Reflections On Air Carrier Safety

by

G. M. Bruggink

The scenario is not unusual. An air safety investigator gets a call from an apprehensive citizen wanting to know what the safest carrier is for a particular trip. Calls like this seem to be based on the assumptions that the risks of air travel vary with the caliber of the carrier, and the government agency that investigates the industry's mishaps is in the best position to provide the desired information. What are the chances that the caller will get a candid response to his inquiry?

After many years of exposure to aviation's dark side, an investigator may develop certain preferences that could lead him to avoid certain operators or types of equipment. However, he can ill afford to share his unquantifiable misgivings with the public. He must follow the party line by describing the industry's grand design: All carriers operate under the same rules, the regulatory authority certificates personnel and equipment and sees to it that all carriers meet government standards, and therefore, the public should not expect different levels of safety in such a well-regulated and monitored industry.

The investigator's response may be diplomatic and soothing but its accuracy is open to question. In a 1987 Boeing study of crew-caused accidents involving the worldwide Boeing fleet (347 operators) during a 10-year period, it was found that:

> Sixteen percent of the operators have crew-caused accident rates higher than the fleet average, and these operators account for over 80 percent of the total accidents.[1]

So much for the notion of equality in air carrier safety performance.

There must be more to a good record than the heavy hand of government in the form of regulations, surveillance and enforcement. According to the same Boeing study, what tends to differentiate one carrier from another is strong management awareness of, and responsiveness to, the controllable factors that underlie accidents and incidents. Carriers with a superior record seem to develop and enforce safety-oriented policies, procedures and practices that go beyond perfunctory compliance with government standards. The study lists several of the successful strategies used by carriers who "characterize safety as beginning at the top of the organization."

The logical question at this point is: What keeps some carriers from incorporating the proven elements of accident avoidance in their own operations? Could it be that there are influences other than economics, scheduling and competition that can relax management's vigilance and discourage safety initiatives?

Let us answer these questions by explaining how certain notions about accident causation and prevention may interfere with management's recognition and acceptance of pivotal safety duties. Three of these popular but misleading notions are:

- The number of accidents is so small and their causes so random, that attempts to improve would place an undue burden on the industry.
- The safety-consciousness of air carriers is demonstrated by the fact that carrier management is seldom cited in the probable (primary) cause statement in accident reports.
- Although the role of carrier personnel is often mentioned in causal statements — the solution of the human error problem lies with the human factors experts.

The "Random" Nature of Accidents

Managerial inertia can be induced by the belief that the air carrier accident record has improved to the point where the few accidents that still occur are too random in nature to offer practical countermeasures. This self-defeating view is also found in the April 1988 report of the U.S. Aviation Safety Commission:

> Aviation accidents are rare events; each has unique elements that make patterns difficult to detect. [2]

The suggestion that corrective action is dependent upon the discovery of a trend or a pattern is misleading. Even one occurrence can establish a trend that demands immediate remedy. (Examples: loss of a DC-10 cargo door; installing chip detectors without an O-ring in L-1011 engines; misinterpretation of the term "Cleared for the approach"). Furthermore, the notion that the rarity of accidents hampers their prevention is disproved by the performance of carriers who have not lost a passenger for several decades. Those carriers do not need the prodding of government inspectors to react to unwarranted risks.

It can hardly be claimed that not enough is known about accidents and the role of the human element in their causation. Over the past 50 years (1938-1987), about 214,000 of these "rare events" were investigated and analyzed in the U.S. alone. These were all civil aircraft accidents, most of them involving general aviation. If the military experience is added, the total number of investigations may approach a quarter of a million. That this gigantic learning experience paid dividends is proven by the spectacular decline in accident rates in all forms of flying.

Admittedly, less than two percent of these accidents involved air carriers. However, the preventive insights gained from carrier accidents may equal that of all others due to their greater depth of investigation and the availability of in-flight recorders. As a result, the wealth of collected accident data makes it difficult to visualize a human error that has not occurred before. Even when new technology changes the opportunities for error and their consequences, the basic error mechanism should already be on the books. For instance, there seems to be no reason to treat the human factors aspects of the following accidents as new and unforeseeable manifestations of human fallibility:

- The B-767 that made a deadstick emergency landing following fuel exhaustion.
- The Airbus 320 that plowed into trees at the end of the runway following a flyby.

Complaints about the absence of patterns in aviation's enormous wreckage trail ignore a basic characteristic of most accidents: the repetitiousness of previously identified, but ignored compromises that converged in time and space to trigger the event. In retrospect, almost any accident seems easily preventable by just a mild exercise of anticipation on the part of carrier management. It is the great merit of the Boeing study that it promotes the perception of avoidable risks by showing that most of the elements of failure (accidents and incidents) have their counterparts in the proven elements of success (safety). In addition, most of the recommended managerial and operational techniques — especially those dealing with standardization and discipline — do not provide the usual excuse for inaction in the form of cost and scheduling penalties.

Management's Low-Profile in Causal Statements

Air carriers will always play the pivotal role in the complex scheme of tasks, responsibilities and interests that govern their safety reputation. Before the release of each flight, the carrier functions as the last checkpoint and the final judge of the status and acceptability of all elements that affect the safety of that flight, including:

- The adequacy of operational standards and procedures.
- The competence level of its personnel.
- The airworthiness of its equipment.
- The quality of the infrastructure: airports, ATC, weather services, etc.

Given the overriding responsibilities of the air carrier, one would expect frequent identification of management's role in accident cause. Strangely enough, carrier management has low visibility in accident cause tabulations. This phenomenon is displayed conspicuously in the earlier-mentioned report of the U.S. Aviation Safety Commission. The Commission's staff tabulated the "primary cause" of 593 accidents based on its own analysis of U.S. National Transportation Safety Board accident data from 1970 to 1985. (See table).

