The U.S. Air Traffic Control System Wrestles with the Influence of TCAS

Although TCAS II has been credited with averting inflight aircraft collisions, its implementation continues to cause disagreements between pilots and controllers.

by
V.J. Mellone and S.M. Frank

A significant increase in incident reporting related to Traffic Alert and Collision-avoidance System (TCAS II) implementation prompted a closer examination of how TCAS II is affecting pilots and air traffic controllers.

In July 1992, the U.S. Federal Aviation Administration (FAA) and the U.S. National Transportation Safety Board (NTSB) asked the U.S. National Aeronautics and Space Administration's (NASA) Aviation Safety Reporting System (ASRS) to complete a data base analysis of TCAS II incident reports.

The ASRS research team identified evidence of increasing air traffic controller consternation with and resistance to the implementation of TCAS II technology into the U.S. airspace system. There were also strong indications from the data set that the aviation community, government agencies and industry may have unwittingly underestimated the influence of TCAS II avoidance maneuvers on air traffic controllers and flight crews.

The study's objectives were to analyze the effects of TCAS II avoidance applications on pilot-controller interactions and to suggest strategies that could promote a more harmonious human-technology interaction.

The study was limited to a randomly selected data set of 174 ASRS reports from the January 1992-March 1993 period. The data set specifically included pilot and controller reports that involved traffic advisory (TA) and resolution advisory (RA) incidents.

A TA identifies nearby traffic meeting "certain minimum separation criteria," according to an FAA advisory circular (AC) issued in August 1993. An RA provides flight crews with aural and display information advising whether or not a particular maneuver should be performed to maintain safe separation from a threat aircraft.

The research addressed four issue areas: Were there any significant changes in TCAS II reporting during the past three years? Do TCAS II avoidance actions influence the air traffic control (ATC) system? Is there evidence of contention between pilots and controllers because of TCAS II applications?

Are there effective strategies that could enhance pilot-controller cooperation?

The ASRS reports were randomly drawn from a pool of 780 TCAS II incidents from the same period involving TAs and RAs. The 174 reports accounted for approximately 11 percent of the 1,522 TCAS II full-form reports in the ASRS data base. For reasons of maximum currency, the data set included 55 unprocessed reports from the January-March 1993 period. There were a total of 109 pilot reports, 51 controller reports and 14 reports where both a pilot and controller submitted reports on the same TCAS II incident.

A coding instrument was developed to extract pertinent information from the records. The coding instrument addressed several areas. The key points are described in Table 1.

Table 1

Key Traffic Alert and Collision-avoidance System (TCAS II) Coding Points

P1	Pilot Use of TCAS II Advisory
P2	Pilot-initiated Avoidance Actions
P3	Air Traffic Control (ATC)-initiated Avoidance Actions
P4	Traffic Alert (TA)/Resolution Advisory (RA) Causal Factors
P5	Pilot Communications to ATC about TA/RA
P6	ATC Reactions to TA/RA
P7	Pilot Comments About TCAS II Incident
P8	TCAS II Application: Prevented-caused
P9	Evidence of Pilot/Controller Contention

Source: Batelle/U.S. National Aeronautics and Space Administration, Aviation Safety Reporting System

Development of the coding form required a number of iterations of trial codings and comparisons to validate the instrument. A team of experienced ASRS pilot and air traffic controller analysts was assigned to analyze and code the 174 reports, and the completed coding forms were entered into a data base program for statistical analysis. The data was reviewed, tabulated and summarized.

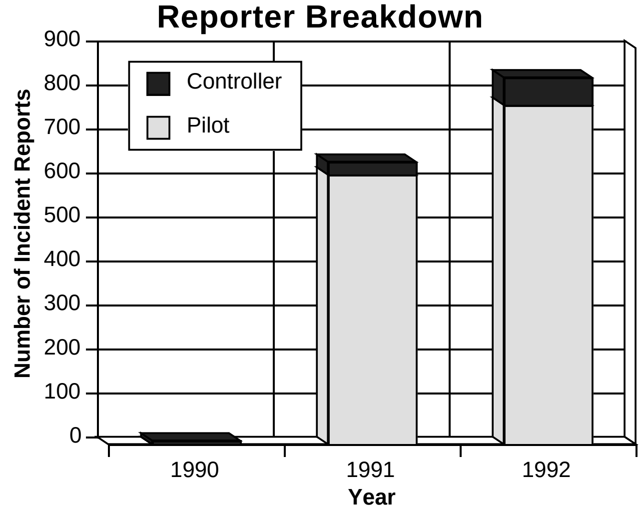
Since 1956, the aviation community has attempted, in the face of widely spaced, but successive commercial aircraft midair collisions, to conceive and implement an airborne collision avoidance system. In 1987, the U.S. Congress mandated the installation of TCAS II on all air carriers with 30 or more passenger seats by the end of 1993. To date, more than 4,000 air carrier and business aircraft are TCAS II equipped.

TCAS II is an aircraft-based airborne collision avoidance system that provides information, independent of the ground-based ATC system, of the proximity of nearby aircraft. It alerts pilots, visually and aurally, to potentially threatening situations (intruders) by monitoring the position, closure rate, and altitude of nearby transponder-equipped aircraft. TCAS II offers the pilot both TAs and RAs. RAs are limited to vertical avoidance maneuvers if an intruder comes within approximately 25 seconds to 30 seconds of closure.

Initial testing of TCAS II in 1984-85 by two major air carriers, in a limited operational environment, determined that "TCAS II is safe and operationally effective, [and] operates harmoniously in the air traffic control system." The testing data indicated that "approximately 50 percent of the alarms will be 'preventive' and the pilot will not deviate from his flight path. The average deviation will be approximately 300 feet (91 meters) based on a 1,500 foot-per-minute (457 meters-per-minute) climb or descent."[1]

The reporting of TCAS II incidents increased significantly from 1990-1992 (Figure 1). The increase

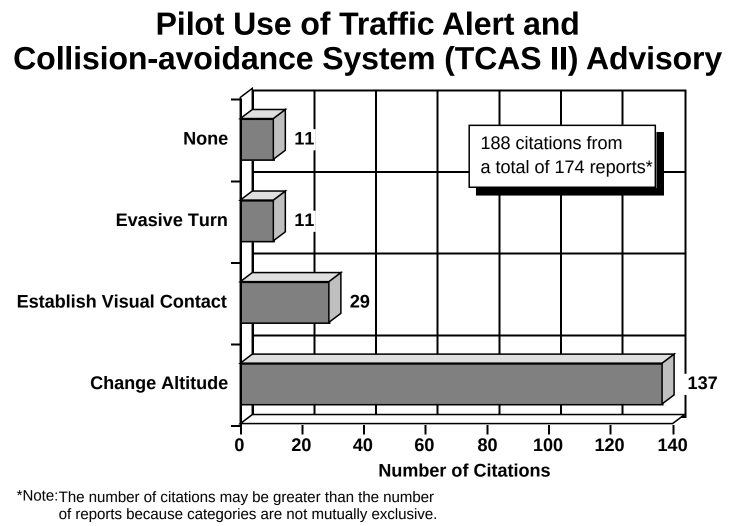
Traffic Alert and Collision-avoidance System (TCAS II) Incident Reporter Breakdown



Source: Batelle/U.S. National Aeronautics and Space Administration, Aviation Safety Reporting System

Figure 1

included a total of 99 TCAS II incident reports from controllers. This is the largest number of controller reports to ASRS on a single topic since the August 1981 air traffic controllers' strike. The total breakdown of controller reporters on TCAS II incidents included 37 reports from en route controllers, 58 reports from terminal radar controllers and four reports from tower controllers. The overall increase in TCAS II incident reporting can also be attributed to the number of air carrier and business aircraft that are installing TCAS II equipment in accordance with the requirements of U.S. Federal Aviation Regulation (FAR) 121.356 and, prospectively, FAR 91.221 and 135.180. The reporting trend has continued upwards as flight crews and controllers experience various TCAS II avoidance advisory situations.



Source: *Batelle/U.S. National Aeronautics and Space Administration, Aviation Safety Reporting System,*

Figure 2

Figure 2 depicts the actions taken by pilots in conjunction with a TCAS II RA based on the data set. The majority of pilot actions were precipitated by RAs (92 percent).

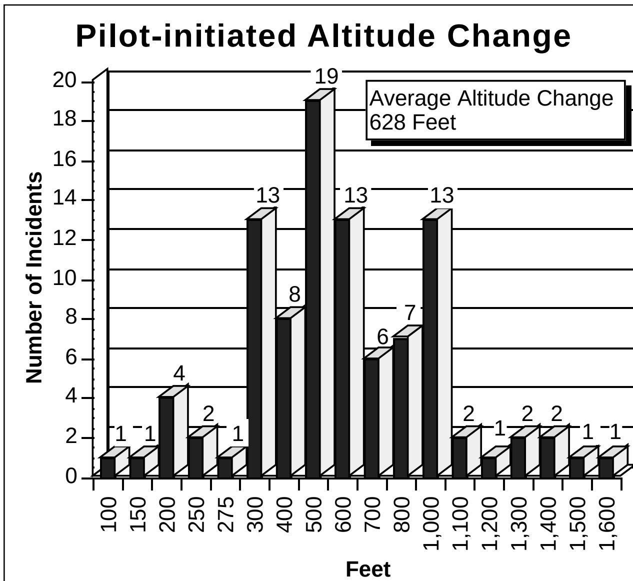
Altitude changes ranged from 100 feet (30 meters) to 1,600 feet (488 meters), as indicated in Figure 3, with an average altitude change of 628 feet (191 meters). In contrast, the designers of TCAS II expected altitude deviations to average 200 feet to 300 feet (61 meters to 91 meters). Initial TCAS II simulation testing did not reveal that some aircraft would deviate by 1,000 feet (305 meters) or more and intrude upon other occupied altitudes.

As shown in Figure 4 (page 4), the pilot informed ATC after reacting to the RA in the majority of incidents (93). In 15 incidents, the pilot did not notify ATC about the RA maneuver. In 26 incidents, the pilot either forewarned ATC (9) or informed ATC while complying with the RA (17). A number of controller reports indicate that this response pattern is a major source of their concern because of the impact of the unanticipated avoidance deviations on the controllers' air traffic situation.

It is here that the dual impacts of TCAS II applications can be seen. Analysis of the reporter narratives verify that TCAS II has been instrumental in preventing many near midair collisions (NMACs) and other conflicts. (Figure 5, page 4).

Reporter narratives also confirm that ATC workload has increased. Pilot actions to avoid one conflict sometimes precipitated a loss of separation or airborne conflict with another non-intruder aircraft in the same vicinity (Figure 6, page 5).

There were indications in the reporter narratives that the process of assimilating TCAS II into the ATC system was affecting pilot-controller interactions. Intensive coding analysis of the 174 reports



Source: *Batelle/U.S. National Aeronautics and Space Administration, Aviation Safety Reporting System*

Figure 3

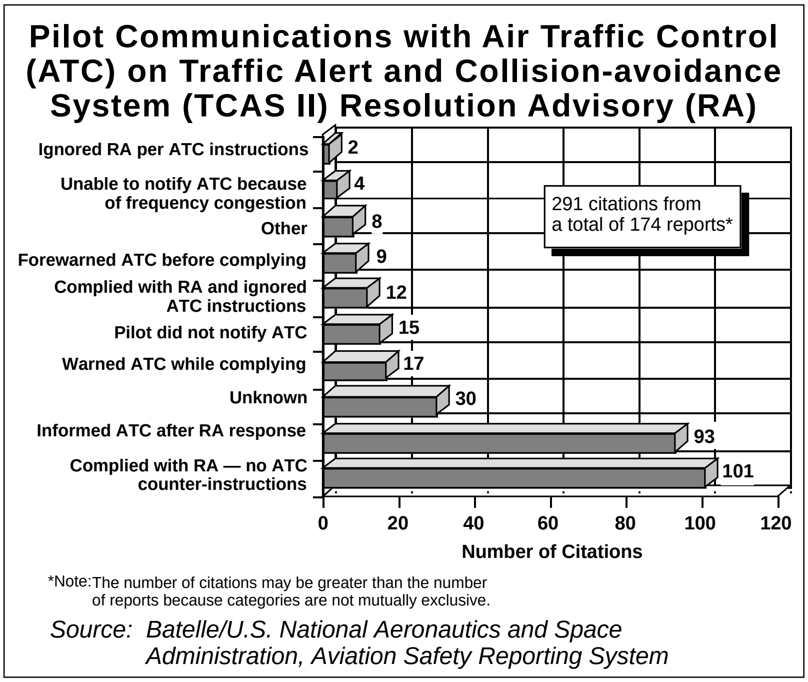


Figure 4

verified that a degree of contentiousness existed in approximately 24 percent of the reports. Figure 7 (page 5) shows that in a majority of the incidents (95), disagreement was not evident in the reporter's narrative. However, in the 43 episodes related to TCAS II applications, and 27 episodes unrelated to TCAS II applications, there was inferred or stated evidence of contention based on the narrative comments of the reporter.

