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MARCH 1994

FLIGHT SAFETY DIGEST

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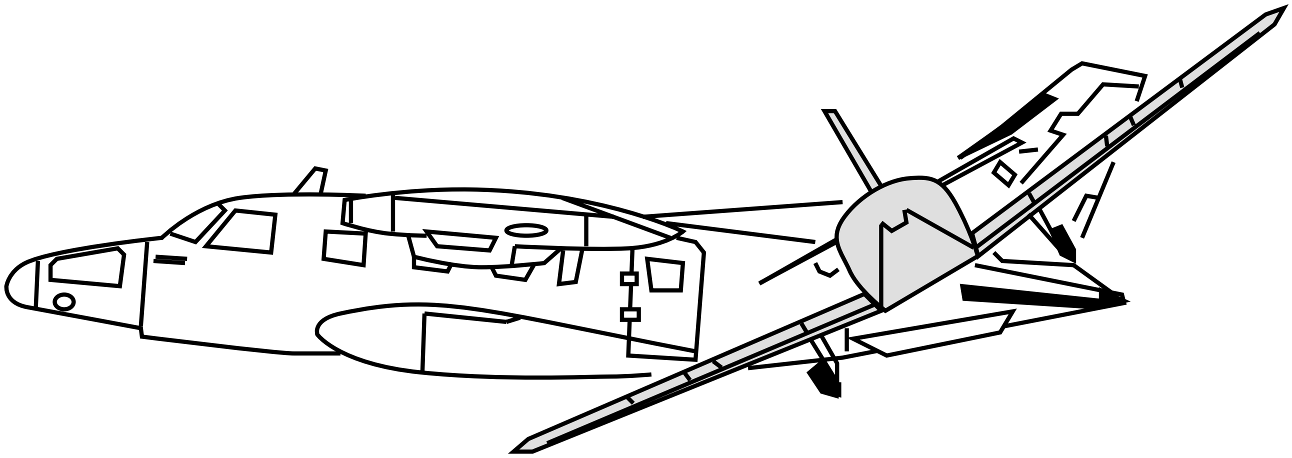

FLIGHT SAFETY FOUNDATION

For Everyone Concerned With the Safety of Flight

Flight Safety Digest

Vol. 13 No. 3 March 1994

Flight Safety Foundation is an international membership organization dedicated to improving aviation safety. Nonprofit and independent, the Foundation was launched in 1945 in response to the aviation industry's need for a neutral clearinghouse to disseminate objective safety information, and for a credible and knowledgeable body that would identify threats to safety, analyze the problems and recommend practical solutions to them. Since its beginning, the Foundation has acted in the public interest to produce a positive influence on aviation safety. Today, the Foundation provides leadership to nearly 600 member organizations in 75 countries.

Limitations of See-and-Avoid Concept Cited in Fatal Midair Collision

The fatal midair collision of a Mitsubishi MU-2 and a Piper Saratoga near Indianapolis, Indiana, U.S., prompted the U.S. National Transportation Safety Board to reiterate the need for additional safeguards in situations in which the see-and-avoid concept is particularly vulnerable.

by
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The concept of operating under visual flight rules (VFR) was originally referred to as "see and be seen." Student pilots were drilled on the extreme importance of keeping their heads on "swivels" to scan as wide a range of the airspace as possible. A pilot rarely forgets this fundamental practice.

As more airplanes took to the skies and the number of actual and near midair collisions increased, "see and be seen" was replaced by "see and avoid." From a safety standpoint, it was no longer satisfactory just to be seen. Once a pilot saw conflicting traffic, the pilot also had to take steps to avoid the traffic. U.S. Federal Aviation Regulations (FARs), 14 CFR Part 91, Subpart B — Flight Rules, Section 91.113 places the responsibility to see and avoid other aircraft squarely on the pilot and states:

"When weather conditions permit, regardless of whether an operation is conducted under instrument flight rules (IFR) or VFR, vigilance shall be maintained by each person operating an aircraft so as to see and avoid other aircraft. When a rule of this section gives another aircraft the right-of-way, the pilot shall give way to that aircraft and may not pass over, under, or ahead of it unless well clear."

See and avoid. It sounds simple. See and avoid works well in most instances. But when the concept does not work, it is usually a case of "don't see, can't avoid." Such a case was the midair collision between a Mitsubishi MU-2B-60 and a Piper Saratoga PA-32-301 that occurred near the Greenwood Municipal Airport, Greenwood, Indiana, U.S., on Sept. 11, 1992. The MU-2 pilot and four passengers and the Piper Saratoga pilot were killed. Two people on board the Piper were seriously injured. Weather observations at Indianapolis International Airport showed 4,500 feet (1,372 meters) scattered, 25,000 feet (7,625 meters) scattered, visibility 15 miles (24.1 kilometers).

The U.S. National Transportation Safety Board (NTSB) determined that "the probable cause of the accident was the inherent limitations of the see-and-avoid concept of the separation of aircraft operating under VFR that precluded the pilots from recognizing a collision hazard and taking actions to avoid the collision. Contributing to the cause of the accident was the failure of the MU-2 pilot to use all of the air traffic control services available to him by not activating his IFR flight plan before takeoff. Also contributing to the cause of the accident was the failure of both pilots to follow recommended traffic pattern procedures as contained in the U.S.

Federal Aviation Administration (FAA) *Airman's Information Manual (AIM)* for airport arrivals and departures."

The report said that the major safety issues related to the accident were "the continuing problem of deficiencies in the see-and-avoid concept, as a primary means of collision avoidance, and the failure of pilots to fully utilize the air traffic control system … "

The NTSB said its investigation determined that the Saratoga would have "appeared briefly in the lower left corner of the MU-2's windshield at least 20 seconds before impact" and that the MU-2 would have "appeared in the right front windshield of the Saratoga 25 seconds before the accident." It added that the sun "would not have been in the normal field of vision" of either pilot.

Based on information the NTSB obtained from both survivors on the PA-32, the pilot yelled a warning and turned the airplane left before the collision.

"As a result of the collision, the [PA-32's] pilot-in-command was incapacitated, and the pilot-passenger assumed control of the PA-32 and made an emergency landing," the report said.

Autopsies determined that "the pilot and the passengers of the MU-2 died of multiple traumatic injuries sustained at ground impact following the collision," the report said. "The autopsy of the pilot of the PA-32 revealed neither what incapacitated him following the collision nor why he did not exit the burning airplane following the ground impact sequence." The PA-32 pilot died of smoke inhalation and burns, the report said.

The report said, "The passenger-pilot in the right front seat and the passenger in the rear cabin of the PA-32 survived the collision and exited the airplane after it came to rest in the back yard of a house." It added, "Although the cockpit and cabin of the MU-2 were not compromised during the collision, the airplane was uncontrollable."

Greenwood Municipal Airport is an uncontrolled (no control tower) airport approximately 12 miles (19.3 kilometers) southeast of Indianapolis International Airport. It has one asphalt runway 3,462 feet (1,056 meters) long, with runway headings of 180 and 360 degrees. It reported 42,400 aircraft operations (7,208 air taxi, 24,168 general aviation locals, 10,600 general aviation itinerants and 424 military) for the year ending June 1992. Like many other airports without a control tower, Greenwood is equipped with one type of common traffic advisory frequency (CTAF), known as UNICOM. The report said, "The UNICOM is explained in the AIM as a 'nongovernmental air-ground radio communication station which may provide airport information at public use airports where no tower or Flight Service Station (FSS) exists. On pilot request, UNICOM stations may provide pilots with weather information, wind direction, the recommended runway or other necessary information.'" UNICOM also affords pilots a means of communicating their intentions (airport position, taxi, takeoff, landing, traffic pattern position, etc.) to other aircraft and pilots using or in the vicinity of the airport.

The report said that the major safety issues related to the accident were "the continuing problem of deficiencies in the see-and-avoid concept, as a primary means of collision avoidance, and the failure of pilots to fully utilize the air traffic control system … "

The report said that when the airport does not have a control tower, pilots are required to comply with FARs, Part 91.127, "Operating on or in the Vicinity of an Airport," which states in part that:

"(a) *General*. Unless otherwise required by Part 93 of this chapter, each person operating an aircraft shall comply with the requirements of this section and, if applicable, of Part 91.129.

"(b) Each person operating an aircraft to or from an airport without an operating control tower shall —

"(1) In the case of an airplane approaching to land, make all turns of that airplane to the left …

"(3) In the case of an aircraft departing the airport, comply with any traffic patterns established for that airport in Part 93."

The report said that Greenwood does not have a traffic pattern established under FARs Part 93 ("Special Air Rules and Airport Traffic Patterns"), and that Part 91.127 does not include a traffic pattern altitude or specified departure procedure. "Like most uncontrolled airports, there are no specified VFR arrival or departure procedures for the Greenwood Airport," the report said.

