred in daylight and were not complicated by mountainous terrain. One significant factor that helped minimize injury and damage during the cruise events involving mechanical failure was the absence of human error in resolving the mechanical problem. Sufficient time, sufficient altitude, daylight and good weather provided a lower-workload environment that helped the crew resolve the problem.

Three accidents and two incidents occurred during ground operations. One accident and two incidents involved the aircraft striking taxi lights with their propellers.

Some factors affecting pilot decision making are common to all aspects of fixed-wing aviation, such as conducting operations in adverse weather, but the unique aspects of EMS operations (including concern about the patient's condition and especially demanding communication requirements) also have an effect on the pilot decision-making process.

Seventy-five of the 103 ASRS reports (73 percent) discussed non-adherence to U.S. Federal Aviation Regulations (FARs); of these, 60 percent involved noncompliance with air traffic control (ATC) clearances, usually deviations from altitude assignments or heading assignments. Sixteen reports involved near-midair collisions, and seven reports involved runway incursions.

The following report about an event that occurred during night IMC in a mountainous region provides some insight into EMS operations:

> During the flight, the medical crew was very worried about the patient's condition. The flight crew had to initiate radio calls and relay messages between the hospital and the medical crew. As the flight progressed, the medical crew became increasingly distressed. There was a lot of noise as the blood-covered doctor yelled

Table 2
Weather Conditions During U.S. Commercial EMS Airplane Accidents and Incidents, 1983–2000

	Ground			Takeoff			En route			Approach and Landing		
	All Accidents	Fatal Accidents	Incidents	All Accidents	Fatal Accidents	Incidents	All Accidents	Fatal Accidents	Incidents	All Accidents	Fatal Accidents	Incidents
VMC	1	–	2	7	1	10	–	–	12	11	2	21
IMC, MVFR	–	–	–	2	1	1	2	1	3	10	8	4
Unspecified	2	1	–	2	–	–	3	2	–	2	2	–
Total	**3**	**1**	**2**	**11**	**2**	**11**	**5**	**3**	**15**	**23**	**12**	**25**

EMS = Emergency medical services VMC = Visual meteorological conditions IMC = Instrument meteorological conditions MVFR = Marginal visual flight rules weather conditions

Source: Patrick Veillette, Ph.D.

instructions to the nurses. This was distracting to the flight crew. Approximately 20 minutes prior to landing, our destination [airport] went below landing minimums. The first officer was taking care of all ATC communications, and I was talking to the company and the hospital on the other radio. The first officer told me that we were cleared from FL 210 [Flight Level 210] to 14,000 feet. We began descent and accomplished the in-range checklist. Passing FL 180, we set altimeters to 29.89. The radio traffic became very busy now, as we tried to coordinate our plans with the hospital. A nurse came forward to the cockpit to discuss options with the hospital. Our destination was then changed from Anchorage to Elmendorf AFB [Air Force Base]. The first officer then copied the Elmendorf ATIS [automatic terminal information system], while I requested permission to land from base operations. We leveled at 14,000 feet, and I asked the first officer to read the ATIS to me. When the first officer read the local altimeter setting as 28.89, I asked him to recheck the ATIS while I listened. I reset my altimeter and climbed back up to 14,000 feet. I asked the first officer to notify ATC of our intentions and to turn off all non-ATC communication radios. We proceeded to Elmendorf and landed.

Post flight: When I asked the first officer how he could have missed the low altimeter setting, he replied the ATIS lacked the normal phraseology. Contributing factors: Fatigue — the first officer was out of his normal sleep cycle. He was filling in while the full-time night … first officer was on time off. We had flown several nights before, and the first officer said that he hadn't done well with all of the schedule swapping. I also had not slept more than several hours in the previous day or so. Although we were legal to fly, as the FARs are concerned, we were fatigued. Phraseology — I learned in a conversation later that day with an ATC controller that the use of the phrase "altimeter low low" is no longer required with reporting abnormally low altimeter settings. I believe that, if the first officer had heard "low low," this altitude deviation would not have happened. Aircraft configuration — The communication radios used by the medical team are in the cockpit. The medical crewmember must kneel between the pilot seats, talk on a hand mike and listen on the overhead speaker. This system works quite well normally, but during times of high cockpit workload, it can be very distracting. We, of course, only allow this kind of communication to go on above 10,000 feet. There is no cockpit door to isolate the flight crew from the noise and chaos that happens in the back of the airplane during a medical emergency.[2]

Fifty ASRS reports involved distractions (Figure 4, page 44). Of these, 15 were a result of mechanical malfunctions, 14 were a result of a patient's condition; nine reports involved distractions caused by rapidly changing weather; five

continued on page 45

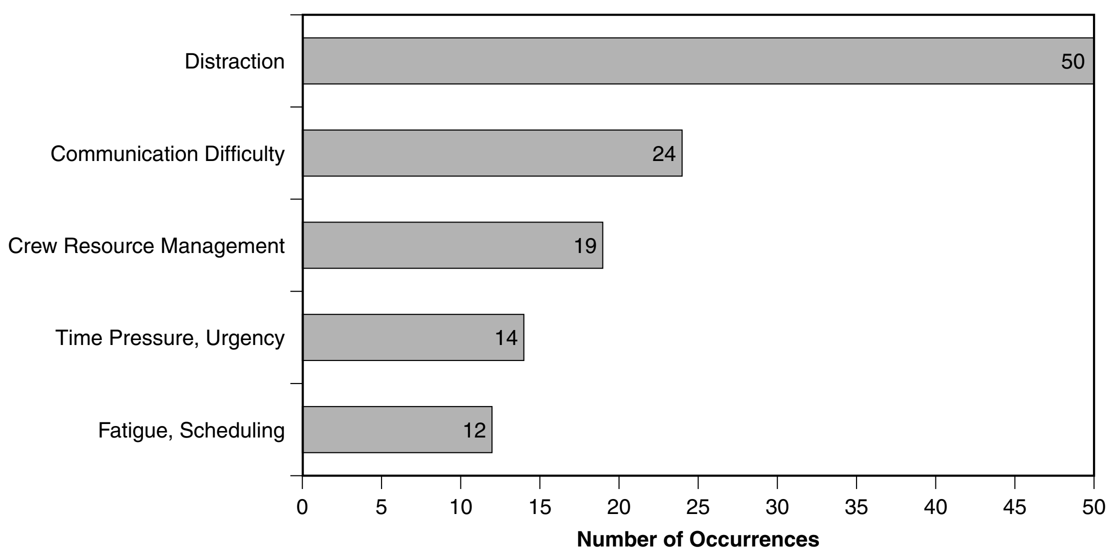
Table 3
Mechanical Failures Involved in U.S. Commercial EMS Airplane Accidents and Incidents, 1983–2000

	Taxi	Takeoff	En route	Approach and Landing
Engine				
Incidents	–	3	7	1
Nonfatal accidents	–	3	1	–
Fatal accidents	–	–	–	–
Landing gear, brakes, tires				
Incidents	–	3	–	9
Nonfatal accidents	–	1	–	1
Fatal accidents	–	–	–	–
Flight control				
Incidents	–	2	–	–
Nonfatal accidents	–	–	1	–
Fatal accidents	–	–	–	–
Door, door seals				
Incidents	–	–	3	–
Nonfatal accidents	–	–	–	–
Fatal accidents	–	–	–	–
Other				
Incidents	1	–	4	1
Nonfatal accidents	–	–	–	1
Fatal accidents	–	–	–	1

EMS = Emergency medical services

Source: Patrick R. Veillette, Ph.D.

Human Error Factors Cited In U.S. Commercial EMS Airplane Events Reported to NASA ASRS 1988–1999



Note: Some reports involved more than one contributing factor.
EMS = Emergency medical services
NASA ASRS = U.S. National Aeronautics and Space Administration Aviation Safety Reporting System

Source: Patrick R. Veillette, Ph.D.

Figure 4

involved monitoring multiple radio frequencies; four involved monitoring other traffic; and three involved navigational programming duties.

In 18 of the 42 accidents, a patient was on board; 14 of those accidents involved faulty pilot decision making.

The following ASRS report describes how a patient's condition influenced the decision-making process:

> The flight was conducted using the "Lifeguard" designation. The forecasted weather indicated visibility on the order of 1/2-[mile] to 1/4-mile [805 meters to 403 meters] in fog. Prior to departing en route to Salt Lake [City, Utah], I made checks of the weather trends, current surface analysis and forecasts for the area. The updates indicated that the RVR [runway visual range] at Salt Lake was fluctuating between 1,800 feet and 3,500 feet [549 meters and 1,068 meters] and holding to those values, with en route weather being clear. Approximately 30 minutes out, I was advised by the medical team in the aircraft that the patient was in a time-critical condition and that an undelayed arrival into Salt Lake was urgently needed. I advised Salt Lake Center of patient status. Upon being vectored for the ILS [instrument landing system] 34L approach, the reported RVR was at 800 feet [244 meters], 800 feet, and 600 feet [183 meters]. I advised ATC that I would need to "take a look" at the approach, with the following factors in mind: 1) FARs provide for deviations from the minimums to meet emergency requirements. 2) The ILS 34L approach is certified for Category III operations and was fully functional, to include attendant lighting and markings. 3) I was confident in my ability to safely conduct the approach. 4) I was fully prepared to make a missed approach, regardless of any medical problem if adequate forward visibility for landing and rollout was not available. 5) The aircraft was equipped with a fully functioning flight director system and a radar altimeter. 6) I have well in excess of 100 hours PIC [pilot-in-command] time in type. The approach and landing were accomplished without incident or problem.[3]

ATC Handbook 7110.65 states that aircraft with Lifeguard call signs will be given priority handling. Thirteen ASRS reports involved problems with obtaining priority handling from ATC and deviations from ATC clearances to expedite the transfer of patients.

In seven ASRS reports, a patient's condition had worsened so much that the pilots chose to operate from closed airports in violation of FARs. In six instances, pilots conducted takeoffs or landings below the prescribed minimums — actions that can result in enforcement action from FAA.

One recommendation from the 1988 NTSB study of commercial EMS helicopter safety was to develop procedures to isolate flight operation decisions from medical decisions.[4] A 1995 NASA study that analyzed EMS reports submitted to ASRS between 1986 and 1991 found that EMS pilots continued to indicate that there was a lack of isolation from medical decisions. The study found that isolation may not be a realistic goal when a pilot observes the medical staff's anxiety and expressions of urgency, both in speech and nonverbal signs.[5]

Critical information regarding runway conditions was not transmitted to pilots in 14 accidents — nine involving contaminated runway surface conditions and five involving uncontrolled wildlife grazing on marginally lighted and unimproved runways.

Twenty-four ASRS reports involved communication problems, including 20 instances in which pilots did not comply with ATC clearances and deviated from assigned altitudes or assigned courses.

Seven ASRS reports involved problems obtaining accurate weather information.

Nineteen reports involved problems with crew resource management. Thirteen reports described situations involving an adverse cockpit authority gradient (a situation that can exist when a relatively inexperienced captain is paired with a more experienced co-pilot or when a captain's experience, stature and authority far exceed the experience, stature and authority of a relatively new co-pilot.)