DISTRIBUTION OF PRIMARY CAUSE OF ACCIDENTS (1970-1985)*

U.S. Scheduled Domestic Operations

	Part 121	Part 135
	Air Carriers	Commuters
Equipment	25%	36%
Seatbelt	26	1
Weather	15	20
Pilot	13	27
ATC	5	3
Ground Crew	4	4
Gen. Aviation	3	2
Company	0	0
Other	9	7
	100%	100%
Total number of accidents	296	297

*Adapted from Volume II (staff background papers) of the Report of the Aviation Safety Commission, April, 1988. (Chart includes accidents, e.g. injuries from seatbelts)

It will be noted that not a single primary cause is attributed to "company" (carrier management) during these 16 years. However, in fairness to the commission's staff, it must be pointed out that its lack of recognition of management's role is a reflection of the NTSB's appraisal of that role in accident reports. The probable (primary) cause portion of the NTSB's conclusions seldom cites carrier management.

It can be argued that management is implicated every time carrier personnel are identified in the primary cause. That would be a valid argument if the management implications were clearly spelled out in the causal text. However, the search for "The Cause" tends to be limited to the actions of persons who had the last opportunity to prevent the accident. Generally, this involves licensed personnel with a hands-on responsibility for the daily operation and movement of aircraft. Even if distinct shortcomings on the part of the carrier helped set the stage for the accident, their catalytic function is usually assigned a subordinate role in the contributing factors section of the causal statement. Enabling or predisposing factors with a remote but tenable connection with "The Cause" are routinely omitted, regardless of their significance.

Self-imposed rules of evidence that stress the probability of who was most at fault, rather than the objective identification of each failure of the system's protective functions, have probably done more to dull management's perception of its safety duties than any other factor. That universal problem has been the subject of so many papers that further comments are superfluous. Instead, some actual cases will be used to demonstrate that carrier safety responsibilities are seldom properly reflected in the traditional causal statement.

The following cases came from a randomly selected International Civil Aviation Organization (ICAO) *Accident Digest* ; digest No. 30 contains seven reports of accidents that occurred in 1983. To limit the scope of the review, only the fatal air carrier accidents were selected. There were three; each occurred in a different country.

Takeoff Accident
(11 January 1983, Detroit, Mich., U.S.)

The DC-8 was operated as a scheduled cargo flight. Following a night takeoff, the airplane pitched up sharply, climbed about 1000 feet, rolled to the right and descended rapidly. The airplane was destroyed; the crew of three was killed.

The basic accident mechanism involved the setting of the horizontal stabilizer trim; it was found at 7.5 units ANU (aircraft nose-up), which was the previous landing setting. "Had any one of six distinct procedural requirements involving all three crewmembers been followed, the stabilizer trim should have been set within acceptable limits at takeoff." It was also found that:

- The captain and first officer did not have the prescribed crew rest, and might have been fatigued.

- The first and second officer swapped seats about 65 seconds before takeoff with the approval of the captain.

- The second officer, who made the takeoff, had failed to qualify as a DC-8 first officer. He had been qualified as a first officer on the B-737 but had lost that qualification after a year on the line. He was permanently removed from all pilot duties by mutual agreement with the company.

The causal statement summarized what happened without offering an explanation for the crew's compromising behavior:

> **Probable Cause:**
>
> Flight crew's failure to follow procedural checklist requirements and to detect and correct a mistrimmed stabilizer before the airplane became uncontrollable.
>
> **Contributing Factor:**
>
> The captain's allowing the second officer, who was not qualified to act as a pilot, to occupy the first officer's seat and to conduct the takeoff.

In the body of the report the investigating authority expresses its "concern about the flight crew's disregard of federal and company rules and regulations." Undoubtedly, the carrier, the regulatory authority and the pilot's association had similar concerns. But what did they do about it?

Flight crews do not operate in a vacuum. Their actions and attitudes are a reflection on those who employ and represent them. Those who consider this an unfair indictment should ask themselves: Is it reasonable to assume that this was the first time these three crew members used a casual approach to vital duties?

The reason is not given why this accident report contains no safety recommendations. One conjecture should embarrass the entire industry: Appeals made in past recommendations for higher professional standards seem to have been futile; therefore, why reiterate the obvious?

Controlled Flight Into Terrain
(27 November 1983, Madrid, Spain)

The B-747 was operated as a scheduled passenger flight. While maneuvering and descending during a nighttime ILS approach, the aircraft struck the ground about eight miles from the airport and 250 feet above airport elevation. The weather at the destination had been reported as: visibility 8 km; mist, 3/8 stratus coverage at 1000 feet; 5/8 stratocumulus coverage at 1800 feet. The airplane was destroyed. Of the 192 occupants, 181 were killed.

There were several procedural irregularities that contributed to the flight's deviation from the approach profile. One of them seems particularly relevant. When the captain, who was flying, told the first officer to "switch to the marker," the latter made a 900-foot error in reporting the required crossing altitude. He reversed the first two digits of the correct figure of 3282. The captain, apparently, accepted 2382. That could explain why he continued his descent below 3282 without having reached the marker.

Also noteworthy is that the ground proximity warning system (GPWS) began to sound ten seconds before impact. The captain "calmly said, 'OK, OK' and took no corrective action. Five seconds later (he) again said, 'OK,' disconnecting the autopilot at the same time and slightly reducing the aircraft's rate of descent." The company's prescribed crew response to the GPWS is not discussed in the report.

The causal statement outlines what happened:

> **Probable Cause:**
>
> The captain, without having any precise knowledge of his position, set out to intercept the ILS on an incorrect track without initiating the published instrument approach maneuver; in doing so he descended below all the area safety minima until he collided with the ground.
>
> **Contributing Factors:**
>
> - Inaccurate navigation by the crew.
> - Failure of the crew to take the prescribed action when the GPWS sounded.
> - Deficient teamwork on the flight deck.
> - Approach control provided imprecise position information to the flight.
> - The approach controller did not maintain a proper watch on the radar scope. (Although he had handed off the flight to the tower controller, he had not informed the flight that radar service was terminated.)

This accident is a classic example of how several compromises in the expected performance of flight crew and traffic controllers converged to produce a disaster. The attempt to find a pattern in such a random event sequence is what creates the notion about the "unique elements" in accidents. There is nothing unique about the cause-related factors in this accident. That observation applies especially to the reasons why the GPWS did not have its intended life-saving effect.

Controlled Flight Into Water (16 July 1983, Isles of Scilly)

The Sikorsky S-6IN was on a scheduled passenger flight to an island about 30 nm from the coast. While approaching the island in poor visibility the helicopter gradually descended from its intended height of 250 feet, without either pilot being aware of this, and flew into the sea. Both sponsons were torn free at impact; the helicopter rolled over and sank. Of the 26 occupants, four passengers and the two pilots survived.