The NTSB interviewed four local pilots, including the MU-2 backup pilot, concerning arrival and departure procedures for the airport, and those pilots produced four procedures, "none of which resembled the procedures outlined in the AIM."

The NTSB noted that the operation of a flight under IFR, but in visual meteorological conditions (VMC), does not relieve a pilot of the responsibility to see and avoid other aircraft. The receipt of traffic advisories also does not relieve participating VFR pilots of their responsibilities to see and avoid other traffic.

The four pilots interviewed by the NTSB said that a left-hand pattern was used at Greenwood. Nevertheless, there was disagreement about the airport's pattern altitude. Of the four pilots interviewed, "two of them chose 1,000 feet [305 meters], one 800 feet [244 meters], and the other 2,000 feet [610 meters]," the NTSB said.

[FAA Advisory Circular (AC) 90-66 recommends a traffic pattern 1,000 feet above ground level. The airport directory published by the U.S. National Oceanic and Atmospheric Administration (NOAA) lists Greenwood's pattern altitude as 800 feet.]

The PA-32 was leased to a flight school. The instrument-rated private pilot, 54, had logged a total of 1,200 flight hours, 150 of which were in the PA-32. The NTSB noted that he had flown 10 or 12 times a year. The aircraft does not require a second pilot, but an instrument-rated private pilot certificated for single-engine airplanes was in the right seat with access to the flight controls. The flying pilot's daughter was a passenger in the Piper.

Earlier in the day, the PA-32 left Eagle Airport (7 miles [11.3 kilometers] west of Indianapolis) for a landing at Greenwood Municipal Airport with an en route stop at Terry Airport (14 miles [22.5 kilometers] northwest of Indianapolis). The purpose of the flight was to talk to a mechanic at Terry Airport, to take aerial photos of the pilot's new office building (about one mile [1.6 kilometers] east of where the midair collision took place) and to provide flying practice for both pilots.

The pilot's daughter told the NTSB in a post-accident interview that "we were getting ready to film the office" just before the collision. The report said that one passenger was using a video camera and the other was using a still camera to photograph the building site. "The cameras were destroyed in the impact and post-crash fire," the report said.

The Saratoga pilot departed under VFR and had not filed a flight plan. At 1445:17, the PA-32 pilot advised the Indianapolis departure west/satellite controller that he had departed Terry Airport and would land at Greenwood. The direct route of flight from Terry to Greenwood put the airplane inside the Airport Radar Service Area (ARSA), which required the pilot to be in contact with air traffic control. The controller issued a discrete transponder code, radar-identified the airplane and instructed the pilot to climb and maintain 2,500 feet (762.5 meters). At 1451:47, the controller transferred control of the airplane to the east/satellite controller.

At 1451:58, the pilot transmitted, "Indy Approach eight two four one nine with you at two point five [2,500 feet (762.5 meters)] going to Greenwood [Airport]," to which the controller replied, "Cherokee four one nine roger maintain uh VFR I'll have a course for you in about five miles [8 kilometers]."

"Approximately two minutes later, the controller advised, 'Cherokee four one nine you may proceed on course to Greenwood advise the airport in sight.' This transmission was acknowledged by the pilot. At 1455:51, the controller stated, 'Cessna Four er Cherokee four one nine, the airport twelve to one o'clock there and three miles [4.8 kilometers].' The pilot replied, 'Ah four one nine we have the airport.' At 1455:57, the controller said, 'November four one nine roger surface winds at Indianapolis [Airport] zero two zero at eight, squawk VFR radar service terminated frequency change approved.' At 1456:03, the pilot replied, 'Ah four one nine, thank you very much.' There were no further communications with the pilot of the PA-32," the report said.

The controller told NTSB investigators that, when the pilot reported Greenwood Airport in sight, he saw no radar targets in the vicinity of the PA-32 and that radar service was terminated. He stated that he saw the transponder change from "0301" to "1200" (which now deactivated the conflict alert system) and that he no longer monitored the flight path of the airplane.

The NTSB noted that the radar controller terminated radar services when the PA-32 was about three miles from Greenwood. The FAA *Air Traffic Control Handbook* 7110.65G, Air Traffic Control (ATC), paragraph 7-107 advises controllers to "terminate ARSA service to aircraft landing at other than the primary airport at a sufficient distance from the airport to allow the pilot to change to the appropriate frequency for traffic and airport information." The timing of the change in communications was inconsistent with the AIM, which recommends that pilots initiate UNICOM communications approximately 10 miles (16 kilometers) from the airport. The NTSB considered these factors but believed that the late communications changeover did not relieve the pilots of each airplane of their responsibility to see and avoid each other. Moreover, the NTSB said, the PA-32 pilot should have used both of his aircraft's two very high frequency (VHF) transceivers — one for UNICOM, and

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one for ATC — when he was approaching Greenwood.

The MU-2 was certificated for single-pilot operations. The pilot, 68, had logged a total of 19,000 hours, of which about 9,000 hours were in the MU-2. The pilot held a commercial pilot certificate with an instrument rating and he was reported to be in good health.

The MU-2 departed from Huntingburg (Indiana) Airport en route to Greenwood Airport, and arrived at Greenwood Airport at about 1400 hours. At about 1430, four passengers arrived. The pilot filed two flight plans with the Terre Haute Flight Service Station: one for the flight from Huntingburg to Greenwood and one for the flight from Greenwood to Columbus, Ohio, with a departure time of 1400.

At 1456:41 (about 44 seconds after the PA-32 was released by the controller), the MU-2 pilot contacted the controller, "Indy Approach Mitsubishi seven four Foxtrot Bravo over." At this time, the controller responded, "Mitsubishi seven four Fox Bravo Indy," but was aware of neither the location of the airplane nor the pilot's intentions. The MU-2 pilot said, "Roger, I'm off the ground Greenwood standing by for clearance to Columbus." At 1456:51, the controller said, "Seven four Fox Bravo roger squawk four five six four and ident maintain uh at or below five thousand." Because the controller knew that the pilot was requesting a prefiled IFR clearance, he had to look away from the radar screen to locate the proper flight progress strip, the report said. "He then had to confirm the information on the strip and issue the correct discrete code to establish contact. The controller stated that he did not see a radar target (MU-2) depart from Greenwood; he therefore had to establish radar identification. It was during this process that the collision occurred. Radar contact had not yet been established; therefore, traffic could not have been issued."

The MU-2 pilot's departure procedure from Runway 36 at Greenwood did not follow recommendations in the *AIM*. He began a right turn immediately after liftoff. According to his backup pilot, the pilot had developed his own arrival and departure procedures at Greenwood. Departing on Runway 36, he would climb straight out to 500 feet or 700 feet (152.5 meters or 213.5 meters) and then initiate a right turn, thus avoiding inadvertent penetration into the Indianapolis ARSA. On the accident flight, this also placed the airplane on a heading toward the destination of Columbus. As a consideration to his passenger's comfort, he usually retracted the flaps up in a gradual right turn as the MU-2 accelerated in the climb. It is possible, the NTSB said, that the MU-2 pilot expedited his departure to obtain his IFR clearance while airborne before he had to refile his flight plan.

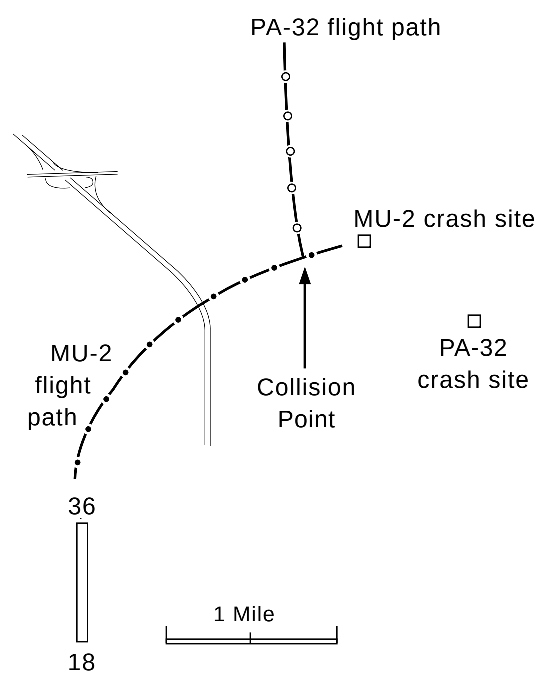
The NTSB noted that, in the approximately 60 seconds from liftoff to the collision, the MU-2 pilot would normally have had to perform many duties, including performing the after-takeoff checklist, making radio calls to UNICOM and to departure control, flying the airplane, raising the landing gear, raising the flaps, adjusting the transponder and adjusting the engine controls.

"The MU-2 was departing the Greenwood Airport traffic pattern, and the PA-32 had announced landing intentions at Greenwood Airport immediately prior to the collision," the NTSB report said.