One pilot discussed such a problem in this ASRS report:

> I was dispatched to fly a Lifeguard trip. First, I am a new employee with the company, type rated as a captain Part 135, riding as a first officer with the company chief pilot. The chief pilot takes care of all flight planning and filing of plan without any discussion with myself. Later I found that the captain is filing as … [having area navigation (RNAV) capability] when the aircraft … [has no RNAV]. Therefore, we cannot accept any clearance direct via RNAV. I found this out only after we had accepted several clearances and were unable to comply, sometimes missing our waypoint by as much as 30 nm [nautical miles (56 kilometers)]. Second, about 250 nm [463 kilometers] from our destination airport, center stated a clearance to descend to FL 370. At this point, the captain took the radio away and refused to descend, based on the idea that we were a Learjet and should receive better handling from ATC. Some 50 miles [93 kilometers] later and [after] about 15 minutes of arguing with ATC, [the captain] finally complied. My situation is this: I mentioned to the captain about the aircraft not having an RNAV and told him that the flight plan was a violation. I also mentioned and asked him not to argue with ATC and please don't [refuse to] comply with their request unless there is an emergency. His reply to this is that he is the captain,

I am the co-pilot, and not to concern myself with his job. To me, this completely defeats the purpose of a two-pilot crew. I am in a serious situation here, being a new hire and flying with the chief pilot. As a young pilot, I have run into this experience several times in my aviation career. I feel that more attention should be given to the training of the captain-first officer as a team and not a student-instructor relationship.[6]

Fourteen ASRS reports involved time pressure caused by rapid flight preparation, which is characteristic of EMS operations, including the two reports from which these excerpts were taken:

Failed to remove rudder lock during preflight. Recognized situation after liftoff from Runway 32. Requested to return for landing on Runway 6L. Accomplished normal landing without incident. Cause: Medevac [medical evacuation] flight that was rushed to get off the ground. Preflight inspection was incomplete.[7]

Flying on a Lifeguard flight, we took off on Runway 35L. After takeoff, the tower asked us if we had a takeoff clearance, and we said that we thought so. … I'm not positive whether or not we had a takeoff clearance. Contributing factors include the urgency of a Lifeguard flight.[8]

The extent to which rapid flight preparation — and the accompanying sense of urgency — was involved in accidents is unknown, but six NTSB accident reports involving EMS airplane operations included indications of rapid flight preparation and a sense of urgency.

Pilots of EMS airplanes and EMS helicopters experience the same effects from 24-hour operations and rotating shifts. Twelve ASRS EMS airplane reports involved problems with pilot fatigue and crew scheduling.

Figure 5 and Figure 6 show the time of day at which some accidents and incidents occurred. The greatest concentrations of incidents (28 incidents, or 54 percent) occurred during the two consecutive four-hour periods (1001 to 1800 hours) that comprise the typical workday. The greatest concentration of accidents (five accidents, or 28 percent) however, occurred during the single four-hour period from 0201 local time to 0600 local time.

Darkness contributed to 20 accidents (48 percent) and 20 incidents (38 percent). Twelve ALAs, eight approach-and-landing incidents, five takeoff accidents and five takeoff incidents occurred in darkness. Twenty-four ASRS reports (23 percent) also involved events that occurred in darkness.

Table 2 (page 43) shows the frequency of IMC accidents in various phases of flight. Fourteen accidents (33 percent) and eight incidents (15 percent) occurred in IMC. Ten IMC-related accidents (24 percent of all accidents), including eight fatal accidents (44 percent of all fatal accidents), occurred during approach and landing. Twenty-nine ASRS reports (28 percent) involved events that occurred in IMC.

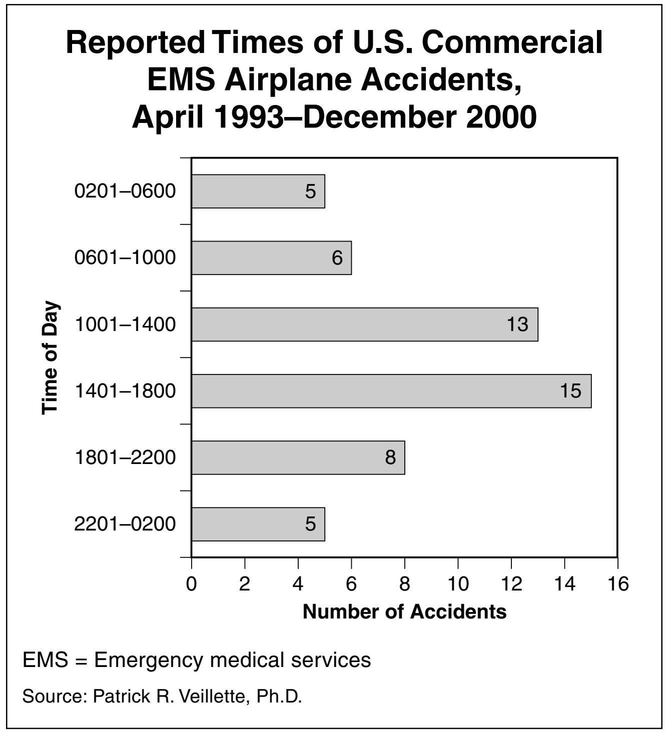


Figure 5

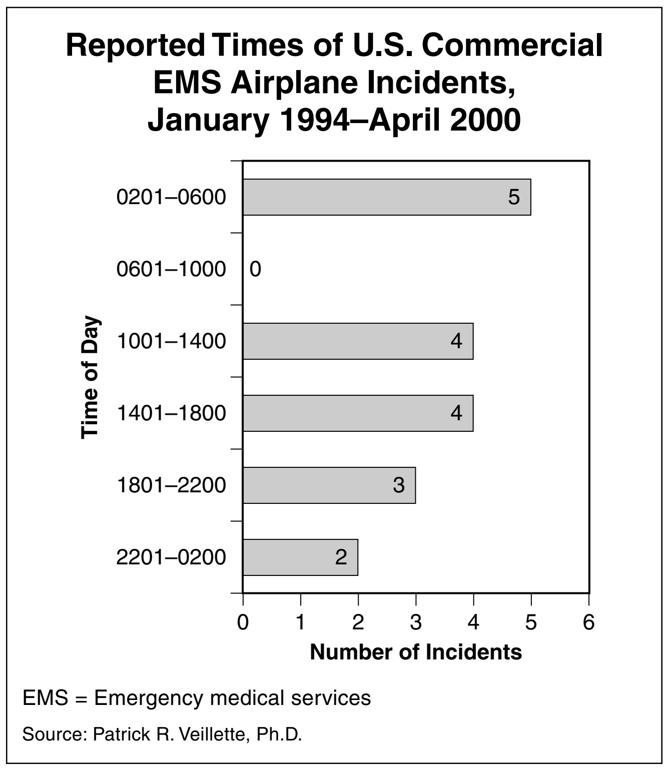


Figure 6

Improper execution of instrument approach procedures was involved in seven accidents, all of them fatal. Six of those accidents occurred in mountainous terrain. Five of the seven accident aircraft were flown by single-pilot crews; two aircraft had two-pilot crews. Five of these accidents occurred in IMC, and five accidents occurred in darkness. Three of the aircraft were powered by turboprop engines, two had reciprocating engines, and two had turbojet engines.

EMS airplane pilots who submitted reports to ASRS from 1988 through 1999 had an average of 3,696 flight hours; pilots involved in incidents in the FAA incident database from 1984 through 2000 had an average of 3,219 flight hours. Three NTSB accident reports indicated that pilot experience was a contributing factor to the accident.

Thirteen ASRS reports involved problems with low experience and qualifications of the second-in-command, necessitating some form of intervention and extra guidance from the pilot-in-command and causing a distraction within the cockpit.

Of the 103 EMS airplane reports submitted to ASRS, 41 reports (40 percent) involved turbojet aircraft, 32 reports (31 percent) involved turboprop aircraft, and 30 reports (29 percent) involved reciprocating-engine aircraft. Fifty-seven of the aircraft (55 percent) were operated with two-pilot crews. Of 53 EMS airplane incidents in the FAA database, eight incidents (15 percent) involved turbojet aircraft, 17 incidents (32 percent) involved turboprop aircraft, and 28 incidents (53 percent) involved reciprocating-engine aircraft. Thirty-seven incident aircraft (70 percent) were operated by single-pilot crews. Of 42 accidents in the NTSB accident database, four accidents (10 percent) involved turbojet-powered aircraft, 16 accidents (38 percent) involved turboprop-powered aircraft, and 22 accidents (52 percent) involved reciprocating-engine aircraft. Thirty-four accident aircraft (81 percent) were operated by single-pilot crews.♦

Maj. Stephen E. Wood, U.S. Air Force Reserve; Phyllis Upchurch, chief pilot, Air Med, and captain, Learjet, Citation, IA Jet; and Matthew McNamara, first officer, Canadair Regional Jet CL-65, contributed to the research and preparation of this report.

About the Author

Patrick R. Veillette, Ph.D., a professional pilot with more than 13,000 flight hours, is a Boeing 727 first officer for a U.S. air carrier. He formerly flew emergency medical services fixed-wing operations, aerial fire fighting operations and charter-aircraft flight operations; investigated failure modes, weaknesses and performance capabilities of aircraft involved in accidents and was an accident investigator for the U.S. Department of Agriculture. Veillette received a bachelor's degree in aeronautical engineering from the U.S. Air Force Academy and a doctorate in civil engineering from the University of Utah and studied accident investigation on the undergraduate level and the graduate level. He has conducted numerous research projects on flight deck 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.

Notes and References

1. The NASA ASRS is a confidential incident-reporting system. The ASRS Program Overview said, "Pilots, air traffic controllers, flight attendants, mechanics, ground personnel and others involved in aviation operations submit reports to the ASRS when they are involved in, or observe, an incident or situation in which aviation safety was compromised. … ASRS de-identifies reports before entering them into the incident database. All personal and organizational names are removed. Dates, times, and related information, which could be used to infer an identify, are either generalized or eliminated."

   ASRS acknowledges that its data have certain limitations. ASRS Directline (December 1998) said, "Reporters to ASRS may introduce biases that result from a greater tendency to report serious events than minor ones; from organizational and geographic influences; and from many other factors. All of these potential influences reduce the confidence that can be attached to statistical findings based on ASRS data. However, the proportions of consistently reported incidents to ASRS, such as altitude deviations, have been remarkably stable over many years. Therefore, users of ASRS may presume that incident reports drawn from a time interval of several or more years will reflect patterns that are broadly representative of the total universe of aviation-safety incidents of that type."

2. NASA ASRS. Report no. 226133. November 1992.

3. NASA ASRS. Report no. 200718. January 1992.

4. U.S. National Transportation Safety Board. *Commercial Emergency Medical Service Helicopter Operations*. NTSB/SS-88/01. Washington, D.C., U.S., 1988.

5. Connell, L.J.; Reynard, W.D. "Incident Reports Highlight Hazards in EMS Helicopter Operations." *Helicopter Safety* Volume 21(July–August 1995).

6. NASA ASRS. Report no. 273825. June 1994.

7. NASA ASRS. Report no. 241366. May 1993.

8. NASA ASRS. Report no. 163015. November 1990.

Appendix
Commercial EMS Airplane Accidents and Incidents In the United States, 1983–2000

Date	Location	Airplane Type	Airplane Damage	Injuries
Dec. 9, 1983	Put-in-Bay, Ohio	Cessna 207	substantial	4 fatal

The pilot and three medical personnel took off in the airplane on a dark night for an over-water flight to an island in Lake Erie to provide medical assistance to a heart patient. No record of a weather briefing was found. Sheriff's personnel received a radio call from the airplane that said, "We are in it." Witnesses said that there was patchy fog in the area. When the airplane did not arrive at its destination, a search began. The airplane was found along the planned route.

Date	Location	Airplane Type	Airplane Damage	Injuries
Jan. 18, 1984	Honolulu, Hawaii	Cessna 402	minor	2 uninjured

In day visual meteorological conditions (VMC), the pilot inadvertently retracted the landing gear on the landing rollout.

Date	Location	Airplane Type	Airplane Damage	Injuries
Feb. 16, 1984	San Carlos, California	Cessna 414	minor	4 uninjured

The engine surged during the takeoff roll in night VMC. The right tire failed after the pilot rejected the takeoff.

