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# In-flight Medical Incapacitation and Impairment of U.S. Airline Pilots: 1993 to 1998

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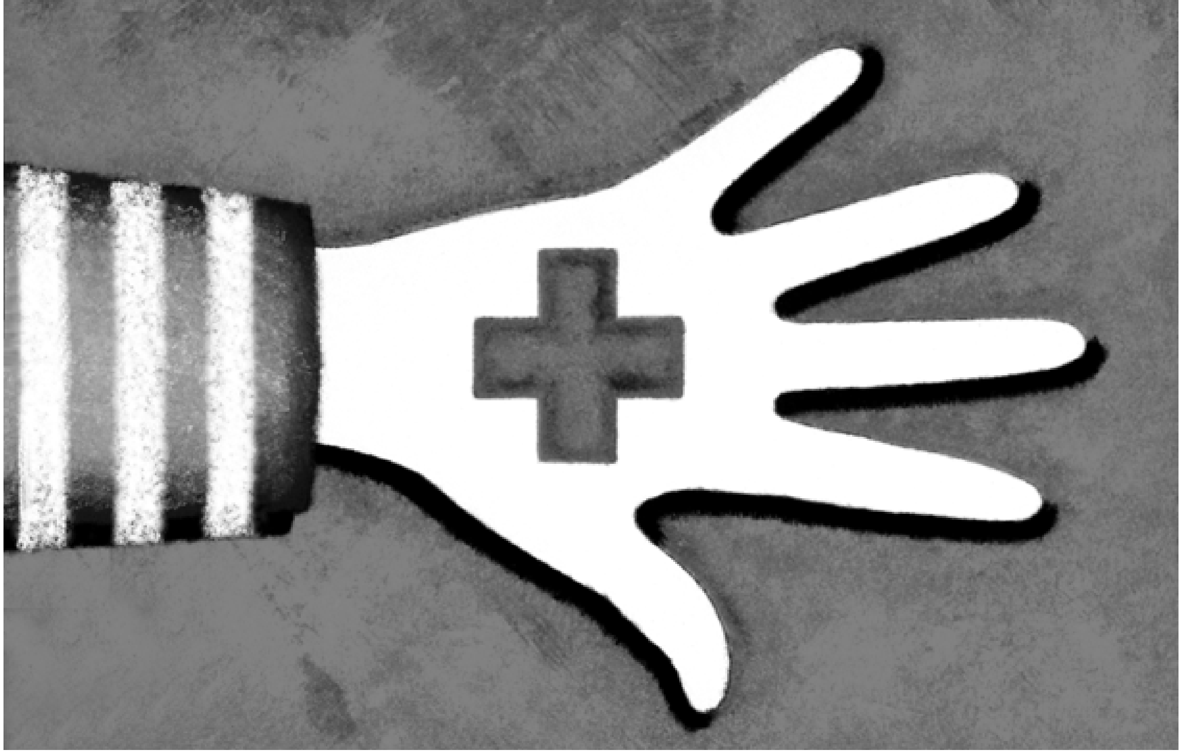



# In-flight Medical Incapacitation and Impairment of U.S. Airline Pilots: 1993 to 1998

**A study by the Civil Aerospace Medical Institute of the U.S. Federal Aviation Administration found that in-flight medical events involving U.S. airline pilots were rare. In the six years covered by the study, 50 medical events occurred involving flight crewmembers; of those, two events resulted in nonfatal accidents.**

— CHARLES A. DEJOHN, ALEX M. WOLBRINK AND JULIE G. LARCHER

The first fatal aircraft accident occurred in 1909, and by the end of 1910, there were 38 aviation fatalities. For some time, it was believed that the first accidents attributed to pilot in-flight medical incapacitation occurred in 1911; however, after reviewing these cases, Parmet and Underwood-Ground[28] believed that they were the result of pilot error. Therefore, the date of the first aircraft accident attributed to pilot in-flight medical incapacitation is still unknown.

Over the years, there have been many studies of airline pilot medical incapacitation.[4,6,8,19,23,24,29,30] Most studies can be classified as either direct studies of in-flight medical events, career-termination studies, simulator studies, questionnaire studies or epidemiological studies. In addition, Li[22] recently performed a comprehensive review of pilot-related factors in aircraft accidents.

## In-flight Medical Event Studies

In 1969, Buley[4] summarized three sets of airline pilot incapacitation data. First, he reported on the progress of a collaborative study initiated by the International Civil Aviation Organization (ICAO) and performed by the International Federation of Air Line Pilots' Associations (IFALPA) and the

International Air Transport Association (IATA). Buley examined in-flight deaths of airline pilots between 1961 and 1968. He found 17 reported cases of airline pilot deaths, all resulting from heart disease. Five of the 17 cases ended in aircraft accidents, four of which were fatal, resulting in 148 fatalities. Another five cases nearly resulted in accidents. Of the 17 events, seven occurred on the ramp, five while en route, four during approach and one during landing rollout. Buley next reviewed 42 cases of nonfatal in-flight incapacitation in pilots of IATA-member airlines between 1960 and 1966. In 24 of the 42 cases, causal organic disease was diagnosed. The most common categories of incapacitation were epileptiform manifestations (6), coronary occlusions (4) and renal/ureteric colic (4).

In 1975, Raboutet and Raboutet[30] reviewed 17 incidents of sudden incapacitation in French professional civil pilots between 1948 and 1972. They found five cases of myocardial infarction, three cases of angina pectoris, two cases of ischemic heart disease, two cases of epileptic seizures and one case each of diabetes, pulmonary embolism, cerebral vascular accident, atrial fibrillation and intestinal hemorrhage of unknown etiology. Fortunately, none of the cases resulted in aircraft accidents or the death of the pilot, and only two cases resulted in the complete incapacitation of the pilot due to epileptic seizures. Raboutet and Raboutet stated that for an incapacitation accident to occur, the incapacity must: (1) affect the pilot at the controls, (2) be sudden, (3) be total and (4) take place during a critical phase of flight.

Chapman[7] reviewed IATA data and found 208 in-flight medical incapacitations between 1965 and 1977, which included 13 cardiac cases, or one cardiac incapacitation per year. He calculated the probability of an accident due to cardiac incapacitation to be about $10^{-10}$, assuming: (1) one accident per 400 incapacitations (i.e., one accident every 400 years), (2) 600 flying hours per pilot per year and (3) subtle incapacitation during a critical phase of flight.

Martin-Saint-Laurent and associates[23] found 10 cases of sudden in-flight incapacitation out of a population of 1,800 Air France pilots and flight engineers from 1968 to 1988. The most common causes of in-flight incapacitation were cardiac arrhythmias (2) and epileptic seizures (2). Two out of the 10 flights diverted. The two pilots who suffered epileptic seizures and one pilot from the arrhythmia group who had an in-flight episode of atrial fibrillation (followed by a cerebral vascular accident with hemiparetic and epileptic seizure on the ground following the flight) were all permanently grounded. Five others were temporarily grounded. No action was taken against one pilot who experienced hypoxia and another who experienced carbon dioxide intoxication.

## Career Termination Studies

Preston[29] followed 1,000 U.K. airline pilots and found that 73 were permanently grounded for medical causes between 1954 and 1965. Of the 73 pilots, the most common causes for loss of employment were psychiatric (36), cardiovascular (8), respiratory (6) and diabetes (4). Preston attributed the low incidence of cardiovascular groundings to possible Anglo-Saxon racial differences between this group of pilots and other pilots, and the high incidence of psychiatric groundings to poor pilot-selection procedures.

Lane[21] examined IATA loss-of-license insurance data and estimated the overall incidence of in-flight incapacitation to be 0.06 per 1,000 pilots per year.

Kulak, Wick and Billings[20] performed a similar study of career termination due to loss of licensure insurance in members of the U.S. Airline Pilots Association [Air Line Pilots Association, International (ALPA)] from 1955 through 1966. They found 891 cases of career termination: 229 due to accidents and 662 the result of disease. The rate of death and disability due to accidents was 2.07 per 1,000 pilots per year, while the rate for disease was 8.05 per 1,000 pilots per year. Although the overall rate for cardiovascular disease was only 2.91 per 1,000 pilots per year, the age-specific rate ranged from zero for pilots under 30 years of age to 27.33 for pilots between 55 and 58 years of age. Flying accidents accounted for the majority of career terminations for all age groups. Using the incapacitation-incidence rates for termination due to disease by age and the age distribution of active ALPA pilots, the authors estimated the probability of serious in-flight incapacitation by age. Their estimates ranged from one per 58,000 pilots for the 30 to 34 year age group to one per 3,500 pilots for the 55 to 59 year age group.

## Simulator Studies

Harper, Kidera and Cullen performed two simulator studies, one dealing with obvious and maximal loss of function,[14] and the other with subtle or partial loss of function.[13] Although operationally interesting discoveries were made — for example, the mean time to detect subtle incapacitation was 1.5 minutes, and 25 percent of the simulator sessions ended in "aircraft accidents"[13] — the studies were not designed to address medical causes of in-flight incapacitation.

Chapman[7] analyzed more than 1,300 simulator exercises in which the subtle incapacitation of the flying pilot was programmed to occur at a critical phase of flight. Two protocols were used. The first involved 500 exercises where major aircraft-system failures were simulated as part of the drill. In 485 of the 500 cases, it was determined there would not have been any danger to an actual aircraft. In 15 cases, it was believed that safety of flight would have been at risk. In eight cases, it was considered that aircraft accidents would have resulted. The second protocol involved 800 exercises without simultaneous aircraft-system failures. In this series, only 10 out of the 800 were believed to have represented a risk to safety of flight, and in two cases, the observers believed that an aircraft accident would have resulted. Again, these studies did not address medical causes of in-flight incapacitation.

There are inherent problems when simulator results are used to predict in-flight outcomes. Crews that "crashed" in the Harper, Kidera and Cullen study, for example, stated, "We wouldn't let it happen in a real airplane."[13] Also, in addition to the obvious difficulty of attempting to predict possible in-flight outcomes from simulated data in the Chapman study, there was the added drawback of foreknowledge by the subjects, since they knew there would be an incapacitation at some time during each drill.

## Questionnaire Studies

Buley[4] reviewed the results of a questionnaire administered to pilots of IFALPA-member associations in 1967, in which 27 percent of approximately 5,000 respondents reported about 2,000 incidents of significant in-flight incapacitation. Safety of flight was affected in 4 percent of cases. Almost one-half of reported incapacitations occurred in the en route phase of flight. Unfortunately, the IFALPA questionnaire was administered to actively flying airline pilots; therefore, pilots with more serious medical conditions, who may have suffered more severe types of incapacitation, had been previously eliminated and were not part of the study. This skewed the data by eliminating the potential for reporting more serious medical conditions while including the less serious conditions reported by actively flying pilots. In addition, most of the conditions addressed in the questionnaire were temporary in nature and would usually result in pilot impairment (i.e., nausea, vomiting, indigestion, etc.) rather than total incapacitation and would not likely be addressed by medical certification.

In 1971, Lane[21] updated the 1967 IFALPA questionnaire data, analyzed by Buley[4], with IATA data for 1962 through 1968 that was provided to ICAO. Lane added 51 additional, non-accident cases to Buley's original 17 cases, for a total of 68 cases. He then calculated that the probability of an incapacitating event resulting in an accident would be 5/68, or 0.074.

In 1991, James and Green[19] replicated Lane's 1967 IFALPA survey with similar results. Of 1,251 respondents, 29 percent reported at least one incident of in-flight incapacitation severe enough to require another crewmember to assume their duties. The most common causes of incapacitation were gastrointestinal (58.4 percent), earache due to a blocked ear (13.9 percent) and faintness or general weakness (8.5 percent). The most common phases of flight where incapacitations occurred were en route (42.1 percent), followed by climb (18.4 percent), descent (17.3 percent) and on the ramp (11.4 percent). Safety of flight was believed to be potentially affected in 45 percent of cases and definitely affected in 3 percent of cases. Of those reporting that safety of flight had been affected, 43 percent stated that the incapacitation event placed the

**The mean time to detect subtle incapacitation was 1.5 minutes.**

remaining aircrew under maximum workload. As with the 1967 Buley study, the questionnaire was administered to actively flying airline pilots, again eliminating the potential for reporting more serious medical conditions. In addition, the study did not provide incapacitation rates that would allow for comparison with similar studies.

### Epidemiological Studies

Castelo-Branco and associates[6] found 13 deaths and eight medical incapacitations in a longitudinal evaluation of deaths and disease in 408 active Portuguese airline pilots between 1945 and 1983. The most common causes of death were accidents, myocardial infarcts and cancer. By relating the number of deaths and incapacitations with the number of pilots at risk, they calculated incidence rates by age group. Death and incapacitation rates ranged from zero per 100 pilots at risk for the 20 to 24 year age group to 3.64 per 100 pilots at risk for the 55 to 59 year age group. Although this is an excellent longitudinal study of airline pilots for an extended period and provides valuable insight into causes of death and disease, it does not directly reflect causes of in-flight incapacitation.

### Summary of Incapacitation Study Methodologies

Most previous studies we reviewed did not use data from actual in-flight medical events. Instead, indirect measures, such as career termination due to permanent medical grounding or loss-of-licensure insurance data and general epidemiological data, were used to approximate the frequency of in-flight medical events. These studies provided information on the frequency and categories of in-flight medical events; however, they did not include incapacitation rates, making meaningful comparison between studies difficult. Although in-flight medical incapacitation rates can be inferred, these data are not directly based on in-flight medical events.

The objective of this study was to provide incapacitation rates that could be easily compared with similar studies of in-flight medical incapacitation.

## Methods

Details of aircrew in-flight medical events aboard U.S. airlines between 1993 and 1998 were collected by the U.S. Federal Aviation Administration (FAA) Civil Aerospace Medical Institute's (CAMI's) Aerospace Medical Research Team and stored in a Microsoft Access 2000 Database (Version 9.0). The official method of case notification was through the use of a Medical Case Alert Form (Appendix A, Figure A-1, page 16); however, many cases were discovered through the FAA Administrator's Daily Bulletin, telephone calls, news media, periodic searches of the U.S. National Transportation Safety Board (NTSB) and FAA accident databases and direct interaction between the CAMI and the NTSB.

Event data included incident, operational, pilot and final-disposition information. Incident information included a brief narrative and/or full report of the event when available, including injuries and/or fatalities. Operational information included the date, time, location, type of operation, accident or incident classification, phase of flight, airline, flight number, aircraft number, type of aircraft, origin, destination, and diversion details. Pilot information included the pilot's name, social security number, age, gender, class of medical certificate, pilot certificate number, FAA medical history, aircrew position, occupation, and employer. NTSB numbers were recorded, and a unique CAMI incapacitation-database number was also assigned to each case. The authors could not independently verify the validity of much of the information collected from sources outside of CAMI, including aircrew statements, airline records and hospital records, etc. In most cases, this information had to be accepted without confirmation.

Cases were reviewed by the authors and classified as either an "impairment" or "incapacitation." Individuals were classified as impaired when they could still perform limited in-flight duties, such as read checklists or perform radio communications, even though their performances may have been degraded. Examples of impairments include food poisoning, the use of monovision contact lenses, fatigue and kidney stones. Individuals were considered incapacitated when they could no longer perform any in-flight duties. Examples of incapacitation include heart attacks and epileptic seizures.

Cases were also classified as "possible," "probable" or "certain," depending on the degree of confidence in the supporting evidence. For airline events, the other aircrew members were witnesses to the occurrence, and reports were required by the airline. In addition, in cases serious enough to require further evaluation and treatment, the hospital record provided additional confirmation.

Each case was also assigned to one of several broad medical categories. Incapacitation categories included loss of consciousness (LOC), cardiac, neurological, gastrointestinal, urological, vascular, medication, hypoxia, decompression sickness, and injury. Impairment categories included respiratory, cardiac, gastrointestinal, infectious disease, vision and reaction to medication.

## Results

### Frequency and Rate of In-flight Medical Events

We found 39 incapacitations and 11 impairments of U.S. airline pilots on 47 flights during the period 1993 to 1998. (More than one pilot was affected on three flights. See Table A-1, Case Summaries, in Appendix A, page 17). During this period, U.S. airlines flew a total of 85,732,000 revenue-passenger hours;[26] therefore, the rate of in-flight incapacitations and impairments was 0.04549 per 100,000 hours (95 percent confidence interval [CI] 0.04545, 0.04553) and 0.01283 per 100,000 hours (95 percent CI 0.01281, 0.01285), respectively.