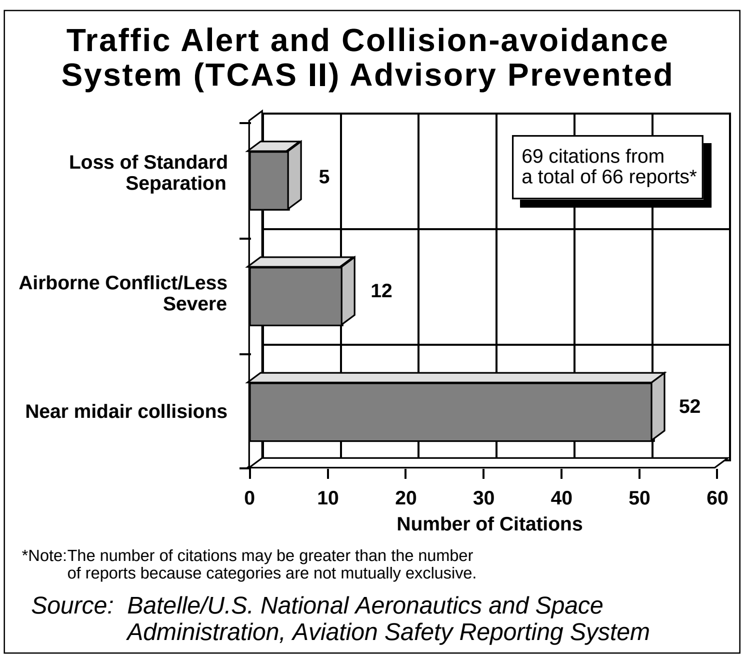


Figure 5

TCAS II has definitely prevented or reduced the threat of airborne conflicts as reflected by the majority of favorable ASRS reports and evidenced by the following statements from ASRS reports:

- "It is the captain's opinion that TCAS II saved about 100 lives today. I am a firm believer in TCAS II forever" (ASRS Pilot Report No. 212377); and,

- "Gap in updating of radar-displayed Mode C misled me to think air carrier [name deleted] was still level at flight level 310 (31,000 feet [9,455 meters]). Situation was resolved by TCAS" (ASRS Controller Report No. 225920).

However, there have been side effects related to the controllers' sense of a loss of control of the aircraft nominally under their jurisdiction. Apprehensive controllers increasingly wonder "Who is in control?" when TCAS II-equipped aircraft execute avoidance maneuvers or apply non-standard uses of TCAS II without prior notification or coordination with ATC.

In a recent U.S. congressional hearing on TCAS II, Air Line Pilots Association (ALPA) President J. Randolph Babbitt testified that "line pilots have strongly endorsed TCAS II and would emphatically resist any efforts to reduce its operational effectiveness."[2] But, at the same hearing, National Air Traffic Control Association (NATCA) President Barry Krasner ominously warned that TCAS II "is an airborne system that works improperly and erodes an already precarious margin of safety in the skies."[3] The pilot community, particularly ALPA, sees TCAS II as a "last ditch, they-may-have-hit-if-something-is-not-done piece of equipment that gives [the pilot] a way out if the rest of our ATC system has somehow unaccountably failed."[4]

Looking at the steps taken in implementing TCAS II, it appears that TCAS II designers may not have fully anticipated all the ways that pilots would act, and controllers would react, once TCAS II was broadly implemented. More than 2.5 million revenue miles later, with TCAS II installed in more than 70 percent of the air carrier fleet and with several hundred RAs reported, the following issues have become evident:

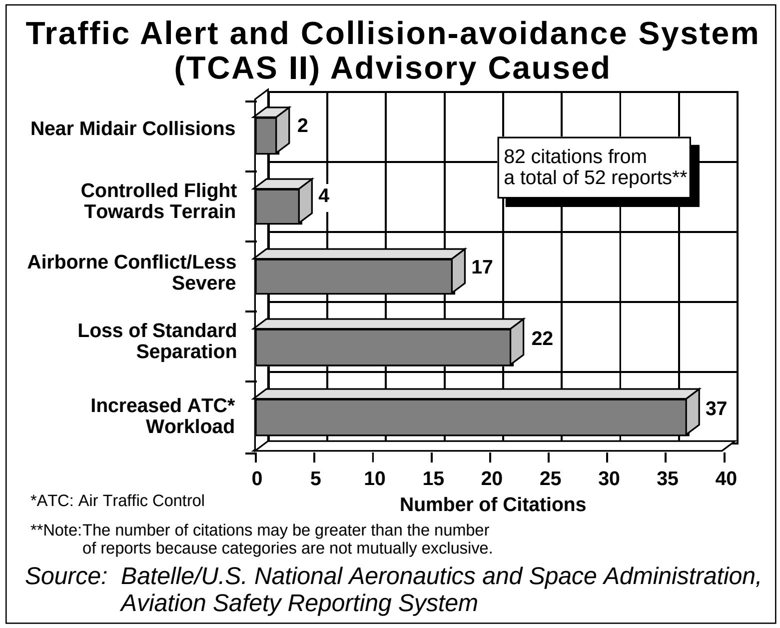


Figure 6

Training and preparation have not been adequate. Both pilot and controller initial TCAS II training has been inadequate for the unexpected avoidance actions being encountered. A recent NTSB recommendation to the FAA stated that "both controllers and pilots need more training in the traffic alert and collision-avoidance system."[5] There appears to have been a lack of operational human factors impact analysis preparatory to implementing TCAS II system-wide.

One major air carrier's TCAS II flight crew indoctrination video indicated that resolution command altitude changes would typically require a 200-foot to 300-foot (61-meter to 91-meter) maneuver. The initial FAA controller TCAS II training video tape conveyed that the implementation of TCAS II would be "transparent to the controllers" and the RAs would be limited to "200 feet to 300 feet" in altitude changes. However, both FAA and ASRS RA altitude-change data now confirm that the average altitude change is more than double what was originally anticipated.

An FAA report said "air traffic controllers have expressed major concern about the magnitude of the altitude displacements in response to some corrective RAs. The data provide evidence that a problem exists in the way the pilots use the system or in the way pilot training is implemented."[6]

An ALPA statement noted: "Senior FAA officials admitted [during the International TCAS Conference, Jan. 7-9, 1992, Washington, D.C.] that TCAS training for controllers and controller involvement ... have been too little, too late."[7]

Ad hoc fixes have been necessary. Subsequent fixes to unanticipated TCAS II logic deficiencies convey an after-the-fact approach to the overall problems with the technology, i.e., nuisance RAs, phantom intruders, RA commands being contradicted by counter-instructions from controllers, etc.

A statement in the NATCA News noted that "the GENOT (FAA General Notice RWA 3/141) is riddled with ambiguities and contradictions that decrease the safety margin. TCAS is not reliable enough for the FAA to order controllers to take such a hands-off position."[8]

The FAA recently announced its intention of mandating TCAS II software logic changes (change 6.04)

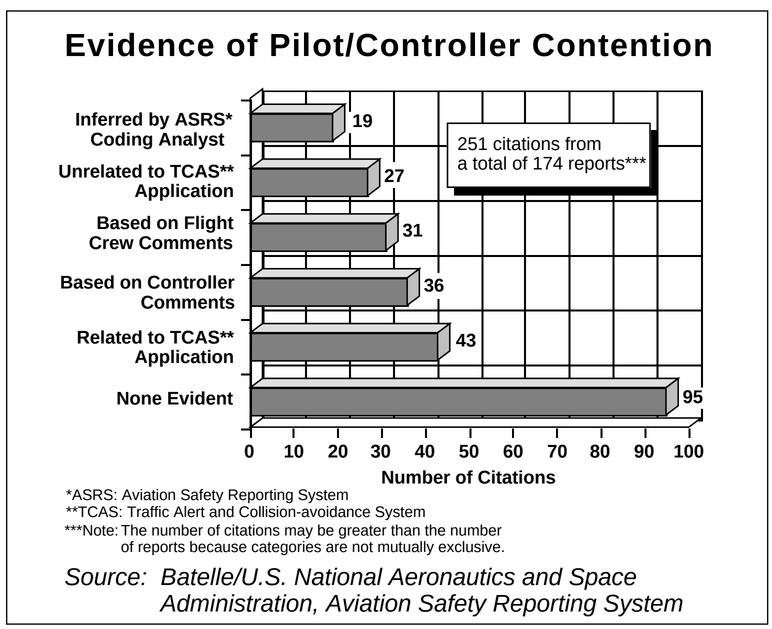


Figure 7

by Dec. 31, 1993, through the release of a notice of proposed rule making (NPRM) and the subsequent issuance of an airworthiness directive (AD). This fine tuning of TCAS II software logic should eliminate a majority of the nuisance RAs. However, the changes will, in some instances, reduce RA warning time, and they have provoked strong reservations from ALPA and others, as illustrated below:

- "There is some industry concern that proposed modifications … will further complicate TCAS implementation and safety risks;"[9] and,

- Pilots are in a quandary about how to respond to TCAS II alerts. Pilots are being placed in a dilemma about making split-second decisions whether to ignore controller advisories on separated traffic or to follow RA commands.

The following statements were taken from ASRS pilot reports:

- "Center later admonished us for descending from altitude and stated traffic was level … ." (ASRS Pilot Report No. 205812);

- "We did not inform the controller of the evasive action in a timely manner" (ASRS Pilot Report No. 212715); and,

- "ATC took offense to TCAS and its use in the air traffic system. I have been finding that ATC is not too fond of TCAS because it takes away their authority" (ASRS Pilot Report No. 206966).

Controllers feel conflict about the appropriate response to RA-commanded deviations. Controllers have recently been instructed by the FAA to not countermand RAs which could contradict avoidance commands. In some instances, the controller becomes a passive observer to potential loss of separation situations, contrary to all prior training and basic instincts as an air traffic controller:

- "TCAS should only be used as an advisory tool for pilots and should not override air traffic control instructions" (ASRS Controller Report No. 232487); and,

- "Pilot of air taxi [name deleted] elected to respond to RA from aircraft [name deleted] and descended [toward] aircraft [name deleted]. This is insane at best and a blatant misuse of technology" (ASRS Controller Report No. 209177).

There are indications of nonstandard use of TCAS II by pilots.

There are indications of nonstandard use of TCAS II by pilots. The ASRS has received a number of TCAS II incident reports that clearly identify nonstandard applications of TCAS II:

- "I cannot have pilots using TCAS II for visual separation. There is no TCAS II separation" (ASRS Controller Report No. 202301);

- "Approach appeared to not have the 'big picture.' TCAS was used to ensure safe traffic separation" (ASRS Pilot Report No. 183286);

- "Cannot have pilot using TCAS II to maintain spacing" (ASRS Controller Report No. 202301); and,

- "ALPA's ATC committee cautions pilots ... not to use TCAS to provide their own air traffic control and self-separation."[10]

The conclusions of the TCAS II incident analysis verified the following points:

- TCAS II has definitely enhanced flight safety and is widely supported by the commercial pilot community;

- Air traffic controllers have been confused and occasionally alarmed by the variety of RA applications seen in terminal and en route airspace;

- The requirements associated with the implementation and subsequent nurturing of TCAS II may not have fully anticipated the "growing pains" that have influenced both pilots and controllers;

- Initial TCAS II training did not adequately prepare pilots and controllers for the surprises generated during RA situations;

- TCAS II applications have had an influence on the respective roles of the pilot and the controller; and,

- Behavioral ramifications need to be fully evaluated in concert with ergonomic issues.