Date	Location	Airplane Type	Airplane Damage	Injuries
March 30, 1984	Parkersburg, West Virginia	Piper PA-34-200T	none	2 fatal, 2 uninjured

The pilot conducted an unscheduled landing because of the medical condition of the patient. The airplane was turned off the taxiway into the grass and stopped. Rescue personnel found the pilot collapsed over the controls because of a heart attack; the nurse was administering cardiopulmonary resuscitation to the patient. Both the pilot and the patient died.

Date	Location	Airplane Type	Airplane Damage	Injuries
Nov. 5, 1984	Denver, Colorado	Piper PA-34-200T	substantial	5 uninjured

The pilot was taxiing the airplane when a small truck approached from the right about 50 feet (15 meters) away. After realizing that the vehicle driver did not see the airplane, the pilot stopped. The truck driver said that he stopped before crossing the taxiway, saw only an airliner about 600 feet (183 meters) away and proceeded across the taxiway. The driver of a second truck recalled seeing the airplane with taxi and navigation lights on.

Date	Location	Airplane Type	Airplane Damage	Injuries
Feb. 9, 1985	Central Point, Oregon	Gulfstream 680F	destroyed	4 fatal

The pilot reported loss of power from both engines during descent to landing and declared an emergency. Seven seconds later, the pilot said, "Gonna hit it." Witnesses saw the airplane gliding, with wings level, toward the runway. The sound of an engine revving was heard, and the airplane pitched up and rolled left to an inverted position. The aircraft exploded on impact. An investigation showed no engine malfunction or fuel system malfunction. The airplane had experienced a power loss after descending from 15,500 feet to 12,000 feet one week earlier with the same pilot. After about 1 1/2 minutes, power was restored.

Date	Location	Airplane Type	Airplane Damage	Injuries
April 19, 1985	Tuba City, Arizona	Cessna U206G	destroyed	6 fatal

Weather conditions were described as marginal for the early morning flight in darkness. The airplane was being returned to the departure airport when it descended into desert terrain 10 miles (16 kilometers) from the airport.

Date	Location	Airplane Type	Airplane Damage	Injuries
Aug. 28, 1985	Seattle, Washington	Cessna 414	minor	2 uninjured

In night VMC, the crew was unable to extend the left-main landing gear. The pilot landed the airplane with the landing gear up. The landing gear had been caught in the wheel well because of a faulty gear bearing.

Date	Location	Airplane Type	Airplane Damage	Injuries
Oct. 10, 1985	St. Joseph, Missouri	Cessna 414	none	3 uninjured

During cruise flight in day VMC, the occupants heard a thump, then observed a decrease in manifold pressure and oil pressure in one engine. The pilot shut down the engine and conducted a precautionary landing.

Date	Location	Airplane Type	Airplane Damage	Injuries
Oct. 22, 1985	Juneau, Alaska	Learjet 24D	destroyed	4 fatal

Arriving at an airport to pick up a patient, the pilot was cleared for a localizer-type directional aid (LDA) approach in night instrument meteorological conditions (IMC). The pilot should have flown southeast toward the very-high-frequency omnidirectional radio-tactical air navigation (VORTAC), intercepted the localizer and tracked the localizer inbound. The pilot reported that the airplane was inbound while descending through 9,500 feet. The airplane impacted a mountainside at 3,500 feet MSL. No pre-impact mechanical malfunction was found. There was evidence that both navigation devices were set to the localizer frequency, but the distance-measuring equipment (DME) control head had been left inadvertently in the "hold" position, locking the DME to the incorrect navigation aid.

Date	Location	Airplane Type	Airplane Damage	Injuries
Dec. 12, 1985	Omaha, Nebraska	Piper PA-32-300	substantial	2 serious, 2 minor

The airplane was climbing through 2,800 feet when the pilot retarded the throttle to climb power, and the engine lost power. The pilot selected an open field for a forced landing, but the airplane collided with trees during the approach. An inspection revealed four broken teeth on the crankshaft drive gear. A medical patient who was being transported on an unapproved litter installed in place of the middle seats and rear seats struck the back of the right-front seat during the accident and was injured.

Date	Location	Airplane Type	Airplane Damage	Injuries
July 25, 1986	Louisville, Kentucky	Beech BE58	minor	3 uninjured

During landing in day VMC, the propeller blades struck the runway. The pilot applied power, extended the landing gear, and made a safe landing.

Date	Location	Airplane Type	Airplane Damage	Injuries
Feb. 20, 1987	Flagstaff, Arizona	Cessna 441	destroyed	2 fatal

The airplane was being flown in snow in night IMC to transport a maternity patient. The pilot began a VOR approach, reported problems with his avionics and decided to conduct a missed approach. During the missed approach, he said that he lost the inverter, then the gyros. Radar vectors were being provided when he said, "We have a big problem here." Radio contact and radar contact were lost, and the airplane struck terrain seven miles (11 kilometers) from the airport. On the previous flight, the co-pilot's attitude indicator had malfunctioned, and the pilot took off before the problem was corrected. The pilot did not have the company-required experience in the aircraft type.

Appendix
Commercial EMS Airplane Accidents and Incidents In the United States, 1983–2000 *(continued)*

Date	Location	Airplane Type	Airplane Damage	Injuries
March 13, 1987	Chinle, Arizona	Cessna 414	substantial	1 minor, 2 uninjured

The pilot said that the runway lights on one side of the runway were inoperative and that he made an approach in night VMC to the wrong side of the lights that were operative. When he realized that the airplane was not aligned with the runway, he initiated a go-around. The airplane collided with a fence beside the runway and struck terrain.

Date	Location	Airplane Type	Airplane Damage	Injuries
March 27, 1987	Eagle, Colorado	Learjet 24	destroyed	3 fatal

After refueling, the airplane was diverted to pick up a patient. Radar service was terminated after the controller cleared the aircraft for an LDA approach in night VMC. The last radio contact occurred when the crew replied, "We're eight [minutes] to 10 [minutes] out, and it's clear ahead." The airplane struck an 8,022-foot mountaintop while in the approach configuration. The pilot was believed to have been circling to land in dark-night conditions.

Date	Location	Airplane Type	Airplane Damage	Injuries
June 21, 1987	Bridgeport, California	Rockwell 690	destroyed	2 fatal

Dark-night VMC prevailed, and the destination airport was in a mountain valley where the only ground-reference lights were in the town adjacent to the airport. Witnesses saw the airplane fly over the town and the airport at pattern altitude, then fly over a lake north of the airport. About one mile (1.6 kilometers) from the runway, the aircraft pitched up, rolled inverted and dived into the lake. The aircraft was heading away from the only ground reference lights and was over a reflective body of water near the base-turn point when the accident occurred. Witnesses heard increased engine noise and propeller noise before impact. The pilot was on the fourth night of his shift cycle and was giving flight instruction during the day.

Date	Location	Airplane Type	Airplane Damage	Injuries
July 15, 1987	Honolulu, Hawaii	Cessna 414	minor	4 uninjured

Upon approach for landing in day VMC, an unsafe-nose-gear indication occurred. Manual gear extension was used. The nose gear collapsed on rollout.

Date	Location	Airplane Type	Airplane Damage	Injuries
July 28, 1987	Cuba, New Mexico	Cessna 414	substantial	3 uninjured

The aircraft was dispatched to pick up a critically ill patient. The state police blocked a section of highway for landing. The pilot landed the airplane on the highway, but during the landing roll, the underside of the right wing struck a road-marker post. The pilot believed that the damage was minor and continued the mission. Later, two U.S. Federal Aviation Administration (FAA) inspectors re-examined the aircraft. They said that the two-inch-wide (five-centimeter-wide) tear in the right aileron constituted substantial damage.

Date	Location	Airplane Type	Airplane Damage	Injuries
Aug. 24, 1987	Cedar City, Utah	Piper PA-34-200T	none	5 uninjured

Oil was observed coming from the engine cowling and the airplane was flown in day VMC back to the departure airport. Cylinder push rods and rocker arms were replaced.

Date	Location	Airplane Type	Airplane Damage	Injuries
Oct. 27, 1987	Fresno, California	Mitsubishi MU-2B	none	5 uninjured

In day VMC, the landing gear failed to extend for landing, and the emergency extension system was used to lower the landing gear. An inspection found a broken wire at the gear-down solenoid.

Date	Location	Airplane Type	Airplane Damage	Injuries
Oct. 29, 1987	Chinle, Arizona	Cessna T210	minor	2 uninjured

In day VMC, the pilot was unable to stop the airplane on the wet dirt runway because of inadequate braking. The airplane ran off the runway and struck a gate.

Date	Location	Airplane Type	Airplane Damage	Injuries
Feb. 18, 1988	Fresno, California	Piper PA-31-350	none	3 uninjured

The airplane encountered severe turbulence during flight in day IMC. The turbulence increased the patient's pain, and the pilot conducted a precautionary landing.

Date	Location	Airplane Type	Airplane Damage	Injuries
March 20, 1988	Palo Alto, California	Gulfstream 690A	minor	5 uninjured

In day VMC, the airplane struck a kite flown by a child in the final approach path to the runway.

Date	Location	Airplane Type	Airplane Damage	Injuries
April 5, 1988	St. Paul, Minnesota	Beech B90	substantial	5 uninjured

The airplane was being flown in visual conditions above a solid cloud layer and sustained substantial damage during an uncommanded hard pitch-over. The pilot recovered control of the airplane, and the flight continued to its destination. Testing of the pilot's wheel-trim switch showed that the switch stuck in the closed or actuated position and did not return to the "center off" position. This occurred during temperature cycling from room temperature to below freezing and back again. The cabin heater had failed with an outside temperature of minus 26 degrees Celsius (minus 15 degrees Fahrenheit), and the cabin was cold.

Date	Location	Airplane Type	Airplane Damage	Injuries
April 21, 1988	Flagstaff, Arizona	Cessna 340	minor	3 uninjured

The pilot attempted a takeoff in day IMC, in weather that was below minimums. The left-main landing gear hit deep snow, causing the aircraft to veer off the runway. The nose gear collapsed.

Date	Location	Airplane Type	Airplane Damage	Injuries
May 2, 1988	Atlanta, Georgia	Beech 55	substantial	4 uninjured

The pilot was conducting an intersection departure in VMC when the entry door opened. The pilot lost directional control, and the airplane ran off the departure end of the runway. Examination of the door failed to disclose any mechanical problem.

Date	Location	Airplane Type	Airplane Damage	Injuries
June 16, 1988	Nashville, Tennessee	Cessna 500	none	6 uninjured

In day VMC, the airplane experienced a thermal overheat in the battery. A post-flight inspection found faulty battery installation.