Collision geometry was determined by the NTSB using radar data (Figure 1). That geometry showed a closure rate of 234 knots between the two airplanes on a 038-218 degree magnetic bearing. For the MU-2, the relative bearing of the other airplane was 30 degrees to the left of straight ahead, and for the PA-32, the other airplane was 45 degrees to the right. The collision angle was 105 degrees just before the collision.

The collision angle at impact was very close to 90 degrees because the PA-32 made a steep bank to the left (about 45 degrees) just before the collision. This action was supported by evidence that there was no contact between the left wings of either airplane. Examination revealed that there was contact between the belly of the PA-32 and the leading edge deicing boot of the MU-2's

Flight Paths of the Accident Aircraft

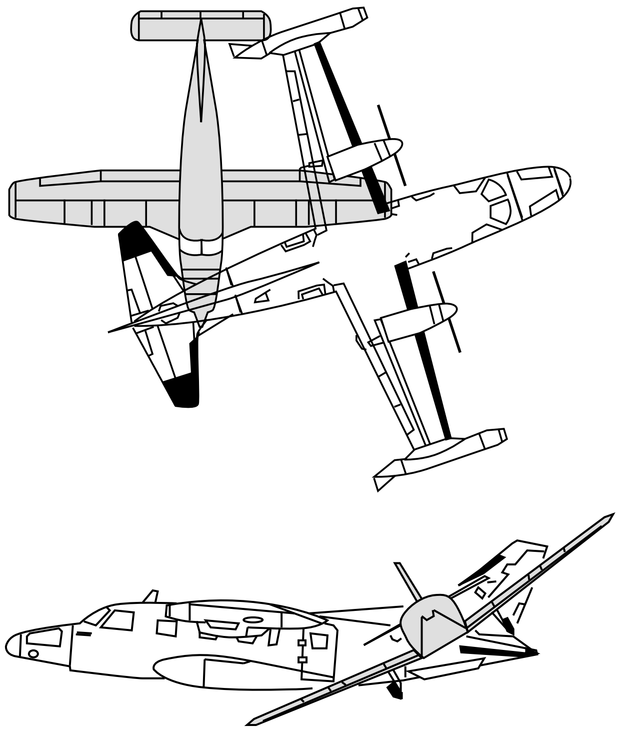


Source: U.S. National Transportation Safety Board

Figure 1

left horizontal stabilizer. The nose landing gear of the PA-32 made contact with the elevator torque tube of the MU-2 (Figure 2).

Horizontal View and Planview of the Airplanes at Impact



Source: U.S. National Transportation Safety Board

Figure 2

The collision occurred as the MU-2 climbed through 2,100 feet (640.5 meters) on a course of 070 degrees at a ground speed of 168 knots, climbing at approximately 1,200 feet (366 meters) per minute. The collision damage on the MU-2 was confined to the empennage. Most of the structure forward of the empennage was consumed by a post-impact fire. Structure that was not destroyed showed no evidence of collision damage.

Radar data showed the PA-32 was on a track of 174 degrees, at a ground speed of 127 knots, with a rate of descent of 390 feet (118.9 meters) per minute. Collision damage to this airplane involved the propeller, propeller spinner, engine cowling and belly skin.

The NTSB said that it was probable that the MU-2 appeared suddenly and that the PA-32 pilot made a reactive turn to the left just before impact. The absence of impact marks or damage on those portions of the MU-2 forward of the empennage indicated that the PA-32 passed behind the left wing of the MU-2 as the PA-32 climbed and it contacted the MU-2's empennage. The first contact between the airplanes was one propeller blade of the PA-32, which contacted the tip of the left horizontal stabilizer and the elevator of the MU-2 and separated the balance weight from the elevator.

"After the collision, the MU-2 continued on a northeasterly heading and crashed inverted in the back yard of a house," the report said. "The PA-32 continued a gradual descent in an easterly direction for almost one mile [1.6 kilometers] before it struck and caused minor damage to the roofs of two houses.

"Debris from the two airplanes was scattered over a rectangular residential area approximately one-half by one mile in southern Marion County, Indiana," the report said. "Three houses … were damaged when the fuselage of the MU-2 came to rest in their back yards and caught fire. The PA-32 struck the roofs of two houses causing minor damage. The airplane touched down in the back yard of one of those houses, and its left wing struck and destroyed a children's playhouse. The impact separated the outboard four feet [1.2 meters] of the left wing from the airplane. The airplane then slid through the fence at the rear of the yard and into the back yard of another house, coming to rest next to the rear of the house. A postcrash fire consumed the airplane and a major portion of the house. The fire caused minor damage to an adjoining house."

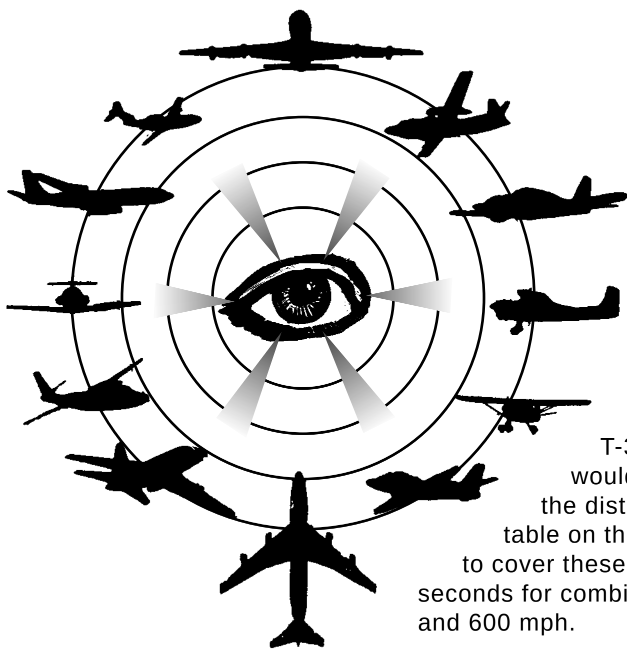
There are many physical, physiological and psychological constraints that have been shown to reduce the human ability to exercise the required degree of vigilance. These limitations include target characteristics, size, color, task variables (such as workload and time at task), observer characteristics (such as age and fatigue) and environmental parameters (such as weather, clouds and glare).

Reaction time after visual acquisition of a target is also a factor in avoiding a collision. FAA AC 90-48C provides data derived from the military on the time necessary for a pilot to recognize an inflight target and to execute an evasive maneuver. AC 90-48C indicates that the total time required to see an object, to perceive the collision threat and to begin to take evasive action is 12.5 seconds. About 6.4 seconds of the 12.5 seconds are required to complete the evasive maneuver after the collision threat is perceived (Table 1, page 6).

The NTSB report described the concept known as "diffusion of responsibility," a tendency on the part of pilots to relax their vigilance in some circumstances. A U.S. National Aeronautics and Space Administration (NASA) study on midair collisions indicated that an inappropriate sense of shared responsibility may occur when an airplane is operating under ATC radar control. A pilot thus relegates a portion of his vigilance responsibility for seeing and avoiding to the controller. The NASA study concluded, "If Aviation Safety Reporting System (ASRS) reports are representative, many pilots under radar control believe that they will be advised of traffic that represents a potential conflict and behave accordingly. They tend to relax their visual scan for other traffic until warned of its presence."

This diffusion of responsibility is supported by the *AIM*. Section 4-81, "Clearance," states: "An ATC clearance means an authorization by ATC, for the purpose of preventing collision between known aircraft, for an

Table 1
Recognition and Reaction Times

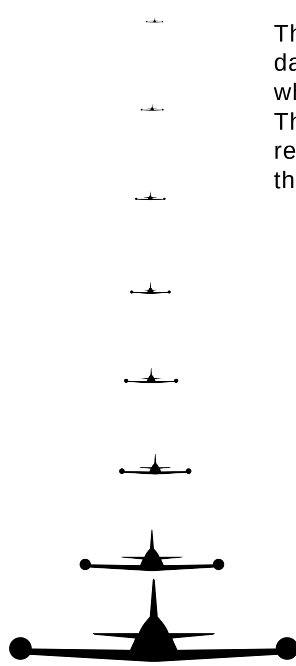


Move back 12 feet from this illustration. From that position, the silhouettes represent a T-33 jet aircraft as it would appear to you from the distances indicated in the table on the left. The time required to cover theses distances is given in seconds for combined speeds of 360 mph and 600 mph.

The blocks on the lower left mark the danger areas for the speeds quoted, when aircraft are on a collision course. This danger area is based on the recognition and reaction times shown in the table on the lower right.

Distance - Speed - Time

MPH	600	360
	Seconds	
10 miles	60	100
6 miles	36	60
5 miles	30	50
4 miles	24	40
3 miles	18	30
2 miles	12	20
1 mile	6	10
1/2 mile	3	5



see object	0.1
recognize aircraft	1.0
become aware of collision course	5.0
decision to turn left or right	4.0
muscular reaction	0.4
aircraft lag time	2.0
total	12.5

Source: U.S. Federal Aviation Administration (FAA) aircraft to proceed under specified conditions within controlled airspace."