TCAS II Enhancements Suggested

Information provided to the ASRS by pilots and controllers suggests that the following enhancements should be given serious consideration:

- Mandate a requirement for high-performance turbojet aircraft to reduce their vertical speed below 1,500 feet per minute (457 meters per minute) when 1,000 feet (305 meters) from their assigned level-off altitude;

- Require pilots to select TA mode only when established on the final approach for parallel approaches, in visual meteorological conditions (VMC) at airports where the parallel runways are less than 4,300 feet (1,311 meters) apart;

- Require pilots to notify ATC whenever a TA becomes a "yellow circle intruder" to warn ATC of a probable RA situation. A "yellow circle intruder" refers to a display on TCAS instrumentation that illuminates a solid amber circle when a TA is issued. As flight crew workload and frequency congestion permits, the pilot should also cite the clock position, direction of flight, and altitude of the intruder;

- Require ATC to issue the pilot all Mode C traffic in his vicinity upon being informed of yellow circle intruder;

- Direct pilots not to exceed a 500-foot (152-meter) altitude change during an RA response unless the intruder is displayed to be climbing or descending within 500 feet of the TCAS II aircraft's altitude;

- Expand and vigorously promote TCAS II simulation training for flight crews and controllers. The FAA training academy should consider developing and distributing ATC TCAS II situational training scenarios for immediate use at all terminal radar and en route center dynamic simulation training labs;

- The FAA and major aviation organizations including ALPA, Aircraft Owners and Pilots Association (AOPA), American Pilots' Association (APA), National Business Aircraft Association (NBAA) and NATCA should sponsor joint pilot/controller area and regional TCAS II workshops to promote cooperative dialogue between the constituencies; and,

- ATC facility managers, through the support of the air carriers and the Air Transport Association of America (ATA), should actively promote TCAS II familiarization flights for controllers. The opportunity to ride jumpseat, observe TCAS II situations and engage in constructive dialogue with flight crews should promote a better understanding of their respective professional concerns.

> ***"For TCAS to work as designed, immediate and correct crew response to TCAS advisories is essential."***

According to AC 120-55A, issued in August 1993, TCAS II is "intended to serve as a backup to visual collision avoidance … and air traffic separation service."

The AC adds: "For TCAS to work as designed, immediate and correct crew response to TCAS advisories is essential." Flight crews, the AC said, are expected to respond to TCAS according to the following guidelines:

- Respond to TAs by attempting to establish visual contact with the intruder aircraft while maintaining ATC assigned clearance; and,

- When an RA occurs, the pilot flying should respond immediately "… unless the flight crew has definitive visual" contact with the aircraft causing the RA. The AC said the initial vertical speed response is expected within five seconds and that altitude excursions "typically should be no more than 300 [feet] to 500 feet [91 meters to 152 meters] to satisfy the conflict."

But the AC cautioned: "ATC may not know when TCAS issues RAs. It is possible for ATC to unknowingly issue instructions that are contrary [opposite] to the TCAS RA indications. Safe vertical separation may be lost during TCAS coordination when one aircraft maneuvers opposite the vertical direction indicated by TCAS and the other aircraft maneuvers as indicated by ATC. As a result, both aircraft may experience excessive altitude excursions in vertical-chase scenarios because of the aircraft maneuvering in the same vertical direction. Accordingly, during an RA, do not maneuver contrary to the RA based on ATC instruction." ♦

[Editor's Note: This article was adapted from *Behavioral Impact of TCAS II on the National Air Traffic Control System*, a Battelle program report for NASA's Aviation Safety Reporting System, April 1993.]

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U.S. Airline Industry Safety Record Improves Despite Deregulation and Huge Financial Losses

The U.S. Airline Deregulation Act of 1978 raised concerns about its impact on safety. Although there was an increase in fatal accidents after its enactment, trends have improved each year since.

by
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[Editor's Note: *In the January 1991* Flight Safety Digest, *Gerard Bruggink first examined the safety aspects of airline deregulation. He concluded then that a series of accidents following deregulation could be a harbinger of poor performance to come unless the airline industry quickly came to terms with the changes and upheaval that deregulation caused. Following is Bruggink's updated assessment based on recent accident statistics.*]

During the three-year period 1990-1992, U.S. airlines operating under Part 121 of the U.S. Federal Aviation Regulations (FAR) set several records.

In number of departures and hours flown per fatal accident, this was the industry's best three-year performance. And for the first time, the number of aircraft occupant deaths was less than that in scheduled Part 135 (commuter) accidents. Financial losses, however, reached an all-time high despite an unprecedented level of passenger traffic.

The airlines' financial plight is mentioned only because it does not seem to fit the prevailing notion that poor economics tend to provoke shortcuts that lead to accidents. The staggering financial losses did not have the corner-cutting effect typically associated with economic survival because these losses were an inherent part of competitive strategies.

The prediction that the Airline Deregulation Act of 1978 would adversely affect air carrier safety is also being questioned. Although deregulation's destabilizing influence on the work force may have played a role in several accidents, the overall trend since 1978 has been one of improvement, with the exception of 1987-1989. That makes the 1990-1992 performance all the more remarkable and justifies an emphasis on the more intangible elements of success in accident avoidance and on the individuals who deserve credit for this.

This article deals only with the safety performance of U.S. carriers because a lack of consistency in the worldwide reporting of exposure and accident data precludes meaningful comparison.

There is no agreed-upon method to measure safety. The common practice of using past accident experience as a yardstick is flawed because it equates the absence of accidents with safety — without accounting for the close calls and the hundreds of daily incidents and malfunctions that are absorbed by the system. However, using those occurrences in a safety formula would not only discourage their reporting and investigation, but also create a bias against the most forthright carriers. This leaves accident rates as an imperfect but credible measure of safety performance.

A pivotal asset of the air transport industry is the public's trust in the safety of the system.

A variety of accident rates have been used: per million aircraft miles; per 100 million revenue passenger kilometers; per 100,000 departures; per 100,000 hours, etc. Most of them are expressed in decimal fractions that do not convey a clear picture of year-to-year changes. A more informative yardstick would be the use of hours flown per accident, which is nothing but a variation of the rate per 100,000 hours. To convert such a rate into the number of hours flown per accident, divide 100,000 by the rate. For example, an accident rate of .05 per 100,000 is the equivalent of 100,000 = 2 million hours per accident. The same method is used to calculate the number of departures per accident.

A pivotal asset of the air transport industry is the public's trust in the safety of the system. This means that the industry is best served by a performance yardstick that is readily understood by the public. Expressing safety in hours flown (or the number of departures) per accident would satisfy that requirement. This leaves one question open: Should all accidents be considered or just the fatal ones?

The conspicuity of fatal accidents creates headlines that shape the public's perception of aviation safety, and public concern about being in a fatal accident should be approached head-on. The most visual method to accomplish this is to publish the number of hours flown or departures per fatal accident.

According to a broad interpretation of International Civil Aviation Organization (ICAO) definitions, a fatal accident involves the death of any person as a result of the operation of an aircraft while there was intent for flight. The inconsistency in the application of this definition is easily demonstrated. A refueling mishap that results in a fire and the death of the refueler while the aircraft is at the gate with passengers or crew members aboard is treated as a fatal aircraft accident. When the same mishap occurs in association with periodic maintenance it is not considered a fatal aircraft accident, although the catastrophic potential is comparable and of concern to the traveling public.

The same definition may skew the accident statistics by not excluding work-related accidents that do not threaten the safety of the aircraft. Some examples are propeller-to-person accidents involving ground personnel and fatal injuries associated with activities at the gate, such as the towing or push-back of aircraft. These industrial mishaps should not become part of the fatal aircraft accident statistics just because they happened while there was intent for flight. Once they go into the statistical blender, these accidents assume the same weight as the collision of two Boeing 747s in Tenerife, Canary Islands, and distort the true risks of flying.

The U.S. air carrier accident experience presented here is derived from annual statistics compiled by the U.S. National Transportation Safety Board (NTSB). Exposure data (hours flown and the number of departures) were provided to the NTSB by the U.S. Federal Aviation Administration (FAA).

All fatal accidents in Part 121 operations are used in the calculations, including suicide and sabotage accidents. No distinction is made between fixed-wing and rotary-wing aircraft, passenger or cargo service, scheduled and non-scheduled operations, revenue and non-revenue flights.

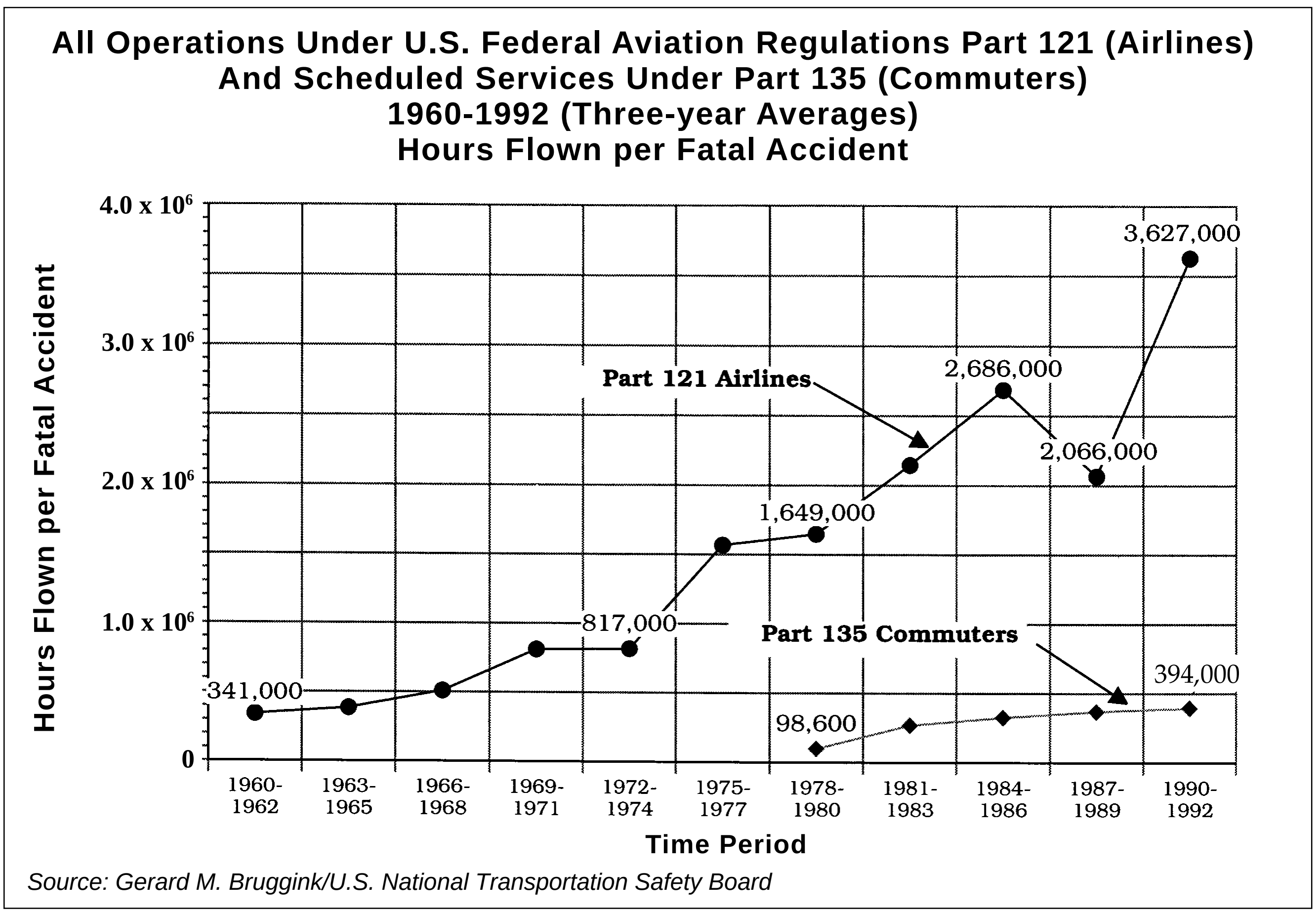
The beginning of the first full year (1960) of jet operations was the starting point for this analysis. The 33-year period 1960-1992 produced a total of 240 fatal accidents. Of these, 16 were not used in the calculations because they were more properly characterized as industrial accidents. These single-fatality mishaps include:

- Eight ground crew deaths during the towing or push-back of aircraft;
- Three propeller-to-person strikes;
- Two ground crew deaths during maintenance work at the gate;
- One stowaway;
- One infant, accompanied by parents, strangled by a seatbelt; and,
- One passenger who fell from a truck-mounted platform during a maintenance delay. His presence on that platform was not authorized.