Appendix
Commercial EMS Airplane Accidents and Incidents In the United States, 1983–2000 *(continued)*

Date	Location	Airplane Type	Airplane Damage	Injuries
June 17, 1988	West Palm Beach, Florida	Learjet 24	minor	3 uninjured
The pilot overshot the runway centerline during landing in day VMC. The pilot took corrective action, but the airplane floated 4,000 feet (1,120 meters) down the 7,991-foot (2,437-meter) runway and landed long with the spoilers extended. A tire failed during the rollout, and the aircraft ran 30 feet (nine meters) off the end of the runway.				
July 29, 1988	Pittsburgh, Pennsylvania	Cessna 550	none	8 uninjured
During a flight in night IMC, the crew heard a loud noise. The cabin pressure decreased, and the pilots conducted an emergency descent. The door seal had failed.				
Nov. 25, 1988	Salt Lake City, Utah	Mitsubishi MU-2	none	4 uninjured
The airplane lost rudder effectiveness after rotation. The pilot recovered control and conducted a safe emergency landing in night VMC.				
Jan. 30, 1989	Lander, Wyoming	Beech E90	substantial	5 uninjured
During the takeoff roll in night VMC, the pilot saw two deer running across the runway and rotated the airplane abruptly to avoid a collision. The pilot said that he felt a “moderate” impact and, after determining that the left-main landing gear had been damaged, diverted to Casper, Wyoming, where the airport had longer runways. After burning off excess fuel, the pilot made an intentional wheels-up landing. Post-accident investigation revealed parts of the left-main landing gear and two dead deer on the runway at Lander.				
May 23, 1989	Denver, Colorado	Beech E90	minor	4 uninjured
The airplane was landed in night VMC after the pilot observed a gear-unsafe indication.				
May 31, 1989	Tuba City, Arizona	Beech E90	substantial	4 uninjured
The pilot said that security personnel told him that there were animals on the runway. He circled in night VMC until the runway was clear. As the airplane touched down, two horses crossed the runway. The pilot attempted to go around, but the airplane collided with the animals, and the pilot rejected the go-around. The left-main landing gear collapsed, and the airplane slid to a stop. A post-accident fire was extinguished quickly.				
July 26, 1989	Springdale, Arkansas	Beech BE90	minor	4 uninjured
During a flight in night VMC, the pilot failed to check that the landing gear had been extended for landing and landed the airplane with the landing gear retracted. The amber (landing-gear-up) light was on after sliding to a stop. The landing-gear warning horn was inoperative.				
Aug. 8, 1989	Las Vegas, Nevada	Cessna 414	minor	3 uninjured
The airplane was landed in heavy rain in night VMC. While the airplane was being taxied, the windshield broke. Pits caused by the impact of loose rocks were discovered on the windshield and propellers.				
Aug. 21, 1989	Gold Beach, Oregon	Beech C90	destroyed	3 fatal
Witnesses heard the airplane circle twice before the approach. Fog had developed, and visibility was about one mile (1.6 kilometers) with cloud bases at 200 feet to 300 feet. The airplane was observed emerging from the fog in a steep left turn and descending rapidly, right of the centerline and on a one-mile final. The left-bank angle increased to near 90 degrees when the airplane’s nose dipped, and the airplane collided with a parked vehicle 150 feet (46 meters) right of centerline and 50 feet (15 meters) short of the runway.				
Feb. 9, 1990	Rapid City, South Dakota	Mitsubishi MU-2	destroyed	1 fatal, 2 serious, 2 minor
Witnesses said that after takeoff, the airplane entered an unusually steep, nose-high attitude while still at low airspeed. One witness (an airline transport pilot) said that the airplane reached an altitude of 75 feet to 100 feet and appeared to slow and enter a roll. The airplane struck terrain in a nose-down attitude, left of the runway. A coupling shaft had failed in the left engine because of fatigue, and the left propeller had feathered. The pilot failed to maintain adequate airspeed, which resulted in a loss of control.				
April 1, 1990	Boulder, Colorado	Cessna 421C	destroyed	2 fatal, 1 serious
The airplane was observed flying erratically at a low altitude before striking terrain in a residential area. Autopsies on both occupants included findings of massive traumatic injuries sustained during a struggle. The accident report said that the patient apparently planned to kill himself by jumping out of the airplane over the mountains because he believed that he had an inoperable brain tumor.				
April 30, 1990	Scottsdale, Arizona	Cessna 421	minor	3 uninjured
The pilot did not receive a nose-gear-down light when approaching to land in day VMC. The aircraft was landed with the nose landing gear retracted. Maintenance technicians found a disconnected actuating rod.				
July 15, 1990	Benton Harbor, Michigan	Learjet 24D	substantial	2 uninjured
The aircraft was being flown in night IMC to pick up human organs for transplant. The pilot conducted an instrument landing system (ILS) approach and emerged from clouds at about 1,100 feet, with about six miles (10 kilometers) visibility. He reported that the high-intensity approach lights were on full bright and affected his night vision. He was unable to see the runway surface, and the aircraft floated. The pilot was unable to stop the aircraft before running off the end of the runway.				
Dec. 6, 1990	Miami, Florida	Learjet 25B	none	4 uninjured
One engine flamed out during flight in day VMC.				
April 9, 1991	Beckley, West Virginia	Beech BE200	none	4 uninjured
The fire-warning light on the right engine illuminated during climb in night IMC. The pilot shut down the engine and returned to the airport. During landing on a wet runway, the aircraft hydroplaned and swerved off the runway.				

Appendix
Commercial EMS Airplane Accidents and Incidents In the United States, 1983–2000 *(continued)*

Date	Location	Airplane Type	Airplane Damage	Injuries
Feb. 13, 1992	Glenwood Springs, Colorado	Swearingen SA-26AT	destroyed	3 serious, 1 minor, 1 uninjured

The pilot feathered the right propeller after reporting "a bit of a problem" with the right engine. He attempted to divert to the nearest suitable airport in the mountainous terrain during dark-night conditions in a snowstorm, but after a weather briefing, he decided to return to his base. He turned the airplane to the left and re-entered IMC, and the airplane struck a mountainside on a magnetic heading of 092 degrees. The heading to the airport of intended landing was 272 degrees. Thick grease on the right-engine fuel control camshaft caused the engine to flame out.

Date	Location	Airplane Type	Airplane Damage	Injuries
Feb. 18, 1992	Oklahoma City, Oklahoma	Mitsubishi MU-2B	minor	3 uninjured

The front-right outer window separated and struck a propeller during a flight in day VMC, and the right engine flamed out. The pilot landed with the engine shut down and the propeller feathered.

Date	Location	Airplane Type	Airplane Damage	Injuries
March 5, 1992	Freeland, Michigan	Cessna 414	destroyed	3 fatal

While loading a patient and his gear in the aircraft, the aircraft tipped on its tail, forcing the tail bumper upward into the empennage. The pilot refused the offer to have a maintenance technician inspect the damage and said, "This has happened before." After takeoff, the pilot told air traffic control (ATC) that the elevator was jammed and that he was returning for landing. While maneuvering on base leg, he lost control, and the airplane struck terrain.

Date	Location	Airplane Type	Airplane Damage	Injuries
July 11, 1992	Appleton, Wisconsin	Cessna 177RG	minor	2 uninjured

In day VMC, the airplane was landed with the landing gear retracted. The landing-gear-unsafe warning horn was inoperative.

Date	Location	Airplane Type	Airplane Damage	Injuries
Dec. 29, 1992	Sioux Falls, South Dakota	Beech BE90	minor	3 uninjured

The cabin door opened during flight in day IMC and separated from the aircraft. The cabin-door-open-annunciator light bulb was burned out.

Date	Location	Airplane Type	Airplane Damage	Injuries
Dec. 31, 1992	Herlong, California	Rockwell 690B	destroyed	2 fatal

The airplane broke up while flying in an area where standing lenticular clouds had been observed. No evidence was found that the pilot obtained a weather briefing before departure. Pilots flying in the general area reported airspeed variations to their cruise speed that ranged from plus 60 knots to minus 40 knots. An in-flight weather advisory for occasional moderate turbulence was in effect. About one hour after the accident, the weather service issued a significant meteorological weather advisory (SIGMET) for severe turbulence.

Date	Location	Airplane Type	Airplane Damage	Injuries
Jan. 30, 1993	Honolulu, Hawaii	Cessna 414	minor	2 uninjured

A loud noise was heard from the landing gear after takeoff in day VMC. The nose landing gear stuck at a 45-degree angle. The pilot returned for landing. The nose gear collapsed during the rollout.

Date	Location	Airplane Type	Airplane Damage	Injuries
March 26, 1993	St. Paul, Minnesota	Cessna 404	none	4 uninjured

The right engine began to run rough during a flight in night VMC. The pilot secured the engine and returned to the departure airport for landing. The crankshaft was broken in two places.

Date	Location	Airplane Type	Airplane Damage	Injuries
April 6, 1993	Casper, Wyoming	Mitsubishi MU-2	destroyed	4 fatal

The pilot was cleared for an ILS approach in night IMC. Radar data showed the aircraft tracking and descending normally on the DME arc until it descended below radar coverage. The airplane struck the top of a ridge along the localizer centerline before reaching the outer marker. The elevation of the accident site was 5,800 feet. The crossing altitude at the outer marker was 6,700 feet.

Date	Location	Airplane Type	Airplane Damage	Injuries
July 1, 1993	San Angelo, Texas	Gulfstream 681		2 uninjured, 2 minor

During cruise flight in night VMC, the co-pilot's window failed. The pilot diverted to an en route airport and landed. Two flight nurses received minor injuries.

Date	Location	Airplane Type	Airplane Damage	Injuries
Aug. 7, 1993	Augusta, Georgia	Beech C90	destroyed	4 fatal

The pilot was cleared for an ILS approach to the destination airport. While maneuvering in day IMC for the final approach course, the flight encountered convective activity. The tower radar placed the aircraft's position 0.25 mile to 0.5 mile (0.4 kilometer to 0.8 kilometer) east of the final approach course, and ATC questioned the pilot. The pilot said that he was on the localizer. The airplane collided with trees about 1.5 miles (2.4 kilometers) northeast of the airport and 0.5 mile east of the approach course. Weather reports recorded level-four thunderstorm activity in the area.

Date	Location	Airplane Type	Airplane Damage	Injuries
Aug. 7, 1993	Honolulu, Hawaii	Cessna 414	minor	3 uninjured

The door-warning light illuminated during climb in night VMC. The door then fell from the aircraft.

Date	Location	Airplane Type	Airplane Damage	Injuries
March 12, 1994	Phoenix, Arizona	Rockwell 681	substantial	5 uninjured

During a flight in night VMC, the pilot moved the landing-gear selector switch to the "down" position, but the gear did not extend. The pilot used the emergency-gear-extension system, but both main-landing gear extended only partially. The main-landing gear collapsed on landing, resulting in damage to the lower fuselage. No hydraulic fluid was found in the system's lines, which were original equipment and at least 24 years old. A hydraulic leak was found in a metal line that ruptured. The nitrogen system for emergency gear extension also was leaking because of corrosion pitting.

Date	Location	Airplane Type	Airplane Damage	Injuries
April 7, 1994	Elizabethton, Tennessee	Piper PA-31-350	destroyed	2 fatal

The destination airport was uncontrolled and had no instrument approaches. The pilot cancelled IFR and told ATC that the field was in sight. The airport reported visual flight rules (VFR) conditions, but rising mountainous terrain existed to the northeast, and local authorities reported that the top third of the mountain was obscured by clouds. After canceling IFR, no subsequent radio calls were received from the pilot, and the airplane did not arrive at the destination. The wreckage was found near the crest of the mountain.

Appendix
Commercial EMS Airplane Accidents and Incidents In the United States, 1983–2000 *(continued)*

Date	Location	Airplane Type	Airplane Damage	Injuries
July 19, 1994	Taft, California	Cessna 414	destroyed	1 fatal, 3 serious

During arrival at the destination airport in day VMC, the pilot contacted unicom and was advised to land on Runway 25, which has a 2.2 percent uphill grade and is restricted to landings only. After landing, the airplane was refueled and the patient was put on board. The pilot back-taxied on Runway 25 and proceeded to take off uphill with the airplane near its maximum gross weight. There was a tail wind between four knots and 15 knots, and the temperature was about 100 degrees; density altitude was 3,200 feet. The pilot began a left turn to avoid rising terrain, but the left tip tank contacted the ground, and the airplane cartwheeled. The flaps were found fully extended. The flight manual said that flaps should have been retracted.

Date	Location	Airplane Type	Airplane Damage	Injuries
July 21, 1994	Cozad, Nebraska	Beech C90	none	4 uninjured

On approach in day VMC to the destination airport, the crew was unable to extend the landing gear. They returned to their base and landed after using the backup gear-extension system. An investigation showed that the landing-gear circuit breaker was defective.