The *AIM*'s Pilot/Controller Glossary defines air traffic clearance as "an authorization by air traffic control, for the purpose of preventing collision between known aircraft."

Section 5-71 states, "The air traffic controller is responsible to give first priority to the separation of aircraft." It adds: "The responsibilities of the pilot and the controller intentionally overlap in many areas, providing a degree of redundancy. Should one or the other fail in any manner, this overlapping responsibility is expected to compensate, in many cases, for failures that may affect safety."

But the NTSB said that none of these statements specifies whether the aircraft are being operated under VFR or IFR. The *AIM* and *Air Traffic Control Handbook* 7110.65G prioritize controllers' separation responsibilities. Their primary responsibility is to separate IFR aircraft; their secondary responsibility is to separate IFR aircraft from VFR aircraft and, finally, on a time available basis, to separate VFR aircraft from VFR aircraft.

The NTSB conducted a cockpit visibility study to determine the probable locations and sizes of the PA-32 and the MU-2 as they would have appeared in the windscreens of each airplane.

"To accomplish this, the viewing angle for both airplanes was calculated and plotted for their respective pilots' fields of vision," the report said. "The calculations were based on flightpath, attitude time histories, and length and wingspan of the airplanes."

The report added: "A binocular camera was used to photograph cockpits of two similar airplanes. The camera uses a continuous strip of film to produce a panoramic view of the window configuration. Horizontal and vertical grid lines in 5-degree increments are superimposed on the photographs. The resulting photographs show the outline of the cockpit windows as seen by a pilot rotating his head from side to side. Monocular obstructions within the window, such as windshield or door posts, are also defined by the photographs.

"The position time histories of the airplanes were superimposed on the photographs of the full field of vision for the pilots of both airplanes and the copilot's seat of the PA-32."

The NTSB reviewed the 12.5-second time frame prior to the collision when the time was 1456:41.

"Therefore, the figures were constructed to display the viewing-angle time histories from 1456:28 to 1456:41 (13 seconds) for the PA-32 and from 1456:33 to 1456:41 (eight seconds) for the MU-2," the NTSB said.

The cockpit visibility study revealed that "the PA-32 would have appeared below the horizontal zero eye reference plane, in the lower left corner of the MU-2's windshield, clear of all obstructions from 1456:33 (20 seconds before the collision) to 1456:37. In the following four seconds, it could have appeared in the monocular field of view created by the left windshield post. After that, the 12.5-second window of opportunity to see and avoid was not available."

> ***"The cockpit visibility study showed that the PA-32 may have been visible to the pilot of the MU-2 for eight seconds before the 12.5 seconds theoretically needed to identify and avoid a collision," the report said.***

The report noted: "The MU-2, as viewed by the pilot of the PA-32, was in the right windshield, immediately right of the center windshield post from 1456:28 (25 seconds before the collision) to 1456:41 (12 seconds before the collision). The MU-2's position in the windshield would have moved from just below the horizontal zero eye reference plane to just above the instrument panel during this time. The apparent downward movement of the MU-2 in the PA-32's field of vision would have been caused by the airplanes' converging flight paths.

"The MU-2, as viewed by the passenger-pilot of the PA-32, would have appeared in the monocular field of vision created by the right windshield post from 1456:28 (25 seconds before the collision) to 1456:41 (12 seconds before the collision)."

"The cockpit visibility study showed that the PA-32 may have been visible to the pilot of the MU-2 for eight seconds before the 12.5 seconds theoretically needed to identify and avoid a collision," the report said. "For four of the eight seconds, the PA-32 could have appeared unobstructed in the lower left corner of the MU-2's left windshield. The left windshield post could have limited the MU-2 pilot's view to a monocular view of the PA-32 for the last four seconds. This assumes that the pilot was sitting stationary at the DERP [design eye reference point]. [Each aircraft cockpit has a DERP position that allows maximum cockpit visibility.] However, if the pilot had moved his head forward to adjust his radios or flight controls, or to scan outside, he might have been able to see the PA-32 with both eyes. Any movement from the DERP, whether it is from the pilot moving in the cockpit or the pitch or roll movements of the airplane, would displace the targets accordingly."

It added, "The study showed that the MU-2, as viewed by the PA-32 pilot, would have been positioned in the right windshield of the PA-32, visible for 13 seconds before the 12.5 seconds theoretically needed to identify and avoid a collision, just to the right of the monocular field of vision created by the center windshield post. The pilot-passenger in the right front seat could have had a monocular field of vision of the MU-2 created by the right windshield post during the same period of time."

The NTSB said that it believed "that both pilots, along with the qualified pilot-passenger in the right seat of the PA-32, should have employed scanning techniques to detect potential collision threats. However, it is apparent that the scanning techniques employed did not result in timely identification of the collision threat. Both pilots had an unobstructed view of the other for a short time — four to eight seconds for the MU-2 pilot and 13 seconds for the PA-32 pilot — before the 12.5 seconds necessary to recognize the threat and take evasive action. Cockpit visibility, as indicated by the cockpit photographs, did not effectively explain why the pilots of each airplane did not see the other airplane in time to take evasive action.

"The ability of pilots to detect other airplanes depends largely on the conspicuity of the other airplane, as determined by the airplane's motion, size, color and brightness, compared to the background against which it is observed. Sadly, some of the most important factors for good conspicuity are missing in midair collision situations. When a pilot is on a direct collision course with another airplane (with both airplanes going straight), the other airplane appears to be stationary, fixed in the pilot's windscreen, and it does not move. It grows slowly, becoming conspicuously large only in the final brief period before collision when effective evasive action may not be possible.

"These problems are reflected in the visibility study, which shows that even when the MU-2 was engaged in a turn, its motion in the windscreen of the PA-32 was relatively small (as was the PA-32's motion in the MU-2's windscreen). The MU-2 was painted predominantly white and the PA-32 predominantly gray. These colors, which are typical of the general aviation fleet, would not be particularly conspicuous to another pilot against typical backgrounds during the brief period that the airplanes appear large enough for color to be an important factor.

"Both airplanes were equipped with strobe lights, which could be a useful factor for conspicuity even during the day, since they can impart of sense of motion to a midair target that would otherwise appear stationary. Because of the damage, it was not possible to determine whether the strobe lights on the MU-2 or the PA-32 were in use at the time of impact."

The NTSB recommended that flight instructors should emphasize the necessity for scanning techniques during flight training and biennial flight reviews.

"The Safety Board believes that the circumstances of this accident emphasize the limitation of the see-and-avoid concept of separation of aircraft operating under visual flight rules, especially in congested areas near airports," the report said. "In this case, the pilots had extremely limited time to detect a threat and to take evasive actions. The existing regulations permit such operations, which have a small margin of safety for avoiding midair collisions; however, there are many recommended practices that would have provided a greater margin of safety."

The report added: "The FAA has placed emphasis on better pilot education concerning air space and has taken action against pilots who violate air space. However, there is a lack of emphasis on proper scanning techniques."

The NTSB recommended that flight instructors should emphasize the necessity for scanning techniques during flight training and biennial flight reviews. When simulators are used for training and checks, there may be a tendency to overlook and forget scanning techniques. Therefore, emphasis should be added to the pre-takeoff, climb, descent and landing checklists.

In a report on the midair collision of a McDonnell Douglas DC-9 and a PA-28 over Cerritos, California, on Aug. 31, 1986, the NTSB concluded that a contributing factor in the accident was the "limitations of the see-and-avoid concept to measure traffic separation under the conditions of conflict."

In another report on a midair collision of an U.S. Army U-21A airplane and a PA-31 near Independence, Missouri, on Jan. 20, 1987, the NTSB determined that "deficiencies of the see-and-avoid concept as a primary means of collision avoidance" was one of the three probable causes of the accident.

"In both reports, the Safety Board's conclusions were based on a body of laboratory and inflight studies that indicated the great difficulty of reliably seeing other airplanes when there is no warning of an impending collision and when the opposing airplane is as small as a PA-32 or an MU-2," the NTSB report said.

Following the 1987 report, the NTSB recommended that the FAA "expedite the development, certification and production of various low-cost proximity warning and conflict detection systems for use aboard general aviation aircraft."

The NTSB MU-2/PA-32 accident report concluded: "The current accident again underscores the need for low-cost proximity warning and conflict detection systems for use aboard general aviation aircraft. It is now nearly five years since the Safety Board's recommendation was issued, and the FAA has yet to meet the intent of the recommendation."

In addition, the NTSB "urged the FAA to take expedited action to add VFR conflict alert (Mode-C intruder) logic to the automated radar terminal system (ARTS) as an interim measure until implementation of the advanced automation system."

The report said that the FAA responded in 1992 that it was continuing efforts to install Mode-C intruder logic and anticipated that all ARTS sites would have such logic operational by late 1995.