Figure 1 is based on the hours flown per fatal accident, using the averages of the 11 three-year periods between 1960 and 1992. The graph shows a constantly improving trend with the exception of the 1987-1989 period. The hours flown per fatal accident increased by a factor of 10 between the first and the last three-year periods.

Since the introduction of deregulation (1978-1980), the hours flown per fatal accident increased from 1,649,000 to 3,627,000 during the 1990-1992 period.

The reason for the 1987-1989 dip in the graph is the unusually high number (eight) of fatal accidents in 1989. This was the highest annual



Source: Gerard M. Bruggink/U.S. National Transportation Safety Board

Figure 1

number of fatal accidents since 1974. Although different combinations of three-year averages would modify the shape of the graph to some extent, the period with 1989 in it would still have a dip.

With the introduction of the airline hub-and-spoke system in the 1980s, many travelers became dependent on commuter air carriers operating under the provisions of Part 135. Because the commuters are now a vital element of the U.S. air transport system, it is appropriate to compare their safety performance with that of Part 121 operators. Figure 1 (page 11) shows that there is a striking difference between the two operations during the past 15 years.

When the comparison is based on the number of departures per fatal accident (Figure 2), the difference becomes less extreme. Additional details about the accident experience in the two forms of public transportation during the 1990-1992 period are given in Table 1. The conclusions are that the U.S. air transport system operates at two distinct levels of safety; and that the hub-and spoke system offers the public little or no choice in the matter. This disparity has much to do with the lower regulatory standards of Part 135.

The first accident linked to deregulation occurred in January 1982, when a Boeing 737 struck a bridge in Washington, D.C., following a takeoff with ice-contaminated wings and a thrust deficiency. In its analysis of that accident, the NTSB did not cite deregulation directly, but implicated its role. The NTSB said the captain "missed the seasoning experience, normally gained as a first officer, as a result of the rapid expansion of (the carrier)." The

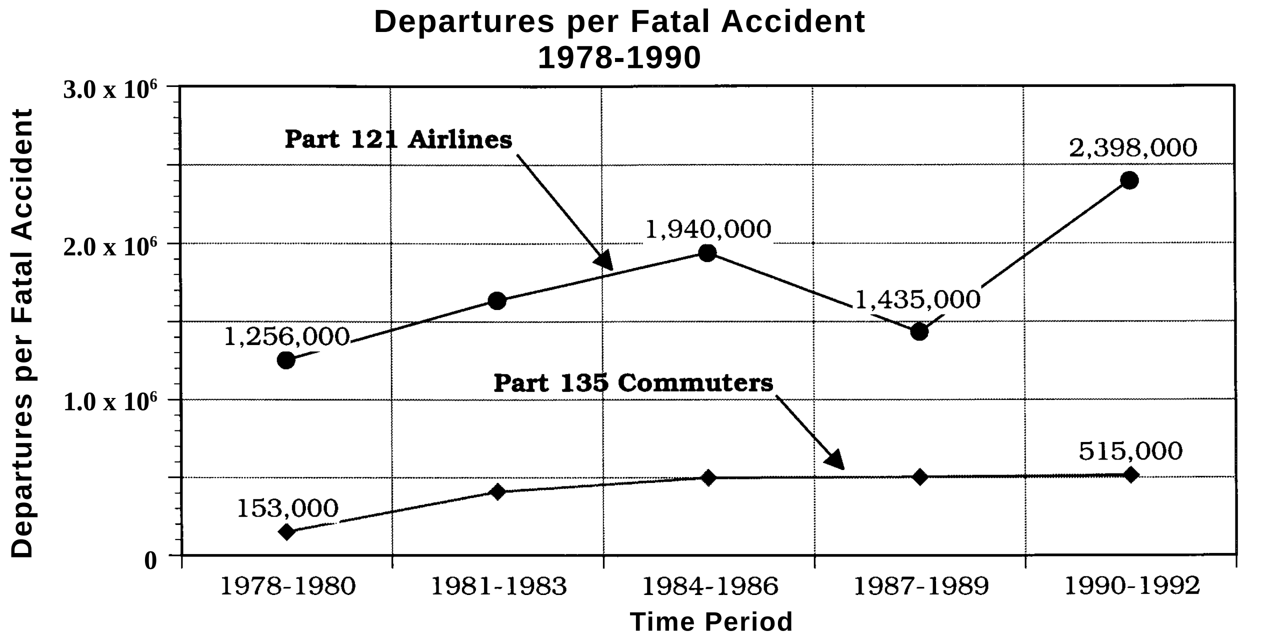
Table 1

Exposure and Fatal Accident Data Part 121 (Airlines) and Part 135 (Commuters) Operations 1990-1992

	Part 121	Part 135
Hours Flown	36,273,000	6,689,000
Departures	23,976,000	8,759,000
Fatal Accidents	10	17
Hours Flown per Fatal Accident	3,627,000	394,000*
Departures per Fatal Accident	2,398,000	515,000
Fatalities		
Crew	19	22
Passengers	73	80

* During the same time period, on-demand air taxis operating under Part 135 flew 86,000 hours per fatal accident.

Source: Gerard M. Bruggink/U.S. National Transportation Safety Board



Source: Gerard M. Bruggink/U.S. National Transportation Safety Board

Figure 2

causal statement listed the crew's "limited experience ... in jet transport winter operations" as a contributing factor.

Before deregulation, it would have been unthinkable that crew experience would be a factor in Part 121 accidents. Carriers voluntarily went beyond the prescribed minimum qualification standards. However, these practices may have been compromised when the explosive increase in airline operations during the mid- and late-1980s required the massive hiring of ground and flying personnel. Two accidents in the 1987-1989 period also support this view.

In November 1987, a McDonnell Douglas DC-9 crashed at Denver Stapleton International Airport while taking off in a snowstorm. The NTSB attributed the accident to contaminated wings and the first officer's rapid takeoff rotation. In its findings, the NTSB stated: "Due to the relatively low experience levels of both crew members in the DC-9, the pairing of these pilots was inappropriate." The NTSB later made an unmistakable reference to the deregulation factor: "The rapid growth of the aviation industry at a time when fewer experienced pilots are in the work force has reduced the opportunity for a pilot to accumulate experience before progressing to a position of greater responsibility. This loss of 'seasoning' has led to the assignment of pilots who may not be operationally mature for positions previously occupied by highly experienced pilots."

Before deregulation, it would have been unthinkable that crew experience would turn up as a factor in Part 121 accidents.

The same theme runs through the B-737 accident at La Guardia Airport in New York in September 1989, which involved a rejected takeoff and a runway overrun. Although the official causal statement cites the captain's failures as the sole explanation for the accident, the report and the safety recommendations leave no doubt about the role played by the pairing of inexperienced crew members. The captain had about 140 hours as a 737 captain; the first officer, who was making the night takeoff, had 8.2 hours in the 737. This was also his first takeoff after 39 days of not flying.

Considering the scrupulous attention given to flight crew experience in accident investigation, it should come as no surprise that this is the only area where the influence of deregulation has been documented. In the equally important area of aircraft maintenance, the available data do not permit such an assessment despite the fact that six of the 16 fatal accidents in 1987-1989 had maintenance implications. Those implications include:

- The takeoff warning system was not operating in the two cases where the crew began the takeoff in the wrong configuration;

- There were two explosive decompressions, one caused by loss of a cargo door and the other caused by failure of the fuselage skin;

- A DC-9 crashed on takeoff after the cargo door opened; and,

- There was one catastrophic engine failure.

There is reason to believe that the influx of new and less experienced personnel, combined with competitive pressures, may have compromised established maintenance standards during those years.

The safety performance of the airlines during the 1990-1992 period can best be appreciated by a review of the 10 fatal accidents that occurred (Table 2, page 14). Three of them involved cargo aircraft. The DC-6 crash in Guatemala is included in the performance calculations because it was listed as a Part 121 operation.

The trespasser who was struck by a Boeing 727 on a runway in Phoenix, Arizona (Table 2), was a patient from a nearby mental institution. The captain rejected the night takeoff at a speed of 105 knots and returned to the ramp.

The 84-year-old person injured in a turbulence accident (Table 2) died 20 days later. The aircraft experienced clear air turbulence while flying under the overhang of a thunderstorm. The seatbelt sign was on but the instruction was not enforced.

The most unusual aspect of the seven accidents involving passenger operations is the number of runway collisions. There were three: one during takeoff and two while landing. They are a disturbing reminder that airports remain high-risk areas.

A DC-9 and a Fokker F-28 crashed on takeoff because of ice or snow contamination on the wings. The F-28 had been deiced twice, but 35 minutes elapsed between the last deicing and takeoff. The DC-9 was not deiced.

The DC-8 accident at Swanton, Ohio (Table 2), occurred when control was lost during a missed approach and was attributed to the captain's apparent spatial disorientation, which resulted from physiological factors and/or a failed attitude indicator.

The NTSB was unable to determine the cause(s) of a Boeing 737 accident in Colorado Springs, Colorado (Table 2). Several possibilities were explored, including a meteorological phenomenon and a malfunction in the aircraft's control system.

What distinguishes the 1990-1992 fatal accident record from the preceding period is not just the lower number of accidents, but the absence of documented deregulation and proven maintenance factors. The contrast between the two periods is too great to ascribe to chance, and suggests the question: Does deregulation no longer affect the airlines' safety performance? A definitive answer

Table 2

Fatal Accidents and Fatalities
U.S. Federal Aviation Regulations Part 121 Air Carriers — All Operations
1990-1992

Date	Location	Operator	Service	Aircraft	Passenger	Crew	Other	Nature of Accident
1/18/90	Atlanta, Ga.	Eastern	Passenger	B-727	0	0	1	Runway collision with general aviation aircraft during landing.
3/13/90	Phoenix, Ariz.	Alaska	Passenger	B-727	0	0	1	Aircraft struck trespasser on runway during takeoff.
5/5/90	Guatemala	Translados	Cargo	DC-6	0	3	24	Crashed into residential area after takeoff.
10/3/90	Atlantic Ocean	Eastern	Passenger	DC-9	1	0	0	Passenger died as result of injuries during inflight turbulence.
12/3/90	Detroit, Mich.	Northwest Northwest	Passenger Passenger	DC-9 B-727	7 0	1 0	0 0	Runway collision in fog. One aircraft taking off.
2/1/91	Los Angeles, Calif.	USAir	Passenger	B-737	20	2	12	Runway collision with Metroliner after landing.
2/17/91	Cleveland, Ohio	Ryan	Cargo	DC-9	0	2	0	Crashed on takeoff (contaminated wings).
3/3/91	Colorado Springs, Colo.	United	Passenger	B-737	20	5	0	Crashed on approach (cause undetermined).
2/15/92	Swanton, Ohio	Air Transport International	Cargo	DC-8	0	4	0	Crashed during missed approach.
3/23/92	Flushing, NY	USAir	Passenger	F-28	25	2	0	Crashed on takeoff (contaminated wings).
Totals					73	19	38	

Source: Gerard M. Bruggink/U.S. National Transportation Safety Board cannot be given because it will never be known what the safety level might have been without deregulation. Nevertheless, there is a tentative explanation for the superior 1990-1992 performance. Using the number of departures in successive three-year periods as a measure of growth since the start of deregulation, the diminishing rate of expansion in 1990-1992 becomes apparent:

Total Number of Departures

1978-1980	16,327,000
1981-1983	16,370,000
1984-1986	19,408,000
1987-1989	22,963,000
1990-1992	23,976,000

In the 1990-1992 period, the number of departures grew by one million; in the two preceding periods, departures grew by three and 3.5 million respectively, which explains the massive hirings during those years. A reasonable conclusion is that by 1990-1992, the work force had become more experienced while a more stable productivity tempo improved the harmony between job demands and skill levels.