Date	Location	Airplane Type	Airplane Damage	Injuries
July 29, 1994	Polacca, Arizona	Cessna 421	substantial	5 uninjured

In day VMC, the pilot said that he observed the windsock hanging limp and initiated an approach to Runway 22. After turning final, he observed that the aircraft floated more than usual, and he suspected that there was a tail wind. Upon touchdown, a bird struck the co-pilot's windshield, and he may have delayed braking. He said that, after touchdown, the braking action was less than normal because of the roughness of tar and dirt on the runway surface. The airplane overran the runway. The nose gear collapsed during a 180-degree turn back to the runway.

Date	Location	Airplane Type	Airplane Damage	Injuries
Aug. 15, 1994	Eugene, Oregon	Cessna 414	minor	3 uninjured

One engine ran rough on initial climb in day VMC. The pilot feathered the propeller and landed. A piston connecting rod had penetrated the engine case.

Date	Location	Airplane Type	Airplane Damage	Injuries
Nov. 15, 1994	Dallas, Texas	Mitsubishi MU-2B	minor	5 uninjured

The aircraft struck large birds on final approach in day IMC. The windshield was broken. The pilot conducted a go-around to check the landing gear and then landed the airplane.

Date	Location	Airplane Type	Airplane Damage	Injuries
Dec. 14, 1994	Chinle, Arizona	Cessna 421C	substantial	5 uninjured

In night VMC, after touchdown on the main landing gear on a dirt airstrip, the airplane's nose settled and moved to the right. The airplane slid sideways and off the runway to the right, hitting a barbed-wire fence. Neither the pilot nor the maintenance technician on board heard unusual noises from the nose landing gear during the landing. The nose-landing-gear trunion failed because of overloading.

Date	Location	Airplane Type	Airplane Damage	Injuries
Jan. 31, 1995	Chinle, Arizona	Cessna 421	substantial	3 uninjured

The airplane was dispatched in day VMC to a dirt runway. Police said that the runway was dry, despite a recent snowstorm. On touchdown, however, the pilot observed that the runway felt softer than usual. About 400 feet to 500 feet (122 meters to 153 meters) after touchdown, the airplane encountered a dip in the runway and became slightly airborne. The pilot lost control of the airplane, which departed the runway and ran into a barbed-wire fence. Although the runway surface appeared dry, there was dry dirt or powder about one inch to two inches (2.5 centimeters to 5 centimeters) deep with a soft layer underneath.

Date	Location	Airplane Type	Airplane Damage	Injuries
Feb. 9, 1995	Ainsworth, Nebraska	Beech BE90	none	5 uninjured

A loss of torque occurred in the no. 1 engine, followed by an increase in engine temperature and engine vibration. An emergency was declared with ATC, and the pilot conducted a normal descent and landing in day VMC. Investigation revealed a failure of the gas-turbine section.

Date	Location	Airplane Type	Airplane Damage	Injuries
March 1, 1995	Valentine, Nebraska	Beech BE200	none	7 uninjured

While in cruise flight in day VMC, the airplane had an engine failure. The pilot returned to the departure airport for a single-engine approach and landing.

Date	Location	Airplane Type	Airplane Damage	Injuries
March 28, 1995	San Antonio, Texas	Cessna 421	none	3 uninjured

After departure in day VMC, the right engine ran rough. The pilot declared an emergency and returned for landing. A fuel-injector line had cracked on the no. 1 cylinder of the right engine.

Date	Location	Airplane Type	Airplane Damage	Injuries
June 3, 1995	Susanville, California	Cessna 421	minor	4 uninjured

During landing in night VMC, the aircraft veered off the runway and into soft dirt. The propeller hit a sign. The pilot reported a brake malfunction.

Date	Location	Airplane Type	Airplane Damage	Injuries
Aug. 21, 1995	Truth or Consequences, New Mexico	Cessna 421C	minor	4 minor

The aircraft struck terrain during an attempted takeoff in day VMC.

Date	Location	Airplane Type	Airplane Damage	Injuries
Aug. 21, 1995	Mesa, Arizona	Learjet 23	minor	5 uninjured

The airplane was landed long and fast in day VMC and ran off the runway into mud. The engines ingested mud.

Date	Location	Airplane Type	Airplane Damage	Injuries
Aug. 27, 1995	Chinle, Arizona	Cessna 421C	substantial	2 uninjured

The pilot and flight nurse were returning in night VMC to the company base. The pilot conducted the night landing on Runway 17 to avoid obstacles on the approach end of Runway 35. Witnesses said the winds were southerly at about 30 knots when the pilot attempted the landing. The windsock was not illuminated, and the airport was unattended. The pilot said that, after touchdown, he observed that the windsock indicated a strong tail wind. The pilot applied maximum braking, but the airplane ran off the departure end of the runway. The aircraft traveled down an embankment and through a ditch and collided with two steel irrigation posts. An investigation found that the airplane had touched down at the midpoint of the runway.

Appendix
Commercial EMS Airplane Accidents and Incidents In the United States, 1983–2000 *(continued)*

Date	Location	Airplane Type	Airplane Damage	Injuries
Sept. 11, 1995	Ontario, California	Piper PA-31	minor	3 uninjured

The airplane experienced an engine fire en route in night VMC. The pilot diverted the airplane and landed safely. The no. 6 cylinder exhaust stack had cracked, and exhaust burned through the cowling.

Date	Location	Airplane Type	Airplane Damage	Injuries
Nov. 17, 1995	Delta, Utah	Cessna 441	none	5 uninjured

The pilot reported surging of the left engine until he retarded the power lever. He diverted in day VMC to the nearest en route airport. The propeller governor was replaced.

Date	Location	Airplane Type	Airplane Damage	Injuries
Jan. 8, 1996	Spokane, Washington	Cessna 401	destroyed	3 fatal, 1 serious

After an abbreviated weather briefing, the pilot expressed anxiety about possible low visibility, fog and dark-night conditions for landing and timely transport of the dying patient. During an ILS approach, the airplane was well above the glideslope until close to the middle marker. The airspeed decreased from 153 knots to 100 knots while the vertical speed increased from 711 feet per minute (fpm) to 1,250 fpm. About one mile from the runway and at 500 feet AGL, the aircraft abruptly turned left of the localizer course and gradually descended. The airplane struck a pole, flew into a building and burned. The pilot lacked experience in conducting actual instrument approaches. He had difficulty with instrument flying during recent training and in FAA flight checks.

Date	Location	Airplane Type	Airplane Damage	Injuries
Jan. 31, 1996	Flagstaff, Arizona	Beech E90	destroyed	3 fatal

During the initial climb in day IMC, the pilot observed a landing-gear-unsafe light. He requested clearance to an area of VFR weather, where he manually extended the landing gear with safe-gear indications. The flight department asked the pilot to return to base. The pilot obtained an IFR clearance for an ILS approach, which included an eastbound procedure turn. Radar data showed an outbound track west of the published course and no procedure turn. The aircraft was in a steep descent when it struck terrain at 10,500 feet, about 10 miles (16 kilometers) west of the final approach course.

Date	Location	Airplane Type	Airplane Damage	Injuries
Aug. 15, 1996	Anchorage, Alaska	Piper PA-31-310	none	4 uninjured

During a flight in night VMC, the pilot selected landing-gear down, and only two of the three landing-gear lights illuminated. The pilot used the operator's manual, slowed the aircraft to 104 knots and tried unsuccessfully to hand-pump the gear down. ATC and fire fighting personnel told the pilot that the landing gear was down. The pilot conducted a normal landing.

Date	Location	Airplane Type	Airplane Damage	Injuries
April 14, 1997	Minneapolis, Minnesota	Piper PA-31-325	none	2 uninjured

When the pilot selected the landing-gear down during an approach in day VMC, the pilot did not observe the left-main landing gear down-and-locked indication. The pilot cycled the gear several times, then selected the gear up and flew to his home airport, where he landed the airplane without damage. Inspection showed that the left-main landing-gear downlock hook was not engaging the overcenter cam because of a frozen actuating rod end.

Date	Location	Airplane Type	Airplane Damage	Injuries
June 13, 1997	San Antonio, Texas	Cessna 421	none	3 uninjured

The airplane pitched down at rotation in day VMC. The pilot rejected the takeoff, and the airplane overran the runway. Inspection showed that the elevator cables were crossed.

Date	Location	Airplane Type	Airplane Damage	Injuries
Aug. 31, 1997	Albuquerque, New Mexico	Beech E90	substantial	4 uninjured

During initial climb in day VMC, the right-main landing gear failed to retract fully. Prior to landing, the right-main landing gear did not lock in the down position. The pilot secured the right engine, feathered the right propeller and conducted a precautionary landing. During the landing roll, the right-main landing gear collapsed. The right wing suffered buckling damage during the impact. Inspection showed that the right-main landing-gear retraction/extension torque tube had failed because of fatigue.

Date	Location	Airplane Type	Airplane Damage	Injuries
Oct. 24, 1997	Portland, Maine	Learjet 24	minor	5 uninjured

After the airplane accelerated past 80 knots during the takeoff roll in night VMC, there were indications that one right-main landing-gear tire or both right-main landing-gear tires had failed. The takeoff was rejected. The pilot experienced a loss of directional control, and the airplane veered left into grass, struck a runway light and came to a stop back on the runway.

Date	Location	Airplane Type	Airplane Damage	Injuries
Jan. 8, 1998	Phoenix, Arizona	Jetstream 3101	substantial	6 uninjured

In night VMC, the pilot taxied the airplane to the ramp to meet a waiting ambulance. The airplane was observed entering the ramp on the east side of a covered parking structure. The airplane's tail hit the top of the parking structure, which seriously damaged the top three feet (0.9 meter) of the vertical stabilizer. The pilot continued taxiing through the parking structure, and the airplane struck the roof in three places.

Date	Location	Airplane Type	Airplane Damage	Injuries
Jan. 29, 1998	Chinle, Arizona	Piper PA-34-200T	substantial	2 uninjured

The pilot said that he overflew the airport at 500 feet AGL to verify that the runway was clear. He said that it was a dark, moonless night but that the runway lights and the aircraft landing lights were illuminated. During the landing roll, the pilot moved the airplane slightly to the left to avoid hitting a horse. As he straightened the airplane, a second horse appeared about 50 feet (15 meters) ahead. The airplane struck the horse with the left wing just left of the engine at about 70 knots, then headed toward an airport-boundary fence. As the pilot tried to steer away from the fence, the airplane skidded to the left. The left-main landing gear collapsed and the left propeller struck the ground several times before the airplane stopped.

Date	Location	Airplane Type	Airplane Damage	Injuries
Feb. 23, 1998	Corpus Christi, Texas	Cessna 401	minor	5 uninjured

The airplane was landed in night VMC with the landing gear retracted, sustaining damage to the main-landing-gear doors, wing flaps and both propellers.

Appendix
Commercial EMS Airplane Accidents and Incidents In the United States, 1983–2000 *(continued)*

Date	Location	Airplane Type	Airplane Damage	Injuries
March 18, 1998	Show Low, Arizona	Cessna 421	substantial	3 uninjured

The pilot said that his windshield was partially covered with heavy, wet snow. Snow was falling before the planned night takeoff, visibility was about two miles (three kilometers), and the runway was wet with some accumulation of snow and slush. The pilot believed that the snow would not be a factor once he began the takeoff roll. Inspection showed that airplane was lined up with the runway-edge lines when the takeoff roll began; the right wheel departed the pavement about 500 feet to 750 feet (153 meters to 229 meters) into the takeoff roll. The airplane departed the runway, and the nose landing gear collapsed in mud.

Date	Location	Airplane Type	Airplane Damage	Injuries
March 18, 1998	Denver, Colorado	Learjet 25	minor	2 uninjured

The airplane landed with a crosswind in day IMC, skidded off the side of the ice-covered and snow-covered runway and stopped in snow.