"The Safety Board believes that the FAA is accepting too great a risk by not agressively pursuing the development and implementation of this program," the report said. "While the Safety Board is unable to determine with any certainty that the Mode-C intruder program would have prevented this accident, it is conceivable that if such a program had been in operation, it could have generated an alert that would have directed the controller's attention to the radar scope. At that time, if the controller recognized the potential collision threat, an alert could have been issued that might have averted the collision."

The NTSB made a number of recommendations to the FAA that involve developing and publishing procedures in various FAA publications.

The NTSB also recommended that "pilots departing in VMC, with intentions of obtaining IFR clearances, obtain ATC clearances prior to becoming airborne when two-way radio communication with ATC is available on the ground."

When operating at uncontrolled airports, pilots should be aware of the departure and arrival procedures for those airports. The NTSB suggested that "consideration should be given to establishing entry and departure corridors for high performance airplanes that are separate from low performance airplanes at uncontrolled airports." Use and stay tuned to the UNICOM frequency for airport traffic advisories, the NTSB recommended, and question any transmission if a problem is anticipated.

When operating at tower-controlled airports, maintain two-way radio contact with the tower while within the airport traffic area.

If faced with a heavy cockpit workload, recognize the requirement for vigilance outside the cockpit, particularly in and around the airport environment. A head down in the cockpit will produce the "don't see, can't avoid" syndrome. When there is a two-pilot aircrew aboard the airplane, one pilot should always be watching outside for conflicting traffic during takeoff, climb, descent and approach. During climb and descent in VMC, consider making gentle left and right banks at a frequency that permits continuous visual scanning of the airspace around the aircraft. Compensate for blind spots because of aircraft design and flight attitude by moving the head or maneuvering the aircraft.

Pilots should take seriously the findings of AC 90-48C regarding the total time required to see an object, to perceive the collision threat and to begin to take evasive action — 12.5 seconds.♦

Editorial note: The preceding article was adapted from the U.S. National Transportation Safety Board's report *Midair Collision, Mitsubishi MU-2B-60, N74FB, and Piper PA-32-301, N82419, Greenwood Municipal Airport, Greenwood, Indiana, September 11, 1992.* Report No. NTSB/AAR-93/05, adopted in September 1993. The 78-page report includes illustrations and appendices.

About the Author

John A. Pope established John A. Pope & Associates, an aviation consulting firm located in Arlington, Virginia, U.S., after retiring in 1984 as vice president of the U.S. National Business Aircraft Association. He specializes in developing comprehensive operations manuals for corporate flight departments. Pope is a former Washington editor for "Aviation International News." He served as a command pilot in the U.S. Air Force and the Air National Guard. He retired as a colonel from the U.S. Air Force Reserve after 33 years of service.

1993 Statistics Show Increase in U.S. Air Carrier Accidents, No Passenger Fatalities

Data compiled by the U.S. National Transportation Safety Board also show that charter airlines experienced their fourth consecutive year without a fatal accident.

by
Editorial Staff

Recently released U.S. National Transportation Safety Board (NTSB) statistics indicated that while the number of accidents experienced by U.S. scheduled airlines increased in 1993, there were no passenger fatalities for that year.

According to the NTSB's preliminary aviation accident data, the fatal accident rate for the scheduled airlines was the lowest in 13 years. At the same time, air taxis and general aviation registered their lowest number of fatalities on record.

The NTSB said that 800 people were killed in 2,158 civil aviation accidents either in the U.S. or involving U.S.-registered aircraft in 1993, down from 998 fatalities in 2,221 accidents in 1992.

The major scheduled airlines experienced only one fatal accident, and that involved a ground crew member who was struck by a propeller. The fatal accident rate of 0.013 fatal accidents per 100,000 departures was the lowest since 1980, when there were no fatal accidents among scheduled airlines.

The NTSB said that during the same period the airlines experienced more accidents in 1993 (23) than the previous year (16), resulting in a higher total accident rate per 100,000 departures, 0.297 vs. 0.207. For reporting purposes, NTSB regulations define an accident as an occurrence that results in substantial damage to an aircraft or serious injury to an occupant.

Charter airlines experienced their fourth consecutive year without a fatal accident, the NTSB said.

The fatal accident rate for commuter airlines dropped from 0.240 to 0.127 per 100,000 departures, but fatalities increased from 21 in 1992 to 24 in 1993. The total accident rate dropped from 0.756 to 0.509, the NTSB said.

On-demand air taxis registered their lowest number of fatalities in the NTSB's reporting history with 42. There were 70 fatalities in 1992. The total accident rate in 1993 dropped from 3.78 per 100,000 aircraft hours to 3.38, and the fatal accident rate from 1.19 to 0.90, the NTSB said

General aviation accidents registered historic lows in number of accidents (2,022), fatal accidents (385), and fatalities (715). While the fatal accident rate dropped in 1993 to 1.67 per 100,000 aircraft hours from 1.87 the previous year, the total accident rate per 100,000 aircraft hours rose from 8.71 to 8.79.

The NTSB said that aircraft flying in the U.S. logged approximately 39,993,000 hours in 1993, according to figures supplied by the U.S. Federal Aviation Administration.

Table 1
Accidents, Fatalities and Rates
Air Carriers and General Aviation — 1993 (Preliminary Data)

	Accidents		Fatalities		Aircraft Hours		Accident Rates Per 100,000 Aircraft Hours		Accident Rates Per 100,000 Departures	
	Total	Fatal	Total	Aboard	Flown	Departures	Total	Fatal	Total	Fatal
Air Carriers Operating Under Part 121										
Scheduled	23	1	1	0	11,900,000	7,732,000	0.193	0.008	0.297	0.013
Nonscheduled	0	0	0	0	624,000	312,000	0	0	0	0
Air Carriers Operating Under Part 135										
Scheduled	16	4	24	23	2,369,000	3,144,000	0.675	0.169	0.509	0.127
Nonscheduled	71	19	42	42	2,100,000	n/a	3.38	0.90	n/a	n/a
General Aviation+	2,022	385	715	712	23,000,000	n/a	8.79	1.67	n/a	n/a
U.S. Civil Aviation	2,131*	409	782	777						
Foreign-registered Aircraft Accidents in the U.S.	14	5	9	9						
Unregistered Aircraft Accidents in the U.S.	13	8	9	9						

+ Accidents involving U.S.-registered civil aircraft not operating under U.S. Federal Aviation Regulations Part 121 or Part 135.
* Accidents and fatalities in the categories do not necessarily sum to the figures in U.S. Civil Aviation; differences are because of collisions involving aircraft in different categories.
n/a Data not available.

Source: U.S. National Transportation Safety Board Exposure data estimate source: U.S. Federal Aviation Administration (FAA).

Table 2
Accidents, Fatalities and Rates — U.S. Air Carriers Operating Under U.S. Federal Aviation Regulations (FARs) Part 121
All Scheduled and Nonscheduled Service (Airlines)* — 1982-1993

	Accidents		Fatalities		Aircraft	Aircraft Hours		Accident Rates@ Per Million Aircraft Miles		Accident Rates@ Per 100,000 Aircraft Hours		Accident Rates@ Per 100,000 Departures	
Year	Total	Fatal	Total	Aboard	Miles Flown#	Flown#	Departures#	Total	Fatal	Total	Fatal	Total	Fatal
1982	20	5	235	223	2,938,513,000	7,040,325	5,351,133	0.0065	0.0014	0.270	0.057	0.355	0.075
1983	24	4	15	14	3,069,318,000	7,298,799	5,444,374	0.0078	0.0013	0.329	0.055	0.441	0.073
1984	17	1	4	4	3,428,063,000	8,165,124	5,898,852	0.0050	0.0003	0.208	0.012	0.288	0.017
1985	22	7	526	525	3,631,017,000	8,709,894	6,306,759	0.0061	0.0019	0.253	0.080	0.349	0.111
1986	24	3	8	7	4,017,626,000	9,976,104	7,202,027	0.0057	0.0005	0.231	0.020	0.319	0.028
1987	36	5	232	230	4,360,521,000	10,645,192	7,601,373	0.0080	0.0009	0.329	0.038	0.460	0.053
1988	29	3	285	274	4,503,426,000	11,140,548	7,716,061	0.0062	0.0004	0.251	0.018	0.363	0.026
1989	28	11	278	276	4,605,083,000	11,274,543	7,645,494	0.0061	0.0024	0.248	0.098	0.366	0.144
1990	24	6	39	12	4,970,087,000	12,150,116	8,224,902	0.0048	0.0012	0.198	0.049	0.292	0.073
1991	26	4	62+	49	4,850,850,000	11,900,023	7,985,630	0.0054	0.0008	0.218	0.034	0.326	0.050
1992	18	4	33	31	5,087,723,000	12,495,667	8,080,791	0.0035	0.0008	0.144	0.032	0.223	0.050
1993P	23	1	1	0	5,147,000,000	12,524,000	8,044,000	0.0045	0.0002	0.184	0.008	0.286	0.012