With the widespread introduction of the jet transport in the early 1960s, the industry launched a vehicle that will still be dominating the skies over the continents long after its supersonic offspring have taken over the ocean routes. No amount of technology can circumvent the laws of physics that set a practical limit on the speeds that can be achieved economically without sonic impact.

Although the 1990-1992 safety record gives reasons for satisfaction, there can be no guarantee of a similar or better performance in the future.

The accident record of the first-generation jets attests to the adjustment problems faced by manufacturers, airlines and the FAA. It was a costly learning process that eased the introduction of subsequent generations of jet aircraft, starting in the early 1970s. Their increasing reliability and maintainability produced a safety milestone in the mid-1970s, when the number of flying hours per fatal accident exceeded one million for the first time.

At about the same time it became apparent that airplane performance was maturing at a faster rate than the performance of the humans in the system. The NTSB's sharpened focus on the human factors role in accidents created new insights in the preventive potential of training concepts, procedures and engineering solutions to problems such as controlled-flight-into-terrain (CFIT) accidents. The beneficial effects of subsequent improvements in these categories are evident in Figure 1 (page 3). By the mid-1980s, the number of hours flown per fatal accident rose to 2.6 million.

The current maturity level of the subsonic transport is unquestionably the most constant contributor to the industry's safety performance, provided there is compatibility between the competence of the work force and the demands of the machine. True harmony in that regard may not be achievable until a particular make and model has become a stable fixture in the inventory of an airline. It would be unwise to unsettle a developing competence level with the rash introduction of technologies that increase the error potential in maintenance and operations for the sake of a fractional gain in airspeed or fuel consumption. Nor should technological hubris be allowed to override the proven concepts of redundancy that have served the industry so well in the past.

Although the 1990-1992 safety record gives reasons for satisfaction, there can be no guarantee of a similar or better performance in the future. The element of chance in the causation and prevention of accidents provides ample reason to temper confidence with wariness. Moreover, there is no predictable relationship between the nature of an error or compromise and the severity of its consequences. For example:

- In 1977, the seemingly innocuous term "O.K.," followed by a short pause, was interpreted by a go-minded 747 captain in Tenerife, Canary Islands, as confirmation of his (false) assumption that he was cleared for takeoff; 574 people died in the Tenerife collision; and,

- Recently, a deadheading captain prevented a potential disaster when he told a cabin attendant to warn the flight crew that the flight spoilers were up. At the time, the flight was next in line for takeoff and the speed brake handle was down and in the detent. The crew taxied back to the gate where it was discovered that the speed brake control cable had failed.

Another factor that cannot be taken for granted is the public's trust in the safety of air travel. As long as the fear of flying is dormant, the public seems to be more concerned with fares than the caliber of a carrier and its equipment. Nevertheless, the public's trust can easily change into avoidance behavior when a series of accidents draws widespread negative attention to a particular operator, aircraft type or type of operation. The FAA's stamp of approval on an aircraft or an operation has no commercial value unless the public also approves.

What brightens the outlook of the future is an apparent commitment to excellence at the working level that goes beyond pay scale and contract. During the past three years, an average of 21,900 flights a day were launched with unprecedented results in departures and hours flown per fatal accident. Perfunctory task performance alone could not have accomplished this.

This overview of the safety performance of Part 121 operators has highlighted some of the less obvious elements of success in accident avoidance. Two of these are worth repeating:

- To capitalize on the safety potential of the mature jet transport, the industry must provide stability in the work environment; and,

- To meet its safety obligations, the industry must establish experience criteria that exceed the certification and qualification standards in the FAR.

There are no reasons to suspect that the validity of these findings suffers from the acknowledged shortcomings of basing safety performance on fatal accident data. ♦

About the Author

Gerard M. Bruggink has been an aviation consultant since his retirement in 1979 from the U.S. National Transportation Safety Board (NTSB). He has published more than 25 papers on aviation safety.

During his 10 years at the NTSB, Bruggink served as field investigator, chief of the Human Factors Branch, accident inquiry manager and deputy director of the NTSB's Bureau of Accident Investigation. He was an air safety investigator for the U.S. Army Safety Center and chief of the Human Factors Branch at the Aviation Crash Injury Research Division of the Flight Safety Foundation. He was also a flight instructor, safety officer and accident investigator for the U.S. Air Force and U.S. Army contract flight schools.

Prior to immigrating to the United States, Bruggink was a flight instructor, safety officer and accident investigator for the Netherlands Air Force. A native of the Netherlands, he was a fighter pilot during World War II. He saw action in the Pacific theater and was interned as a prisoner of war.

Bruggink has been honored with the James H. McClellan Award from the Army Aviation Association of America and the Jerome Lederer Award from the International Society of Air Safety Investigators.

Commercial Jet Fleet Accident Statistics Reviewed

by
Editorial Staff

The *Statistical Summary of Commercial Jet Aircraft Accidents*, *Worldwide Operations 1959-1992*, published by the Boeing Commercial Airplane Group, Airplane Safety Engineering, and *Commercial Jet Transport Safety Statistics 1958-1992*, published by the Douglas Aircraft Safety Data Office, Flight Standards and Safety Group, provide a wide spectrum of statistical data relating to worldwide commercial jet fleet operations.

The Boeing report tracks nine manufacturers of commercial jet aircraft — 26 significant types (eight Boeing) and 10,916 aircraft in service as of Dec. 31, 1992 (6,204 Boeing).

The Douglas statistics relate to the following aircraft: Airbus models A300/310/320, BAe (BAC) One-Eleven, BAe-146, Boeing models 707, 720, 727, 737, 747, 757, 767, McDonnell Douglas models DC-8/9/10, MD-11, MD-80, Lockheed L-1011, and Fokker models F-28 and F-100.

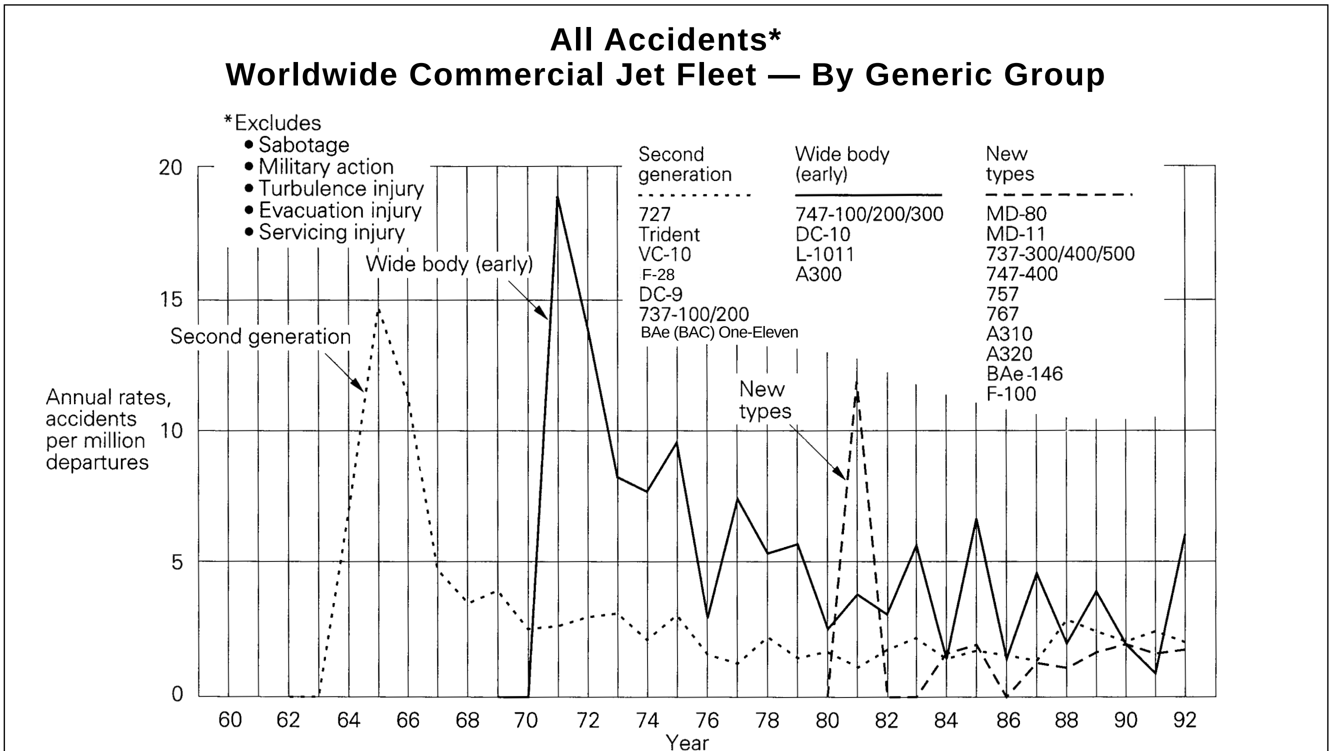
Accidents serious enough to warrant attention in the Douglas report amount to only one percent of the 184,000 safety-related events tracked in the Douglas Safety Information System data base, which includes information from the U.S. National Transportation Safety Board (NTSB), the International Civil Aviation Organization (ICAO),Airclaims Major Loss Record, the U.K. Civil Aviation Authority, Flight Safety Foundation and local and national news sources.

The Boeing summary of all accidents from 1959 to 1992 (Figure 1, page 18) categorizes the worldwide commercial jet fleet as follows:

Second generation: Boeing 727, Trident, BAe VC-10, BAe (BAC) One-Eleven, DC-9, 737-100/200, Fokker F-28;

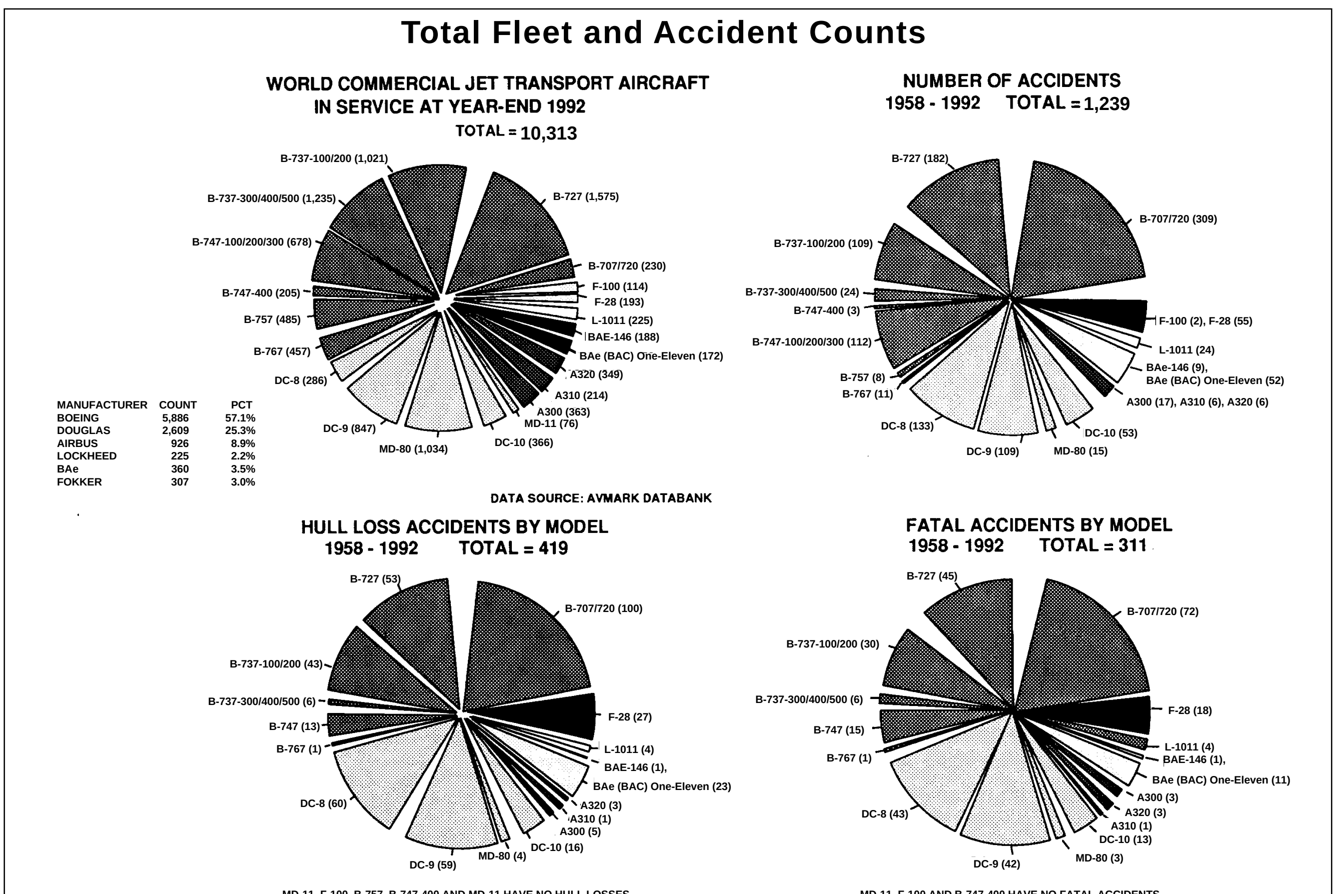
Wide body (early): Boeing 747-100/200/300, DC-10, L-1011, A300; and,

New types: MD-11, MD-80, Boeing 737-300/400/500, 747-400, 757, 767, A310/320, BAe-146, and Fokker F-100.