Date	Location	Airplane Type	Airplane Damage	Injuries
April 1, 1998	Chinle, Arizona	Cessna 421	minor	3 uninjured

The airplane was traveling too fast and landed a greater distance than usual from the runway threshold during a night landing in VMC. The airplane ran off the departure end of the runway.

Date	Location	Airplane Type	Airplane Damage	Injuries
Oct. 18, 1998	Eagle Pass, Texas	Cessna 421	destroyed	5 minor

The pilot taxied the airplane in dark-night conditions and scanned the sky with the monochrome weather radar. The closest storm activity shown was 15 miles from the runway. After takeoff, the pilot began a 10-degree turn at 1,500 feet, and the airplane suddenly descended. The vertical speed indicator indicated an 800 fpm descent. The descent continued until the tail struck the ground. The airplane stopped and was engulfed by fire. A review of Doppler weather radar showed thunderstorms in the area.

Date	Location	Airplane Type	Airplane Damage	Injuries
Jan. 18, 1999	Clovis, New Mexico	Beech E90	none	3 uninjured

During descent in day VMC, the control yoke moved to the full-forward position. The pilot eased back on the yoke, and the nose pitched up. The pilot maintained control by use of power and elevator trim and conducted a normal landing. Post-incident examination revealed a drooping wire beneath the pilot's seat. The insulation around the elevator-down cable had chafed and had caused a short circuit. The elevator cable had been burned through and had separated. No circuit breakers were opened and no fuses were blown.

Date	Location	Airplane Type	Airplane Damage	Injuries
July 1, 1999	Polacca, Arizona	Cessna 421B	substantial	1 minor

The airplane was on a positioning flight in day VMC after an engine change. The pilot moved the fuel selector from the main fuel tank to the auxiliary fuel tank, and the left engine stopped. The pilot attempted to restore power by switching fuel tanks and turning on the boost pumps. He said that he did not feather the left propeller because he hoped to regain engine power. The pilot maneuvered to land on some bushes when he realized that the airplane could not be flown to the runway.

Date	Location	Airplane Type	Airplane Damage	Injuries
Aug. 27, 1999	Glennallen, Alaska	Learjet 35	substantial	4 uninjured

During final approach in day IMC, to descend and to align the aircraft with the centerline, the first officer turned the airplane to the right, retarded the throttles and applied nose-down elevator. As the airplane crossed the runway threshold, the airspeed decreased rapidly, and an excessive descent rate was noted. The captain took control of the airplane and applied full power to cushion the touchdown, which he said was "firm" but within acceptable limits. He said that the initial touchdown was made on the left-main landing gear. Ground personnel found a three-foot by four-inch (91-centimeter by 10-centimeter) scrape on the lower portion of the left wing-tip fuel tank and wrinkling of the upper-left wing panel adjacent to the left wing-tip fuel-tank attach point.

Date	Location	Airplane Type	Airplane Damage	Injuries
Jan. 28, 2000	Phoenix, Arizona	Beech BE90	minor	4 uninjured

The pilot landed the airplane in night VMC and was told to exit left onto a taxiway that was a reverse high-speed exit. There were no taxiway turn lines leading off the runway. As the pilot turned back onto the taxiway, he saw a white runway-edge light in the center of the taxiway. The pilot mistakenly thought it was a post light and increased the rate of turn, hitting a blue taxiway-edge light.

Date	Location	Airplane Type	Airplane Damage	Injuries
Feb 16, 2000	Springfield, Missouri	Cessna 340	minor	4 uninjured

The pilot conducted an emergency landing in day VMC after the right engine lost power. Investigation revealed that the turbocharger had failed.

Date	Location	Airplane Type	Airplane Damage	Injuries
April 19, 2000	Hyannis, Massachusetts	Learjet 35	minor	6 uninjured

The pilot flew the airplane on an ILS approach in light rain in day IMC. The airplane touched down in the first 1,000 feet (305 meters) of the runway, and the pilot deployed the spoilers, applied braking and began to slow the airplane. The crew observed that they were approaching the runway-end lights and steered left to avoid them. At about 60 knots, the airplane left the runway and continued 154 feet (47 meters) into the grass. The outboard tires of both main landing gear failed.

Date	Location	Airplane Type	Airplane Damage	Injuries
Nov. 11, 2000	Phoenix, Arizona	Cessna 441	minor	3 uninjured

The pilot began a takeoff in night VMC, believing that the airplane was lined up on the runway centerline. At 10 knots forward speed, the right propeller contacted a runway-edge light. The takeoff was rejected, and the airplane was returned to operations. An inspection showed that one blade of the right propeller was damaged and the right wing flap was dented.

Date	Location	Airplane Type	Airplane Damage	Injuries
Dec. 13, 2000	Pensacola, Florida	Cessna 421B	substantial	4 uninjured

The landing gear would not retract after takeoff in night VMC. During landing, the aircraft veered to the left and ran off the runway. The left-main landing gear separated, and the aircraft stopped in a grass area off the runway.

Source: Patrick R. Veillette, Ph.D., from reports by the U.S. National Transportation Safety Board and the U.S. Federal Aviation Administration.

Accident Rates Decrease Among U.S. Commuter Airlines in 2000

Preliminary data compiled by the U.S. National Transportation Safety Board for 2000 show that the accident rates for on-demand operations increased.

FSF Editorial Staff

Preliminary statistics compiled by the U.S. National Transportation Safety Board (NTSB) show that, from 1999 to 2000, the accident rates among commuter[1] aircraft operated under U.S. Federal Aviation Regulations (FARs) Part 135 generally decreased and that the accident rates among on-demand[2] aircraft operated under FARs Part 135 increased.[3]

Table 1 (page 56) shows that commuter aircraft in 2000 were involved in 12 accidents, including one fatal accident in which five people were killed.

(The fatal accident occurred Sept. 18, 2000, in Nuiqsut, Alaska. The NTSB preliminary accident report said that a Piper PA-31T3 operated by Cape Smythe Air Service was being operated under visual flight rules in visual meteorological conditions on a scheduled flight to Nuiqsut from Deadhorse, Alaska. Witnesses said that the twin-turboprop airplane touched down on the runway with the landing gear retracted. "The belly pod lightly scraped the runway for about 40 feet [12 meters], but the airplane transitioned to a climb," the report said. The landing gear was extended while the airplane climbed to about 100 feet to 150 feet [31 meters to 46 meters] above the ground. The airplane then began a descending left turn and struck the ground. The pilot and four passengers were killed.[4])

The preliminary statistics for 2000 show that 975,000 departures were conducted and 550,000 hours were flown by commuter aircraft. The total-accident rates were 1.231 per 100,000 departures and 2.182 per 100,000 flight hours. The fatal-accident rates were 0.103 per 100,000 departures and 0.182 per 100,000 flight hours.

In 1999, commuter aircraft were involved in 13 accidents, including five fatal accidents in which 12 people were killed. That year, 841,040 departures were conducted and 452,031 hours were flown by commuter aircraft. The total-accident rates were 1.546 per 100,000 departures and 2.876 per 100,000 flight hours. The fatal-accident rates were 0.595 per 100,000 departures and 1.106 per 100,000 flight hours.

Preliminary data for 2000 show that on-demand aircraft were involved in 80 accidents, including 22 fatal accidents in which 71 people were killed.

Table 2 (page 57) shows that 2,430,000 hours were flown by on-demand aircraft in 2000. The total-accident rate was 3.29 per 100,000 flight hours. The fatal-accident rate was 0.91 per 100,000 flight hours.

In 1999, on-demand aircraft were involved in 73 accidents, including 12 fatal accidents in which 38 people were killed. That year, 2,260,000 hours were flown by on-demand aircraft. The total-accident rate was 3.23 per 100,000 hours. The fatal-accident rate was 0.53 per 100,000 flight hours.♦

Notes and References

1. Before March 20, 1997, commuter operations were conducted under U.S. Federal Aviation Regulations (FARs) Part 135 in aircraft with 30 or fewer passenger seats and with a maximum payload capacity of 7,500 pounds (3,402 kilograms) or less. Beginning March 20, 1997, commuter operations have been conducted under

Part 135 in non-turbojet airplanes with fewer than 10 passenger seats and in rotorcraft; scheduled service in turbojet airplanes and in other airplanes with 10 or more passenger seats have been conducted under FARs Part 121. The U.S. Federal Aviation Administration (FAA) defines a *commuter operation* as any scheduled operation consisting of "at least five round trips per week on at least one route between two or more points according to the published flight schedules."

2. The FAA defines an *on-demand* operation as: a public-charter flight conducted in an aircraft with 30 or fewer passenger seats and a maximum payload capacity of 7,500 pounds or less; a scheduled passenger-carrying operation consisting of "less than five round trips per week on at least one route between two or more points according to the published flight schedules" conducted in a non-turbojet airplane with fewer than 10 passenger seats and a maximum payload capacity of 7,500 pounds or less, or in a rotorcraft; or an all-cargo operation conducted in an airplane with a maximum payload capacity of 7,500 pounds or less, or in a rotorcraft.

3. U.S. National Transportation Safety Board (NTSB) SB-01-07, March 16, 2001.

4. NTSB Accident/Incident Database report no. ANC00MA125.

Table 1
Accidents Among Aircraft in Commuter* Operations Conducted Under U.S. FARs Part 135, 1982–2000

	Accidents		Fatalities				Accidents per 100,000 Flight Hours		Accidents per 100,000 Departures	
Year	All	Fatal	Total	Aboard	Flight Hours	Departures	All	Fatal	All	Fatal
1982	26	5	14	14	1,299,748	2,026,691	2.000	0.385	1.283	0.247
1983	16	2	11	10	1,510,908	2,328,430	1.059	0.132	0.687	0.086
1984	22	7	48	46	1,745,762	2,676,590	1.260	0.401	0.822	0.262
1985	18	7	37	36	1,737,106	2,561,463	1.036	0.403	0.703	0.273
1986	14	2	4	4	1,724,586	2,798,811	0.812	0.116	0.500	0.071
1987	33	10	59	57	1,946,349	2,809,918	1.695	0.514	1.174	0.356
1988	18	2	21	21	2,092,689	2,909,005	0.860	0.096	0.619	0.069
1989	19	5	31	31	2,240,555	2,818,520	0.848	0.223	0.674	0.177
1990	15	4	7	5	2,341,760	3,160,089	0.641	0.171	0.475	0.127
1991	23	8	99	77	2,291,581	2,820,440	1.004	0.349	0.815	0.284
1992	23	7	21	21	2,335,349	3,114,932	0.942	0.300	0.706	0.225
1993	16	4	24	23	2,638,347	3,601,902	0.606	0.152	0.444	0.111
1994	10	3	25	25	2,784,129	3,581,189	0.359	0.108	0.279	0.084
1995	12	2	9	9	2,627,866	3,220,262	0.457	0.076	0.373	0.062
1996	11	1	14	12	2,756,755	3,515,040	0.399	0.036	0.313	0.028
1997	16	5	46	46	982,764	1,394,096	1.628	0.509	1.148	0.359
1998	8	0	0	0	353,735	707,071	2.262	–	1.131	–
1999	13	5	12	12	452,031	841,040	2.876	1.106	1.546	0.595
2000**	12	1	5	5	550,000	975,000	2.182	0.182	1.231	0.103

* Before March 20, 1997, commuter operations were conducted under U.S. Federal Aviation Regulations (FARs) Part 135 in aircraft with 30 or fewer passenger seats and with a maximum payload capacity of 7,500 pounds (3,402 kilograms) or less. Beginning March 20, 1997, commuter operations have been conducted under Part 135 in non-turbojet airplanes with fewer than 10 passenger seats and in rotorcraft; scheduled service in turbojet airplanes and in other airplanes with 10 or more passenger seats have been conducted under FARs Part 121. The U.S. Federal Aviation Administration defines a *commuter operation* as any scheduled operation consisting of "at least five round trips per week on at least one route between two or more points according to the published flight schedules."