P Preliminary data.
* Includes accidents involving deregulated all-cargo air carriers and commercial operators of large aircraft when those accidents occurred during U.S. Federal Aviation Regulations (FARs) Part 121 operations.
# Source of estimate: U.S. Federal Aviation Administration (FAA).
+ The fatality total includes the 12 persons killed aboard a Skywest commuter aircraft and the 22 persons killed aboard a USAir airliner when the two aircraft collided on a runway.
@ The following suicide/sabotage cases are included in “Accidents” and “Fatalities” but not in “Accident Rates”:

			Fatalities	
Date	Location	Operator	Total	Aboard
8/11/82	Honolulu, Hawaii	Pan American	1	1
4/02/86	Near Athens, Greece	Trans World	4	4
12/07/87	San Luis Obispo, California	Pacific Southwest	43	43
12/21/88	Lockerbie, Scotland	Pan American	270	259

Source: U.S. National Transportation Safety Board

Table 3
Accidents, Fatalities and Rates
U.S. Air Carriers Operating Under U.S. Federal Aviation Regulations (FARs) Part 121
All Scheduled Service (Airlines)* — 1982-1993

								Accident Rates@					
								Per Million		Per 100,000		Per 100,00	
	Accidents		Fatalities		Aircraft	Aircraft		Aircraft Miles		Aircraft Hours		Departures	
Year	Total	Fatal	Total	Aboard	Miles Flown#	Hours Flown#	Departures#	Total	Fatal	Total	Fatal	Total	Fatal
1982	16	4	234	222	2,806,885,000	6,697,770	5,162,346	0.0053	0.0011	0.224	0.045	0.291	0.058
1983	22	4	15	14	2,920,909,000	6,914,969	5,235,262	0.0075	0.0014	0.318	0.058	0.420	0.076
1984	13	1	4	4	3,258,910,000	7,736,037	5,666,076	0.0040	0.0003	0.168	0.013	0.229	0.018
1985	17	4	197	196	3,452,753,000	8,265,332	6,068,893	0.0049	0.0012	0.206	0.048	0.280	0.066
1986	21	2	5	4	3,829,129,000	9,495,158	6,928,103	0.0052	0.0003	0.211	0.11	0.289	0.014
1987	32	4	231	229	4,125,874,000	10,115,407	7,293,025	0.0075	0.0007	0.306	0.030	0.425	0.041
1988	28	3	285	274	4,260,785,000	10,521,052	7,347,575	0.0063	0.0005	0.257	0.019	0.367	0.027
1989	24	8	131	130	4,338,031,000	10,597,922	7,269,094	0.0055	0.0018	0.226	0.075	0.330	0.110
1990	22	6	39	12	4,712,159,000	11,524,726	7,931,256	0.0047	0.0013	0.191	0.052	0.277	0.076
1991	25	4	62+	49	4,583,718,000	11,253,868	7,675,489	0.0055	0.0009	0.222	0.036	0.326	0.052
1992	16	4	33	31	4,816,075,000	11,866,213	7,719,715	0.0033	0.0008	0.135	0.034	0.207	0.052
1993P	23	1	1	0	4,885,000,000	11,900,000	7,732,000	0.0047	0.0002	0.193	0.008	0.297	0.013

P Preliminary data.
* Includes accidents involving deregulated all-cargo air carriers and commercial operators of large aircraft when those accidents occurred during U.S. Federal Aviation Regulations (FARs) Part 121 operations.
\# Source of estimate: U.S. Federal Aviation Administration (FAA).
\+ The fatality total includes the 12 persons killed aboard a Skywest commuter aircraft and the 22 persons killed aboard a USAir airliner when the two aircraft collided on a runway.
@ The following suicide/sabotage cases are included in “Accidents” and “Fatalities” but not in “Accident Rates”:

			Fatalities	
Date	Location	Operator	Total	Aboard
8/11/82	Honolulu, Hawaii	Pan American	1	1
4/02/86	Near Athens, Greece	Trans World	4	4
12/07/87	San Luis Obispo, California	Pacific Southwest	43	43
12/21/88	Lockerbie, Scotland	Pan American	270	259

Source: U.S. National Transportation Safety Board

Table 4
Accidents, Fatalities and Rates
U.S. Air Carriers Operating Under U.S. Federal Aviation Regulations (FARs) Part 121
All Nonscheduled Service (Airlines)* — 1982-1993

								Accident Rates					
								Per Million		Per 100,000		Per 100,000	
	Accidents		Fatalities		Aircraft	Aircraft		Aircraft Miles		Aircraft Hours		Departures	
Year	Total	Fatal	Total	Aboard	Miles Flown#	Hours Flown#	Departures#	Total	Fatal	Total	Fatal	Total	Fatal
1982	4	1	1	1	131,628,000	342,555	188,787	0.0304	0.0076	1.168	0.292	2.119	0.530
1983	2	0	0	0	148,409,000	383,830	209,112	0.0135	0.0000	0.521	0.000	0.956	0.000
1984	4	0	0	0	169,153,000	429,087	232,776	0.0236	0.0000	0.932	0.000	1.718	0.000
1985	5	3	329	329	178,264,000	444,562	237,866	0.0280	0.0168	1.125	0.675	2.102	1.261
1986	3	1	3	3	188,497,000	480,946	273,924	0.0159	0.0053	0.624	0.208	1.095	0.365
1987	4	1	1	1	234,647,000	529,785	308,348	0.0170	0.0043	0.755	0.189	1.297	0.324
1988	1	0	0	0	242,641,000	619,496	368,486	0.0041	0.0000	0.161	0.000	0.271	0.000
1989	4	3	147	146	267,052,000	676,621	376,400	0.0150	0.0112	0.591	0.443	1.063	0.797
1990	2	0	0	0	257,928,000	625,390	293,646	0.0078	0.0000	0.320	0.000	0.681	0.000
1991	1	0	0	0	267,132,000	646,155	310,141	0.0037	0.0000	0.155	0.000	0.322	0.000
1992	2	0	0	0	271,648,000	629,454	361,076	0.0074	0.0000	0.318	0.000	0.554	0.000
1993P	0	0	0	0	262,000,000	624,000	312,000	0.0000	0.0000	0.000	0.000	0.000	0.000

P Preliminary data.
* Includes accidents involving deregulated all-cargo air carriers and commercial operators of large aircraft when those accidents occurred during U.S. Federal Aviation Regulations (FARs) Part 121 operations.
\# Source of estimate: U.S. Federal Aviation Administration (FAA).

Source: U.S. National Transportation Safety Board

Table 5
Accidents, Fatalities and Rates
U.S. Air Carriers Operating Under U.S. Federal Aviation Regulations (FARs) Part 135
All Scheduled Service (Commuter Air Carriers)* — 1982-1993

	Accidents		Fatalities		Aircraft	Aircraft		Accident Rates@ Per Million Aircraft Miles		Per 100,000 Aircraft Hours		Per 100,000 Departures	
Year	Total	Fatal	Total	Aboard	Miles Flown#	Hours Flown#	Departures#	Total	Fatal	Total	Fatal	Total	Fatal
1982	26	5	14	14	222,355,000	1,299,748	2,026,691	0.117	0.022	2.000	0.385	1.283	0.247
1983	17	2	11	10	253,572,000	1,510,908	2,328,430	0.067	0.008	1.125	0.132	0.730	0.086
1984	22	7	48	46	291,460,000	1,745,762	2,676,590	0.075	0.024	1.260	0.401	0.822	0.262
1985	21	7	37	36	300,817,000	1,737,106	2,561,463	0.070	0.023	1.209	0.403	0.820	0.273
1986	15	2	4	4	307,393,000	1,724,586	2,798,811	0.049	0.007	0.870	0.116	0.536	0.071
1987	32	10	59	57	350,879,000	1,946,349	2,809,918	0.091	0.028	1.644	0.514	1.139	0.356
1988	19	2	21	21	380,237,000	2,092,689	2,909,005	0.050	0.005	0.908	0.096	0.653	0.069
1989	18	5	31	31	393,619,000	2,240,555	2,818,520	0.046	0.013	0.803	0.223	0.639	0.177
1990	15	3	6	4	450,067,000	2,336,952	3,159,763	0.033	0.007	0.642	0.128	0.475	0.095
1991	22	8	99+	77	381,464,000	2,171,067	2,647,876	0.058	0.021	1.013	0.368	0.831	0.302
1992	23	7	21	21	442,107,000	2,181,390	2,911,168	0.050	0.016	1.009	0.321	0.756	0.240
1993P	16	4	24	23	489,000,000	2,369,000	3,144,000	0.033	0.008	0.675	0.169	0.509	0.127

P Preliminary data.