The island airport had an elevation of 116 feet above sea level; there were no navigational or approach facilities. Toward the end of the flight the captain was flying at 250 feet radio altimeter height, in visual contact with a flat, calm sea, with no discernable horizon. There was haze, but the forward visibility appeared to exceed the company minimum of 900 meters. According to the investigating authority, the weather conditions close to the island were such "as to make the assessment of attitude and height by external reference difficult, (and) they were also capable of causing a pilot to be deceived into believing that adequate cues were available for safe control of a helicopter's flight path — at least for short periods of time."

The inadvertent descent from 250 feet probably began when the captain reduced power to decrease airspeed. The required close coordination of power and attitude "would be difficult to achieve in the external visual conditions that pertained without references to the flight instruments." Since the captain expected to sight land shortly he was looking outside and ahead. At the same time, the first officer was concentrating on radio communications and on the terrain mapping features of the radar set. Company procedures did not require the continuous monitoring of flight instruments by one pilot in the existing conditions.

The helicopter was equipped with radio altimeters, although this was not mandatory at the time for off-shore operations. The 250-foot trip point in the system activated the landing gear audio warning when the aircraft descends below 250 feet with the gear up. The island was approached with the gear down so this aural cue was absent.

The radio altimeter indicators had a moveable decision height bug. (The captain's was set at 200 feet) When the actual height is at or below the bug setting, a small amber light at the top of the instrument is illuminated. This system "is unlikely to attract the attention of a pilot not looking at the instrument panel because the radio altimeters are mounted low on the panel." There were no company procedures for use of the decision height warning system.

> **Probable Cause:**
>
> The accident was caused by the commander not observing and correcting an unintentional descent

before the helicopter collided with the surface, while he was attempting to fly at 250 feet by only external visual reference in conditions of poor and deceptive visibility over a calm sea.

Contributing Factors:

- Inadequate flight instrument monitoring.
- A combination of weather conditions which were unsuited to visual flight.
- Insufficiently detailed company operating procedures.
- Lack of an audio height warning alarm.

It is regrettable that the results of this thoroughly investigated and reported accident had to be squeezed into the traditional causal format. As a result, the accident is attributed to a mission-oriented pilot while those who tolerated the compromises that set the stage are assigned a secondary role under Contributing Factors. Statistically, this will always be known as a pilot-error accident, although the causes behind "The Cause" are clearly identified in the contributing factors.

These three cases illustrate how a quasi-legal approach to the weighing of accident factors in the causal statement distorts the preventive implications of even the most-thoroughly investigated accidents. The differentiation between probable (primary) causes and contributing factors is an anachronism that should have been discarded with the tailskid. The regrettable but universal preoccupation with the spotlighting of the most visible participants not only distorts all causal tabulations but downgrades carrier management's safety accountability.

Human Error: A Problem for the Experts

During a 1983 Symposium of Aviation Psychology, the International Air Transport Association (IATA) representative posed this question: "Do we (the airlines) really know the extent to which our problems lie in the human factors domain or the extent to which this discipline can provide the best answers to our problems?" [3]

The speaker raised a valid question. Aviation's biggest problem area — human error avoidance — seems in the process of becoming the exclusive domain of behavioral, human engineering and related disciplines. Of course, these disciplines will always play a leading role in fitting the machine and the task to the man. However, their specialization may limit their perspective to the more mundane and tangible aspects of the human problem. When they suggest, nevertheless, that the solution lies in their further study of ever-expanding data bases, they reinforce the notion that the complexity of this problem eludes conventional solutions. This notion may have given the human factors field a mystique that discourages air carrier acknowledgement of its own role.

The tendency to shift certain safety responsibilities from the carriers to the human factors professionals is evident in the report of the DC-9-82 accident in Detroit on August 16, 1987. The crew of the scheduled passenger flight took off without realizing that they had not extended the flaps and slats and the takeoff warning system failed to alert them. Immediately after liftoff the aircraft began to roll, struck several obstacles, and broke up as it slid across the ground. There were 156 fatalities.

The report's findings, which are part of the official conclusions, give no hint of why the crew did not accomplish the prescribed taxi checklist or of any attenuating circumstance. According to the causal statement, this was a case of unmitigated crew error made irreversible by a malfunctioning warning system.

Probable Cause:

Flight crew's failure to use the taxi checklist to ensure that the flaps and slats were extended for takeoff.

Contributing Factor:

The takeoff warning system did not warn the flight crew that the airplane was not properly configured for takeoff. The reason for the absence of electrical power (to this system) could not be determined.

The report contains seven safety recommendations addressed to the U.S. Federal Aviation Administration (FAA). One of them bears on the subject of this discussion:

> Convene a human performance research group of personnel from NASA [U.S. National Aeronautics and Space Administration], industry, and pilot groups to determine if there is any type or method of presenting a checklist which produces better performance on the part of user personnel.

This recommendation probably found its rationale in a statement from a management sciences professor who testified during the investigation that he, "did not know of any human factors research on how a checklist should be designed and he could not find anything in his library on the subject." Regardless of its merits or applicability in this case, the recommendation shows how government initiatives in the human factors area can supersede the more immediate responsibilities of the carriers in the same area. After decades of user experience, carriers and pilot groups should already have decided on the preferred presentation of checklists.

Actually, the more basic issue in this accident was the crew's non-adherence to standard company procedures. Since neither crew member seemed to be uncomfortable with the deviations from checklist procedures, it was theorized, "that this manner of checklist performance was one to which each had been exposed and become familiar with over a lengthy period." This was probably the most revealing observation in the report. Its message is clear: An attitude of disrespect for the disciplined application of checklist procedures does not develop overnight; it develops after prolonged exposure to an atmosphere of indifference.

As already stated, the possibility of a connection between crew behavior and operational climate is not mentioned in the formal conclusions. Instead, a discussion in the report, and two safety recommendations, stress the significance of cockpit resource management (CRM) training in ensuring adherence to crew coordination procedures. The potential value of CRM in reducing crew errors cannot be questioned. However, these programs do not absolve the carriers, and pilot unions, from their obligations to ensure that crews possess the vital qualities that cannot be instilled in a simulator or a classroom, such as discipline and respect for regulatory, company and peer group standards.