## Probability of an Accident Due to an In-flight Medical Event

There were two nonfatal aircraft accidents due to the in-flight medical impairment of the pilots. One was caused by the pilot's visual impairment due to the use of monovision contact lenses during an approach. The other was caused by flight crew fatigue. Combining the 39 incapacitations and 11 impairments gives 50 in-flight medical events on 47 flights; therefore, the probability that an in-flight medical event would be associated with an accident was two out of 50 events, or 0.04.

There were 54,295,899 flights and 217 accidents involving U.S. Federal Aviation Regulations Part 121 scheduled and nonscheduled airlines between 1993 and 1998.[25,27] The probability of an aircraft accident for a pilot experiencing an in-flight medical event is summarized in Table 1.

The "law of rare events" states that the total number of events of interest will assume (approximately) the Poisson distribution if: (a) the event may occur in any of a large number of trials, but (b) the probability of occurrence in any given trial is small. Examples of events that follow a Poisson distribution are doctor visits, absenteeism in the workplace, mortgage prepayments, loan defaults, bank failures, insurance claims, and aircraft accidents.[5] Assuming that accidents involving pilot in-flight medical events can be described using a Poisson distribution, there is a statistically significant difference between the proportion of accidents given an in-flight medical event, compared with the proportion of accidents in the absence of such an event ($z = 3.08$, $p < 0.001$).

**Table 1**
**Probability of an Accident Given an In-flight Medical Event**

| | | Accident | | |
|---|---|---|---|---|
| | | Yes | No | Total |
| In-Flight Event | Yes | 2 | 48 | 50 |
| | No | 215 | 54,295,634 | 54,295,849 |
| | Total | 217 | 54,295,682 | 54,295,899 |

Source: Civil Aerospace Medical Institute, U.S. Federal Aviation Administration

## Age and Gender Distribution of In-flight Medical Events

All pilots who had an in-flight event were males. The average age for incapacitations was 47.0 years (range 25 to 59 years), while the average age for impairments was 43.3 years (range 27 to 57 years). Figure 1 (page 6) shows the age distribution for the percentage of U.S. airline pilots having in-flight incapacitations and impairments between 1993 and 1998 based on the average age distribution for professional pilots (from a recent FAA study; Appendix A, Figure A-2, page 16).[3]

Examination of Figure 1 suggests an increase in in-flight medical incapacitations with increasing U.S. airline pilot age.

Figure 2 (page 7) shows the percent of pilot in-flight medical incapacitations by age group. A linear regression of the data shown in Figure 2 indicates that the percentage of in-flight incapacitations increased with pilot age group ($R^2 = 0.69$, $p < 0.01$).

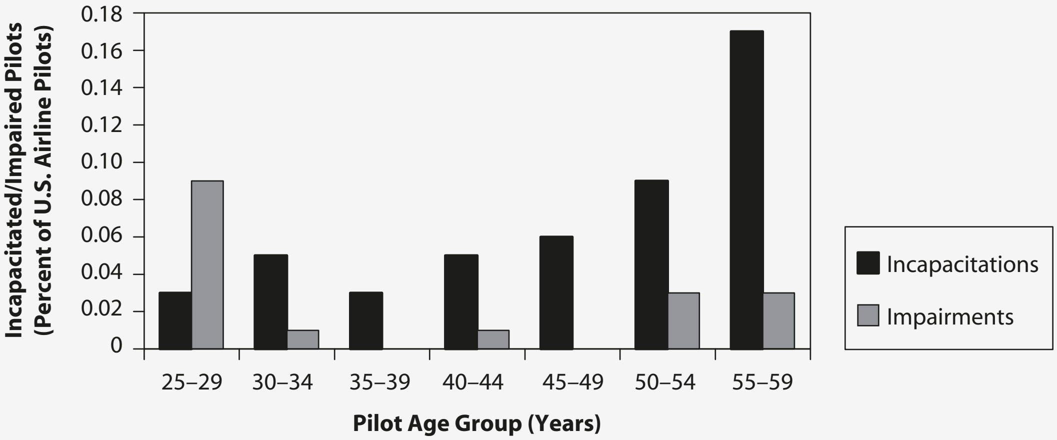
## Causes of In-flight Medical Incapacitations

Although events were placed in categories for purposes of convenient classification, many involved more than one aeromedical issue and could not be easily sorted. While several events included an LOC, it was often secondary to a primary medical condition, which had a more profound affect on the in-flight event. Examples included epileptic seizures, heart attacks and strokes, which were classified separately from LOC. On the other hand, in cases such as hypoxia and decompression sickness, the LOC had the greatest affect on the in-flight event; therefore, these cases were grouped under LOC. For these reasons, in this section we discuss *causes* rather than *categories* of in-flight medical events.

All 39 in-flight medical incapacitations were classified as "certain." The most frequent causes were LOC (11), gastrointestinal (7), neurological (6), cardiac (5) and urological (3). Of the 11 LOC cases, four were caused by vasovagal syncope, two were the result of hypoxia, one was the result of neurogenic syncope, one was due to pain secondary to a duodenal bulb ulcer, one resulted from decompression sickness, and two were due to unknown causes. The seven gastrointestinal cases included two cases of cholelithiasis, two cases of intestinal gas expansion with altitude, two cases of possible food poisoning, and one case of gastroenteritis. Four of the six neurological cases were grand mal seizures, one was an alcohol-withdrawal seizure, and one was a petit mal seizure. Three of the six cardiac cases were fatal myocardial infarctions, one was a fatal dysrhythmia, one cardiac case involved a nonfatal coronary spasm, and another case involved unstable angina. All three urological cases involved renal lithiasis.

Less frequent causes of in-flight medical incapacitation included diabetes (1), vascular (1), reaction to medication (1) and traumatic injury (1). The

**Figure 1**
**U.S. Airline Pilot In-flight Medical Incapacitations and Impairments by Age**
**1993 to 1998**




Source: Civil Aerospace Medical Institute, U.S. Federal Aviation Administration

diabetes case involved a second officer who had had two hypoglycemic episodes within a three-month period, one at the gate resulting in his removal from the aircraft prior to flight and another in flight. The vascular case involved an Airbus captain with a history of chronic, controlled atrial fibrillation who decided to discontinue his digoxin and propranolol (medications) on his own and developed a temporoparietal cerebral infarct during landing. One pilot suffered heart palpitations that were attributed to an herbal medication he was taking for weight control; another suffered an injury when hydraulic fluid came into contact with his eye during an aircraft preflight inspection.

## Categories of In-flight Medical Incapacitation and Age

Figure 3 (page 8) shows the most frequent categories of in-flight medical incapacitation by age. Examination of the figure suggests an increase in incapacitations with pilot age. Also, the data in Figure 3 suggest that more serious categories, such as LOC secondary to ulcers, cardiac events like myocardial infarctions and neurological seizures, occurred more frequently in older pilots. At the same time, the less serious medical categories, such as gastrointestinal events due to gas expansion and food poisoning and LOC due to vasovagal syncope, occurred more frequently in younger pilots.

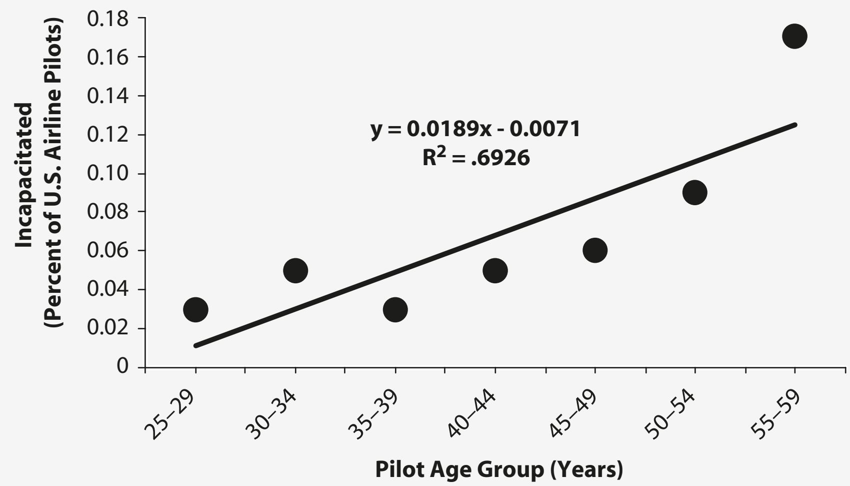
## Categories of In-flight Medical Impairments

All of the 11 in-flight medical impairments were classified as "certain." Categories of in-flight medical impairment included respiratory (4), fatigue (2), vision (2), cardiac (1), gastrointestinal (1) and infectious disease (1). Three of the four respiratory cases occurred on the same taxiing Douglas DC-8 aircraft when carbon dioxide poisoning, caused by fumes from dry ice carried in the cargo compartment, impaired the captain, first officer and jump-seater. The fourth respiratory case was due to barosinusitis. The two fatigue cases occurred on a DC-8 flight, resulting in an accident with three serious injuries. The captain had been awake 40 of the previous 66 hours and the first officer for 47 of the 66 hours prior to the accident. Of the two vision cases, one occurred when a Boeing 737 captain looked directly into a laser that appeared to be tracking the aircraft from the ground, resulting in a temporary loss of night vision. The other occurred when a McDonnell Douglas MD-88 struck the approach lights during an approach to a landing because of the captain's use of monovision contact lenses, resulting in three minor injuries on evacuation of the aircraft. The cardiac case involved a 57-year-old Lockheed L-1011 captain who had been experiencing retro-sternal chest pain since the previous day, which became more continuous in flight and began radiating to his left jaw and arm. Although the clinical impression of the attending physician was unstable angina, his electrocardiogram (ECG) was normal on physical examination. One Empresa Brasileira de Aeronáutica (Embraer) EMB-120 captain was diagnosed with viral gastroenteritis and secondary dehydration, and an MD-88 first officer was found to have a viral infection that led to a vasovagal response.

## Fatal In-flight Events

Four pilots died as a result of their in-flight incapacitating event; however, no passenger deaths resulted from these incapacitations. No pilot deaths resulted from in-flight medical impairments. The mean age of the four pilot fatalities was 53 (range 48 to 56 years). All four deceased pilots were pronounced dead because of cardiac events after being transported to the hospital. Three of the four deaths resulted from myocardial infarctions (MIs), while one was the result of a cardiac dysrhythmia. Two of the three pilots who suffered MIs and the pilot who died as a result of a fatal dysrhythmia had cardiac medical histories that were documented in the pilot's FAA medical record. As a result, pathology codes, history codes or both were assigned by the FAA prior to their in-flight medical events. Two of the three flights where the pilots suffered an MI and the one flight where the pilot suffered an arrhythmia diverted to alternate airports because of the in-flight medical events; however, the one flight that did not divert when the first officer suffered an MI was inbound to their final destination at the time. Cardiopulmonary resuscitation was attempted in all cases. Safety of flight was seriously affected only once temporarily when the first officer's foot became lodged against the rudder pedal when he stiffened, requiring the captain to apply opposite rudder pressure until the foot could be dislodged.

**Figure 2**
**Age Distribution of In-flight Medical Incapacitations of U.S. Airline Pilots 1993 to 1998**




Source: Civil Aerospace Medical Institute, U.S. Federal Aviation Administration

## Safety of Flight and In-flight Medical Events

Safety of flight is negatively affected during any in-flight medical event; however, we considered safety of flight to be a factor during an event only when there was imminent danger of an aircraft accident resulting from the medical event. We found that on seven of the 47 flights it was seriously affected. The mean age of the seven pilots involved in flights where safety of flight was seriously affected was 48.4 years (range 42–56, standard deviation [SD] = 4.5), and the mean age of the 41 pilots who were not involved in flights where safety of flight was seriously affected was 45.7 years (range 25–59, SD = 10.7). There was no significant difference in the mean age between the two groups. As previously discussed, two of the seven flights ended in aircraft accidents. The seven cases are summarized below.

- A 45-year-old B-737 first officer experiencing an alcohol-withdrawal seizure suddenly screamed, extended his arms up rigidly, pushed full right rudder and slumped over the yoke during an approach. The aircraft descended to 1,000 feet above ground level in an uncoordinated turn to 25 degrees angle of bank before flight attendants could pull the first officer off the controls, allowing the captain to recover the airplane. "Mayday" calls were made, and the captain executed a missed approach before making a successful landing.

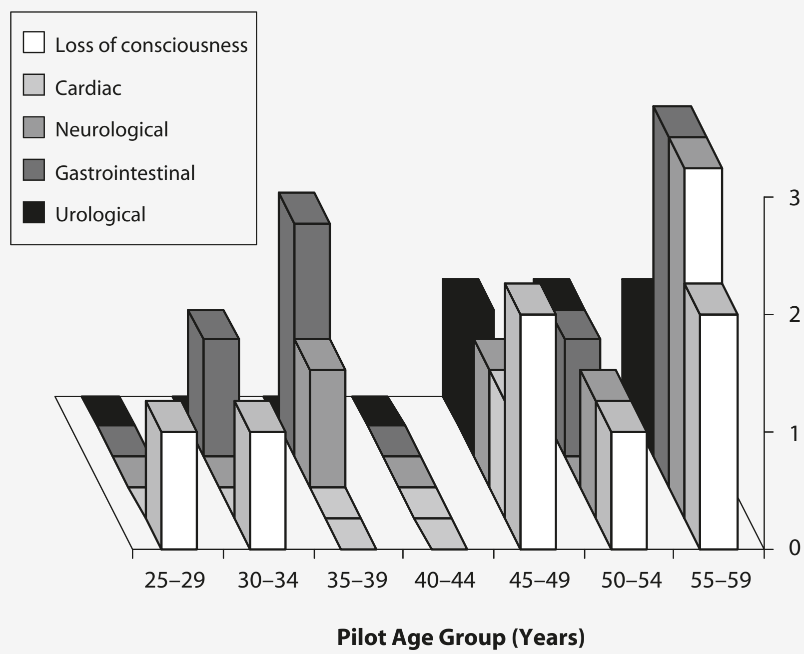
- When a 48-year-old McDonnell Douglas DC-9 first officer's foot became lodged against a rudder pedal after he stiffened during a heart attack, the captain had to apply opposite rudder to control the aircraft until the foot could be dislodged.

- A 44-year-old flight engineer and a 42-year-old captain lost consciousness when the flight engineer accidentally turned off a flow pack with the cargo-heat-outflow valve open, depressurizing their Boeing 727 at 33,000 feet. The captain and flight engineer regained consciousness only after the first officer donned his oxygen mask and made an emergency descent.

- A 49-year-old captain stiffened so violently during an epileptic seizure after landing that he suffered a fractured shoulder and a lumbar compression fracture. At the same time, he applied such force to the rudder pedals that he caused the aircraft to turn sharply and stop suddenly. The first officer had to remove the captain from the controls to taxi the aircraft to the gate.

- During an approach flown at higher-than-normal airspeed, a 56-year-old Airbus A300 captain suffering a cerebral infarction did not ask for the landing gear to be extended and simply nodded agreement when the first officer questioned him about it. After touchdown, the captain used reverse thrust for longer than required and applied full takeoff power on the taxiway. After the first officer reduced power, the captain again applied takeoff power, and the first officer shut down the engines and called for assistance.

**Figure 3**
**Most Frequent Categories of In-flight Medical Incapacitation by Age***




* Number of cases per 39 total events

Source: Civil Aerospace Medical Institute, U.S. Federal Aviation Administration

- When a 48-year-old MD-88 captain wearing monovision contact lenses attempted to make a visual approach over water under reduced lighting conditions in rain and fog, he perceived the aircraft to be higher than it actually was. This resulted in a steeper-than-normal final approach, causing the aircraft to strike the approach lights. Although no one was hurt on impact, three passengers received minor injuries during the evacuation following the accident.