Source of estimate: U.S. Federal Aviation Administration (FAA)

+ The fatality total includes the 12 persons killed aboard a Skywest commuter aircraft and the 22 persons killed aboard a USAir airliner when the two aircraft collided on a runway.

@ Rates are based on all accidents including some involving operators not reporting traffic data to U.S. Department of Transportation Research and Special Programs Administration (RSPA).

The following attempted suicide case is included in “Accidents” but not in “Accident Rates”;

Date	Location	Operator	Fatalities Total	Fatalities Aboard
4/17/92	Lexington, Kentucky	Mesaba Airlines	0	0

* Includes accidents involving all-cargo air carriers when those accidents occurred during scheduled 14 CFR 135 operations. All-cargo air carriers no longer meet the RSPA definition for ‘Commuters’.

Source: U.S. National Transportation Safety Board

Table 6
Accidents, Fatalities and Rates
U.S. Air Carriers Operating Under U.S. Federal Aviation Regulations (FARs) Part 135
Nonscheduled Operations (On-Demand Air Taxis) — 1982-1993

	Accidents		Fatalities		Aircraft	Accident Rates Per 100,000 Aircraft Hours	
Year	Total	Fatal	Total	Aboard	Hours Flown#	Total	Fatal
1982	132	31	72	72	3,008,000	4.39	1.03
1983	141	27	62	57	2,378,000	5.93	1.14
1984	146	23	52	52	2,843,000	5.14	0.81
1985	154	35	76	75	2,570,000	5.99	1.36
1986	117	31	65	61	2,690,000	4.35	1.15
1987	97	30	65	63	2,657,000	3.65	1.13
1988	101	28	59	55	2,632,000	3.84	1.06
1989	111	25	83	81	3,020,000	3.68	0.83
1990	106	28	50	48	2,249,000	4.71	1.24
1991	87	27	70	66	2,241,000	3.88	1.20
1992	76	24	70	67	2,009,000	3.78	1.19
1993P	71	19	42	42	2,100,000	3.38	0.90

P Preliminary data.

Source of estimate: U.S. Federal Aviation Administration (FAA). Hours flown for the years 1982 through 1991 have been revised to reflect the results of the FAA’s General Aviation Activity and Avionics Non-respondent Survey.

Source: U.S. National Transportation Safety Board

Table 7
Accidents, Fatalities and Rates
U.S. General Aviation* — 1982-1993

Year	Accidents Total	Accidents Fatal	Fatalities Total	Fatalities Aboard	Aircraft Hours Flown#	Accident Rates Per 100,000@ Aircraft Hours Total	Accident Rates Per 100,000@ Aircraft Hours Fatal
1982	3,233	591	1,187	1,170	29,640,000	10.90	1.99
1983	3,077	556	1,069	1,062	28,673,000	10.73	1.94
1984	3,016	545	1,042	1,021	29,099,000	10.35	1.87
1985	2,738	498	955	944	28,322,000	9.66	1.75
1986	2,582	474	967	878	27,073,000	9.54	1.75
1987	2,494	447	838	823	26,972,000	9.24	1.65
1988	2,386	460	800	792	27,446,000	8.69	1.68
1989	2,230	431	768	765	27,920,000	7.97	1.53
1990	2,214	442	766	761	28,510,000	7.76	1.55
1991	2,170	431	781	767	27,226,000	7.96	1.58
1992	2,074	447	862	860	23,792,000	8.71	1.87
1993P	2,022	385	715	712	23,000,000	8.79	1.67

P Preliminary data.
Source of estimate: U.S. Federal Aviation Administration (FAA). Hours flown for the years 1982 through 1991 have been revised to reflect the results of the FAA's General Aviation Activity and Avionics Non-respondent Survey.
* U.S.-registered civil aircraft not operating under U.S. Federal Aviation Regulations (FARs) Part 121 or Part 135.
@ Suicide and sabotage accidents are excluded from rates as follows:
Total – 1982 (3), 1983 (1), 1984 (3), 1985 (3), 1987 (1), 1988 (1), 1989 (5), 1990 (1), 1991 (3), 1992 (1)
Fatal – 1984 (2), 1985 (2), 1987 (1), 1989 (4), 1991 (2), 1992 (1)

Source: U.S. National Transportation Safety Board

Table 8
Fatal Accidents and Fatalities
U.S. Air Carriers Operating Under U.S Federal Aviation Regulations (FARs) Part 121
All Scheduled Service (Airlines) – 1993 (Preliminary Data)

Date	Location	Operator	Service	Aircraft	Fatalities Passenger	Fatalities Crew	Fatalities Other	Fatalities Total	Total Aboard	Reported Type of Accident
4/4	Chicago, Illinois	Simmons Airlines, dba: American Eagle	Passenger	ATR 42-300	0	0	1	1	48	Ground crew member struck by propeller

Source: U.S. National Transportation Safety Board

Table 9
Fatal Accidents and Fatalities
U.S. Air Carriers Operating Under U.S Federal Aviation Regulations (FARs) Part 121
All Scheduled Service (Commuter Air Carriers) – 1993 (Preliminary Data)

Date	Location	Operator	Service	Aircraft	Fatalities Passenger	Fatalities Crew	Fatalities Other	Fatalities Total	Total Aboard	Reported Type of Accident
4/3	Nome, Alaska	Ryan Air Service	Passenger	Cessna 207	1	1	0	2	2	Crashed into flat terrain shortly after takeoff.
7/12	Las Vegas, Nevada	Air Nevada Airlines	Passenger	Cessna 402-C	2	1	0	3	3	Lost control and crashed while returning to airport for a precautionary landing.
11/5	Newark, New Jersey	Northeast Express Airlines, dba: Northwest	Passenger	Fairchild SA227-AC	0	0	1	1	15	Ground crew member struck by propeller.
12/1	Hibbing, Michigan	Airlink Express Airlines II, dba: Northwest	Passenger	BAe 3101	16	2	0	18	18	Crashed three miles short of airport during approach.

Source: U.S. National Transportation Safety Board

dba: Doing business as

Publications Received at FSF Jerry Lederer Aviation Safety Library

Causes of Operational Errors Studied

Wide-ranging reports look at communications between controllers and pilots.

by
Editorial Staff

Reports

Prinzo, O. Veronica; Britton, Thomas W. *ATC/Pilot Voice Communications — A Survey of the Literature.* Report No. DOT/FAA/AM-93/20. November 1993. 35p.; ill. Includes bibliographical references, tables, glossary. Available through the National Technical Information Service.*

Keywords

1. ATC — Pilot Communications.

2. Communication Taxonomy.

Summary: This is a survey of voice radio communications literature. The 43 reports in the review represent survey data, field studies, laboratory studies, narrative reports and reviews in the field. The survey topics pertain to communications taxonomies (classifications), acoustical correlates and cognitive/psycholinguistics perspectives.

Communications taxonomies were used to identify the frequency and types of information that make up routine communications, as well as communications involved in safety-related events such as operational errors and pilot deviations. The acoustical methodologies identified the qualities of a speaker's voice that could be used to monitor stress, mental workload and other psychological or physiological factors that affect performance. Examples of these qualities are loudness, pitch and speech rate. The cognitive/psycholinguistic research offered an information-processing perspective for understanding how pilots' and controllers' memory and language comprehension processes affect their ability to communicate effectively with one another.

This literature analysis of the air traffic control (ATC)/pilot voice radio communications was performed to provide an organized summary for the systematic study of interactive communications between controllers and pilots. Recommendations are given for new research initiatives, communications-based instructional materials and human factors applications for new communications systems. [from abstract]

Rodgers, Mark D., editor. *An Examination of the Operational Error Database for Air Route Traffic Control Centers*. December 1993. 29p.; ill. Includes bibliographical references, tables, appendix. Available through the National Technical Information Service.*

Keywords

1. Air Traffic Control.

2. Operational Errors.

3. Human Performance.

4. Human Factors.

5. Workload.

Summary: Monitoring the frequency and determining the causes of operational errors (OEs) — defined as the loss of prescribed separation between aircraft — is one approach to evaluating the operational safety of the air traffic control system. The Federal Aviation Administration (FAA) refers to the loss of separation standards between aircraft as an OE. The extent to which separation is lost determines the severity of the error.

The first of two studies in this report examines the relationships between error occurrence, controller workload (number of aircraft and traffic complexity) and causal factors involved. The FAA's Final Operational Error/Deviation Reports for Air Route Traffic Control Center (ARTCC) facilities during calendar years 1985-1988 comprises the data base.

A majority of the errors occurred under conditions of below average (25 percent) or average (39 percent) complexity. Complexity and number of aircraft were highly correlated. Nevertheless, there was a significant difference across facilities in average workload during an event.