** Data for 2000 are preliminary.

Source: U.S. National Transportation Safety Board

Table 2
Accidents Among Aircraft in On-demand* Operations Conducted Under U.S. FARs Part 135, 1982–2000

	Accidents		Fatalities			Accidents per 100,000 Flight Hours	
Year	All	Fatal	Total	Aboard	Flight Hours	All	Fatal
1982	132	31	72	72	3,008,000	4.39	1.03
1983	142	27	62	57	2,378,000	5.97	1.14
1984	146	23	52	52	2,843,000	5.14	0.81
1985	157	35	76	75	2,570,000	6.11	1.36
1986	118	31	65	61	2,690,000	4.39	1.15
1987	96	30	65	63	2,657,000	3.61	1.13
1988	102	28	59	55	2,632,000	3.88	1.06
1989	110	25	83	81	3,020,000	3.64	0.83
1990	107	29	51	49	2,249,000	4.76	1.29
1991	88	28	78	74	2,241,000	3.93	1.25
1992	76	24	68	65	1,967,000	3.86	1.22
1993	69	19	42	42	1,659,000	4.16	1.15
1994	85	26	63	62	1,854,000	4.58	1.40
1995	75	24	52	52	1,707,000	4.39	1.41
1996	90	29	63	63	2,029,000	4.44	1.43
1997	82	15	39	39	2,250,000	3.64	0.67
1998	77	17	45	41	2,751,000	2.80	0.62
1999	73	12	38	38	2,260,000	3.23	0.53
2000**	80	22	71	68	2,430,000	3.29	0.91

* The U.S. Federal Aviation Administration defines an on-demand operation as: a public-charter flight conducted in an aircraft with 30 or fewer passenger seats and a maximum payload capacity of 7,500 pounds (3,402 kilograms) or less; a scheduled passenger-carrying operation consisting of "less than five round trips per week on at least one route between two or more points according to the published flight schedules" conducted in a non-turbojet airplane with fewer than 10 passenger seats and a maximum payload capacity of 7,500 pounds or less, or in a rotorcraft; or an all-cargo operation conducted in an airplane with a maximum payload capacity of 7,500 pounds or less, or in a rotorcraft.

** Data for 2000 are preliminary.

FARs = Federal Aviation Regulations

Source: U.S. National Transportation Safety Board

Circular Describes Methods of Showing Compliance With Turbine Engine Bird-ingestion Standards

Requirements described in the FAA document reflect the results of an analysis of bird-strike risks.

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Advisory Circulars

Bird Ingestion Certification Standards. U.S. Federal Aviation Administration (FAA) Advisory Circular (AC) 33.76-1. Jan. 19, 2001. 8 pp. Available through GPO.*

The AC provides guidance and acceptable methods for demonstrating compliance with U.S. Federal Aviation Regulations Part 33.76 type certification standards for turbine engine ingestion of large birds and small birds. Test requirements described in the AC reflect recent analysis of the risks presented to turbine aircraft by bird strikes.

Announcement of Availability: FAA-S-8081-5D, Airline Transport Pilot and Aircraft Type Rating Practical Test Standards for Airplane. U.S. Federal Aviation Administration (FAA) Advisory Circular (AC) 61-122D. Feb. 9, 2001. 4 pp. Availability.**

The AC announces the availability of the practical test standards and provides information on obtaining paper copies and electronic copies of the standards. Flight instructors and applicants may find it helpful to have copies of the test standards for test preparation, because the standards are used by FAA inspectors and pilot examiners when conducting practical tests. [This AC cancels AC 61-122C, *Announcement of Availability: FAA-S-8081-5C, Airline Transport Pilot and Aircraft Type Rating Practical Test Standards for Airplane — with Change 1*, dated March 1, 1999.]

Crew Resource Management Training. U.S. Federal Aviation Administration (FAA) Advisory Circular (AC) 120-51D. Feb. 8, 2001. 28 pp. Available through GPO.*

This AC provides guidelines for developing, implementing, reinforcing and assessing crew resource management (CRM) training programs. CRM involves the effective use of all available resources: human, hardware and information. CRM includes flight crewmembers, flight attendants, maintenance personnel and other personnel, such as air traffic controllers, who routinely work with the cockpit crew and are involved in flight safety decisions. CRM training focuses on situational awareness, communication skills, teamwork, task allocation and decision making within a comprehensive framework of standard operating procedures. The guidelines in this AC primarily apply to U.S. Federal Aviation Regulations Part 121 operators who are required to provide training for pilots, flight attendants and aircraft dispatchers. Nevertheless, other operators may also find the guidelines useful in addressing human performance issues. [This AC cancels AC 120-51C, *Crew Resource Management Training*, dated Oct. 30, 1998.]

Reports

ATSB Survey of Licenced Aircraft Maintenance Engineers in Australia. Australian Transport Safety Bureau. February 2001. 28 pp. Figures, tables, annexes, references.

About 12 percent of airline accidents worldwide involve aircraft maintenance errors. Australian Transport Safety Bureau (ATSB) data show that 4.5 percent of Australian aircraft accidents involve maintenance deficiencies.

As part of its ongoing safety programs, ATSB conducted a survey of licensed aircraft maintenance engineers in Australia to identify safety issues in maintenance — with an emphasis on human factors or human aspects of the job — that were potential risks to the safety of aircraft or the safety of maintenance workers. More than 95 percent of occurrences identified by survey respondents involved human factors. The human factors included job pressure, equipment deficiencies, training inadequacies, fatigue, communication and coordination, and inadequately documented or inadequately designed procedures. (An analysis of survey results and preliminary survey conclusions was published in the Flight Safety Foundation *Aviation Mechanics Bulletin*, November–December 2000. The ATSB report contains air safety recommendations resulting from the survey.)

The report includes the following recommendations to the Australian Civil Aviation Safety Authority and maintenance organizations:

- Whenever possible (to reduce the risk of repetition of a maintenance error), the same task on each element of a critical, multiple redundant system on an aircraft should not be performed during the same maintenance visit, regardless of whether the aircraft is being maintained in accordance with extended-range twin-engine operations requirements;

- Duty limits and work schedules should be managed to reduce fatigue on the job;

- Maintenance personnel should receive appropriate recurrent training and human factors training;

- Clear error-reporting policies should be introduced and used as positive safety indicators, and staff should be encouraged to report incidents related to human error;

- Maintenance personnel should receive regular feedback on maintenance incidents; and,

- Appropriate equipment, tooling and spares should be available and adequately maintained.

Aviation Competition: Regional Jet Service Yet to Reach Many Small Communities. U.S. General Accounting Office (GAO). February 2001. GAO-01-344. 53 pp. Figures, tables, appendixes. Available through GAO.***

The GAO, which conducts research for the U.S. Congress, examined data for U.S. regional jet (RJ) operations of major network carriers from January 1997 through October 2000. (For purposes of this report, RJs are defined as newer aircraft that have been placed into service since 1993 and are designed to seat up to 70 passengers.) The GAO analysis shows that major airlines provide RJ service to 157 U.S. cities, 8 percent of which have populations of less than 100,000. Seventy-five percent of the cities served have populations greater than 250,000. Air carriers use RJs, in part, to expand into new markets, but mostly to supplement mainline jet service in existing markets. While the number of RJs in operation has increased significantly, 60 percent of RJ service is to pre-existing markets.

The GAO said that although specialists agree that RJs have added to the congestion and delays encountered by the U.S. air traffic system and by airports, there is little agreement or conclusive evidence about the extent of the contributions of RJs to those problems.

How to Commercialize Air Traffic Control. Poole, Robert W. Jr.; Butler, Viggo. Reason Public Policy Institute, Reason Foundation. Policy study 278. February 2001. 49 pp. Tables, references.

In the United States, debate continues on problems involving the U.S. air traffic control (ATC) system, flight delays, passenger dissatisfaction and lost economic productivity. The Reason Public Policy Institute (RPPI) (a nonpartisan policy research organization based in California, U.S.) is among advocates of the commercialization of the ATC system. In this report, RPPI discussed details of its plan for a new ATC system for the United States. Drawing upon experiences of countries that have "corporatized" their ATC systems — including Australia, Canada, Germany and the United Kingdom — the RPPI plan recommends "the shifting of ATC out of the Federal Aviation Administration and into a new, nonprofit corporation that would operate the system like a business." The plan would establish a board of directors composed of aviation stakeholders, would shift ATC funding from general revenues to user fees and would separate ATC services from regulatory oversight and safety oversight. The report discusses structural, governance, funding and human resources aspects of these changes.

Implementing Flight 2005 — Raising the Flight Level: Initiatives and Measures 2001–2003. Transport Canada. January 2001. Document TP 13712. 16 pp.

In 1999, Transport Canada developed a new civil aviation safety framework, Flight 2005, to guide its focus on aviation safety for a five-year period. Key goals of Flight 2005 are to continue improvements in aviation safety and to increase public confidence in Canada's civil aviation programs.

"Actions are aimed at enhancing safety data use, deploying resources to areas of highest risk, introducing safety-management systems, consistently assessing human factors, and continuing and enhancing open communications," the report said.

The report identifies specific initiatives for each of the actions and related performance measures.

Vision 2050: An Integrated National Transportation System. U.S. Federal Transportation Advisory Group (FTAG). February 2001. Charts. 22 pp. Available from U.S. Federal Aviation Administration (FAA) and U.S. National Aeronautics and Space Administration (NASA).****

FTAG operates under the auspices of the FAA Research, Engineering and Development Advisory Committee and the NASA AeroSpace Technology Advisory Committee. FTAG and its bipartisan member organizations advise the U.S. government and the transportation community on transportation-related issues. This report describes FTAG's proposal for a national transportation system to move people and objects safely, economically and on time and identifies technology, concepts and research that would enable the United States to implement the proposal. The report said that the system would not depend on foreign energy and would be "environmentally compatible."

CAA Safety Plan 2001–2002. Civil Aviation Authority of New Zealand. November 2000. Appendix. 18 pp.

While preparing the safety plan, the New Zealand Civil Aviation Authority (CAA) identified external factors that could influence significantly or change the aviation industry during the next 15 years. CAA also identified areas in which accident rates could be reduced to meet safety goals by 2005. The report discusses the problems and safety indicators, corrective actions and safety-improvement goals for each problem. The report also discusses issues such as aircraft collisions with objects (including wire strikes and bird strikes), controlled flight into terrain, fuel management, aircraft icing management, inadequate CAA/client relationships, industry skill shortages and inadequate industry safety culture.

Index to FAA Office of Aviation Medicine Reports: 1961 Through 2000. Collins, William E.; Wayda, Michael E. U.S. Federal Aviation Administration (FAA) Office of Aviation Medicine (OAM). DOT/FAA/AM-01/1. January 2001. 83 pp. Figures. Available through NTIS.*****

This report is a compilation of indexes to all FAA aviation medicine reports published from 1961 through 2000. Reports are indexed chronologically, alphabetically by author or co-author and alphabetically by subject. The reports include those issued by the Civil Aeromedical Research Center, Civil Aeromedical Research Institute (CARI), Civil Aeromedical Institute (CAMI) and FAA OAM. The report includes a foreword titled "Some Historical Observations of CARI/CAMI 1960–1984," and an article titled "A Brief History of OAM Research Funding, Staffing and Technical Report Production."♦

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Internet: http://www.gao.gov

**** Federal Aviation Administration (FAA)
Internet: http://research.faa.gov/aar/redac_rm.htm
National Aeronautics and Space Administration (NASA)
Internet: http://aerospace.nasa.gov/library/FTAG

***** National Technical Information Service (NTIS)
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Accident/Incident Briefs

Engine Ice Blamed for BAE 146 Power Loss

The airplane was flown between storm cells at Flight Level 260, and then an uncommanded thrust reduction occurred in the no. 4 engine.