- A cargo DC-8 crashed on approach because the aircrew's judgment, decision making and flying abilities were impaired by fatigue. The 50-year-old captain had been awake for 40 of the previous 66 hours, and the 54-year-old first officer had been awake for 47 of the previous 66 hours prior to the accident. The captain entered an approach-turn stall and failed to recover, resulting in the accident, which caused serious injuries to himself, the first officer and second officer.

## In-flight Medical Events and Similar Medical Histories

There are times when the airman's FAA medical record contains coding that is similar to the category assigned to an in-flight event. While we found no pilots whose in-flight medical impairments were categorized similarly to the codes assigned in their FAA medical history, nine of 39 incapacitations were categorized similarly to the codes assigned in the pilot's FAA medical record.

## Diversions Resulting From In-flight Medical Events

A flight diversion occurs whenever the aircraft lands at a destination other than the originally intended airport. Nineteen of the 39 flights involving incapacitated pilots and three of the 11 flights with impaired pilots diverted because of the in-flight medical event. The odds of a flight diverting are, therefore, 0.48 (95 percent CI 0.33, 0.64) in the case of an in-flight medical incapacitation and 0.27 (95 percent CI 0.01, 0.54) in the event of an impairment. In three of the

19 diversions (16 percent) for incapacitated pilots, the aircrew member did not survive, while in all three diversions for impaired pilots, the affected crewmember did survive.

Of the 19 diversions for incapacitated pilots, three were classified as cardiac cases, three as gastrointestinal, three as epileptic seizures, two as hypoxia and eight due to other causes. Two of the three cardiac cases were fatal heart attacks, one in a 48-year-old pilot and the other in a 56-year-old pilot, and one was a fatal arrhythmia in a 55-year-old pilot. One of the gastrointestinal cases was due to food poisoning, one the result of intestinal gas expansion with an increase in altitude, and the third was suspected to be peritonitis. The two hypoxia cases occurred on the same flight when the flight engineer accidentally depressurized the aircraft at 33,000 feet, and both the captain and flight engineer temporarily lost consciousness. The first officer eventually donned his oxygen mask and made an emergency descent. Eight cases classified as "other" included decompression sickness, unknown LOC, cholelithiasis, renal lithiasis, muscle cramps, chest pain of unknown origin, vertigo secondary to labyrinthitis, and vasovagal syncope. The three diversions for impaired pilots included one case of cardiac chest pain in a 57-year-old pilot due to unstable angina, one case of viral infection leading to a vasovagal syncopal response in a 51-year-old pilot and one case of barosinusitis during climb in a 43-year-old pilot.

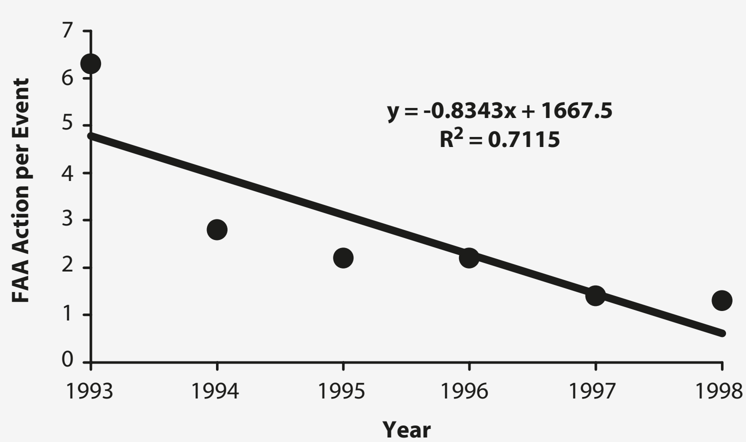
## Aeromedical Certification Actions Resulting From In-flight Medical Events

The 39 in-flight medical incapacitations led to 16 medical certificate denials (Table A-1, cases 2, 5, 7, 9, 12, 13, 18, 21, 37, 38, 39, 89, 96, 100, 175, and 178). In addition, a special-issuance code was assigned to one pilot (Table A-1, case 2), 16 history codes were assigned to 10 pilots (Table A-1, cases 2, 5, 11, 12, 27, 32, 33, 73, 82, and 175), 37 pathology codes were assigned to 22 pilots (Table A-1, cases 2, 5, 7, 9, 10, 11, 12, 13, 14, 18, 21, 29, 31, 32, 37, 38, 39, 73, 95, 96, 175, and 178), and four ECG codes were assigned to one pilot (Table A-1, case 12). Also, 11 pilot medical certificates were reaffirmed (Table A-1, cases 14, 20, 33, 34, 35, 39, 81, 82, 87, 95 and 98), five pilots were eventually recertified (Table A-1, cases 2, 5, 9, 18 and 73), and in two cases, no codes needed to be assigned (Table A-1, cases 16 and 17).

The 11 in-flight medical impairments led to three denials (Table A-1, cases 19, 218 and 219). In addition, six pathology codes were assigned to three pilots (Table A-1, cases 19, 218 and 219), three medical certificates were reaffirmed (Table A-1, cases 30, 74 and 86), and in five cases, no codes were assigned (Table A-1, cases 83, 84, 85, 97 and 148).

Figure 4 shows the trend in the number of aeromedical certification actions per in-flight

**Figure 4**
**Trend of U.S. Federal Aviation Administration (FAA) Actions for In-flight Medical Events***




* Number of cases per 50 total events

Source: Civil Aerospace Medical Institute, U.S. Federal Aviation Administration medical event (incapacitations and impairments) for all types of actions, including the assignment of special issuance codes, ECG codes, history codes, pathology codes, as well as certificate denials, recertification, and reaffirmation. As shown in the figure, there was a significant decrease in the number of aeromedical certification actions per event between 1993 and 1998 ($p<0.05$).

## Discussion

### Frequency and Rate of In-flight Events

We found 39 in-flight medical incapacitations for a rate of 0.045 per 100,000 hours and 11 impairments for a rate of 0.013 per 100,000 hours on 47 U.S. airline flights between 1993 and 1998. It is interesting that there were approximately four times as many incapacitations as impairments, since impairments were generally less serious events and could be expected to occur at least as frequently as incapacitations. This is probably a reporting phenomenon. Incapacitated pilots were generally more seriously ill than impaired pilots. Consequently, incapacitations resulted in more declared emergencies, flight diversions, ambulance requests and hospitalizations than impairments. Therefore, an incapacitation would probably have been better documented than an impairment. Since many of the impairment cases were less well documented, any record would have depended on pilot self-reporting, something that would probably be avoided by most pilots.

**Two accidents resulted from pilot in-flight medical impairments, while no incapacitations resulted in accidents.**

Ironically, the only two accidents resulted from pilot in-flight medical impairments, while no incapacitations resulted in accidents. This may have been because of the insidious nature of the two impairment accidents. When a dramatic incapacitating event, such as a heart attack or epileptic seizure occurs, it is often obvious and can be dealt with by the unaffected crewmember. In the two impairments that ended in aircraft accidents, the pilots were probably not aware there was a problem. In one case, the pilot normally flew with monovision contact lenses. In the other case, the pilots were probably aware they were fatigued but were not cognizant of how seriously it was affecting their performance at the time.

Martin-Saint-Laurent et al.[23] studied sudden in-flight incapacitation in Air France pilots and flight engineers from 1968 to 1988 and reported an incapacitation incidence of 0.044 per 100,000 flight hours. While this is very close to the rate found for incapacitations in this study, the Martin-Saint-Laurent et al. study included categories that would have been classified as impairments in this study; therefore, a more appropriate comparison would be to include incapacitations and impairments together. Combining incapacitations and impairments gives a total of 48 in-flight medical events and a rate of 0.059 per 100,000 flight hours, which is only slightly higher than the rate in the Martin-Saint-Laurent et al. study.

A review of all U.S. Air Force (USAF) accidents coded for incapacitation, preexisting disease or other acute illnesses between 1978 and 1987 yielded an incapacitation rate of 0.019 per 100,000 flight hours.[24] This rate is less than half the rate in the Martin-Saint-Laurent[23] study and this study; however, the USAF study involved military pilots who may have been younger and in better physical condition, and it was restricted to events that resulted in aircraft accidents. We found that incapacitations rarely resulted in accidents; in fact, there were no accidents among the Martin-Saint-Laurent et al. cases and two accidents in this study, neither of which was fatal.

Two additional studies dealing with U.S. airline pilots were based on loss-of-licensure data, rather than in-flight events, and reported incapacitation rates based on the number of pilots incapacitated per year instead of flight time;[20,21] therefore, their results could not be compared with the results of this study in a meaningful way.

The two major airline-pilot incapacitation studies that dealt with in-flight medical events provide only qualitative results,[4,19] which do not allow for meaningful comparison with other quantitative studies.

### Probability of an Accident Due to an In-flight Medical Event

Froom reported that less than 1 percent of all aircraft accidents are due to pilot in-flight incapacitation.[11]

Lane calculated a probability of 5/68 or 0.074.[21] However, Lane included categories that were classified as impairments in our study. Combining incapacitations and impairments in this study, we calculated the probability of an accident to be 2/50 or 0.04, about half of the probability found in the Lane study. The difference in proportions may be due to differences in the types of aircraft operations in the two studies. While we have included only U.S. airline pilot in-flight medical events, only two of the five flights in the Lane study were airline flights, and one of those was a positioning flight. Also, two of the five accidents in the Lane study involved cargo aircraft, and one was a U.S. Department of Defense charter flight.

The proportion of military-pilot in-flight medical incapacitations leading to accidents was much higher, probably due to the difference in the operational environment. Rayman reported that the probability of an accident was 20/146, or 0.14, in one study of Air Force pilot incapacitations from 1970 to 1980,[32] and 28/59, or 0.47, in another Air Force study from 1966 to 1971.[31]

Although we found a statistically significant difference between the chance of an accident (given there was an in-flight medical event), compared with flights where there was no in-flight medical event, this difference must be interpreted in terms of its operational significance. The in-flight events in the two accidents are not representative of most other in-flight events. In neither case was the flight crew acutely affected by a medical condition in the same sense as a pilot who suffers chest pain from a heart attack or abdominal pain from a kidney stone, for example. These events might have ultimately led to an accident because they did not represent dramatic events that could have been detected and dealt with by the unaffected pilot. Some authors have made clear distinctions between obvious incapacitation and subtle incapacitation.[7,14] Raboutet and Raboutet even asserted that an incapacitation needed to be complete for an accident to result.[30] However, it is easy to imagine scenarios that involve: (1) incapacitation of the non-flying pilot, which increases the workload on the flying pilot to an unsafe level, (2) the subtle, insidious incapacitation of a crewmember that is not apparent until a critical phase of flight, (3) the partial incapacitation of a crewmember that degrades performance to an unsafe level and (4) the incapacitation of a crewmember during a noncritical phase of flight that continues into a critical phase, resulting in an unacceptable increase in workload for the flying pilot. Any of these situations could result in an aircraft accident without meeting the Raboutets' criteria. In addition, Crowley[8] also found the conditions described by Raboutet and Raboutet overly restrictive. Our findings suggest that a subtle, unperceived impairment might be more dangerous than an obvious, complete incapacitation. Although safety of flight was severely affected in seven of the 47 flights studied, accidents resulted in only two of those flights. In the other five flights, where the incapacitating event was not subtle, the unaffected pilot was able to recognize the emergency and prevent an accident, even in those situations where the event occurred on short final.

**A subtle, unperceived impairment might be more dangerous than an obvious, complete incapacitation.**

## Age Distribution of In-flight Medical Events

Some studies examining the Age 60 Rule for airline pilots have focused on pilot performance and aircraft accident data.[3,16,17,18] Hyland et al. studied all accidents involving pilots with Class I medical certificates and found a decrease in accident rate with age.[16,17,18] Broach et al. found a "U"-shaped curve with a decrease in accidents with increasing age, followed by a slight increase in older age groups for professional pilots holding Class I or Class II medical certificates and airline transport pilot (ATP) or commercial pilot certificates.[3]

Other researchers have suggested that replacement of older, experienced pilots by younger, inexperienced pilots could adversely affect flight safety, and it may be preferable to grant waivers to experienced pilots with an increased incidence of disease-related, in-flight sudden incapacitation than to replace them with younger, inexperienced pilots.[2,11] Froom reported that inexperienced pilots have a two to three times increased incidence of pilot-error-related accidents and cautioned that the estimated risk of in-flight medical incapacitation needed to be balanced by a consideration of pilot experience.[11]

We found a significant increase in the percentage of incapacitations, with age among the most

**Safety of flight was severely affected in 15 percent (seven out of 47) of the flights we studied.**

frequent categories of in-flight medical incapacitation for U.S. airline pilots; however, we did not find a significant difference between the mean age of pilots where safety of flight was seriously impacted and those pilots where safety of flight was not seriously at issue.

### Categories of In-flight Medical Events

Although many studies have dealt with pilot medical incapacitation, few have analyzed in-flight medical events.[6,7,13,14,19,21,29] Studies of in-flight medical events had different results or categorized cases differently, making comparison between studies difficult; however, we found no significant differences between four in-flight studies[4,24,31,32] when they were compared by categorizing cases with the same classification scheme used in this study and compared using a Krushal-Wallis analysis of variance (ANOVA).

### Fatal In-flight Medical Events

Only three in-flight medical-incapacitation studies reported fatalities;[24,30,31] however, it was not always clear when fatalities occurred or how many fatalities occurred in several other studies. Rayman reported 24 fatalities in a six-year study of sudden in-flight incapacitation in USAF pilots, or four fatalities per year.[31] In addition, in a 10-year study of in-flight incapacitation in USAF pilots, McCormick and Lyons[24] found one pilot was fatally injured in the crash of his single-seat aircraft after suffering a myocardial infarction in flight, for a rate of 0.1 fatalities per year, while Raboutet and Raboutet,[30] in a 25-year investigation of professional French pilots, found that one pilot suffered a massive pulmonary embolism in flight and died about one month post-crash, yielding a rate of 0.04 fatalities per year.

We found four deaths in our six-year study, which equates to 0.67 fatalities per year. The wide range in fatality rates per year from 0.04 to four in other studies can be partially explained by the fact that pilot fatalities resulting from in-flight medical incapacitation are very rare, random events; therefore, exposure time should be considered in evaluating them. Fatality rates based on flight-time exposure were not provided in earlier studies; therefore, comparisons were not possible. Accounting for flight-time exposure, we calculated a fatality rate of 0.00467 per 100,000 flight hours (95 percent CI 0.00465, 0.00468).

### Safety of Flight and In-flight Medical Events

Chapman[7] analyzed over 1,300 simulator exercises using two protocols. In the first protocol, the authors determined that safety of flight was at risk in 15 out of 500 (3 percent) of the cases, and it was believed that an accident would have resulted in eight (1.6 percent) cases. In the second protocol, 10 out of 800 (1.25 percent) were believed to have represented a risk to safety of flight; in two (0.25 percent), the authors believed aircraft accidents would have resulted.

A survey by IFALPA conducted by Bennett[1] showed that the pilots surveyed considered that safety was only significantly threatened in 3 percent of the incidents because there was time available to warn the other pilot of the problem.

Buley[4] reviewed IFALPA in-flight incapacitation questionnaire data and reported that 40 percent of responding aircrew members believed that safety of flight was not affected, 56 percent believed it was potentially affected, and 4 percent were convinced that safety of flight was actually affected.

Our data showed that safety of flight was severely affected in 15 percent (seven out of 47) of the flights we studied. This figure is higher than those reported by Chapman, Bennett or Buley. Differences in the percentage of flights where safety of flight was affected might be due to differences in methods among studies. In our study, we reviewed actual in-flight events and judged whether the circumstances would have severely affected safety of flight. In the studies conducted by Chapman, the researchers were required to determine if what was done in a flight simulator would have affected safety of flight in the aircraft under similar circumstances. The Buley study was the only one that collected safety of flight data directly from aircrew members; however, Buley's study would have relied on the ability of pilots to recall details of events that may have occurred many years earlier. Stone and Shiffman[34] recently reported that retrospective assessments may be prone to recall bias and distortion. In addition, Hunter[15] recently reported that exposure to hazardous aviation events may be associated with risk misperception by pilots. These factors suggest why pilots in the Buley study might have perceived the risk to safety of flight for a past event as being less than it actually was.