Source: Boeing Commercial Airplane Group

Figure 1



Source: Douglas Aircraft Company

Figure 2

The annual accident rate for second-generation aircraft, which peaked in 1965 at about 14.6 per million departures, fell to less than four in 1969 and has never risen above this figure. Wide bodies reached a peak of 19 in 1971, fell and then increased to about 9.5 in 1975, and have never risen above this rate again. Rates for new-type aircraft climbed to about 12 from 1980 to 1981, then fell sharply to zero in 1982, after which they hovered about one or two.

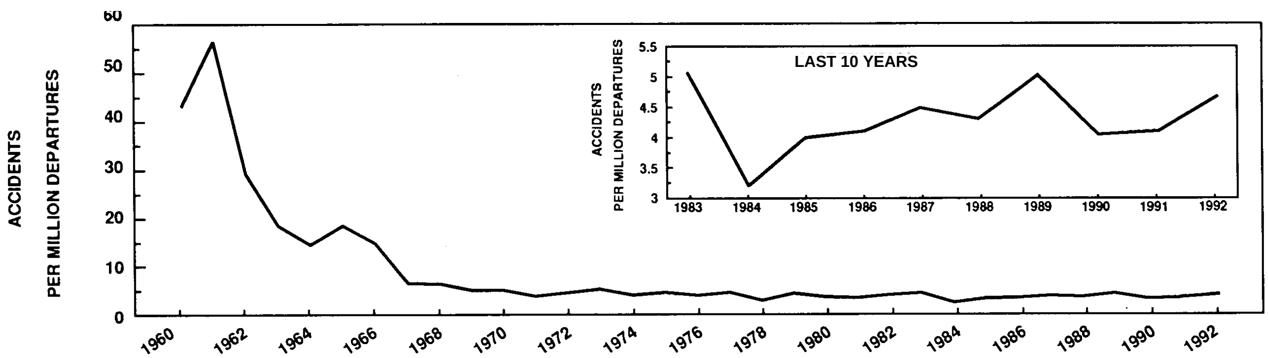
Of a total of 1,239 accidents, 309 involved Boeing 707/720s, 182 involved Boeing 727s, 133 involved DC-8s, 112 involved Boeing 747-100s, 200s and 300s, 109 involved DC-9s, and 109 involved Boeing 737 100s and 200s, according to the Douglas report findings from 1958-1992 (Figure 2, page 18).

Of the worldwide commercial jet transport aircraft in service at year-end 1992, Boeing and Douglas accounted for 57.1 percent and 25.3 percent, respectively.

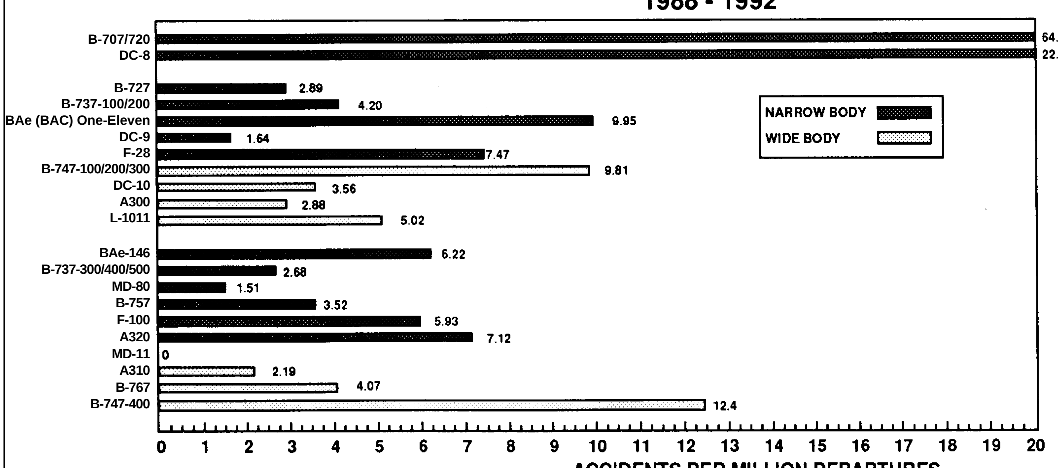
As for accidents per million departures from 1988 to 1992 (Figure 3), 64.83 are attributed to the Boeing 707/720 (narrow body), 22.39 to the DC-8 (narrow body), 12.4 to the 747-400 (wide body), 9.95 to the BAe (BAC) One-Eleven (narrow body), and 9.81 to Boeing 747 models 100, 200 and 300 (wide body). The peak in accidents per million departures from 1960-1992 occurred about 1961 (56), but has remained near 5.0 since 1969.

In terms of hull-loss accidents (Figure 4, page 20), Boeing's statistics showed second-generation accident rates from 1959-1992 peaking at about six per million departures in 1965, then dropping and remaining at about one or two. Wide-body accident rates reached a high of about 4.5 in 1972, then fell and rose, but never more than four.

Accident Rates
Commercial Jet Transport Aircraft
1960-1992



1988 - 1992

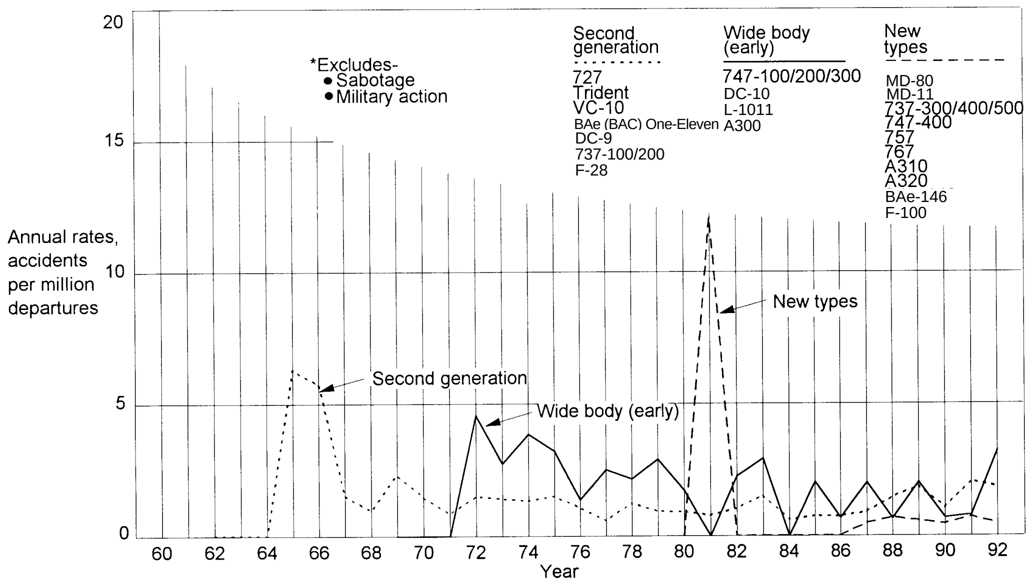


	ACCIDENTS	DEPARTURES 1988-1992
B-707/720	34	524,478
DC-8	21	937,865
B-727	33	11,426,825
B-737-100/200	45	10,725,255
BAe (BAC) One-Eleven	6	904,818
DC-9	9	8,548,491
F-28	8	2,007,420
B-747-100/200/300	3	2,650,057
DC-10	4	1,967,675
A300	1	2,082,913
L-1011	1	1,194,372
BAe-146	1	1,286,971
B-737-300/400/500	5	7,090,273
MD-80	2	6,614,237
B-757	0	1,986,332
F-100	0	337,174
A320	3	843,228
MD-11	0	37,123
A310	1	2,287,503
B-767	1	1,967,675
B-747-400	0	241,851

Source: Douglas Aircraft Company

Figure 3

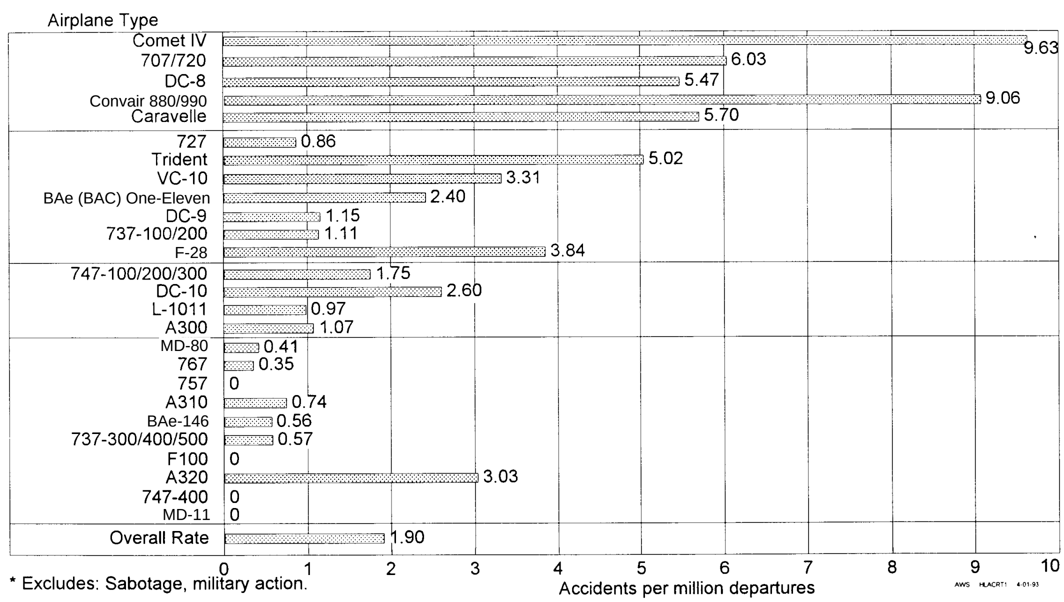
Hull-loss Accidents*
Worldwide Commercial Jet — By Generic Group