Summation

It was explained how erroneous notions about the nature of accidents, their causation and prevention can discourage air carrier safety initiatives. The review of four operational accidents showed how causal statements that highlight the human factors aspects of an accident can divert attention from the role of company factors. To halt further dilution of its safety accountability, the air carrier industry should take the following position:

> Unless management first acknowledges its own role in the development of operational settings that pro voke errors, human error avoidance programs can not serve their intended purpose in a practical and cost-effective manner.

Safety cannot be efficiently imposed from without; its foundation must be laid in the corporate boardroom. No amount of government surveillance and enforcement action can compensate for top management's inability or unwillingness to meet its safety obligations.

In an article on air carrier safety in the ICAO *Bulletin*, November 1987, the chief executive of a European airline asked:

> Can you think of anything that would pay a bigger dividend than being perceived by the entire market as the world's safest airline? [4]

The answer, of course, is "no", but only if the airline industry would permit deterioration of its collective safety performance to the point where the public finds reason to discriminate between "good" and "bad" carriers. This situation has not yet materialized to the extent that the public has taken notice. However, without unqualified acceptance of their safety duties, the carriers may face a future where competition is no longer governed by marketing experts but by public rejection — for safety reasons — of certain carriers or aircraft. ♦

References

1. L. G. Lautman and P. L. Gallimore, "Control of the Crew-Caused Accident," Boeing Airliner Magazine, April-June 1987.

2. Aviation Safety Commission, Volume I (Final Report and Recommendations), Volume II (staff background papers). April, 1988. U.S. Government Printing Office.

3. Lawson C. White, "Hiding Behind the Skirts of Human Factors or Not Skilled Enough?" Proceedings of the Second Symposium on Aviation Psychology, Columbus, Ohio, U.S., April 25-28, 1983, Ohio State University.

4. Jan Carlzon, "Flight Safety Comes First in a Competitive Environment." Presentation to Flight Safety Foundation Board of Governors, Stockholm, Sweden, June 11, 1986.

Reports Received At FSF

GAO/RCED-86-185BR. *Airline Inspections — Comparison of Airlines With and Without Military Contracts.* General Accounting Office Report. June 1986. U.S. General Accounting Office, P.O. Box 6015, Gaithersburg, MD 20877 U.S..

Summary: Using the information gathered by FAA in its National Air Transportation Inspection (NATI), and information supplied by Military Airlift Command (MAC), GAO identified airlines with MAC contracts. GAO's analysis of NATI inspection data shows that airlines with MAC contracts, as a group, had a lower level of compliance with FAA regulations than airlines not contracting with MAC.

Specifically, the GAO team found: FAA selected a higher percentage of MAC contract airlines for the more in-depth Phase II NATI inspections; MAC contract airlines had a higher rate of severity level 3 comments than airlines without MAC contracts; and MAC contract airlines had a higher percentage of unsatisfactory inspections than other airlines. The GAO analysis did not determine the reasons for differences between MAC and non-MAC contract airlines.

GAO/RCED-87-208. *Aviation Weather — Status of FAA's New Hazardous Weather Detection and Dissemination Systems.* General Accounting Office Report. 28 pages. September 1987. U.S. General Accounting Office, P.O. Box 6015, Gaithersburg, MD 20877 U.S.

Summary: More than 50 percent of all fatal air carrier accidents are in some way attributable to weather. The Chairman of the House Committee on Science, Space, and Technology requested GAO to review FAA's plans for new hazardous weather systems and determine, among other things:

• how FAA plans to address the problem of detecting wind shear and other hazardous weather around airports and what unresolved issues remain.

• whether hazardous weather information will be transmitted to pilots in a more timely manner.

• when these new systems will be available and what their cost is estimated to be.

The GAO team found that the enhanced LLWAS although more effective than the existing wind-shear detection system, cannot detect shears that occur above or beyond its ground based sensors. The terminal NEXRAD radar system will have a much greater range and will be able to more accurately determine the location of wind shears than the enhanced LLWAS, but it is only an interim system that will be installed at 19 airports. It will be replaced by the terminal Doppler weather radar, as it becomes available.

FAA will award a procurement contract for 100 terminal Doppler radars in 1988, even though some of the radar's performance objectives have not been realized. The ASR-9 radar will provide improved weather detection by distinguishing between six levels of precipitation. The higher the rate of precipitation, the more likely that it contains phenomena associated with thunderstorms.

FAA is beginning to research the feasibility of automatically transmitting hazardous weather data directly to pilots from its new detection systems, but such a communication system is at least a decade away, according to current NAS plan projections. The air traffic controller will continue as the primary source of weather information to pilots.

DOT/FAA/AM-87/4. *1986 Survey of Aviation Business Operators: Their Views of FAA Airworthiness Inspectors.* Schroeder, D.J., Collins, W.E., Schaffer, C.W. Jr., and Dollar, C.S. 29 pages. March 1987. Office of Flight Standards, FAA, Washington, DC 20591 U.S.

Summary: A nationwide survey of 8,854 aviation business operators was conducted to assess their perceptions of, and satisfaction with, the performance of the FAA's avionic and maintenance airworthiness inspectors (AWIs). Results are based on returns received from 45 percent of the overall sample. User ratings on 21 items were analyzed and comparisons were made for each FAA region.

A criterion based on other research concerning consumer satisfaction with services was used to identify positive aspects of AWI performance and areas of performance in need of improvement. Overall satisfaction with AWI performance was fully acceptable and within the range of levels reported in the literature for higher ranking professional/technical services. Users felt very positive about AWI knowledge of FAA regulations and policies, AWI courtesy, and their thoroughness.

Areas that could be targeted for improvement included: the consistency and clarity of the technical interpretations, the frequency of visits, and reliance on AWIs for counseling in either regulatory or technical areas. The results will provide FAA management with the means to pinpoint high-rated and low-rated facilities and determine what features differentiate the less from the more successful. Corrective action plans based on the data can then be devised and implemented.