## In-flight Medical Events and Similar Medical Histories

There are times when the airman's FAA medical record contains coding that is similar to the category assigned to an in-flight event. We found no pilots whose in-flight medical impairments were categorized similarly to the codes assigned in their FAA medical records. However, nine of 39 incapacitations were categorized similarly to the codes assigned in the pilot's FAA medical record. It should be noted that the similarities between the assigned incapacitation categories and the corresponding FAA medical codes do not necessarily imply a cause-and-effect relationship and do not in any way suggest the airman should not have been medically certified because of the documented preexisting condition. For example, an airman with hypertension controlled with medication may be assigned a pathology code of 485 and issued a valid medical certificate. If the airman then suffers a stroke in flight, it might be argued that there could have been a relationship between the airman's hypertension and the stroke, since hypertension is a risk factor for stroke. However, the stroke could also have resulted from an undiagnosed cerebral aneurism.

In addition, an FAA medical code does not necessarily imply the airman should have been disqualified. Airmen often have codes assigned (pathology codes, history codes or ECG codes) to indicate the presence of medical conditions that are not disqualifying.

## Diversions Resulting From In-flight Medical Events

Diversions for medical purposes represent a significant problem for commercial air carriers.[9] Delay to original destination, passenger inconvenience, increased risk to safety, and cost factor into the complexity of aircraft diversions.[12] The exact cost of a medical diversion typically ranges between approximately US$3,000 and $100,000, depending upon whether fuel needs to be dumped before landing and whether or not passenger overnight accommodations are arranged.[33] Landing weight is also a consideration, and valuable fuel may have to be jettisoned to attain a suitable landing weight for a premature touchdown. While it is more difficult to put a dollar amount on safety of flight, this is perhaps the most important consideration in any diversion situation. If the unaffected pilot is forced to proceed via an unplanned route to an unexpected destination and perform an unfamiliar instrument approach, this could reduce the margin of safety still further in an already hazardous situation.

Nineteen of the 39 flights involving incapacitated pilots and three of the 11 flights with impaired pilots diverted. The diversion rate for all in-flight medical events was 22 out of 47, or 46.8 percent of flights. This is over twice the 20 percent diversion rate reported by Martin-Saint-Laurent et al.[23] in a study of in-flight incapacitation in commercial aviation in Air France pilots and flight engineers from 1968 to 1988. Since the methodologies of the two studies are very similar, the difference in percentages of diverted flights is probably due to other factors. One reason might be differences in the corporate culture between U.S. airlines in the 1990s and Air France in the 1960s that might have influenced the flight crews' decision to divert the flight. Another reason could be differences in the type of operation between the U.S. domestic airlines and Air France. For example, if many of the Air France flights were international flights, diversions for medical events may not have been practical because continuing to the destination would often be as appropriate.

## Aeromedical Certification Actions Resulting From In-flight Medical Events

The pathology, history and ECG codes assigned as a result of FAA Aerospace Medical Certification Division (AMCD) action become part of the airman's FAA medical record and have been incorporated into the new computerized document-imaging and workflow system. It must be noted that more than one type of action was taken in some cases. For example, a pilot may have been assigned a pathology code, been denied as a result of an in-flight medical event and then eventually recertified with a special-issuance medical certificate.

Although there was a significant decrease in the number of

**The diversion rate for all in-flight medical events was 22 out of 47, or 46.8 percent of flights.**

certification actions per in-flight medical event with time, it did not appear to reflect any change in FAA aeromedical certification policy, nor did it appear to be a function of the frequency of in-flight medical events. In fact, the frequency of events increased with time, and the effect of frequency was accounted for in Figure 4. One possible explanation for the trend was the chance distribution of events. An examination of the events showed those that occurred between 1993 through 1995 generally required more certification actions, while the events from 1996 to 1998 generally required fewer certification actions. Between Jan. 1, 1993, and Dec. 31, 1995, there were two cases of fatigue resulting in an aircraft accident with serious injuries, an alcohol-withdrawal seizure, three cardiac events, three neurological events, a vasovagal syncopal episode, two episodes of LOC, and two miscellaneous events. The average number of FAA certification actions per event for this group was 3.6. In contrast, between Jan. 1, 1996, and Dec. 31, 1998, there were two neurological cases, three cardiac cases, four cases of vasovagal syncope, five gastrointestinal cases, three cases of carbon-dioxide poisoning, two cases of hypoxia, three cases of renal lithiasis, two cases of unknown LOC, and two miscellaneous cases. In addition, there was one case each in the following categories: endocrine, vascular, vision, trauma, laser-illumination blindness, medication use, and respiratory. The mean number of FAA aeromedical certification actions per event for the post-1996 group was 1.7, which is about half that of the pre-1996 group. Therefore, the decreasing trend in the number of certification actions with time appears to have been due to random causes and not any purposeful change in FAA aeromedical certification policy.

In-flight medical incapacitation and impairment cases are regularly reviewed at CAMI medical staff meetings attended by physicians from the AMCD and the Aerospace Medical Research Division. Details of the in-flight event, as well as the pilot's medical history, are evaluated in deciding what action to take and which codes to assign. This process is very important because it may affect future aeromedical certification decision making, should the airman develop future medical problems or experience another in-flight event.

It is important to note the FAA actions taken in the 39 in-flight medical incapacitation cases and 11 impairment cases we studied represent action after the fact. In many instances, the FAA AMCD denies medical certification applications for airline pilots, possibly preventing many serious in-flight events. One FAA study[10] reported an overall denial rate for medical reasons of 4.3 per 1,000 active aviators for calendar years 1987 and 1988. The highest age-specific denial rate was for the 55 to 59 age group, and the most significant causes for denial for all age groups were coronary artery disease (8.5 percent), disqualifying medications (6.2 percent), psychoneurotic disorders (6.1 percent), myocardial infarction (5 percent) and disturbance of consciousness (4.4 percent).

## Conclusions

In-flight medical events in U.S. airline pilots were very rare; resulting aircrew deaths were even more rare, and resulting aircraft accidents were extremely rare. Fortunately, in the six years and nearly 86 million flight hours covered by this study, there were no passenger fatalities caused by pilot in-flight medical events. The two aircraft accidents resulted in serious injuries to three aircrew members and minor injuries to three passengers.

One study, focusing on professional pilot performance and aircraft accident data, found a relationship between pilot age and performance.[3] Still, other researchers have argued that replacement of older, experienced pilots by younger, inexperienced pilots could adversely affect flight safety. We found a significant increase in the percentage of incapacitations with age. However, there was no difference between the mean age of pilots involved in flights where safety of flight was seriously affected and the mean age of pilots not involved in such flights.

Although there was a significant difference between the probability of an aircraft accident, given an in-flight medical event, this result must be interpreted in its operational context. Both accidents involved the subtle impairment of the pilot in ways that are not classically thought of as medical incapacitation, and it may be that subtle impairment of a pilot is more dangerous than obvious medical incapacitation.

The most important factor that appears to be responsible for the exceptionally good U.S. airline safety record associated with in-flight medical incapacitations is the presence of a second pilot. In five out of the seven cases where safety of flight was considered to be severely affected, the aircraft was taken over by the unaffected pilot who made a successful landing. In the two cases where the affected pilot remained at the controls after subtle impairment, both resulted in an aircraft accident.

Aeromedical studies on incapacitation have been few in number, retrospective and less detailed than most other scientific studies. There is a lack of high-quality data, which has led to a lack of adequate research and inadequate information and recommendations. To be most valuable, future research needs to be based on actual in-flight medical events and should be normalized to a useful denominator, such as flight time, to allow for meaningful comparison between studies. Since the most frequent categories of incapacitation were LOC, cardiac, neurological and gastrointestinal (occurring mostly in older pilots), future research should be directed toward these areas.■

[FSF editorial note: This report has been reprinted from the Civil Aerospace Medical Institute (CAMI) of the U.S.

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## Figure A–1

### MEDICAL CASE ALERT
(Including incapacitations, special medical circumstances, etc.)

| | | | | |
|---|---|---|---|---|
| 1. AIRCRAFT ACCIDENT/INCIDENT | 1A. DATE | 1B. TIME | 1C. LOCATION | 1D. NUMBER/TYPE |
| 1E. NUMBER OF PERSONS ON BOARD | 1F. PILOT FATALITY ☐ YES ☐ NO | | 1G. COPILOT FATALITY ☐ YES ☐ NO | |
| 2A. OCCUPANT STATUS | X Pilot ☐ Cabin Crew ☐ Co-Pilot ☐ Passenger | 2B. FULL NAME | | 2C. SEX ☐ Male ☐ Female |
| 3. MEDICAL CLASS ☐ I ☐ II ☐ III | 3A. SOCIAL SECURITY NUMBER (Airmen Only) | | | |
| 3B. ANY KNOWN MEDICAL CONDITIONS (ex: SODA, SI, Undisclosed medication or condition, Path Codes) | | | | |
| 4. INJURY STATUS | | | | |
| 5. ESTIMATED ROLE OF INCAPACITATION | ☐ NONE | ☐ POSSIBLE | ☐ CERTAIN | |
| 6. ESTIMATED ROLE OF IMPAIRMENT | ☐ NONE | ☐ POSSIBLE | ☐ CERTAIN | |
| 7. POSSIBLE FACTORS INVOLVED IN THE MISHAP | 7a ☐ Medical condition<br>7b. ☐ Medication<br>7c. ☐ Alcohol<br>7d. ☐ Marijuana/Illicit drug<br>7e. ☐ Carbon Monoxide<br>7f. ☐ Pesticide | | 7g ☐ Hypoxia<br>7h. ☐ Spatial disorientation<br>7i. ☐ Fatigue<br>7j. ☐ Emotional Stress<br>7k. ☐ Other (specify) | |
| 8. TOXICOLOGICAL DATA | PERFORMED BY:<br>Address 1:<br>Address 2:<br>City: State: Zip Code:<br>Phone: | | FINDINGS: | |
| 9. AUTOPSY DATA | PERFORMED BY:<br>Address 1:<br>Address 2:<br>City: State: Zip Code:<br>Phone: | | COMMENTS: Pending | |
| 10. FAA/NTSB IIC FEEDBACK | PROVIDED BY:<br>Address 1:<br>Address 2:<br>City: State: Zip Code:<br>Phone: | | | |
| 11. NARRATIVE COMMENTS: (Elaborate on any of the above, or other significant factors. Use a separate sheet if additional space is needed. | | | | |
| Medical person completing form: (Name) | | (Phone) | | DATE: |

Source: Civil Aerospace Medical Institute, U.S. Federal Aviation Administration

## Figure A–2
### Average Age Distribution of U.S. Professional Pilots, 1993 to 1998


LE = less than or equal to GE = greater than or equal to

Source: Civil Aerospace Medical Institute, U.S. Federal Aviation Administration

**Table A-1**

**Case Summaries**

| Case | Year | Age | Safety of Flight Issue | Deceased | Event | Category | Civil Aerospace Medical Institute (CAMI) Narrative |
|---|---|---|---|---|---|---|---|
| 2 | 1994 | 45 | Yes | No | Incapacitation | Alcohol Withdrawal Seizure | The F/O suddenly screamed, extended his arms up rigidly, pushed full right rudder and slumped over the yoke. Aircraft descended to 1,000 feet before flight attendants pulled the F/O off the controls. "Mayday" calls were made, and the captain made a full missed approach before making a successful normal landing. Oxygen was administered for about seven minutes. F/O had another grand mal seizure at the hospital. |
| 3 | 1994 | 52 | No | Yes | Incapacitation | Cardiac | Aircraft was on approach with the F/O flying when his left arm slid off the throttles and he lay back in the seat. CPR was performed. It appeared to be a heart attack. |
| 4 | 1994 | 55 | No | Yes | Incapacitation | Cardiac | The captain became limp at the controls. CPR was performed. The second officer moved into the captain's seat, the F/O declared an emergency, and the flight was diverted. An uneventful, overweight landing was made. The captain was transported to a hospital, where he was pronounced dead. |
| 5 | 1995 | 59 | No | No | Incapacitation | Vasovagal | The captain lost consciousness and slumped across the center pedestal. Oxygen was administered, and the captain regained consciousness in 30 to 40 seconds. However, he passed out again, and recovered again. F/O landed the aircraft; captain taxied to the gate. |
| 6 | 1995 | 48 | Yes | Yes | Incapacitation | Cardiac | The F/O complained of heartburn, profuse sweating, tingling in both of his arms and nausea. His appearance was described as ashen gray. The captain assumed control. Symptoms passed and the F/O resumed flying. F/O complained that the heartburn pains were returning, so the captain assumed control and diverted.<br><br>F/O eventually lost consciousness, began twitching and stiffened, and loudly exhaled. CPR was performed. The F/O's left leg had become lodged against the left rudder when he stiffened, requiring the captain to apply right rudder to control the aircraft until the F/O's leg was dislodged. |
| 7 | 1995 | 57 | No | No | Incapacitation | Neurological | During descent from cruise, the captain failed to respond to a heading from air traffic control and did not respond to the F/O. What was described as a grand mal seizure followed. The F/O landed the aircraft, and the captain was taken to a local area hospital. (Hospital suspected a brain tumor of the left temporal lobe.) |
| 9 | 1995 | 56 | No | No | Incapacitation | LOC Gastrointestinal | The captain became nauseated, stomach became bloated and uncomfortable, then he lost consciousness. The flight was diverted. Upon landing, the captain was taken to a hospital. |
| 10 | 1995 | 41 | No | No | Incapacitation | Miscellaneous | The F/O experienced severe back pain soon after takeoff. The captain declared an emergency, and the flight returned to its place of origin. |

**Table A-1**

**Case Summaries** *(continued)*

| Case | Year | Age | Safety of Flight Issue | Deceased | Event | Category | CAMI Narrative |
|---|---|---|---|---|---|---|---|
| 11 | 1996 | 37 | No | No | Incapacitation | Gastrointestinal | The F/O became medically incapacitated in flight, and the flight diverted. The F/O was admitted to a hospital for treatment of possible peritonitis. He remained in a hospital for two days and was sent home by train. The F/O had had an appendectomy two months before the incident. |
| 12 | 1996 | 56 | No | No | Incapacitation | Vasovagal Gastrointestinal | The captain experienced severe abdominal pains and became medically incapacitated in flight. He was taken to a hospital, where workups including CT scan, gastrointestinal consultation and treadmill tests concluded that the event was probable gastroenteritis with vasovagal response. He had a near-syncopal episode during treadmill. Neurological and gastrointestinal workups were within normal limits. |
| 13 | 1996 | 43 | No | No | Incapacitation | Endocrine | The second officer became hypoglycemic. He was on oral anti-hypoglycemic agents and had a similar episode six weeks prior at the gate. This resulted in his being removed from the aircraft prior to the flight. Medical certificate was surrendered by the airman. |
| 14 | 1996 | 47 | No | No | Incapacitation | Vasovagal Gastrointestinal | Takeoff was rejected due to the F/O's incapacitation. F/O had slumped over in the cockpit but "recovered" as they were taxiing back to the gate. He appeared pale and was sweating profusely. The F/O was taken to a hospital and held overnight. He reported eating a bad sandwich the day before. |
| **16*** | **1996** | **44** | **Yes** | **No** | **Incapacitation** | **Hypoxia** | **The aircraft experienced decompression at 33,000 feet. The F/O made an emergency descent. It appears the flight engineer may have turned off the right flow pack with the cargo-heat-outflow valve open. Cabin altitude increased toward 33,000 feet and the F/O donned his mask. The captain, flight engineer and flight attendant lost consciousness but regained consciousness during descent. Oxygen masks deployed for all passengers. The captain took over the aircraft and landed.** |
| **17*** | **1996** | **42** | **Yes** | **No** | **Incapacitation** | **Hypoxia** | **The aircraft experienced decompression at 33,000 feet. The F/O made an emergency descent. It appears the flight engineer may have turned off the right flow pack with the cargo-heat-outflow valve open. Cabin altitude increased toward 33,000 feet and the F/O donned his mask. The captain, flight engineer and flight attendant lost consciousness but regained consciousness during descent. Oxygen masks deployed for all passengers. The captain took over the aircraft and landed.** |