Source: Boeing Commercial Airplane Group

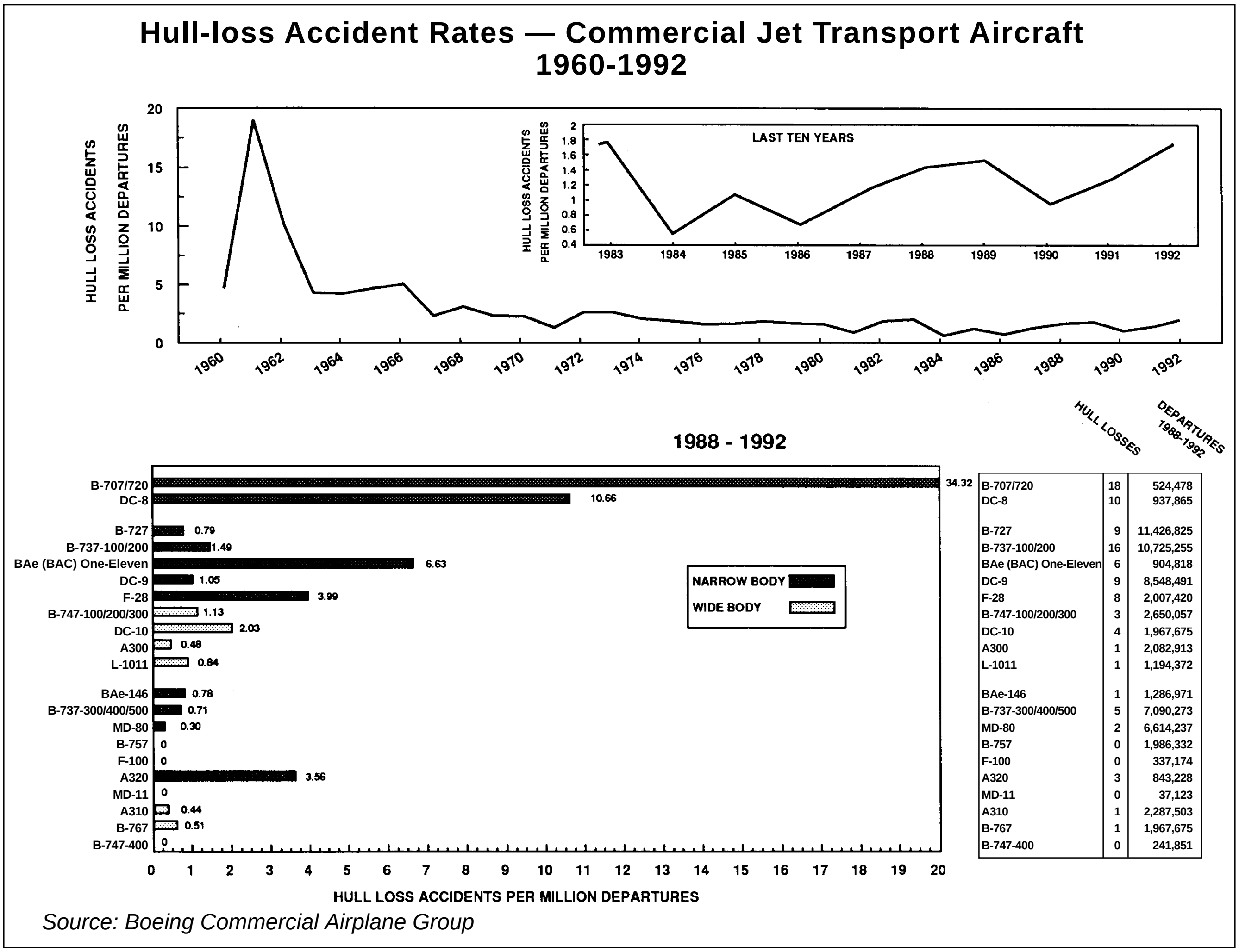
Figure 4

Hull-loss Accidents*
Worldwide Commercial Jet Fleet — 1959-1992



Source: Boeing Commercial Airplane Group

Figure 5



	HULL LOSSES	DEPARTURES 1988-1992
B-707/720	18	524,478
DC-8	10	937,865
B-727	9	11,426,825
B-737-100/200	16	10,725,255
BAe (BAC) One-Eleven	6	904,818
DC-9	9	8,548,491
F-28	8	2,007,420
B-747-100/200/300	3	2,650,057
DC-10	4	1,967,675
A300	1	2,082,913
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A320	3	843,228
MD-11	0	37,123
A310	1	2,287,503
B-767	1	1,967,675
B-747-400	0	241,851

Figure 6

New types jumped from zero to 12 in the 1980-1981 period, then dropped to zero in 1982, and only started to climb slightly after 1986.

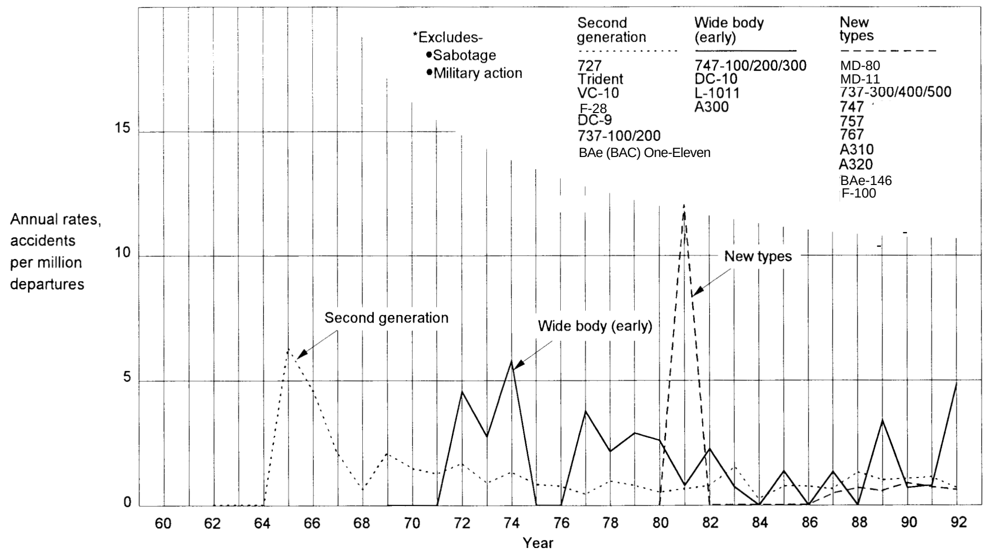
An examination of airplane type showed the Comet IV responsible for 9.63 accidents per million departures from 1959-1992 and the Convair 880/990, 9.06 (Figure 5, page 20). Rates for all other types were no greater than 6.03. Note that the Boeing report tracks airplane types not mentioned in the Douglas report, e.g., Comet IV and Caravelle.

A breakdown of the U.S. commercial jet fleet during the past decade produced the following numbers: 16.30 accidents per million departures for the Boeing 707/720 and 3.02 for the DC-8 (less than two for all other types). For the same period, non-U.S. commercial jet fleet, the Boeing 707/720 again had the most accidents per million departures, at 31.72; the DC-8 had 16.76, the Caravelle 14.93, the Trident 18.99 (all others were less than five).

Hull-loss accidents from 1958-1992 totaled 419 according to the Douglas report (Figure 2, page 18) — 100 attributed to the Boeing 707/720; 60 to the DC-8; 59 to the DC-9; and 53 to the Boeing 727. The Boeing graph on hull-loss accidents per million departures from 1988-1992 (Figure 6) put the count at 34.32 for the Boeing 707/720, 10.66 for DC-8, and 6.63 for BAe (BAC) One-Eleven (narrow body). For all other aircraft, the number of accidents was less than four. Again, 1961 was the "worst" year in the 1960-1992 span, with about 19 accidents per million departures, but after 1963 the number never rose above five and during the last 10 years it never passed two.

Fatal accident numbers were low for the 1959-1992 period studied in the Boeing report (Figure 7, page 22). Second generation jumped from zero to six from 1964-1965, then dropped and remained at about one from 1970 to 1992. Wide-body numbers showed more peaks and valleys, but never

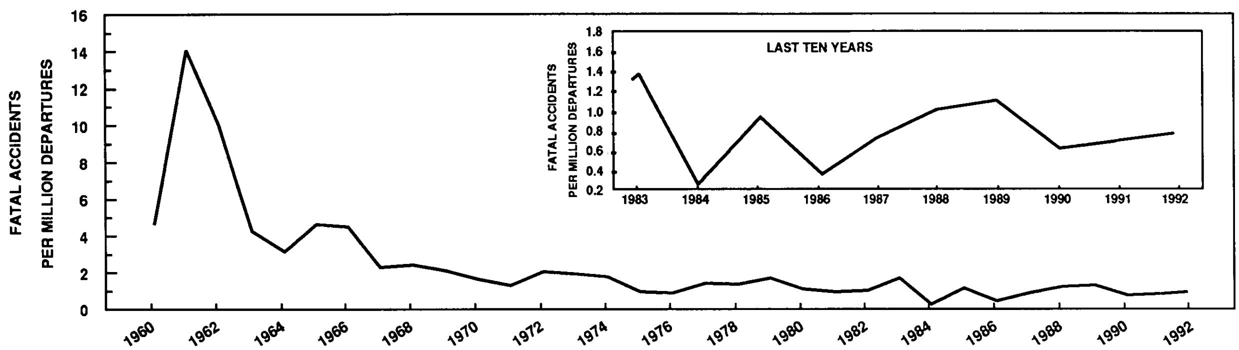
Fatal Accidents *
Worldwide Commercial Jet Fleet — By Generic Group



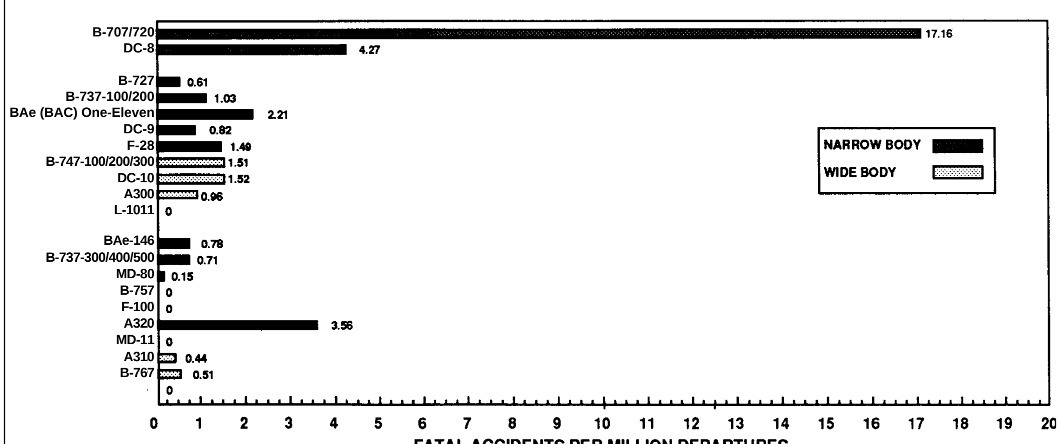
Source: Boeing Commercial Airplane Group

Figure 7

Fatal Accident Rates — Commercial Jet Transport Aircraft 1960-1992



1988 - 1992



	FATAL ACCIDENTS	DEPARTURES 1988-1992
B-707/720	34	524,478
DC-8	21	937,865
B-727	33	11,426,825
B-737-100/200	45	10,725,255
BAe (BAC) One-Eleven	6	904,818
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MD-11	0	37,123
A310	1	2,287,503
B-767	1	1,967,675
B-747-400	0	241,851

Source: Douglas Aircraft Company

Figure 8

extended past 5.5; and new types, with a high of a bit over 12 in 1981, dropped to zero for 1982-1986 and never climbed past one afterward.

According to the Douglas report, fatal accidents in the period 1958 to 1992 numbered 311 (Figure 2). Of this total, 72 were attributed to Boeing 707/720s, 45 to Boeing 727s; 43 to DC-8s; and 42 to DC-9s. Fatal accidents per million departures from 1988-1992 were 17.16 for Boeing 707/720s; for every other aircraft type the number was less than five (Figure 8, page 22).

Fatal accident rates on commercial jet transport aircraft taken as a whole from 1960-1992 totaled about 14 per million departures in 1961, then fell sharply and rose to about five in the 1965-1966 period. They dropped to two or less for 1967 to 1992 (Figure 8).

Accident and damage in the two reports were defined as follows:

An aircraft accident is an event associated with aircraft operation occurring between the time people board an aircraft with the intention of flight until all people have disembarked. It is considered an aircraft accident if, during this time, any person dies or is seriously injured as the result of being in, on, or in direct contact with the aircraft or if the aircraft receives substantial damage. The Douglas report excludes death from natural causes, fatal or serious injury to a passenger that is self-inflicted or inflicted by another, injury to ground support personnel before or after flight, and serious injury involving stowaways or that is not a direct result of aircraft operation.