U.S. Commuter Air Carrier and On-Demand Air Taxi

Commuter Air Carrier

Commuter air carrier refers to those aircraft operators which operate at least five times a week with scheduled service under 14 CFR 135. After recording record-low numbers of accidents and accident rates in 1986, commuter air carriers last year had the highest number of fatal accidents and fatalities since 1980. There were two fatal accidents resulting in four fatalities in 1986 but 10 fatal accidents accounting for 58 fatalities in 1987. The rate of .68 fatal accidents per 100,000 departures in 1987 is the highest in the past seven years.

On-Demand Air Taxi

On-demand air taxi refers to those aircraft operators which operate under 14 CFR 135, other than commuter air carriers. In 1987, on-demand air taxis were involved in 98 accidents — the lowest number of total accidents in a decade. Of the 98 accidents, 31 were fatal accounting for 68 fatalities, one more than in the previous year. Although the accident rate of 8.25 per 100,000 aircraft hours is the lowest ever, the 1.07 fatal accidents per 100,000 aircraft hours is only the median of the fatal accident rates for the past 11 years.

A comparison of total accidents, fatal accidents, fatalities and rates for commuter air carrier and for on-demand air taxi for the period 1977 through 1987 is shown in Tables 1 and 2. Briefs of fatal accidents for commuter air carrier and on-demand air taxi for calendar year 1987 are shown in Tables 3 and 4 respectively.

Table 1

Accidents, Fatalities, and Rates
U.S. Air Carriers Operating under 14 CFR 121
All Scheduled Service
(Airlines*)
1977 - 1987

Year	Accidents Total	Accidents Fatal	Fatalities Total	Fatalities Aboard	Aircraft Miles Flown #	Aircraft Hours Flown #	Departures#	Accident Rates Per Million Aircraft Miles Total	Per Million Aircraft Miles Fatal	Per 100,000 Aircraft Hours Total	Per 100,000 Aircraft Hours Fatal	Per 100,000 Departures Total	Per 100,000 Departures Fatal
1977	19	3	78	69	2,418,645,000	5,798,873	4,936,519	0.008	0.001	0.328	0.052	0.385	0.061
1978	20	5	60	150	2,520,165,000	6,031,743	5,015,939	0.008	0.002	0.332	0.083	0.399	0.100
1979	23	4	351	348	2,791,120,000	6,713,094	5,399,652	0.008	0.001	0.343	0.060	0.426	0.074
1980	15	0	0	0	2,816,303,000	6,797,578	5,352,927	0.005	0.000	0.221	0.000	0.280	0.000
1981	25	4	4	2	2,703,219,000	6,571,288	5,211,867	0.009	0.001	0.380	0.061	0.480	0.077
1982	15	3	233	0	2,698,928,000	6,440,163	4,963,794	0.006	0.001	0.233	0.047	0.302	0.060
1983	22	4	15	14	2,808,566,000	6,649,009	5,033,906	0.008	0.001	0.331	0.060	0.437	0.079
1984	12	1	4	4	3,133,567,000	7,438,497	5,448,150	0.004	0.000	0.161	0.013	0.220	0.018
1985	17	4	197	196	3,319,955,000	7,947,435	5,835,474	0.005	0.001	0.214	0.050	0.291	0.069
1986	20	1	1	0	3,728,429,000	9,356,906	6,440,207	0.005	0.000	0.214	0.011	0.311	0.016
1987P	31	4	231	229	3,875,000,000	9,711,000	6,980,000	0.008	0.001	0.309	0.031	0.430	0.043

P Preliminary data.

* Includes accidents involving deregulated all cargo air carriers and commercial operators of large aircraft when those accidents occurred during 14 CFR 121 operations.

Source of estimate: FAA.

@ Suicide and sabotage accidents excluded from rates as follows:
Total 1987 (1)
Fatal 1987 (1)

Table 2

Accidents, Fatalities, and Rates
U.S. Air Carriers Operating Under 14 CFR 135
Nonscheduled Operations
(On-Demand Air Taxis)
1977-1987

Year	Accidents Total	Accidents Fatal	Fatalities Total	Fatalities Fatal	Aircraft Hours Flown#	Accident Rates Per 100,000 Aircraft Hours Total	Accident Rates Per 100,000 Aircraft Hours Fatal
1977	158	31	118	115	3,304,220	4.78	0.94
1978	198	54	155	152	3,545,753	5.58	1.52
1979	160	30	77	73	3,684,321	4.34	0.81
1980	171	46	105	101	3,617,724	4.73	1.27
1981	157	40	94	92	2,895,827	5.42	1.38
1982	132	31	72	72	3,256,763	4.05	0.95
1983	140	27	62	57	2,574,883	5.44	1.05
1984	146	23	52	52	3,079,007	4.74	0.75
1985	152	35	76	75	2,782,696	5.46	1.26
1986	117	32	67	63	2,913,358	4.02	1.10
1987P	98	31	68		2,900,000	3.38	1.07

P Preliminary data.
Source of estimate: FAA.

Table 3

Fatal Accidents and Fatalities
U.S. Air Carriers Operating Under 14 CFR 135
All Scheduled Service
(Commuter Air Carriers)
1987 (Preliminary Data)

					Fatalities			
Date	Location	Operator	Service	Aircraft	Psgr.	Crew	Other	Total
1/15	Kearns, Utah	Sky West	Psgr	Swearingen SA-226TC	6	2	10	8
3/4	Detroit, Mich.	Northwest Airlink	Psgr	Casa C-212	7	2	9	18
5/8	Mayaguez, Puerto Rico	American Eagle	Psgr	Casa C-212	0	2	0	6
5/27	Atlantic Ocean	Aero Coach Aviation	Psgr	Cessna 402C	0	1	1	1
8/8	Crooked Creek, Alaska	Hermans Inc.	Psgr/ Cargo	Cessna 207	0	1	1	1
9/28	Freeport, Bahamas	Caribbean Express	Psgr	Embraer EMB 110-P-2	0	0	1	10
11/23	Homer, Alaska	Ryan Air Service	Psgr	Beech BE-1900C	16	2	0	21
12/22	Chadron, N.M.	Regional Express	Psgr	Cessna 402C	0	2	0	3
12/23	Kenai, Alaska	South-Central Air	Psgr	Piper PA-31-350	5	1	0	6
12/23	Maunaloa, Hawaii	Panorama Air	Psgr	Piper PA-31-350	7	1	0	8