**Table A-1**

**Case Summaries** *(continued)*

| Case | Year | Age | Safety of Flight Issue | Deceased | Event | Category | CAMI Narrative |
|---|---|---|---|---|---|---|---|
| 18 | 1996 | 31 | No | No | Incapacitation | Vasovagal | While the aircraft was climbing through 28,000 feet, the F/O went limp and slumped to left side of seat. Attempts to revive him were unsuccessful. After approximately 20 to 30 seconds, he started to stir a little, then abruptly started flailing about. The flailing lasted about 10 seconds, knocking off the captain's glasses and turning on the deice switches on the overhead panel. The F/O then came to. Over a period of about five minutes, he regained full consciousness but was drenched in sweat, and "as white as my shirt." He became fully coherent, with complete situational awareness. The flight then proceeded normally to the alternate airport. Initial evaluation was negative, and ECG was normal. |
| 19 | 1996 | 57 | No | No | Impairment | Cardiac | In flight, the captain began experiencing chest pain. The airman reported experiencing intermittent retrosternal chest pain since the previous day. Pain was becoming more continuous with radiation to his left jaw and left arm. The flight diverted, and the captain taxied the aircraft to the gate. The clinical impression was chest pain with possible unstable angina. |
| 20 | 1996 | 41 | No | No | Incapacitation | Miscellaneous | The captain experienced chest pains during flight. A nurse who was on board stated that he appeared pale and anxious; the flight diverted. Upon landing, the captain was taken to a hospital for treatment. The captain was admitted and kept overnight for observation. ECG was performed; he was without chest pain upon entry to the emergency room, stress test performed and enzymes tested. All studies were normal. |
| 21 | 1996 | 56 | Yes | No | Incapacitation | Vascular | A scheduled domestic passenger flight was stopped on the taxiway after landing when the captain became incapacitated. The F/O stated that the captain was flying the aircraft, and during the approach, the captain did not ask for the landing gear to be extended. The approach to the runway was flown at a higher than normal speed, and after touchdown, the captain used reverse thrust for a longer-than-normal time. After exiting the runway onto the taxiway, the captain applied takeoff engine power. The F/O closed the engine power levers, the captain again tried to apply takeoff engine power. The F/O realized the captain was incoherent and closed the engine power levers and shut down the engines. He then called for assistance from the flight attendants and asked the air traffic controller to send out rescue personnel. |
| 27 | 1997 | 37 | No | No | Incapacitation | Gastrointestinal | While en route, the F/O experienced severe stomach pain. The captain decided to divert. Paramedics took the F/O to a hospital. Diagnosis: severe intestinal gas blockage. |

**Table A-1**

**Case Summaries** *(continued)*

| Case | Year | Age | Safety of Flight Issue | Deceased | Event | Category | CAMI Narrative |
|---|---|---|---|---|---|---|---|
| 29 | 1997 | 54 | No | No | Incapacitation | Traumatic Injury | While the F/O was performing the preflight check, a drop of hydraulic fluid (Skydrol) entered into his eye. He was then taken to the local hospital, where the eye was washed out. |
| 30 | 1997 | 34 | No | No | Impairment | Laser Illumination Blindness | The captain was on the controls when he noticed a green light illuminating the aircraft. He reported that his exposure to the light caused a minimal, yet persistent, loss of night vision. |
| 31 | 1997 | 58 | No | No | Incapacitation | Urological | F/O declared an emergency due to the incapacitation of the captain. An onboard doctor determined it was a stomach-related problem. The captain was vomiting, had pain in stomach and was very weak. The F/O landed the aircraft. The captain was taken to a hospital, and kidney stones were passed. |
| 32 | 1997 | 51 | No | No | Incapacitation | Gall Bladder | En route, the F/O developed severe abdominal pains. The captain radioed that the F/O had "gas pain with significant discomfort" and requested paramedics meet the aircraft. An emergency was declared. The F/O was taken to a hospital. Diagnosis was a gall bladder attack; subsequently, surgery was performed. |
| 33 | 1997 | 53 | No | No | Incapacitation | Gastrointestinal | The captain became ill with flu-like symptoms, nausea, vomiting and diarrhea during a trans-Atlantic flight. An onboard physician said the captain was suffering from acute gastroenteritis, secondary to food poisoning. |
| 34 | 1997 | 54 | No | No | Incapacitation | Gall Bladder | The flight declared an emergency and made an unscheduled landing because the flight engineer had a suspected heart attack. He was transported to a hospital in stable condition. Working diagnosis was cholelithiasis. |
| 35 | 1997 | 30 | No | No | Incapacitation | Medication | An emergency was declared after the F/O experienced chest pains. The pilot was taken to the local hospital. Preliminary reports indicated the chest pains were not cardiac-related. |
| 37 | 1998 | 38 | No | No | Incapacitation | Neurological (Seizure) | The F/O was on a break and was asleep when a flight attendant noticed he was bleeding from his mouth and tongue. He was awakened and appeared disoriented. It was assumed the F/O had a seizure while sleeping. He was taken to a hospital and had a seizure while having an ECG. |
| 38 | 1998 | 48 | No | No | Incapacitation | Unknown LOC | The captain experienced severe abdominal pain during flight. He collapsed in his seat and was unresponsive. The captain reported eating at a restaurant. Complaints were diarrhea, vomiting, sweating, panting and abdominal pain. The hospital found him to be dehydrated and administered approximately 3.5 liters of fluid. |

**Table A-1**

**Case Summaries** *(continued)*

| Case | Year | Age | Safety of Flight Issue | Deceased | Event | Category | CAMI Narrative |
|---|---|---|---|---|---|---|---|
| 39 | 1998 | 50 | No | No | Incapacitation | Unknown LOC | The F/O was found unresponsive and an onboard physician was called to attend him. He appeared to have had a seizure and appeared to be unconscious for 30 minutes. He walked through the airport and refused medical attention from the paramedics who had been sent to meet him at the gate; he also refused to be checked at a hospital. |
| 72 | 1998 | 56 | No | Yes | Incapacitation | Cardiac | The F/O told his captain that he was not feeling well shortly before suffering an apparent heart attack. He was observed slumped over in his seat. The flight diverted. CPR was given. Paramedics were waiting at the gate six minutes after the F/O collapsed, but they were unable to revive him. |
| 73 | 1998 | 50 | No | No | Incapacitation | Urological | During flight, the captain suffered severe back pain. The flight diverted. The pain went away after landing but returned on the way to the hospital. Tests at the hospital revealed dilation at the left urethral-vesticular junction, most likely due to a kidney stone. |
| 74 | 1998 | 51 | No | No | Impairment | Vasovagal | The F/O had what was thought to be indigestion before departure. After he stretched and raised an arm, he stated that it felt "heavy" and that a weakness was felt in the arm. He broke out into a cold sweat. |
| 81 | 1998 | 47 | No | No | Incapacitation | Urological | The F/O was having chest and abdominal pains. Hospital diagnosed kidney stones. |
| 82 | 1998 | 56 | No | No | Incapacitation | Cardiac | The captain became intensely nauseated during the flight and developed severe anterior chest heaviness, along with aching discomfort without radiation. The captain broke out into a sweat, and it appeared he was having a heart attack. The captain was treated onboard by two physicians and was given four tablets of nitroglycerin that produced decreased chest discomfort but gave him a headache. |
| **83*** | **1998** | **55** | **No** | **No** | **Impairment** | **Carbon Dioxide Poisoning** | **The aircraft was taxiing to takeoff when all four occupants became short of breath. All occupants donned oxygen masks, and the captain taxied the airplane back to the ramp. The crew was transported to a hospital. Diagnosis was physical impairment resulting from an accumulation in the cockpit of carbon dioxide fumes produced by dry ice, a hazardous material, carried in the main cargo compartment.** |
| **84*** | **1998** | **28** | **No** | **No** | **Impairment** | **Carbon Dioxide Poisoning** | **The aircraft was taxiing to takeoff when all four occupants became short of breath. All occupants donned oxygen masks, and the captain taxied the airplane back to the ramp. The crew was transported to a hospital. Diagnosis was physical impairment resulting from an accumulation in the cockpit of carbon dioxide fumes produced by dry ice, a hazardous material, carried in the main cargo compartment.** |

**Table A-1**

**Case Summaries** *(continued)*

| Case | Year | Age | Safety of Flight Issue | Deceased | Event | Category | CAMI Narrative |
|---|---|---|---|---|---|---|---|
| **85*** | **1998** | **27** | **No** | **No** | **Impairment** | **Carbon Dioxide Poisoning** | **The aircraft was taxiing to takeoff when all four occupants became short of breath. All occupants donned oxygen masks, and the captain taxied the airplane back to the ramp. The crew was transported to a hospital. Diagnosis was physical impairment resulting from an accumulation in the cockpit of carbon dioxide fumes produced by dry ice, a hazardous material, carried in the main cargo compartment** |
| 86 | 1998 | 29 | No | No | Impairment | Gastrointestinal Dehydration | The captain had been feeling ill all day. On approach, he began to vomit, which continued for a few minutes. Local clinic diagnosed gastroenteritis. |
| 87 | 1998 | 31 | No | No | Incapacitation | Miscellaneous | The F/O experienced dizziness when getting up to go for aspirin for an earache. LOC was initially reported, although this was not confirmed. |
| 89 | 1998 | 49 | Yes | No | Incapacitation | Neurological (Seizure) | The aircraft had just landed when the captain apparently had a seizure episode for over a minute and a half. The captain's body became stiff, the back arched, and the captain bit his tongue and dislocated/fractured the left shoulder, also sustaining a lumbar compression fracture. The captain caused the aircraft to turn right and come to a sudden stop due to the stretched position. He regained consciousness shortly thereafter. The F/O removed the captain from the controls and taxied to the gate. |
| 95 | 1998 | 25 | No | No | Incapacitation | LOC Cardiac | During flight the F/O lost consciousness for less than one minute. After regaining consciousness, the F/O was able to fully perform some duties, and the flight continued to the destination. |
| 96 | 1994 | 57 | No | No | Incapacitation | Neurological (Seizure) | During a trans-Atlantic flight, the captain lost consciousness. The aircraft diverted. The captain was in the jump seat at the time, the episode was described as an out-of-body sensation with the head jerking to the right. The captain passed out and became wedged in between the cockpit seats. The captain was unresponsive with arms folded across the chest. The captain was stiff and bit his tongue. However, he regained his senses in less than one minute and did not describe any significant postictal phase. |
| 97 | 1998 | 43 | No | No | Impairment | Respiratory | On departure, the F/O experienced increasing pain and pressure in the sinuses and right inner ear. The pain became worse as the aircraft ascended; pressure increased and was accompanied by numbness. Flight diverted, the pain subsided on descent and was tolerable at sea level. |
| 98 | 1998 | 34 | No | No | Incapacitation | Gastrointestinal | The flight diverted after the F/O became ill. It was reported the F/O had flulike symptoms, cramps and vomiting but did not lose consciousness. |

**Table A-1**

**Case Summaries** *(continued)*

| Case | Year | Age | Safety of Flight Issue | Deceased | Event | Category | CAMI Narrative |
|---|---|---|---|---|---|---|---|
| 100 | 1994 | 59 | No | No | Incapacitation | Miscellaneous | In flight, the captain's performance was poor and inattentive, with portions of his speech being unrecognizable. The F/O assumed all flight deck duties, but the captain wanted to participate, and to avoid a confrontation, the F/O allowed the captain to assist, but the duties became very difficult for the captain to accomplish. After landing, the captain assisted in parking the aircraft but was unable to respond intelligently. |
| 148 | 1996 | 48 | Yes | No | Impairment | Vision | The airplane struck the approach-light structure and the end of the runway deck during the approach. Because of the captain's use of monovision contact lenses, he was unable to overcome the visual illusions resulting from the approach over water in limited light. These illusions led the captain to perceive that the airplane was higher than it was during the visual portion of the approach, and thus, to unnecessarily steepen the approach during the final 10 seconds before impact. |
| 175 | 1993 | 33 | No | No | Incapacitation | Neurological (Seizure) | F/O experienced LOC in flight and experienced feeling disorientated, presyncopal and "numb all over" for 10 seconds prior to the LOC. The F/O was witnessed to have a five-minute episode of tonic-clonic convulsions, with a postictal state accompanied by confusion. |
| 178 | 1994 | 52 | No | No | Incapacitation | LOC, Decompression Sickness | During climbout, the crew was unable to pressurize the airplane. The crew donned oxygen masks and climb was continued to Flight Level 330 (approximately 33,000 feet).<br><br>Shortly after level-off, the captain became incapacitated from decompression sickness. The flight diverted. |
| **218*** | **1993** | **54** | **Yes** | **No** | **Impairment** | **Fatigue** | **Additional factors contributing to the cause were the inadequacy of the flight and duty time regulations applied to U.S. Federal Aviation Regulations, Part 121, supplemental air carrier, international operations, and the circumstances that resulted in the extended flight/duty hours and fatigue of the flight crew.** |
| **219*** | **1993** | **50** | **Yes** | **No** | **Impairment** | **Fatigue** | **Additional factors contributing to the cause were the inadequacy of the flight and duty time regulations applied to U.S. Federal Aviation Regulations, Part 121, supplemental air carrier, international operations, and the circumstances that resulted in the extended flight/duty hours and fatigue of the flight crew.** |

F/O = First officer CPR = Cardiac pulmonary resuscitation CT = Computed tomography ECG = Electrocardiogram LOC = Loss of consciousness

*Bold-faced sequential cases occurred on the same flight (i.e., cases 16-17, 83-85 and 218-219).

# Quick-access Recorders Installed On Most Airplanes in Taiwanese Airline Service

**All helicopters in airline service based in Taiwan, China, had cockpit voice recorders installed, although none had a flight data recorder. Most aircraft in government service did not have any type of flight recorder.**

– FSF EDITORIAL STAFF

A majority of all airplanes operated by airlines based in Taiwan, China, had a quick-access recorder (QAR) for routinely downloading and analyzing flight data in 2004. A cockpit voice recorder (CVR) and a flight data recorder (FDR) had been installed in almost all airline airplanes. Of the helicopters in airline service, all had a CVR, but none had an FDR or a QAR.

Most of the 35 civil aircraft, mainly helicopters, operated by the Taiwanese government had no flight recorder of any type.

The data were obtained in a survey conducted by the Aviation Safety Council of Taiwan (ASC).[1] Airlines surveyed included China Airlines, EVA Airways, UNI Airways, Far Eastern Air Transport, TransAsia Airways, Mandarin Airlines, Daily Air, Sunrise Airlines, Pacific Air, ROC Aviation Co., Great Wing Airlines and Aerospace Industrial Development Corp.

Among all 194 civil airline aircraft (187 airplanes and seven helicopters), 99.0 percent had a CVR and 94.3 percent had an FDR. Among the airplanes, 185 (98.9 percent) had a CVR and 183 (97.9 percent) had an FDR (Table 1, page 25). Only two airplanes, Pilatus Britten-Norman BN-2 Islanders, had neither a CVR nor an FDR; two Dornier DO-228s did not have an FDR.

**Among all 194 civil airline aircraft … , 99.0 percent had a CVR and 94.3 percent had an FDR.**

**Table 1**
**Taiwan, China, Civil Airplanes, Cockpit Voice Recorder (CVR) and Flight Data Recorder (FDR) Use, by Airplane Type, 2004**

| Aircraft Type | Number of Aircraft | Number With CVR | Number With FDR |
|---|---|---|---|
| Airbus A300-600 | 12 | 12 | 12 |
| Airbus A320-231 | 1 | 1 | 1 |
| Airbus A320-232 | 2 | 2 | 2 |
| Airbus A321-131 | 5 | 5 | 5 |
| Airbus A330 | 7 | 7 | 7 |
| Airbus A340-300 | 7 | 7 | 7 |
| ATR-72-201P | 2 | 2 | 2 |
| ATR-72-202P | 1 | 1 | 1 |
| ATR-72-212A | 7 | 7 | 7 |
| Boeing 737-800 | 14 | 14 | 14 |
| Boeing 747-400 | 47 | 47 | 47 |
| Boeing 757-200 | 8 | 8 | 8 |
| Boeing 767-200 | 4 | 4 | 4 |
| Boeing 767-300 | 4 | 4 | 4 |
| De Havilland DH-8-200 | 1 | 1 | 1 |
| De Havilland DH-8-300 | 12 | 12 | 12 |
| Dornier DO-228 | 4 | 4 | 2 |
| Fokker F.100 | 6 | 6 | 6 |
| Fokker F.50 | 6 | 6 | 6 |
| Galaxy Aerospace Astra SPX | 1 | 1 | 1 |
| McDonnell Douglas MD-11 | 12 | 12 | 12 |
| McDonnell Douglas MD-80 | 9 | 9 | 9 |
| McDonnell Douglas MD-90-30 | 13 | 13 | 13 |
| Pilatus Britten-Norman BN-2A-26 | 1 | 0 | 0 |
| Pilatus Britten-Norman BN-2B-26 | 1 | 0 | 0 |
| **Totals** | **187** | **185**<br>**98.9%** | **183**<br>**97.9%** |

Source: Aviation Safety Council of Taiwan, China

The survey sought to determine which airplanes had an FDR that can provide hard-copy (paper) readouts, electronic-file readouts or both (Table 2, page 26). Of the 187 airplanes, 157 (84.0 percent) had an FDR that can provide paper readouts and 91 (48.7 percent) had an FDR that can provide electronic files.