Substantial damage affects structural strength, performance or flight characteristics of the aircraft that would require major repair or replacement of the affected component. Engine failure limited to one engine, bent fairings or cowlings, dents in the skin, damage to landing gear, wheels, tires, flaps, etc., are not considered substantial damage.

Serious injuries are defined as requiring hospitalization for more than 48 hours, beginning within seven days of the injury; resulting in a fracture (except simple fractures of fingers, toes or nose); producing lacerations causing severe bleeding or nerve, muscle or tendon damage; involving injury to an internal organ or involving second- or third-degree burns over more than 5 percent of the body.

A fatal injury as defined results in death within 30 days as a result of the accident. A hostile action includes sabotage, military action, suicide and terrorist acts that cause the accidents/injuries. U.S. and non-U.S. events are identified by the operator’s national registry, not the event’s location. A non-operational event occurs when there is no intent for flight.♦

Publications Received at FSF Jerry Lederer Aviation Safety Library

U.S. Guidelines Issued for Use of Portable Electronic Devices Aboard Aircraft

by
Editorial Staff

New Reference Materials

U.S. Federal Aviation Administration. Advisory Circular 91.21-1, *Use of Portable Electronic Devices Aboard Aircraft*. August 1993. 5 p.

This advisory circular (AC) provides information and guidance to assist aircraft operators with compliance of Federal Aviation Regulations (FAR) Section 91.21, prohibiting the operation of portable electronic devices (PED) aboard U.S.-registered civil aircraft operated by a holder of an air carrier operating certificate or any other aircraft while operating under instrument flight rules.

Section 91.21 allows the operation of PEDs that the operator of the aircraft has determined will not cause interference with the navigation or communication systems of the aircraft. The AC recommends minimum procedures to provide methods to inform passengers of permissible PED operation times, procedures to terminate the operation of the PEDs, procedures for reporting instances of suspected or confirmed interference by PEDs, cockpit-to-cabin coordination, and procedures for determining acceptability of those PEDs that can safely be operated aboard the aircraft.

In addition, the AC recommends prohibiting the operation of any portable electronic device during the takeoff and landing phases of flight. This AC cancels AC 91-47, *Use of Portable Electronic Devices—Radio Receivers*, dated March 23, 1977. [Modified Purpose]

U.S. Federal Aviation Administration. Advisory Circular 21-36, *Quality Assurance Controls for Product Acceptance Software*. August 1993. 6 p.

This advisory circular (AC) provides information and guidance concerning control of software, documentation and related digital input/output data designed for use in the acceptance of airborne products. This AC addresses only those sections of Federal Aviation Regulations (FAR) Part 21, subparts F, G, K, and O where information on computer-aided manufacturing (CAM), computer-aided inspection (CAI) and computer-aided test (CAT) software would be helpful to production approval holders (PAH) and parts suppliers during manufacture, inspection and/or testing of materials and parts. [Modified Purpose]

Reports

U.S. General Accounting Office (GAO). *Aircraft Certification: New FAA Approach Needed to Meet Challenges of Advanced Technology*. Report to the Chairman, Subcommittee on Aviation, Committee on Public Works and Transportation, U.S. House of Representatives. September 1993. 75p. Available through the GAO**.

Keywords
1. Airlines — Certification — United States.
2. Airplanes — United States — Inspection.
3. Aeronautics — United States — Technological Innovations.

Summary: This report examines the U.S. Federal Aviation Administration's (FAA) process for certifying that transport aircraft designs meet safety standards. Because the FAA is responsible for certifying that new aircraft designs and systems meet safety standards, it is crucial that FAA staff understand these new technologies.

The GAO was asked to examine whether FAA staff are effectively involved in the aircraft certification process and if they are provided the assistance and training needed to be competent in the increasingly complex technologies used aboard the latest aircraft designs. According to the report, the FAA has increased delegation during the last 13 years, and its ability to effectively oversee or add value to the certification process as well as understand new technologies has been questioned by internal reviews and FAA and industry officials.

The report states that the FAA now delegates up to 95 percent of certification activities to manufacturers without defining critical activities in which the FAA should be involved. Moreover, the FAA has not provided guidance on the necessary level and quality of the oversight of designees. As a result, FAA staff no longer conduct and oversee such critical activities as the approval of test plans and analyses of hypothetical failures of systems. The report said that the FAA has not provided its staff the assistance and training needed to ensure competence in new technologies. Although the FAA has hired experts to assist staff in the certification process, it has not identified critical points in the certification process that require experts' involvement, according to the report.

In addition, the report said the FAA's training has not kept pace with technological advancements. The GAO found that only one of the 12 FAA engineers responsible for approving aircraft software attended a software-related training course between fiscal years 1990 and 1992. And although the FAA is developing a new training program, it may not have the structure necessary to improve the staff's competence, the report states.

To ensure that FAA staff receive the technical training needed, the GAO recommended that the secretary of transportation direct the FAA to establish specific training requirements for each certification discipline. And to ensure that each staff member meets those requirements, training should be kept as current as possible by identifying the training in new technologies that is available at universities, other government agencies and private industry, the report said. ♦

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Updated Reference Materials (Advisory Circulars, U.S. FAA)

AC Number	Month/Year	Subject
90-66A	08/26/93	*Recommended Standard Traffic Patterns and Practices for Aeronautical Operations at Airports without Operating Control Towers* (cancels AC 90-66, dated Feb. 27, 1975).

Federal Aviation Administration Orders

7400.2D	09/16/93	*Procedures for Handling Airspace Matters* (incorporating all required changes due to the Airspace Reclassification Rule and cancelling Order 7400.2C, dated May 1, 1984).

Speed Brake Cable Misrouting Problem Identified

by
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

Speed Brake Cable Misrouted

Boeing 737-300. No damage. No injuries.

The aircraft was taxiing for takeoff when a passenger, an off-duty captain, notified the crew that the wing spoiler panels were extended.

The flight immediately returned to the gate for a maintenance inspection. The inspection determined that the speed brake down control cable failed because it had been misrouted. The down cable had failed at a point where it rides over a pulley in the right main landing gear well. If the speed brake down cable fails, the spoiler panels are prevented from retracting when the speed brake control level is moved into the down position.

The U.S. National Transportation Safety Board (NTSB) said that after the incident, it researched the service history of speed brake down control cable failures on Boeing 737 aircraft and determined that it was the third failure attributed to misrouting.

"Instead of being routed on the pulley adjacent to the spoiler ratio changer, the cable was riding atop two spacers that attach cable guards to the pulley," the NTSB said. "Wear from riding on these spacers caused the cable to fail 14 inches [35 centimeters] from the spoiler ration changer."

The NTSB noted that if the cable fails on the ground after the aircraft lands, all 10 spoiler panels will remain extended when the lever is placed in the down position. "Since the takeoff configuration warning is based on control lever position and not actual spoiler position, the crew may be unaware that spoiler panels are extended when taking off," the NTSB said.

The NTSB recommended inspections of all Boeing 737 aircraft to make sure the down control cable is correctly installed.

Antenna Strike Damages Tupolev On Missed Approach

Tupolev Tu-154. Substantial damage. No injuries.

The Tupolev with 136 passengers and a crew of nine on board was on a daylight instrument landing system (ILS) approach when it encountered heavy showers and turbulence about two nautical miles (four kilometers) from touchdown.

With engine power momentarily set at flight idle, the aircraft descended below the glidepath. A missed approach was initiated at an altitude of 98 feet (30 meters) above ground level (AGL). However, the right inboard flaps struck an ILS antenna at 20 feet (six meters) AGL, located about 2,133 feet (650 meters) before the runway threshold. The flaps were retracted and the aircraft landed without incident after a go-around.

Air Taxi
Commuter

Powerline Snags Commuter On Night Approach

L-410 Turbolet. Substantial damage. No injuries.

The Turbolet with 13 passengers and a crew of four on board was on final approach at night to a European airport when the top of the vertical stabilizer fin struck a high-tension powerline.

The pilot was able to execute a missed approach and the aircraft landed without further incident. An investigation cited a lack of crew coordination in the cockpit, inadequate monitoring and poor airmanship as causes of the incident.

Engine Fire Linked to Air Taxi Crash

Piper PA-23 Aztec. Aircraft destroyed. Four fatalities.

The twin-engine Aztec with three passengers on board was departing on a daylight flight in the Caribbean when, shortly after takeoff, the pilot advised air traffic controllers that one engine was on fire.

Controllers cleared the aircraft for an emergency landing, but there was no further contact with the pilot. The aircraft crashed in the water just west of the airport, killing the pilot and passengers. An inquiry determined that the pilot likely lost control of the aircraft during the engine-out emergency at too low an altitude to recover.

Corporate
Executive

Course Drift Dooms Twin On Climb-out

Cessna 421. Four fatalities and two serious injuries.

The twin-engine Cessna with five passengers on board was climbing out after a night takeoff when it struck trees and snow-covered terrain at 10,000 feet (3,050 meters) mean sea level (MSL).

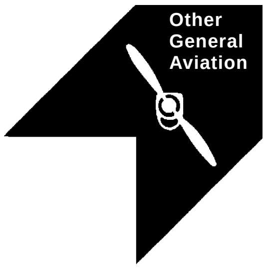
The intended course heading was 110 degrees. The accident site was located eight miles from the airport on a heading of 130 degrees. The weather was reported 500 feet (152 meters) overcast, visibility eight miles (13 kilometers). The pilot, who survived the crash and post-impact fire with serious injuries, told investigators he was attempting to open his flight plan when the aircraft began impacting tall trees. Four passengers were killed and a fifth was seriously injured.

Fuel Exhaustion Shortens Final Approach

Cessna 310. Aircraft destroyed. One serious and three minor injuries.

The Cessna was on final approach when an engine stopped because of fuel exhaustion. A few moments later, the second engine stopped.

The pilot executed an emergency landing about 10,499 feet (3,202) meters before the runway threshold. The pilot was seriously injured. The three passengers received minor injuries.



Airspeed Lost on Final

Beech 55 Baron. Substantial damage. No injuries.

The pilot of the twin-engine Baron was attempting to land on a short field with a line of trees about 131 feet (40 meters) from the runway threshold. The runway was about 2,625 feet (800 meters) long.

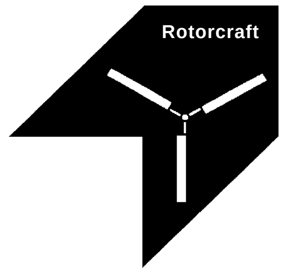
Because of the runway length, the pilot flew at reduced speed for a short-field landing. At the tree line, the aircraft stalled and struck the ground. The pilot and four passengers escaped without injuries. An inquiry determined that the pilot had exercised poor judgment and airmanship during the approach to an uncertified landing field.

Training Flight Ends Abruptly

Cessna 152. Aircraft destroyed. Two serious injuries.

The student pilot was being instructed in pattern flying and touch-and-go landings. At about 30 feet (9 meters) above the runway during the fourth approach, the aircraft yawed to the left as it flared for landing.

The instructor immediately called “I have control,” and applied right rudder and power while attempting to push the control column forward. She was unable to move the control column and realized that the student was still gripping it. Before the instructor could correct the situation, the aircraft stalled and impacted the runway in a nose down attitude. There was no fire, and the injured instructor was able to help the more seriously injured student evacuate the aircraft.



Mountain Crash Blamed on Poor Planning

Aerospatiale SA 365 Dauphin. Aircraft destroyed. Eight fatalities.

The helicopter with six passengers on board departed in visual meteorological conditions, flew into clouds and collided with a mountain about five miles (eight kilometers) from the airport after four minutes of flight.

The aircraft was destroyed during the post-impact fire. An investigation determined the pilot had selected the wrong departure sector and had planned the flight poorly.

Cable Failure Threatens Tail Rotor Control

Sikorsky S-76. Minor damage. No injuries.

The Sikorsky was in cruise flight when the pilot observed a loss of left anti-torque control.

Despite the partial loss of tail rotor control, the pilot was able to continue to an airport where a running landing was executed. A subsequent inspection found that a section of the tail rotor control cable had failed near where it contacts a pulley. There were no injuries. ♦