Table 4

Fatal Accidents* and Fatalities
U.S. Air Carriers Operating Under 14 CFR 135
On-Demand Air Taxi
Calendar Year 1987

Date	Location	Aircraft	Injuries* F	S	M	N	Phase	Reported Type of Accident
1/5	Albuquerque, N.M.	CN T21OM	1	0	0	0	Climbout	Collided with terrain in bad weather.
1/8	Pollockville, N.C.	Bell 206L	4	0	0	0	Emergency Descent	Fire-forced landing. Loss of control.
1/14	Kenai, Alaska	CN 207A	1	4	2	0	Maneuvering	Collided with terrain.
1/16	Cima, Calif.	CN 208	1	0	0	0	Cruise	Collided with terrain.
1/29	Bedford Park, Ill.	CN 210N	1	0	0	0	Cruise	Airframe/system failure. Loss of control.
2/5	Matagorda, Guam	Bell 206L	2	1	1	0	Emergency Landing	Collided with terrain.
2/18	Quincy, Ill.	BH E18S	2	0	0	0	Emergency Descent	Loss of power/control. Collided with terrain.
3/27	Eagle, Colo.	Lear Jet 24A	3	0	0	0	Approach	Crashed with terrain. Fire after impact.
3/29	Kona, Hawaii	Bell 206B	1	2	2	0	Maneuvering	Loss of Power. Ditching.
4/15	Laupahoehoe, Hawaii	Bell 206B	1	1	0	0	Hovering	Crashed into high ground.
4/23	Wilmington, N.C.	Swearingen SA-226TC	2	0	0	0	Emergency Descent	Mechanical failure/ power loss. Collided with objects.
5/7	Nightnute, Alaska	PA-31-350	1	0	0	0	Maneuvering	Collided with terrain.
5/13	Sayre, Pa.	PA-32-300	2	1	0	0	Takeoff	Crashed with terrain. Fire after impact.
6/21	Bridgeport, Calif.	Aero Com. 690	2	0	0	0	Approach	Loss of control due to power loss.
6/24	Hilliard, Fla.	Aero Com. 690	2	0	0	0	Climb to cruise	Airframe/system failure. Loss of control.

Date	Location	Aircraft	Injuries* F	S	M	N	Phase	Reported Type of Accident
6/25	Tannersville, N.Y.	PA-32R-300	1	0	0	0	Cruise	Collided with terrain.
6/26	Boston, Mass.	PA-34-200T	1	0	0	0	Emergency Descent	Loss of control. Collided with high ground.
7/4	Venice, La.	AS 355 F	1	0	0	0	Emergency Descent	Airframe/system failure. Collided with terrain.
7/20	Chicago, Ill.	CN 402B	1	0	0	0	Takeoff climb	Lost control and crashed due to loss of power.
8/21	Washington, D.C.	Bell 206B	3	1	0	0	Hovering	Crashed due to loss of control.
9/21	Hailey, Idaho	CN T210L	3	0	0	0	Climb to cruise	Loss of control.
9/25	Miami, Fla.	BH 18S	2	0	0	0	Takeoff climb	Loss of control. Fire after impact.
10/8	Memphis, Tenn.	BH TC-45L	1	0	0	0	Climb to cruise	Crashed into high terrain.
10/23	Oshtemo Town, Mich.	Ted Smith Aerostar	1	0	0	0	Cruise	Crashed into woods. Burned due to loss of an engine.
10/23	Fairfield, Calif.	CN 208A	1	0	0	0	Cruise	Encountered severe turbulence and lost control.
11/4	Bellingham, Wash.	CN 310N	4	0	0	0	Maneuvering	Collided with terrain.
12/10	Ambler, Alaska	CN 207	1	0	0	0	Cruise	
12/18	Wedron, Ill.	BH 58	1	0	0	0	Emergency Descent	Crashed during uncontrolled approach.
12/21	Eugene Island, Guam	SA 330J	15	0	0	0	Emergency Landing	Collided with objects. Fire after impact.

* Injuries F - Fatal
S - Serious
M - Minor
N - None

* NTSB reported that in 1987, U.S. on-demand air taxis were involved in 31 fatal accidents. However, only 29 fatal accidents were listed in Table 4. The records of 2 fatal accidents could not be identified.

Accident/Incident Briefs

Tire Blew On Takeoff

United Kingdom - April

BAC-111: Minor damage, no reported injuries.

The BAC-111 was taking off from Gatwick Airport for Charles De Gaulle, Paris, when a tire burst. The aircraft circled the airport and landed safely back at Gatwick. Passengers deplaned without incident. The airplane suffered damage to the port inner main tire, hydraulic lines, undercarriage and the underside of the port wing and flap.

Crash Into Mountain

Union of Soviet Socialist Republics - No date

L-410: Aircraft destroyed, fatal injuries to 17.

The airliner was flying in a Siberian blizzard from Muya, a settlement in the Tiaga Forest, to Bagdarin, a regional center, when it flew into a mountain. The aircraft broke apart upon impact, killing the 15 passengers and crew of two.

De-Fence Flight

United Kingdom - No date

B-727: Minor damage to aircraft, garden fence destroyed, no injuries.

The flight from Reykjavik, Iceland, to London was approaching Heathrow Airport when a 65-pound gear door fell off the airplane and landed in the back garden of a home near the airport. The six-foot-square panel demolished a fence but there were no injuries. The airliner, with 76 passengers and a crew of six, landed safely. Initial investigation revealed that some of the attachment fittings had apparently sheared off; no reason was found for the occurrence.

Heavy Single

Japan - May

B-747: No damage, no injuries to 258.

The 747 was about an hour and 15 minutes into a flight from Tokyo to Los Angeles when an engine failed and the captain decided to turn back. Thirty minutes later another engine failed. Then, prior to landing at Tokyo International Airport, a third engine failed. The aircraft, with 239 passengers and a crew of 19, landed safely and taxied to the terminal on the one remaining engine. The cause of the triple engine outage was under investigation.

Abort At V_1

Hong Kong - October 1983

B-747: Substantial damage, no injuries.