The second study analyzes the workload and causal factors related to the severity of OEs at ARTCCs during 1988-1991. Neither the number of aircraft being worked nor air traffic complexity were associated significantly with severity. In general, the causal factors that resulted in greater severity likely involved reduced situational awareness by the controller. The relationship of aircraft profiles and flight levels with OE severity was examined. Facility differences were reviewed regarding controller workload and awareness of the developing error. [from abstract]♦

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Updated U.S. Federal Aviation Administration Reference Materials

Advisory Circulars (ACs)

AC Number	Month/Year	Subject
65-25A	11/06/93	*Aviation Maintenance Technician Awards Program* (cancels AC 65-25, dated Aug. 28, 1992).
150/5220-19	12/07/93	*Guide Specification for Small, Dual Agent Aircraft Rescue and Fire Fighting Vehicles* (cancels AC 150/5220-14A, dated Feb. 25, 1985).
90-43G	12/08/93	*Operations Reservations for High Density Traffic Airports* (cancels AC 90-43F, dated April 22, 1985).
135-10A	12/22/93	*Approved Aircraft Inspection Program* (cancels AC 135-10, dated Sept. 17, 1981).
150/5345-44F	01/05/94	*Specification for Taxiway and Runway Signs* (cancels AC 150/5345-44E, dated Dec. 16, 1991).
25-9A	01/06/94	*Smoke Detection, Penetration, and Evacuation Tests and Related Flight Manual Emergency Procedures* (cancels AC 25-9, dated July 29, 1986).

U.S. Federal Aviation Regulations (FARs)

FARs Part 121	09/01/93	*Certification and Operations: Domestic, Flag, and Supplemental Air Carriers and Commercial Operators of Large Aircraft (change 2, incorporating Amendment 121-234, Protective Breathing Equipment Training, issued Aug. 26, 1993).*

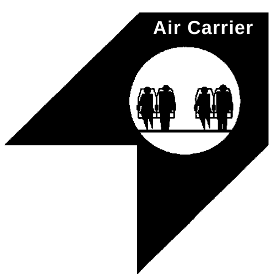
Accident/Incident Briefs

Uncommanded Evacuation Causes Five Injuries

Passengers initiate uncommanded evacuation after a passenger yells, "Fire!"

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.



Uncommanded Evacuation Causes Five Injuries

Boeing 727-200. No damage. Five minor injuries.

During the start of the auxiliary power unit (APU) in preparation for a night flight, several passengers in the darkened cabin observed flame coming from the APU exhaust. A passenger suddenly yelled "Fire!" and other passengers removed the overwing emergency exit windows and began an uncommanded evacuation. A total of 116 passengers and a crew of seven were on board the aircraft.

Fifteen passengers exited onto the wings and several jumped to the ground. The remaining passengers exited through the aft stairs and jetway. All of the injuries occurred when passengers jumped from the wings.

Crowded Taxiway Sets Stage for Collision

Boeing 747-400. No damage. McDonnell Douglas DC-9. Minor damage. No injuries.

The Boeing 747 was cleared to line up, which required passing three aircraft that were holding on the apron. The captain maneuvered to the left of the taxiway centerline because of the narrow clearance.

After being informed by the first officer that there was sufficient clearance to pass a DC-9, the captain continued forward. As the 747 passed the DC-9, the DC-9 crew felt a jolt, which they reported to air traffic control (ATC). Both aircraft were instructed to hold position until a visual inspection could be made. There was visible damage to the DC-9 tailplane, which had been struck by the 747's winglet. There was no visible damage to the 747 winglet and the 747 captain elected to proceed with the daylight flight.

Poor Cockpit Discipline, Improper Autoflight Setting Lead to Commuter Control Loss

Embraer EMB 120. Substantial damage. Thirteen minor injuries.

During climb to cruise level, the aircraft stalled and went out of control at about 17,000 feet (5,185 meters). The flight crew regained control of the aircraft after losing more than 11,000 feet (3,355 meters) of altitude.

However, loads imposed on the aircraft caused extensive damage to the left engine and propeller, and the airplane was not able to maintain level flight after recovery. The aircraft collided with rough terrain after overrunning the runway during an emergency landing.

The U.S. National Transportation Safety Board (NTSB) determined that the probable causes of the accident were the "captain's failure to maintain professional cockpit discipline, his consequent inattention to flight instruments and ice accretion and his selection of an improper autoflight vertical mode, all of which led to an aerodynamic stall, loss of control and a forced landing. Factors contributing to the accident were poor crew discipline (including poor flight crew coordination before the stall) and the flight crew's inappropriate actions to recover from the loss of control. Also contributing to the accident was fatigue induced by the flight crew's failure to properly manage provided rest periods."

The NTSB said the aircraft was in clouds "with zero visibility and that the tops of the clouds extended above 21,000 feet [6,405 meters]."

The flight crew, the NTSB said, did not comply with the sterile cockpit rules as the airplane was passing through 8,000 feet (2,440 meters). It said the flight attendant was present in the cockpit, "engaging in nonpertinent conversation with the captain for four minutes and 27 seconds, up to and during the loss of control."

The NTSB added: "The captain engaged the autoflight system in the 'heading' and 'pitch hold' modes during the initial climbout, obviating the stall and speed protection afforded by other vertical modes. This autoflight system configuration was contrary to the company's training and procedures. During the climb, the pitch was increased by the captain, using the autoflight 'pitch hold' mode, in the minutes before the loss of control."

The stall occurred at a higher than expected airspeed because of wing ice contamination, the NTSB said.

"The captain did not respond immediately to the stick shaker warning, which was followed within two seconds by loss of lateral control," the NTSB said. "Thereafter, the continued exertion of back force on the control column was inappropriate. The airplane recovered … when control forces were relaxed and the landing gear was lowered."

The NTSB said engine operations were normal until after the loss of control. "The crew shut down the left engine and feathered the propellers, mistakenly believing that there was an engine overspeed. Three of the four left propeller blades separated about 35 seconds after the beginning of the event, during the post-stall gyration."

Asymmetric aerodynamic drag cause by the damaged engine made precise control of the aircraft impossible, the NTSB said. The aircraft landed long on a wet runway, resulting in the overrun and injuries, the NTSB said.

"The captain and first officer failed to adequately monitor the progress of the flight during climbout, and the first officer failed to adequately monitor the captain's actions," the NTSB said.

Service Truck Wallops Commuter

Canadair Challenger. Substantial damage. No injuries.

The captain and first officer were completing preflight checks and the aircraft had just been refueled. As the fuel truck drove away, a lavatory service truck was positioning to service the aircraft.

A few seconds later, the lavatory service truck struck the aircraft, throwing the first officer into the captain's seat, and the captain against the cockpit wall. Crew members reported feeling the aircraft move several feet.

The rear right-hand corner of the truck had struck the aircraft fuselage and penetrated about one foot (0.3 meters) into the cabin. Tire marks around the nose gear showed that the aircraft had moved about six feet (1.8 meters). The truck driver said his foot had slipped off the brake.

Corporate Executive

Twin Hits Mountain Obscured by Clouds

Cessna 402. Aircraft destroyed. Three fatalities.

The twin-engine Cessna 402 was in cruise flight at night when it struck a mountain.

It was determined that despite the presence of moonlight, the peaks were obscured by clouds. The pilot and two passengers were killed in the crash.

Engine Failure Forces Aborted Takeoff

Cessna 402. Substantial damage. No injuries.

The takeoff was aborted when the left engine failed. The runway was wet and the aircraft was not able to stop on the pavement. The landing gear collapsed.

It was determined that the aircraft was loaded beyond its maximum weight and that the pilot elected to take off with a right quartering tailwind of 14 knots.

Other General Aviation

High Flare Stalls Single

Cessna 170. Substantial damage. One minor injury.

While attempting to land in gusty winds, the pilot flared high and stalled the aircraft. The right wing tip and nose struck the runway and the aircraft came to rest upright beside the runway.

The pilot suffered a bruised forehead. A passenger was not injured.

Rotorcraft

Survey Flight Ends in Trees

Bell 206B. Substantial damage. No injuries.

The Bell 206 was being used to conduct a low-level forest inventory project. The pilot was turning left toward the sun to set up a picture when the helicopter struck trees on a knoll.

The pilot reported that he was retrieving his camera from the floor and did not realize he was flying toward rising terrain. He did not recover in time to prevent the helicopter from descending into the trees and rolling on its right side.♦

Disaster Response Planning Workshop for Business Aviation

FLIGHT SAFETY FOUNDATION
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May 18-19, 1994

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FLIGHT SAFETY DIGEST

ISSN 1057-5588

Staff: Roger Rozelle, director of publications; Girard Steichen, assistant director of publications; Kate Achelpohl, editorial assistant; and Monique Kohly, production consultant

Subscriptions: US$95 (U.S.-Canada-Mexico), US$100 Air Mail (all other countries), twelve issues yearly. • Include old and new addresses when requesting address change. • Flight Safety Foundation, 2200 Wilson Boulevard, Suite 500, Arlington, VA 22201-3306 U.S. • telephone: (703) 522-8300 • telex: 901176 FSF INC AGTN • fax: (703) 525-6047

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