FSF Editorial Staff

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

Air Carrier

Loss of Power Prompts Flight Diversion

BAE Systems 146. No damage. No injuries.

The airplane was in cruise flight at Flight Level (FL) 280 (28,000 feet) during a night flight in France when a thin layer of clouds was encountered. The flight crew received clearance from air traffic control (ATC) to climb to FL 310, and there they observed on the weather-radar display a line of cumulonimbus clouds about 50 nautical miles (93 kilometers) in front of the airplane. When the clouds were 20 nautical miles (37 kilometers) away, the flight crew requested a descent to FL 260 to fly between two storm cells.

The crew selected engine anti-ice. While flying between the storm cells, the crew observed moisture but no ice on the wings, windshield or windshield wipers. No ice was identified by the ice detector.

After the airplane had passed the storm cells, the fan speed of the no. 4 engine (a Lycoming ALF-502R) decreased and the turbine gas temperature (TGT) increased. The crew shut down the no. 4 engine, completed the rollback emergency check list, transmitted a "pan, pan" urgency call to ATC and diverted to an en route airport.

A rollback – a particular type of uncommanded thrust reduction – is observed as a slow reduction in the high-pressure spool speed (N_1) associated with an increase in TGT and a failure of the engine to respond to movement of the thrust lever.

An investigation found that the rollback on the no. 4 engine was caused by an accumulation of ice on the engine-core supercharger exit guide vanes.

The incident report by the U.K. Civil Aviation Authority (U.K. CAA) said that, at the time of the incident, "a modification (30437A) was [in effect] to improve the anti-icing efficiency and [was] in the process of fleet embodiment. In the interim … an operational limitation was introduced for aircraft with unmodified ALF-502R engines by the issue of a temporary revision to the aircraft flight manual."

The temporary revision said that, to prevent uncommanded thrust reduction, flight was prohibited in known icing conditions or forecast icing conditions above 26,000 feet. The revision said that a forecast of clouds, including cumulonimbus, must be considered a forecast of icing conditions.

The morning of the flight, the significant weather chart for Europe called for "occasional" cumulonimbus clouds at FL 100 to FL 360. The crew had flown through the area earlier without encountering clouds.

The report said, "The aircraft manufacturer's interpretation of the flight manual temporary revision in the context of this weather forecast was that the entire flight should be conducted at or below 26,000 feet.

"The operator's interpretation was that the portion of the flight not affected by known or forecast icing conditions could be conducted above 26,000 feet. The operator also believed that the weather experienced by the crew on the outbound sector gave grounds for re-assessing the forecast."

After the incident, the temporary revision was changed to say that, until the modification was made, "a forecast of *any* cloud, including cumulonimbus activity, must be regarded by the crew as a forecast of icing conditions."

The CAA told the manufacturer to review risks associated with rollback until all engines were modified.

Wheel Separates From Airplane During Landing Roll

Fokker 100. Minor damage. No injuries.

The airplane was being landed at an airport in Australia when the crew and passengers felt a severe vibration from the left-main landing gear as the brakes were applied during the landing roll. The flight crew stopped the airplane on the runway and conducted an inspection, which revealed that the left-main outboard wheel was missing.

The wheel was found on the runway. A fracture analysis showed that the wheel had failed because of a fatigue crack that began at the surface of the metal in a repaired section of the axle-hub-to-wheel-web transition. The report said that the surface had been shot-peened with a process of lower intensity than the shot-peening used during manufacturing, and the reduction in the intensity made fatigue cracks more likely to occur under normal loading conditions.

The manner in which the fatigue crack spread was consistent with the sideways flexing of the wheel web, which would have occurred as wheels were rotated for a crosswind landing or while turning on the ground. The flight crew said that there was a 15-knot crosswind during landing and that similar crosswinds were common at the airport where the incident occurred.

Fatigue Crack Cited in Collapse of Landing Gear

Fairchild SA227-AC Metro III. Substantial damage. No injuries.

Visual meteorological conditions prevailed for the afternoon training flight from an airport in New Zealand. The training session included several takeoffs and landings, and on the third circuit, the pilots (the check-and-training captain and the pilot receiving command training) said that the approach appeared normal until about the last 50 feet, when the descent rate increased.

They described the landing as firmer than normal and firmer than they had expected. The airplane veered to the left and the pilot in training was unable to maintain directional control. The captain ordered a go-around, and the left-main landing gear was observed hanging at about a 45-degree angle. The airplane was flown to another airport with longer runways, where the captain landed the airplane with the landing gear retracted. (In the retracted position, the left undercarriage wheels protruded below the engine nacelle about 45 degrees below the normal position.) The airplane slid off the runway onto grass, then turned about 170 degrees and stopped.

An investigation found no evidence that the airplane had been subjected to a hard landing. The accident report said that the undercarriage failure was caused by a fatigue crack in the left-undercarriage outboard lower drag brace. The fatigue crack began in a recess that had been machined to accommodate a grease fitting near the attachment point to the undercarriage leg. The fatigue crack could not be detected during normal maintenance procedures.

After the accident, the manufacturer issued service bulletins saying that dye penetrant should be used to check the main-landing-gear drag-brace links for cracks, a New Zealand Civil Aviation Authority airworthiness directive was issued requiring the inspections, and the manufacturer said that drag braces would be manufactured from a more durable material.

Cracked Windshield Prompts In-flight Emergency

Dassault Falcon 50. Minor damage. No injuries.

As the airplane climbed through 28,200 feet after a night departure from an airport in Scotland, the flight crew heard a bang and observed that the captain's windshield had shattered. The crew asked air traffic control (ATC) for an immediate descent and completed the "cracked windshield pane" checklist. ATC assigned the airplane the emergency transponder code of 7700, and the crew flew the airplane to the departure airport, where they conducted a normal landing. The windshield remained intact.

Corporate
Business

Ice in Fuel Blamed for Loss of Power

Beech King Air 200C. No damage. No injuries.

Night visual meteorological conditions prevailed for the emergency medical services flight in Sweden. The airplane was in cruise flight at Flight Level 190 (19,000 feet) when the flight crew observed that fuel flow to the left engine was oscillating and that engine thrust was decreasing. The engine then stopped.

The flight crew tried unsuccessfully to restart the engine and decided to continue to the destination airport. They then observed that fuel flow to the right engine was oscillating and that engine thrust was decreasing. They declared an emergency and requested landing clearance at a closer airport.

"During the flight there, it was possible to restart the left engine, but only limited thrust was obtained," the report said. "After touchdown, the pilots obtained normal reverse thrust from both engines."

An investigation revealed that, before the flight, the airplane had been refueled and parked in a warm hangar for about 12 hours. Fuel was not drained before the first flight of the day. After the incident, fuel samples revealed "a fairly small amount" of water in the fuel system.

The report said that the incident probably occurred after water in the fuel froze during flight in an area where outside air temperatures were about minus 40 degrees Celsius (minus 40 degrees Fahrenheit), "temporarily causing a pressure drop or a blockage in the engine fuel system."

Faulty Actuator Prevents Landing Gear From Locking in Place

Cessna Citation V. No damage. No injuries.

As the airplane approached an airport in Canada, the flight crew observed that the right-main landing gear down-and-locked indicator did not illuminate. The crew suspected that the airplane had a hydraulic problem and used the backup pneumatic system to lower the landing gear. They then conducted a normal landing and taxied clear of the runway to shut down the airplane for an inspection.

Visual inspection of the landing-gear actuator showed that the right-main landing gear was not locked in place. The actuator was replaced, the defective part was returned to the manufacturer, and the airplane was returned to service.

Other
General
Aviation

Parachutist Breaks Arm During Jump, Lands on Hangar Roof

Douglas DC-3. No damage. One minor injury.

The aircraft was being flown during a Remembrance Day ceremony to drop poppy petals over a war memorial in England. On similar flights in previous years, some nonpilot crewmembers had parachuted from the airplane as they returned to the departure airport. On this occasion, although the three nonpilot crewmembers wore parachutes, a parachute jump appeared to be unlikely because only one crewmember was fit and qualified for parachuting, because there were clouds 600 feet above ground level (AGL) at the airport and because surface winds were gusting to 30 knots.

Nevertheless, after the petal-drop, weather conditions improved, and the crewmember said that he would jump if the airplane could be flown directly into the 17-knot southwesterly wind and if the airplane could be flown below clouds at least 1,500 feet AGL.

The flight crew told air traffic control (ATC) that they wanted to "come overhead at 1,500 feet and throw one of our passengers out," the accident report said. "The ATC controllers had received no prior notification of a parachute drop, and, because of the informal nature of the request, they initially regarded it as a joke."

ATC told the flight crew that the only air traffic was a landing helicopter and "if you want to, carry on with the detail." The crew slowed the airplane and prepared for the parachutist to jump. As he jumped, the parachutist struck part of the aircraft and broke his left arm.

"His descent immediately became violently unstable, and he fought to regain stability before releasing his parachute," the report said.

The parachute was deployed about 200 feet to 300 feet AGL, but the "low deployment height and unstable descent made a full deployment impossible, and [the parachutist] landed on his back on a hangar roof with the parachute partially deployed."

His ribs and some internal organs were injured by the impact.

"From the ground, the ATC controllers noticed 'a bundle' falling from the aircraft. … On questioning the flight crew, the controllers were advised that a parachutist had indeed left the aircraft, but, because the bundle … had appeared small, the controllers continued to believe that they were the victims of a practical joke. Some time later, the controllers noticed the fire and rescue crews proceeding toward the hangars, but it was not until some 20 minutes later that the controllers became fully aware of the nature of the incident."

Investigation revealed that the airplane's groundspeed when the parachutist jumped was 89 knots (plus or minus five knots), and winds were from the southwest at 25 knots; indicated airspeed (IAS) was 107 knots. The certificate of airworthiness said that, during a parachute drop, the airplane should be flown at 75 knots IAS (plus or minus five knots). The British Parachuting Association said that although higher aircraft speeds sometimes assist the parachutist, they also increase the chances of the parachutist striking the airplane during the jump.

The airplane was used both for parachute jumping and for chemical spraying and was equipped with a spray bar beneath the fuselage. The parachutist was aware of the spray bar and was certain that he did not strike the spray bar during his jump. During the investigation, the U.K. Air Accidents Investigation Branch recommended that the U.K. Civil Aviation Authority clarify whether parachuting can be undertaken in DC-3 aircraft with spray bars installed.

Airplane Strikes Trees During Approach

Cessna 340A. Minor damage. No injuries.

Night instrument meteorological conditions prevailed as the pilot conducted an instrument approach to an airport in Denmark. During the approach, the airplane contacted trees. The pilot conducted a climb, followed by a normal landing.

Inspection of the airplane revealed substantial damage to the horizontal stabilizer and minor damage to the bottom of the fuselage.

Rotorcraft

Faulty Fuel-control Unit Blamed for Power Loss

Sikorsky S-76A. No damage. No injuries.

The helicopter was being flown on an instrument flight plan in Canada when the no. 1 engine experienced a substantial power loss. The flight crew attempted a restart, then shut down the engine and continued to the destination airport, 10 miles (16 kilometers) away for a normal single-engine landing. Maintenance personnel said that the engine fuel-control unit had not supplied enough fuel to maintain normal cruise power.

Helicopter Lifts Off Without Pilot

Hiller UH-12E. Helicopter destroyed. No injuries.

Visual meteorological conditions prevailed for the afternoon aerial application flight in the United States. The pilot said that he conducted a precautionary landing because the application equipment was not functioning properly.

The report said, "As he deplaned the rotorcraft, it lifted off without him, attained an altitude of about 600 feet AGL and crashed."♦

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Flight Safety Digest
 ISSN 1057-5588

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