The final report on this takeoff accident at Hong Kong International Airport is a good example of the combination of ingredients that frequently produces an aviation accident.

After some crew discussions about the surface wind in relation to the aircraft takeoff weight, the jumbo jet began a rolling takeoff under the copilot's control on runway 13 with a wind of 090 at six knots. There were no passengers aboard.

Although all engine parameters were within normal ranges in the initial stages of the takeoff roll, flight data recorder (FDR) information later showed that at about 56 knots IAS the EGT and rpm of engine number 2 began to rise above those of the others; the cause was subsequently attributed to separation of the stage one blade retainer for the high-pressure turbine rotor. The flight engineer noted the readings and reduced throttle settings to bring engine number 2 in line with the others.

Meanwhile, the aircraft was accelerating toward the computed V_1 of 157 knots and V_R of 168 knots. The rpm of engine number 2 began to decrease both because the engineer had retarded the throttle and because of the reduced engine efficiency due to the deterioration of the high-pressure turbine. The EGT continued to rise and by 125 knots

Data reported in the accident/incident briefs on this and the following pages are based upon preliminary information obtained from agencies and organizations participating in the FSF Accident Prevention Program, as well as the news media. They are subject to future revision.

had reached 990 degrees C and should have been shut down. According to the cockpit voice recorder (CVR), the flight engineer reported his concern with the engine to the captain and called for the takeoff to be discontinued at 154 knots. By then, the control column was being pulled back to initiate the rotation.

The captain took control, called “Stop,” closed the throttles, selected reverse thrust and applied full braking. The captain and the flight engineer thought the aircraft would stop safely by the end of the runway and felt that full reverse thrust was being developed by all engines (the number 2 EGT had returned within limits when the throttles were retarded). However, number 2 engine did not actually develop full reverse thrust. As the aircraft was decelerating through 90 knots, a veer to the left began. The captain said he was unable to maintain runway alignment because of the need to maintain full braking.

At a speed of about 55 knots, the airplane ran off the left side of the runway onto the grass 500 feet prior to the end of the runway. It came to rest on soft ground with all landing gear collapsed and the fuselage and engine nacelles resting on the ground. When the nose gear collapsed, it caused severe deformation of the forward fuselage. There was no fire. The crew completed shutdown checks and left the aircraft through the upper deck door using a ladder provided by rescue services.

The cause of the accident was attributed to the takeoff rejection at too high a speed, probably in excess of V_1, at a point where there was not enough runway left to stop. Contributing factors included the effective loss of about 400 feet of runway during the line-up, the rolling takeoff procedure which was calculated to have incurred an additional 900-foot runway distance penalty; the attempt to fix the problem with engine number 2 rather than abandon the takeoff at an earlier point; and, the practice of locating an airspeed indicator bug at the V_2 speed rather than V_1 which may have been more helpful to the crew’s go or no-go decision.

Operational safety recommendations arising from this accident recommended that published takeoff performance calculations include an allowance for the loss of effective runway length based upon the type of line-up procedure. It also suggested consideration be made to prohibit rolling takeoffs when the aircraft is close to maximum weight for the runway and prevailing conditions. Additionally, operators should consider bugging V_1 and V_R speeds prior to beginning the takeoff and a method should be found to indicate to the crew whether aircraft acceleration during takeoff equals the values predicted in the flight manual.

Captain Dies During Landing

United States - No date

DC-10: No damage, no injuries.

During the approach to Newark International Airport, the copilot noted that the approach became erratic on short final and that the airplane landed at a higher than normal sink rate. Shortly after touchdown, when the captain groaned, the copilot thought it was merely a reaction to the harder than normal landing. However, the captain then slumped forward and remained motionless. The copilot took control of the aircraft, reported the emergency to the control tower and continued taxiing to the gate while flight attendants administered CPR until paramedics arrived after docking. The captain could not be revived and later was pronounced dead.

It was discovered afterwards that the captain had been grounded in 1975 because of an abnormal cardiac history accompanied by hypertension. After recovering, he did well enough on stress tests and was put back on flying status with the provision that the airline would monitor his physical condition. Later, during cost-cutting efforts, the airline dropped its physical examination program for flight crews and stopped monitoring this captain. However, he stated that he was still in his airline’s monitoring program during subsequent six-month FAA physical exams.

During the six months prior to his fatal attack, the captain had been treated by a doctor and was receiving medication for his hypertension and his heart ailment. The doctor said he knew that his patient was employed by an airline but not that he was a pilot. When the pilot took his last flight physical, the FAA examiner noticed an EKG irregularity and told the captain to send a stress test to the agency’s aeromedical center in Oklahoma City. He didn’t, and the FAA didn’t follow up.

Air Taxi/ Commuter

Engine Failure

United States - March

Jetstream 31: Aircraft destroyed, no reported injuries to two.

The aircraft was on a mid-afternoon positioning flight near Decatur, Texas. One engine failed and a forced landing was attempted. During the emergency landing the aircraft was destroyed. No injuries were reported to the two crew members, the only occupants aboard.

Engine Fire On Takeoff

United States - No date

DHC-8: Aircraft destroyed, 19 injuries, no fatalities to 40.

The airplane had just taken off from Seattle-Tacoma International Airport with 40 people on board for a flight to Spokane, Wash., and Lewistown, Idaho, when the starboard engine caught fire and experienced a significant loss of power. During a hard emergency landing at the airport, all power and braking were lost. The pilot steered the airplane past a crowded terminal area, striking a number of baggage carts and other ground equipment, continuing to a gate area that was vacant, and crashing into three passenger ramps before stopping. Rescue crews were able to foam the aircraft in less than two minutes after it came to rest and, of the 19 injured passengers, none received life-threatening injuries.

Nose Gear Collapsed

United Kingdom - January

Piper PA-31 Navajo: Minor damage, no injuries to three.

During the preflight inspection by flashlight for an early January morning scheduled passenger flight from Humberside Airport to Glasgow, Scotland, the aircraft commander noticed the underside of the right wing around the landing gear was covered with hydraulic fluid. Because of a history of hydraulic leaks, this was not considered extraordinary enough for further investigation.