A QAR was installed on 130 airplanes (69.5 percent).

All seven of the helicopters in airline service were equipped with a CVR (Table 3, page 26), but none had an FDR or a QAR.

The ASC requested that the airlines report whether they had verified, during an aircraft "C" check or during a shop examination of the FDR, that the FDR was recording its parameters correctly. The proportion of FDRs reported as verified correct was 89.7 percent.

The survey showed that older analog FDR units using magnetic tape rather than digital recording had decreased from the previous year's survey, comprising 5.7 percent of the entire civil airline fleet (including helicopters). For airplanes, the figure was 5.9 percent.

The proportion of CVR units using magnetic tape was also decreasing, the ASC said. A tape CVR was installed in 46 aircraft (23.7 percent of the fleet) in 2004. A solid-state CVR with a 30-minute recording time was installed in 61 aircraft (31.4 percent of the fleet), and a solid-state CVR with a 120-minute recording time was installed in 85 aircraft (43.8 percent of the fleet). (Decimals in the subtotals are rounded.)

Among airplanes, 45 (24.1 percent) had a tape CVR; 55 (29.4 percent) had a solid-state CVR with a 30-minute recording time; and 85 (45.5 percent) had a solid-state CVR with a 120-minute recording time. (Decimals in the subtotals are rounded.)

The survey also included 35 civil aircraft (two airplanes and 33 helicopters) from the National Airborne Service Corps, a government agency into which the aircraft from the Coast Guard Administration, Civil Aviation Administration, National Fire Agency and National Police Agency were merged in 2004. One of the airplanes, a Raytheon Beechcraft King Air 350, had a CVR; the other, a King Air 200, did not. One helicopter, a Sikorsky S-76B, had a CVR and an FDR, and one S-76B had a CVR. No CVR, FDR or QAR was installed in the remainder of the government helicopters. In total, three of the 35 government aircraft (8.6 percent) carried either a CVR or a CVR and an FDR. ■

## Note

1. The survey report is available on the Internet at <www.asc.gov.tw>.

**Table 2**

**Taiwan, China, Civil Airplanes, Flight Data Recorder (FDR) Readout Type and Quick-access Recorder (QAR) Use, by Airplane Type, 2004**

| Aircraft Type | Number of Aircraft | Number With FDR Readout Type | | Number With QAR |
|---|---|---|---|---|
| | | Paper | File | |
| Airbus A300-600 | 12 | 12 | 0 | 12 |
| Airbus A320-231 | 1 | 0 | 0 | 1 |
| Airbus A320-232 | 2 | 0 | 0 | 2 |
| Airbus A321-131 | 5 | 0 | 0 | 5 |
| Airbus A330 | 7 | 0 | 7 | 7 |
| Airbus A340-300 | 7 | 0 | 7 | 7 |
| ATR-72-201P | 2 | 2 | 0 | 1 |
| ATR-72-202P | 1 | 1 | 0 | 1 |
| ATR-72-212A | 7 | 6 | 0 | 6 |
| Boeing 737-800 | 14 | 14 | 0 | 14 |
| Boeing 747-400 | 47 | 46 | 18 | 46 |
| Boeing 757-200 | 8 | 8 | 8 | 1 |
| Boeing 767-200 | 4 | 4 | 4 | 4 |
| Boeing 767-300 | 4 | 4 | 4 | 2 |
| De Havilland DH-8-200 | 1 | 1 | 1 | 0 |
| De Havilland DH-8-300 | 12 | 12 | 12 | 0 |
| Dornier DO-228 | 4 | 0 | 0 | 0 |
| Fokker 100 | 6 | 6 | 0 | 0 |
| Fokker 50 | 6 | 6 | 0 | 0 |
| Galaxy Aerospace Astra SPX | 1 | 1 | 0 | 0 |
| McDonnell Douglas MD-11 | 12 | 12 | 12 | 12 |
| McDonnell Douglas MD-80 | 9 | 9 | 5 | 0 |
| McDonnell Douglas MD-90-30 | 13 | 13 | 13 | 9 |
| Pilatus Britten-Norman BN-2A-26 | 1 | 0 | 0 | 0 |
| Pilatus Britten-Norman BN-2B-26 | 1 | 0 | 0 | 0 |
| **Totals** | **187** | **157**<br>**84.0%** | **91**<br>**48.7%** | **130**<br>**69.5%** |

Source: Aviation Safety Council of Taiwan, China

**Table 3**

**Taiwan, China, Civil Helicopters, Cockpit Voice Recorder (CVR), Flight Data Recorder (FDR), FDR Readout Document and Quick Access Recorder (QAR) Use, by Helicopter Type, 2004**

| Aircraft Type | Number of Aircraft | Number With CVR | Number With FDR | Number With FDR Readout Document | | Number With QAR |
|---|---|---|---|---|---|---|
| | | | | Paper | File | |
| Eurocopter/Kawasaki BK-117B-1 | 3 | 3 | 0 | 0 | 0 | 0 |
| Eurocopter/Kawasaki BK-117B-2 | 4 | 4 | 0 | 0 | 0 | 0 |
| **Totals** | **7** | **7**<br>**100.0%** | **0**<br>**0.0%** | **0**<br>**0.0%** | **0**<br>**0.0%** | **0**<br>**0.0%** |

Source: Aviation Safety Council of Taiwan, China

# FOD-prevention Programs Have Improved Safety

**The single most important factor in a successful foreign object damage (FOD)-prevention program is sustained support by an aviation organization's top leadership. A formal program also must have a way of measuring progress toward meeting its goal.**

— FSF LIBRARY STAFF

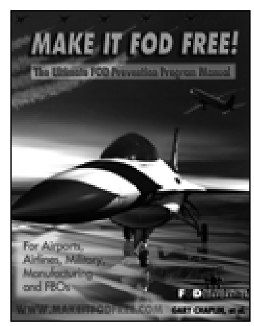
## Books

***Make It FOD Free! The Ultimate FOD Prevention Program Manual.*** Chaplin, Gary et al. Tucson, Arizona, U.S.: The F.O.D. Control Corp., 2004. 212 pp. Figures, glossary.

Gary Chaplin, president of The F.O.D. Control Corp., who edited and contributed to this book, says that a current conservative estimate for the worldwide annual cost of foreign object damage (FOD) is US$3 billion to $4 billion.

At worst, the cost of FOD can go beyond the financial. The accident that involved an EADS Concorde on takeoff at Charles de Gaulle Airport, Paris, France, on July 25, 2000, resulted in 109 fatalities to occupants of the aircraft and four fatalities and six injuries on the ground. [The report by the French Bureau Enquêtes-Accidents (BEA) said that the precipitating probable cause was "high-speed passage of a tire over a part lost by an aircraft that had taken off five minutes earlier."]

"Successful FOD-prevention programs have been pioneered during the past few decades, with the military at the forefront," say the authors. "The process continues evolving today. More recently, many U.S. aircraft manufacturers have developed and implemented outstanding FOD programs. The authors of this book believe, and have proven within their own organizations, that [FOD] *can* be dramatically reduced!"




Thirteen editorial contributors include a Transport Canada wildlife-control specialist, a retired Royal Canadian Air Force colonel and a U.K. Royal Air Force wing commander as well as writers widely experienced in U.S. aviation. Each discusses one or more aspects of successful FOD-prevention programs, including data analysis, FOD-prevention training, ramp action lists, "sterilizing" the workplace, airfield-pavement management and many others.

"The single most important factor in a successful FOD prevention program is the complete commitment and *ongoing* support of your organization's top leadership," say the authors. "Without it the program is handicapped from the start and will suffer a lack of credibility."

New employees who work on ramps, taxiways or runways should not be allowed to begin work until they have attended a FOD-prevention program orientation, say the authors. It recommends the following training practices:

- Define FOD. Don't assume that everyone knows what FOD is. Show photographs of FOD and pass around samples of debris found at your facility;

- Identify the standard operating procedures for FOD and provide a copy to each new employee;

- Emphasize the importance of the "clean as you go" principle and define the rules that apply to daily work routines;

- Review tool and hardware rules, to include tool crib–issued items;

- Review the missing-item report, when to use it and how to submit it;

- Identify FOD-control areas, and show examples of typical FOD charts and metrics;

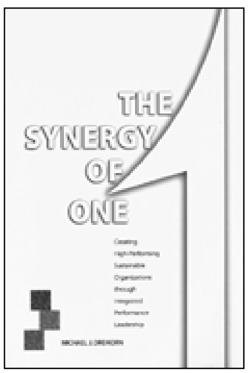
- If the borescope [a tool for visually inspecting otherwise-inaccessible areas] is available at your site, discuss who may use it and general safety rules. Also identify other specialized tools used to locate or remove foreign objects; and,

- Explain the role of the FOD department and how to contact a representative if needed.

Operations managers have at least as much responsibility as ground staff for FOD prevention. "Management support — both actual and perceived at lower levels — is essential to the success of any FOD program; it must be more than just 'lip service,'" say the authors. "It must include creation of a formalized FOD-control program with adequate funding to ensure that the program can sustain itself — especially in the early stages prior to cost savings being recognized. The program needs a responsible contact person with authority to carry out the programs, as well as full support and encouragement from the newly established culture that crosses all boundaries within the organization."

Measurement of results is another important tool for management, the authors say, and an organization's leaders must ask themselves questions such as, "How does your organization compare to others of similar size and fleet type? What measurements will be taken? How will you measure your progress? What is your starting point?"

The authors recommend that, once a program has established what measurements will be taken, the data derived should be sorted into specific categories such as engine, tire, fuselage and bird strikes. Trends, "spikes" (large, brief changes) and anomalies should be noted.




***The Synergy of One: Creating High-performing Sustainable Organizations Through Integrated Performance Leadership.*** Dreikorn, Michael J. Milwaukee, Wisconsin, U.S.: ASQ Press, 2004. 209 pp. Figures, tables, glossary, references, index.

"The more complex an organization's design, the greater the probability that it will fail and increase the number of times work must be processed," says the author, a former quality-assurance executive at Pratt & Whitney who also has held leadership positions with the U.S. Federal Aviation Administration (FAA), McDonnell Douglas, Northrop Electronics and the U.S. Army. Leaders can cure organizational hypertrophy through treating businesses as integrated processes that can be managed as holistic organisms, he believes.

To facilitate management using that principle, the author has created the concept of integrated performance leadership (IPL). The concept "combines aspects of various sciences and theories to bridge the gap between academic postulation and the realities of organizational practice," he says.

An anecdote offered early in the book illustrates an organization that, on one particular day, was not operating as a coherent unit. The organization was an airline, and the incidents described were associated with a business trip taken by the author and a group of executives on flights from Hartford, Connecticut, U.S., to Nagoya, Japan, with two intervening flight changes in the United States.

The incidents included the following:

- During the second segment of the trip, which had been rescheduled because of a missed connection, the author was trying to determine whether the group would make the next connection for a flight from San Francisco, California, U.S., to Nagoya. The flight attendants were unable to provide the information; he telephoned from his airplane seat to his assistant in Hartford, who telephoned the airline and reported back that the airline had rescheduled the group on a flight to Japan one day later, which meant that the group would miss critical business meetings in Japan. Moreover, the author found that the group had been rescheduled before they had boarded the second flight, but they had not been informed of the change; and,

- In San Francisco, the group was told that their checked baggage had not been loaded on the flight that the group had just taken, but would arrive on the next flight. It did not. Then one member of the group noticed that his bag was in a cage outside the airline's luggage office. The author says, "My entire team walked out to the cage and recognized their own bags, and we began a debate with the company representatives about the possibility of those bags being ours. Even when the cage was opened and the bags placed before us, the employees refused to accept that they could be our bags."

The author acknowledges that in the course of his misadventures, several employees of the airline tried to resolve problems, and that one showed exceptional courtesy and concern. But, he says, they were defeated by a dysfunctional system. "It did start to become apparent … that I was doing business with an airline that performed its processes in isolated steps and not as an integrated enterprise," he says.

One basic problem that afflicts many organizations, the author says, is that as they grow in size, they generate many internal sub-organizations that work as closed systems, out of touch with the other sub-organizations or the larger corporate goals. They may define success narrowly in terms of meeting department production targets while neglecting the ultimate goal, which is enabling the company to give customers good service. Leaders operating on IPL principles, the author says, can transform such disconnected micro-management.

The principles integrate resources, accountability, organizational culture, understanding and leadership. Each aspect of the integration, and its relationship to the whole, is examined, he says.

"By clearly and consistently defining performance metrics throughout the organization and ensuring that there is a consistent understanding of expectations, action and interrelatedness at all levels of the organization, we will have greater synergy and commitment to a common objective," the author says. "It is critical that organizations, and especially their leaders, understand the interrelatedness of the organization and understand the roles and value that each member provides within it. We must also understand how our structures and processes relate to the creation of value for the customer."

## Reports

***Specification for an Offshore Helideck Status Light System.*** U.K. Civil Aviation Authority (CAA) Safety Regulation Group (SRG). Civil Aviation Paper (CAP) 2003/06. Version 1. November 2004. 31 pp. Figures, tables, appendixes, references. Available on the Internet at <www.caa.co.uk> or from Documedia.*

This report provides a recommended technical specification for an offshore-helideck status-signaling system, describes operational requirements for the system, outlines a test procedure to measure the performance of flashing lights intended for use as helideck status lights and contains calculations of required intensity for a warning-light system.

Instances of landings on misidentified "rigs" (offshore platforms) in the United Kingdom have been well documented through the Mandatory Occurrence Reporting (MOR) scheme and reached a peak in the late 1990s. In response to industry concerns about these landings and associated safety hazards, the CAA began to focus on the issue. Studies, recommendations and specifications evolved over time.

An early CAA study of offshore platform-identification signs (CAA Paper 92006, *Offshore Platform Identification Signs*, April 1992) determined that the problem could not be resolved through improvements in signage and recommended a new visual aid, a helideck status-signaling system, to help prevent a helicopter landing on an unsafe platform.

A follow-up study (CAA Paper 93020, *Helideck Status Signalling System*, September 1993) was to develop a specification for a status-signaling system that would be capable of indicating three discrete helideck conditions: "the deck is safe and fit to land on"; "the deck is safe but [is] not manned"; and "the deck is unsafe to land on." The study identified practical difficulties associated with implementing such a system — namely, complexity and expense — and recommended a simpler system of two lights to indicate a helideck's unsafe condition.

"While it may be embarrassing for a pilot to land on the wrong rig, it is the view of the CAA that it is not necessarily an issue of safety unless the deck is obstructed or otherwise unfit to accept a helicopter movement," the CAA said in an interim guidance letter issued in December 2003.

The report says, "As a result of [the follow-up] study, a modified objective for the project was accepted. This was 'to develop and validate a specification for a light-signaling system for offshore platforms capable of warning helicopters if the helideck is in an unsafe condition.'

"Examples of an unsafe helideck were considered to be the presence of a gas leak; moving machinery (e.g., a crane) in the area of the helideck; explosives in use on the platform; [and] platform personnel working on or near the helideck."

That specification was published in CAA Paper 98003, *Specification for an Offshore Helideck Status Signalling System*, December 1998.

Recent industry developments and acquired knowledge identified a number of gaps in the original specification and the consequent need to improve the guidance material, says the report, which updates the specification.

The operational requirement for the system is to provide a light signal that pilots will recognize as a warning of unsafe conditions existing on an offshore installation while the helicopter is on its helideck, and at any range within at least 900 meters (2,953 feet) from the offshore installation at all azimuths in meteorological visibilities down to 1,400 meters (4,593 feet), day and night.

The specification addresses the following system characteristics:

- Intensity and intensity control (dimming control);
- Distance at which the signal must be seen by pilots;
- Meteorological visibility conditions;
- Ambient lighting;
- Signal visibility from all possible approach directions and signal visibility while the helicopter is landed on the helideck on any heading;
- Flash rate and flash sequencing of light units;
- Angles of elevation, vertical beam spread and horizontal beam spread;
- International standards for color and color coordinates;
- Number, size and location of light units;
- Activation of light units;
- System integrity and redundancy;
- Protection of system against interference from a single-item failure; and,
- Integration of the light system with platform safety systems.

"The overriding consideration in establishing the performance specification is the effectiveness of the system, i.e., the ease with which the pilot would be able to notice the signal," the report says.

The report says, "The specification contained in this paper supersedes that detailed in CAA Paper 98003 and will be referenced in CAP 437, *Offshore Helicopter Landing Areas: Guidance on Standards*." The recommended technical specification supports the CAA's best-practice guidance material appearing in CAP 437.

***Evaluation of a Head Injury Criteria Component Test Device.*** DeWeese, Richard L.; Moorcroft, David M. U.S. Federal Aviation Administration (FAA) Office of Aerospace Medicine. DOT/FAA/AM-04/18. November 2004. 20 pp. Figures, tables, references. Available on the Internet at <http://www.cami.jccbi.gov> or through NTIS.**

Aircraft seats that are certified to meet requirements of the U.S. Federal Aviation Requirements (FARs) must protect the occupants from serious head injury as defined by the Head Injury Criterion (HIC). Airworthiness standards for certification apply to the following FARs involving emergency-landing dynamic conditions:

- Part 23.562, for normal, utility, acrobatic and commuter category airplanes;
- Part 25.562, for transport category airplanes;
- Part 27.562, for normal category rotorcraft; and,
- Part 29.562, for transport category rotorcraft.

"Currently this [requirement] is demonstrated during a dynamic sled test that includes a 50 percent male-size test dummy, the seat and any surrounding aircraft structure that could be impacted by the occupant's head," says the report.

The objective of the testing was to determine if an alternative method could be correlated with dynamic sled testing. Such an alternative, if validated, could reduce the cost of demonstrating compliance, give seat manufacturers a method of expediting design and testing of HIC-related factors prior to certification, and provide data to support application for certification. Such testing also could be used to develop specifications for materials and specifications for structures that affect HIC results. A HIC Component Test Device (HCTD) was developed with that aim and was evaluated by the FAA Civil Aerospace Medical Institute (CAMI) to determine whether the device could obtain results that would effectively demonstrate compliance with the FARs.

For the evaluation, the HCTD was used with an anthropomorphic test dummy (ATD) head attached to an impact arm that pivoted at the opposite end. The arm pivot was mounted to a block that was free to slide aft during device actuation. During actuation, the arm was propelled in an arc by an air actuator. Dimensions and kinematics of the device were meant to replicate a 50 percent male-size ATD that was restrained by a lap belt during a forward-facing sled test, says the report.

A series of sled tests and component tests were conducted to evaluate predictability and repeatability of the HCTD and to determine the HCTD's degree of correlation with sled tests. Several representative aircraft interior surfaces (padded rigid walls; unpadded composite walls and wall sections; energy-absorbing seat backs; and non-energy-absorbing seat backs) were tested at various head-impact velocities and head-impact angles.

Impact-surface materials tested included thin aluminum sheets; polyethylene foam blocks and foam padding; fiberglass-faced, aluminum honeycomb; fiberglass-faced Nomex honeycomb; and actual class-divider panels from narrow-body aircraft and wide-body aircraft.

"When the results were plotted for all of the corresponding sled [tests] and HCTD tests accomplished during CAMI's evaluation (including previous tests of various interior surfaces and the latest seat-back tests), no clear correlation emerged," said the report. "The degree of correlation varied significantly [among] the various surfaces impacted."

When comparing results for the two test methods, factors affecting correlation were identified. It was found, for example, that the neck flexibility and mass distribution of the HCTD were significantly different from those of the Hybrid II anthropomorphic test dummy (ATD) used in the sled tests.

"This causes the head interaction with the impact surface to differ as well," says the report. "In most sled tests involving impacts onto vertical surfaces, the ATD's neck flexed rearward during the period of head contact with the surface. This allowed the head to rotate rearward as it was pushed down the surface by the momentum of the ATD's torso. Since the neck of the HCTD cannot flex, and its torso is much lighter, the headform tended to not travel down the surface as far and the headform would rebound horizontally after the initial impact."

Impacts with padded rigid walls correlated well, the report says, but impacts with stiff walls or wall sections did not.

The report says, "At its current stage of development, the HCTD does not produce results that correlate with similar full-scale sled tests in all cases. Further investigation is necessary to determine if modifications to the HCTD can improve its degree of correlation with sled tests of actual aircraft components.

"While a single test device that can successfully emulate impacts with the wide variety of surfaces found in commercial transport aircraft would be advantageous, narrowing the focus of the device's usage may be necessary to achieve a useful level of correlation. If modifications are done, then the modified configuration will need to be extensively tested to validate its performance."

## Regulatory Materials

***Aircraft Weight and Balance Control.*** U.S. Federal Aviation Administration (FAA) Advisory Circular (AC) 120-27D. Aug. 11, 2004. Figures, tables, appendixes, glossary. 77 pp. Available from FAA on the Internet at <www.airweb.faa.gov> or from the U.S. Department of Transportation (USDOT).***

Being able to calculate accurately the weight of an aircraft and its center of gravity (CG) before flight is essential to complying with certification limits established for the aircraft. By complying with the weight limits and CG limits and operating under procedures established by the aircraft manufacturer, an operator is able to meet weight-and-balance requirements as specified in the aircraft flight manual.

For example, an operator may calculate takeoff weight and CG by adding the operational empty weight of the aircraft, the weight of the passenger load and the weight of the fuel. The AC says, "When using average weights for passengers and bags, the operator must be vigilant to ensure that the weight-and-balance control program reflects the reality of aircraft loading."

The AC provides guidance for aircraft operators that are required to have an approved weight-and-balance control program under U.S. Federal Aviation Regulations (FARs) Part 91, Subpart K of Part 91, Part 121, Part 125 or Part 135. It also provides guidance to operators in using average weights and estimated weights.

The AC says, "If an operator adopts the suggestions contained in this AC, the operator must ensure that, when appropriate, it replaces discretionary language such as 'should' and 'may' with mandatory language in relevant manuals, operations specifications (OpSpecs) or management specifications (MSpecs)."

The AC begins with discussions of aircraft weighing and loading schedules, how weight is established for individual aircraft and for an aircraft fleet, weighing procedures, and required intervals for routine re-weighing. Operational weight-and-balances elements are used in computing a loading schedule. The operator may use the individual weight of an aircraft in computing operational weight-and-balance, or the operator may choose to establish fleet-empty weights for a fleet or group of aircraft.

The AC says that "each operator complying with this AC must construct a 'loading envelope' applicable to each aircraft being operated. The envelope will include all relevant weight-and-balance limitations. It will be used to ensure that the aircraft is always operated within appropriate weight-and-balance limitations, and will include provisions to account for the loading of passengers, fuel and cargo; the in-flight movement of passengers, aircraft components and other loaded items; and the usage or transfer of fuel and other consumables. The operator must be able to demonstrate that the aircraft is being operated within its certificated weight-and-balance limitations using reasonable assumptions that are clearly stated."

Operators may choose from four methods — standard average weights, average weights based on survey results, segmented weights and actual weights — to determine the weight of passengers, checked bags and carry-on bags. The method selected may depend on aircraft-cabin size and loadability criteria.

- Operators of large-cabin aircraft (those with a maximum type-certificated seating capacity of 71 or more) may use standard average weights for passengers and standard average weights for passengers' bags, or the operators may elect to conduct their own surveys to determine more appropriate average weights;

- Medium-cabin aircraft (those with a maximum type-certificated seating capacity of 30 to 70) should be evaluated against specific loadability criteria or specific loading-schedule criteria to determine whether the aircraft should be considered a large-cabin aircraft or a small-cabin aircraft; and,

- Operators of small-cabin aircraft (with a maximum type-certificated seating capacity of five to 29) may select from several options when calculating the aircraft weight-and-balance, as described in the AC.

The AC contains tabular data on criteria such as standard passenger weights, standard crewmember weights, and standard passenger weights and checked-baggage weights for operators with no-carry-on-bag programs. The AC provides guidance on weight calculations for manifested mail shipments; for special passenger groups that do not fit an operator's standard average-weight profile (e.g., a sports team); carry-on bags and carry-on personal items; heavy bags; and non-luggage bags (e.g., golf bags or bicycles).

To determine standard average-passenger weights, FAA examined data from several large-scale, national health studies conducted by U.S. government health agencies. FAA selected the National Health and Nutrition Examination Survey (NHANES) conducted by the Centers for Disease Control and Prevention (CDC) because it provided the most comprehensive and appropriate data sets. The CDC collects NHANES data annually by conducting scale weighings of about 9,000 individuals in a clinical setting. FAA used the most recent NHANES data set (1999–2000) to calculate the standard average-passenger weights used in this AC.

Those average-passenger weights differ by season, to take into account heavier clothing likely to be worn during the winter (Nov. 1 through April 30, although an operator may make adjustments appropriate to the climate). For summer, for operators with an approved carry-on bag program, the average-adult-male passenger weight is considered to be 200 pounds (91 kilograms), the average-adult female 179 pounds (81 kilograms) and the average child aged 12 years or less 82 pounds (37 kilograms). For winter, the corresponding average weights add five pounds (2.3 kilograms). Average-passenger weights include allowances for five pounds for summer clothing, 10 pounds (4.5 kilograms) for winter clothing, and 16 pounds (7.3 kilograms) for personal items and carry-on bags.

[This AC cancels AC 120-27C, *Aircraft Weight and Balance Control*, dated Nov. 7, 1995; *Joint Handbook Bulletin for Airworthiness* 95-14; and *Joint Handbook for Air Transportation 95-15, Adherence to Advisory Circular 120-27C*, *Aircraft Weight and Balance Control*, dated Nov. 17, 1995.]

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***Radiotelephony Manual.*** Civil Aviation Authority of New Zealand (CAA). Advisory Circular (AC) 91-9 and AC 172-1. Revision 2. Nov. 25, 2004. 57 pp. Illustrations, references, glossary. Available on the Internet at <www.caa.govt.nz> or from the CAA.****

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Radiotelephony (RTF) provides one of the primary means by which pilots and air traffic services (ATS) personnel communicate with each other. Spoken information and instructions, when transmitted correctly, are of vital importance in the safe and expeditious operation of aircraft. The AC says, "The importance of using correct and precise standard phraseology cannot be overemphasized." Concise and unambiguous phraseology used at the correct time is vital, and use of nonstandard procedures or nonstandard phraseology and subsequent misunderstandings have been identified as contributing factors in aviation accidents and aviation incidents, the AC says.

The CAA's intent in establishing phraseology for this manual was to ensure uniformity in RTF communications, thus reducing any ambiguity to a minimum. This AC relates to Civil Aviation Rule (CAR) Part 91 and CAR Part 172 for communications requirements for pilots and ATS. The manual contains information about standards, practices and procedures that the CAA has found to be acceptable means of compliance with associated rules, and it contains guidance material to facilitate compliance.

Correct RTF transmission techniques are important to ensure that messages are heard correctly, the AC says. Important techniques include the following, among others:

- "Do not turn your head away from the microphone [while] talking, or vary the distance between it and your mouth";
- "Use a normal conversation tone, [speaking] clearly and distinctly";
- "Maintain an even rate of speech not exceeding 100 words per minute. When it is known that elements of a message will be written down by the recipient, speak at a slightly lower rate";
- "A slight pause before and after numbers will assist in making them easier to understand";
- "Avoid using hesitation sounds such as 'er'"; and,
- "Depress the transmit switch fully before speaking and do not release it until the message is complete. This will ensure that the entire message is transmitted. However, do not depress the transmit switch until ready to speak."

The CAA's radiotelephony manual illustrates use of standard communications phrases in every phase of flight, from pushback through taxi-in. The correct formats for speaking and reading back various kinds of numbers — flight levels, headings, runway designations, altimeter settings, radio frequencies and others — are shown.

The AC provides examples of urgency phraseology and distress phraseology to be used between pilots and ATS, including for situations such as when an aircraft flight crew announces that it is conducting a go-around or an emergency descent, or ATS informs pilots of wake turbulence.

Examples are based on International Civil Aviation Organization (ICAO) documents. The ICAO documents are listed in the AC in order of precedence as stated in CAR Part 172, *Air Traffic Service Organizations — Certification*, rule 172.105, "Radio and Telephone Procedures." The documents are:

- Annex 10, *Aeronautical Telecommunications*, Volume 2 — "Communication Procedures Including Those With PANS Status";
- Document 4444, *Procedures for Air Navigation Services — Air Traffic Management*; and,
- Document 9432-AN/925, *Manual of Radiotelephony*.

Changes since the last edition are highlighted in the text.■

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800 Independence Avenue S.W.
Washington, D.C. 20591 U.S.

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P.O. Box 31441
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New Zealand

# Airplane Strikes Airport Lights During Approach in Fog

**The captain of the McDonnell Douglas DC-9 said that he observed approach lights beneath the airplane's nose but did not hear or feel anything unusual in the seconds before touchdown.**

— 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

## Brake Line Damaged During Approach

**McDonnell Douglas DC-9. Minor damage. No injuries.**

Before beginning the daytime approach to an airport in the United States, the flight crew received automatic terminal information system (ATIS) reports of visual meteorological conditions. Later, a company dispatcher told them that a special weather observation included information about ceilings at 300 feet and 1,000 feet and visibility of 0.5 statute mile (0.8 kilometer) in fog. The crew briefed the instrument landing system (ILS) approach to Runway 35L.

When the crew received clearance from air traffic control (ATC) for the approach, the first officer was flying the airplane at 9,000 feet. The captain asked ATC for a lower altitude and received clearance to descend to 7,000 feet. The crew intercepted the glideslope and localizer, completed the checklist at 1,000 feet and observed approach lights at 100 feet.

"The captain said he started to see the threshold lights and then heard the 'glideslope' … warning [from the ground-proximity warning system]," the report said. "The captain said he called 'pull up.' He said as they touched down, he thought he could see some approach light bars below the nose but did not feel or hear anything unusual. The landing rollout was normal. After parking, the crew discovered damage to the left main-brake line and loss of hydraulic fluid from the right system."

An inspection found that one approach light 19 feet (six meters) before the paved overrun was broken and that two pairs of parallel tire marks were observed 49 feet (15 meters) before the paved overrun. The left pair of tire marks "ran through three sets of center approach lights in the overrun [and] two runway threshold lights." The marks continued for about 700 feet (214 meters) down the runway, with "light stanchions, broken lens pieces and bulb debris" along the tire marks.

A ground check of the airplane's avionics system revealed no anomalies; the investigation was continuing.

## Vehicle Strikes Airplane at Gate

**Boeing 737. Minor damage. No injuries.**

The flight crew was conducting the "Cleared for Start" checklist at an airport in Northern Ireland when they heard and felt an impact against the airplane. They discontinued the checklist, and ground personnel told the captain that a vehicle had struck the airplane. Shutdown checks were conducted, and passengers exited the airplane using the airstairs.

A vehicle that typically was used to move airstairs and other ground-equipment items in the apron area had struck the left side of the airplane below the flight deck windows, resulting in two cuts — 20 centimeters (eight inches) long and 30 centimeters (12 inches) long — in the fuselage.

The vehicle driver said that he inadvertently placed his foot on the accelerator while he was attempting to apply the brake.