When the gear was raised after takeoff, the gear-down lights went out but the in-transit indicator remained lit and the gear selector did not return to the neutral setting. Since moving the selector to neutral did not help, the gear lever was placed in the down position; only the right main down light illuminated. A fly-by indicated that all the gear appeared to be down. The pilot flew to another airport, where the company's maintenance base was located, and on the way was able to yaw the left main gear down and got a locked indication. He tried to lock the nose gear by putting the selector in the down position and pumping the manual pump handle, which was stiff and would not move more than an inch. With no lock indication, he returned the lever to neutral.

The pilot advised the two passengers on the nature of the problem and instructed them to occupy seats facing the rear cabin door and to be prepared for a quick exit if the gear collapsed on landing. Weather was clear for the landing attempt. The pilot turned the master switch off on final and feathered the propellers before touchdown. The nose gear collapsed when it was lowered to the surface. The aircraft stopped in about 300 feet, slightly off the runway centerline, and the occupants evacuated safely according to plan in about 10 seconds. Aircraft damage was limited to the nose structure.

After the aircraft was ferried gear-down to an overhaul facility, investigation revealed that the hydraulic reservoir fluid level in the gear system was below the standpipe that supplied fluid to the engine-driven gear pumps. Fluid below the pipe supplied the emergency gear-lowering system, and was sufficient for the purpose, but this system had failed to lock the nose gear down. There was not enough fluid, though, above the standpipe for the engine-driven gear pumps. The loss of fluid was traced to leaking right-hand filter seals; three of these leaks had occurred in the previous month.

Corporate Executive

Reluctant Gear Door

United Kingdom - March

Piper PA-23 Aztec: Minor damage, no injuries to two.

After the gear was selected down during final approach to Ronaldsway Airport on the Isle of Man, the gear lever returned to neutral but the right main landing gear down light did not illuminate. The pilot executed a go-around and had the gear checked visually by control tower personnel. They confirmed that the right main gear had not extended.

Because Blackpool was the aircraft's maintenance base, the pilot flew there and made several attempts to lower the gear, including several touch-and-go landings. After all attempts to lower the right main fear proved unsuccessful, the pilot feathered the right propeller and landed with two stages of flaps. The aircraft sustained only minor damage during the landing and the crew evacuated with no injuries. Aircraft damage was limited to the right wing tip, aileron and flap, and to the boarding step. The right main gear doors also were damaged.

Later examination showed that the right main gear door actuator bearing and retaining body had broken and were separated from the steel support. Although the landing gear was free to move, the gear door remained closed and locked, effectively locking the gear up at the same time.

Snapped Cable

United Kingdom - April

Beech C-90 King Air: No damage, no injuries.

While the pilot was trying to install the control locks after engine shutdown, he discovered that the control column would not move forward of the neutral elevator position. Movement was free in the elevator up positions.

It was later found that the autopilot pitch bridle cable had broken and became wrapped around the servo capstan, preventing the control column from moving forward beyond the neutral position.

Other General Aviation

Unfriendly Lagoon

Ceylon - April

Cessna 206: Aircraft destroyed, fatal injuries to one.

The airplane was at an altitude of 5,000 feet during a flight from Colombo when the pilot reported to ground control that he had hit bad weather and the airplane was "wobbling." Radio contact was then lost and the airplane disappeared. The aircraft crashed into Puttalam Lagoon about 110 miles from Colombo, killing the pilot, the sole occupant.

Midair Collision

Italy - April

Cessna 150, SA.260TP: Both aircraft destroyed, fatal injuries to two, unspecified injuries to two.

The two airplanes collided in midair at Vergiate, 30 miles northwest of Milan. Each aircraft had two occupants. The Cessna crashed into a field on the outskirts of town, killing both occupants, and the SA.260 crashed onto the roof of a residence in the center of the town; both occupants of the airplane were injured but there were no casualties on the ground.

Engine Quit

France - April

Pilatus: Aircraft destroyed, fatal injuries to eight, serious injuries to two.

The airplane had just taken off from an airport in Lens, northern France, with nine recreational parachutists and a pilot, when the engine abruptly stopped. The pilot attempted to glide back to the airport but missed it and crashed into a quarry approximately 900 feet from the runway. The pilot and seven of the parachutists were killed and the remaining two occupants were seriously injured.

Cow In The Way

New Zealand - No date

Piper PA-38: Substantial damage, no injuries to one.

After passing the Pudding Hill Aerodrome during a solo cross-country flight, the pilot encountered weather conditions that prompted him to return to this airport for an unplanned landing. He saw a cow on the grass strip and made a low inspection pass; he decided to land to the left of the grazing animal. During the landing off the marked airstrip, the aircraft ran into a small ditch and the right main gear was torn off.

The Rapid Turnaround That Wasn't

New Zealand - No date

Fletcher FU-24:   Substantial damage, no injuries to one.

The agricultural aircraft was engaged in an aerial top dressing operation and had landed to take on another load. The resupplying area required a right turn after loading to line up for takeoff. When the loader was finished and began to back up from the left side of the airplane, the pilot added power and released the brakes. The pilot lost sight of the loader during the right turn and the left tip of the stabilator hit the loader, causing substantial damage to the aircraft. The pilot reported that the accelerator of the loader sometimes hesitated and that this may have caused the machine to back away from the airplane slower then expected.

Snagged Utility Lines

Rotorcraft

United States - April

Aerospatiale AS355: Rotorcraft destroyed, fatal injuries to two, serious injuries to one.

While flying the victim of a traffic accident to a hospital, the helicopter pilot radioed the dispatcher to report that he was running into bad weather and was going to turn back and head for another hospital. The aircraft subsequently hit a power line and crashed in mountainous terrain about 50 miles northeast of downtown Los Angeles. Rescuers reported that debris was spread 100 yards around a snapped power line. The pilot and an attending nurse were killed and the patient was critically injured. A police helicopter took the survivor to a hospital where he underwent emergency surgery.

Crash Into River

Italy - No date

Bell-206: Helicopter damage unspecified, fatal injuries to three.

The helicopter was hired to film footage for the state-run television network. Aboard were the pilot, a television technician and a scripwriter. The aircraft struck a high-tension power cable and crashed into the River Stura, nine miles northwest of Turin. The technician was killed instantly. The other two occupants were alive when they were removed from the wreckage in the river but died on the way to a hospital.