"The driver was unable to stop the vehicle in time to prevent the nearside corner of his tug's roof from striking and puncturing the left side of the fuselage," the accident report said. "During his attempt to avoid the collision, the driver turned the steering wheel hard left; as a consequence, a lamp cluster mounted on the nearside rear corner of the tug's roof struck the fuselage side as the vehicle came to rest, resulting in a second penetration of the fuselage skin."

## A300 Grounded By Stowaway Mouse

**Airbus A300. No damage. No injuries.**

After an evening flight from the People's Republic of China to Singapore, passengers were exiting the airplane when a mouse was observed running through the cabin. The mouse eluded capture.

Because of concerns that the mouse might chew through electrical wiring and cause a safety hazard, the airplane was flown back to China with no passengers. At the airport in China, workers set 36 traps and more than 20 cages, and spread "mousepaper," which has a sticky surface designed to trap mice. After nearly three days of canceled flights, the mouse was captured.

The airplane remained out of service for two more days while electrical systems were inspected for possible damage, the airplane was cleaned and the mouse was tested for disease.

Published reports said that the incident cost the airline an estimated US$100,000 in lost revenue and staffing expenses.

AIR TAXI/COMMUTER

## Dust Cited in Engine Anomaly During Takeoff

**Cessna 441 Conquest. Substantial damage. Two minor injuries.**

During the takeoff roll for a charter flight in Australia, the pilots observed increases in the right-engine exhaust-gas temperature and power. No additional abnormal indications were observed.

The pilot flying rejected the takeoff and moved the throttle levers for both engines in an attempt to reduce power. Left-engine power was reduced to idle, but the right engine remained at maximum power; the airplane veered left, and both the pilot flying and a supervising pilot applied brakes and attempted to maintain directional control. The pilot flying selected "FUEL COMPUTERS OFF" and both "ENGINE STOP" buttons; as he moved the condition levers to "EMER SHUT OFF," the airplane entered the runway strip at about 65 knots. (The runway strip is the ground between a runway and the fly-over area that has been prepared to cause minimal damage in the event of an overrun during takeoff or landing.)

The vibration caused by the airplane moving over rough terrain prevented the crew from confirming that the right-engine stop button was fully depressed and that the condition levers were in the "EMER SHUT OFF" detents. The airplane stopped nose-down in sand about 45 meters (148 feet) left of the runway strip, the crew secured the airplane, and the pilots and four passengers exited.

The accident report said that the investigation revealed "fine, red dust deposits" in, and downstream from, a fuel-control-unit (FCU) air filter and a blocked FCU flow restrictor. The dust trapped air in the FCU control-bellows chamber — a condition that prevented the pilot from controlling fuel supply to the affected right engine. The operator said that the airplane had been operated extensively in hot, dusty areas of Australia.

The report said, "It was unlikely that any action taken by the [pilot flying], other than an immediate and successful shutdown of the affected right engine, would have allowed him to maintain directional control and prevent the aircraft from departing the runway."

As a result of the investigation, maintenance action and a functional test were recommended to detect FCU flow-restrictor blockages. In addition, the operator increased the frequency at which the air-filter elements were cleaned and revised engine shutdown procedures in the event of an uncommanded power increase during takeoff.

## Airplane Runs Off Wet Taxiway After Landing

**De Havilland DHC-8 Dash 8. Minor damage. No injuries.**

Daytime visual meteorological conditions prevailed for the domestic flight in Denmark — the fifth flight of the day for the flight crew, who had been on duty for nine hours when the incident occurred. Rain had been falling for several hours, and the runways and taxiways were wet. The airspeed as the airplane crossed the runway threshold was 134 knots, and touchdown speed was 131 knots.

The airspeed was about 60 knots when the flight crew exited the runway at Taxiway B5, which they believed was a rapid-exit taxiway.

"The commander [captain] for a short while selected full reverse on the left-hand engine and [partial] reverse on the right-hand engine," the report said. Soon afterward, the airplane's left-main landing gear ran off the side of the taxiway; the airplane was traveling at 34 knots. After traveling about 26 meters (85 feet) in the soft grass, the airplane stopped. The flight crew shut down both engines and requested assistance. Passengers were taken to the terminal in a bus.

The final report on the accident said that the threshold airspeed was 13 knots higher than recommended, and the touchdown speed was 10 knots higher than recommended.

"The operator's [operating manual] did not contain a taxi-speed limitation," the report said. "However, the [operating manual] stated than an aircraft should not turn off from a slippery runway until the speed was reduced to a safe level. The Danish AIB [Accident Investigation Board] does not find a turnoff speed of 60 knots safe."

In addition, the report said that Taxiway B5 was not a rapid-exit taxiway. (The International Civil Aviation Organization says that a standard rapid-exit taxiway is designed for aircraft traveling, under wet conditions, up to 50 knots.)

The report said that the captain's decisions "might have been influenced by standard routines instead of considering all operational parameters like wet runway, higher-than-recommended touchdown speed and calm wind. Furthermore, fatigue might have influenced the commander's decision making. …

"The Danish AIB concludes that the flight crew's opinion that Taxiway B5 was a rapid-exit taxiway, combined with decision making based on standard routines and a high turnoff taxi speed most likely caused the aircraft to run off the runway."

## Airplane Strikes Ridge of Snow on Runway

**Raytheon Beech 1900D. Substantial damage. No injuries.**

While being taxied on Runway 02/20, an inactive runway at an airport in Canada, the airplane struck a 2.0-foot (0.6-meter) windrow (ridge of snow) on the runway.

The airport's winter maintenance plan said that, unless wind conditions favored Runway 16/34, snow was to be removed first from Runway 11/29 and other runway and taxiway areas that provide access to Runway 11/29. The section of Runway 02/20 where the Beech 1900D struck the windrow was among those designated to be cleared last.

The winter maintenance plan said that an active runway should be closed if windrows were more than 1.0 foot (0.3 meter) high. There was no provision for closing an inactive runway because windrows in those areas typically were not encountered by taxiing aircraft. In addition, windrows in those areas typically were not reported to the ground controller and were not included in runway-surface-condition reports. Instead, snow-removal crews usually told the ground controller about windrows when they heard requests for a taxi clearance (or a request to taxi) through an area with a windrow.

The final report on the accident said that the flight crew did not see the windrow because of "flat light conditions" in which the snow-covered terrain was difficult to distinguish from the gray sky, and because their attention was diverted by snow-removal equipment elsewhere on the airport. In addition, they had taxied through the area previously and had observed no obstructions.

CORPORATE/BUSINESS

## Airplane Strikes Light Pole, Ground During Approach in IMC

**Gulfstream Aerospace Gulfstream III. Destroyed. Three fatalities.**

Instrument meteorological conditions (IMC) prevailed for the predawn landing at an airport in the United States; weather conditions before the accident included fog, broken ceilings of 100 feet and 600 feet, and surface visibility between 0.3 statute mile (0.5 kilometer) and 0.5 mile (0.8 kilometer).

While being flown on an instrument landing system (ILS) approach to Runway 4, the airplane struck a light pole about 156 feet above the ground and then struck the ground in a field about three nautical miles (six kilometers) southwest of the runway.

A review of radar data and air traffic control (ATC) communications indicated that the airplane "continued to converge on the localizer track for Runway 04, eventually becoming aligned near the end of the last radar returns." The airplane's average descent rate was 1,000 feet per minute during the minute before impact, a preliminary report said. ATC tapes and the cockpit voice recorder indicated that seconds before the impact, a controller had issued a minimum safe altitude warning, telling the flight crew, "Check your altitude; altitude indicates four hundred feet." The crew did not respond, and there were no further communications.

A subsequent check of the ILS revealed no anomalies. The investigation was continuing.

## Mis-set Altimeter Results in 1,000-Foot Altitude Deviation

**Raytheon Beech King Air 200. No damage. No injuries.**

The airplane was being flown from Flight Level 250 (approximately 25,000 feet) to 10,000 feet during a flight in Canada when air traffic control equipment indicated that the airplane was level at 9,000 feet. A controller questioned the pilot, who said that the airplane was level at 10,000 feet. Soon after the controller repeated the altimeter setting, the controller observed that the altitude readout indicated 10,000 feet.

The correct altimeter setting was 29.57 inches of mercury (in. Hg; 1001.4 hectopascals [hPa]). When the flight crew flew the airplane through the transition altitude at 18,000 feet, both crewmembers reset their altimeters, which had been set to 29.92 in. Hg (1013.2 hPa). The pilot flying set his altimeter to 30.57 in. Hg (1035.2 hPa), and the pilot not flying set his altimeter to 29.57 in. Hg. They did not cross-check altimeter settings and the discrepancy was not detected until they were questioned by the controller.

## Engine Failure Results in Forced Landing in Field

**Raytheon Beech Baron 95-B55. Substantial damage. One minor injury.**

Daytime visual meteorological conditions prevailed for the morning takeoff from an airport in the United States. The pilot, the only person in the airplane, said that soon after departure, fuel pressure decreased and the left engine ran rough and then stopped. The pilot was unable to restart the engine.

As he tried to return to the airport for landing, he was unable to maintain altitude and decided to land the airplane in a field; during the landing, the airplane struck several trees and then struck the ground.

A preliminary report said that the pilot had not activated the fuel boost pumps during the takeoff.



## Nose Landing Gear Collapses During Crosswind Landing on Icy Runway

**Cessna 404 Titan. Substantial damage. No injuries.**

A strong, gusty crosswind prevailed for the approach and landing on Runway 27 at an airport in the Falkland Islands, off the southeastern coast of Argentina. About 10 minutes before landing, a controller in the airport air traffic control tower told the crew of the surveying flight that winds were from 200 degrees at 20 knots, with gusts to 28 knots.

The crosswind at the time of landing was between 16 knots and 19 knots; small patches of ice and light snow were on the runway. The captain said that the airplane had crossed the threshold in "a normal and stabilized attitude at 105 knots." The accident report said that the airplane touched down on the left-main wheel first, followed by the right-main wheel and the nosewheel, "with aileron control to the left." After touchdown, as the captain released back pressure on the elevator and moved the throttle levers to idle, he observed the airplane's nose turning right.

"He attempted to apply a small correction using left [rudder] pedal, but the aircraft did not seem to respond," the report said. "The commander [captain] then felt a shock in the right pedal, and the aircraft started to turn to the left. He tried to maintain alignment with normal pedal movements but needed to use greater amplitude on the pedals. With the nose gear not responding to his steering inputs and the aircraft slowing, the commander started to apply the brakes. He felt the aircraft nose go down."

All six propeller blades struck the runway.

Examination of the airplane showed a "structural failure of the forward attachments of the nose landing gear … consistent with overload conditions rather than any existing damage," the report said.

The captain said that the ice and snow on the runway might have contributed to the initial movement of the nose to the right, and the report said that he probably applied more pedal movement, deflecting both the rudder and the nosewheel.

"If the nosewheel, in a deflected position and having low adhesion, then encountered a dry and rough section of the runway surface, the tire deflection would have caused substantial loads in the nose leg structure, additional to those from the crosswind conditions. This would be a reasonable explanation for the structural failure of the nose leg."

## Airplane Noses Over After Tail Wind Landing on Grass Strip

**Antonov An-2. Substantial damage. No injuries.**

Visual meteorological conditions prevailed for the tail wind landing on a private grass runway in Sweden. After touchdown, the airplane flipped over, and the pilot and passenger exited.

The accident report said that after touchdown, the brakes were applied too early and too heavily, probably because the touchdown had occurred further down the runway than the pilot expected. The early, heavy braking was the cause of the accident, the report said. A contributing factor was the absence of information in the flight handbook on landing distance from an altitude of 15 meters (49 feet).

## Nosewheel Bounces Into Propeller During Landing

**Rutan Long-EZ. Minor damage. No injuries.**

The airplane was being landed at an airport in Scotland when the nosewheel separated from the airplane and bounced into the propeller.

An investigation found that the design of the nosewheel bearing had been changed after previous failures in other Long-EZs but that the redesigned bearing had not been installed in the accident airplane. The pilot said that "a period of taxiing with a seized bearing" caused excessive heat, which resulted in failure of the bonding between the fiberglass/metal joint in the nosewheel assembly.

ROTORCRAFT

## Helicopter Strikes Pond During Landing in Fog

**Bell 206. Destroyed. Three fatalities.**

Daytime visual meteorological conditions prevailed for the takeoff for a domestic flight in India, but fog developed en route. The final report on the accident said that the pilot "probably decided to execute [an] unplanned landing while flying in a foggy weather condition."

In the fog, the pilot could not see that the treeless area chosen as a landing site was actually a pond, the report said.

"While executing the landing, [the] pilot realized that he [was] going to land on the water surface and decided to abandon the landing," the report said. "When he tried to pull up … the rear portion of the helicopter hit the water, resulting [in] loss of directional control, and the helicopter started spinning violently."

The helicopter then struck the water.

## Tail-rotor Failure Cited in Rupture of Fuel Tanks

**Robinson R22. Destroyed. One fatality, one serious injury.**

The helicopter was being flown 30 feet to 40 feet above the ground on a cattle-mustering and fence-inspection flight in Australia when the pilot initiated a 180-degree turn. About halfway through the turn, a loud bang was heard and the helicopter rotated quickly and then struck the ground.

A preliminary investigation revealed that the tail-rotor-drive forward flex plate had failed on one side of the connection to the rear drive yoke.

A preliminary report said, "The manner in which the flex plate failed effectively doubled the diameter of its normal rotational path. This allowed the disconnected yoke section to come into contact with and rupture the inner walls of both the left and right fuel tanks. It also cut through the firewall lining above the engine."

The investigation was continuing.

## Helicopter Strikes Mountain During Filming Flight

**Aerospatiale AS 350BA. Destroyed. One fatality, two serious injuries.**

Daytime visual meteorological conditions prevailed for the low-altitude flight in a mountainous area of the United States. The passengers were a cameraman and the director of an automobile commercial, and the pilot maneuvered the helicopter to allow the cameraman to videotape an automobile on the eastbound lane of a two-lane road adjacent to a mountain.

Earlier in the flight, the automobile had been filmed in the westbound lane, which was farther from the mountainside. The director said that, after filming switched to the eastbound lane, the weather conditions were excellent and that no turbulence was encountered.

The helicopter struck the mountain, and main-rotor-blade fragments were found on the mountainside about 30 feet above the road.

The driver of the car that was being videotaped said that he had not observed the accident but that he believed that the helicopter probably struck the mountainside in an area where the road curved.

The video camera was removed from the wreckage and was sent, along with the videotape, to accident investigators. The investigation was continuing. ■

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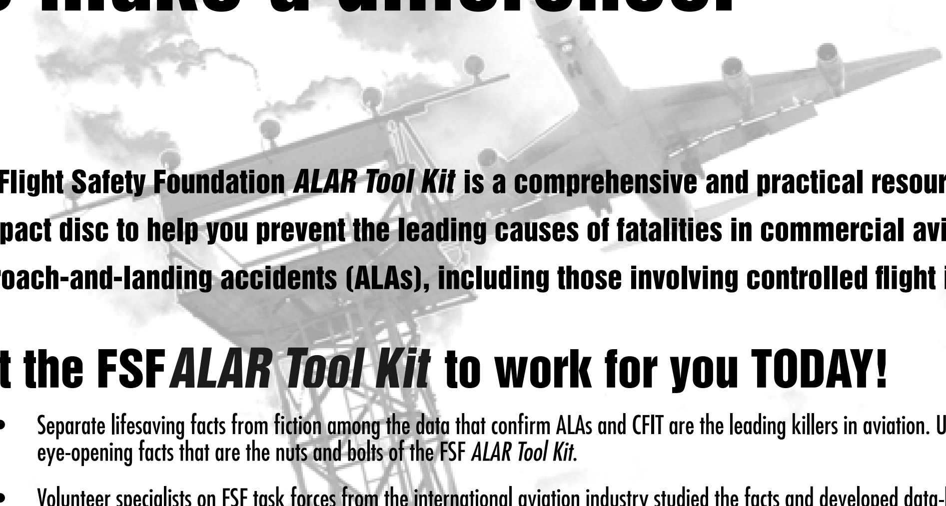

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