An Unfortunate Pattern Observed in U.S. Domestic Jet Accidents

On established U.S. airlines during the period from 1975-89, domestic jet flights that suffered major crashes had nearly twice as many passengers on board as other flights. This excess arose because these flights had both higher seating capacity and far fewer empty seats than usual. The pattern was of very high statistical significance.

by
Arnold Barnett, Ph.D., and Todd Curtis
Sloan School of Management
Massachusetts Institute of Technology
Cambridge, Massachusetts, U.S.

On established U.S. airlines[1] during the past 15 years, the death risk per domestic jet flight has been about one in 10 million. At that rate, a traveler who took one flight at random each day would go 26,000 years on average before being killed in a fatal crash.

Such statistics have been cited to suggest the extraordinary level of safety of U.S. commercial aviation. (The December 1990 *Reader's Digest,* for example, contained an article, "Fly Without Fear," that quoted the second figure above.) But, as usual for risk measures, some qualifying remarks are warranted. The numbers reflect overall averages, which may be optimistic in certain settings. (It has been estimated, for instance, that landings and takeoffs in thunderstorms are at least 400 times as dangerous as those at other times.) Moreover, the calculations are predicated on a completely random choice among flights. But passengers do not select flights at random; as an example, they appear in greater numbers on an average Boeing 747 than on an average McDonnell Douglas DC-9, and on flights the Wednesday before Thanksgiving than on the third Wednesday in January.

So long as travelers do not fly in disproportionate numbers on "hazard-prone" flights, nonuniformities in passenger demand would not bias the aggregate estimate of death risk. One can imagine reasons, however, why this condition might not be satisfied. The authors, therefore, considered it useful to investigate the issue empirically and, in this note, present the results of that investigation.

We indicate that U.S. jet flights, which recently suffered major crashes, averaged nearly twice as many passengers on board as U.S. jet flights that were uneventful. This statistically-significant excess results from two phenomena: a strong association between load factor (percentage of seats occupied) and the risk of a major crash; and, an over-representation of widebody jets among ill-fated aircraft.

Major Crash Defined

In assessing whether more fully occupied flights are statistically riskier than others, it is important to not define "major crash" in a way that artificially induces such a pattern. If, for example, a major crash were defined as one that killed at least 250 passengers, the resulting "finding" that widebody jets accounted for all major crashes would be inappropriate.

In this discussion, we define a crash as major if it results in the death of at least 20 percent of the passengers on board. In practice, the dichotomy "above/below 20 percent" partitions crashes into two vastly different clusters; the former generally entail low survival rates and the heavy loss of life, while the latter usually involve three or fewer fatalities.

... we defined a crash as major if it results in the death of at least 20 percent of the passengers on board.

Data Source Timeframe Established

We focus this study on major U.S. domestic jet crashes over the 1975-89 period on established U.S. air carriers. This emphasis is considered advantageous for three reasons:

- Major crashes caused 98 percent of the deaths on such carriers in that period, and reflect all threats to domestic jet safety that actually took an appreciable toll in lives.

- After two decades of rapid improvement in safety, the mortality risk of domestic jet travel stabilized in the mid-1970s. There was no discernible time-trend in risk over the 15 year span from 1975 to 1989. Thus, this period seems more illuminating about current risks to U.S. air travelers than any longer (or shorter) time span.

- The deregulation of the domestic air transportation industry in 1978 led to the formation of dozens of new jet carriers. Almost all of them have since ceased operations but, while they were active, their collective safety record was inferior to that of "established" U.S. airlines formed well before deregulation. The experiences of these now-defunct carriers are of doubtful relevance to risk patterns today.[2]

From 1975 to 1989, the established U.S. airlines suffered 10 major crashes that, as noted, caused 98 percent of all their jet-passenger deaths. (Nine fatal incidents averaging three deaths each accounted for the other two percent.) Table 1 summarizes key information about these 10 crashes. As noted, our aim here is to investigate not the frequency of major crashes, but whether the flights listed in Table 1 had appreciably different passenger loads than a random sample of 10 domestic jet flights.

Effect of Load Factors Questioned

We consider first whether the aircraft in Table 1 had significantly different percentages of seats occupied (passenger load factors) than did domestic jets as a group. Although a high passenger load factor cannot in itself cause a major jet crash, it might increase the probability that some other factor will cause such an event:

- Compared to other aircraft, fully loaded ones go further down the runway before lifting off, climb more slowly and have higher stall speeds than more lightly loaded aircraft. These circumstances reduce the time and flexibility that the pilot of a heavy aircraft has to respond to emergencies at takeoff.

- During high-traffic periods, security personnel may be under greater stress and be less able to scrutinize each passenger at boarding. Moreover, terrorists might be especially desirous of causing a high death toll[3]. Thus, crowded planes could be more vulnerable to sabotage than others.

- Conceivably, a greater pressure to "keep things moving" in high-traffic conditions can lead to diminished conservatism in operating procedures.

Even if higher passenger load factors do not contribute to air crashes, these crashes may nonetheless tend to occur at times when crowding is unusually high:

- The busy summer vacation season coincides with the period when weather hazards such as thunderstorms are most numerous.

- Because more flights operate during morning and evening rush hours, the risk of midair and runway collisions may be higher at these times. But because rush-hour flights are crowded, a disproportionate number of passengers may be exposed to the higher risk.

Table 1 enables us to move beyond speculation and to test empirically the hypothesis that, in present day domestic jet operations[4], load factor is unrelated to the risk of major crash.

Two Statistical Tests Considered

We test the no-association (unrelated) hypothesis in two ways. The first emphasizes a statistic at the bottom of Table 1; the average seat occupancy rate (load factor) of the 10 accident flights was 84.7 percent. In contrast, U.S. Department of Transportation (DOT) data yield a mean load factor of 59.4 percent for domes-

Table 1
The 10 Major Crashes of Domestic Jet Flights of Established U.S. Air Carriers, 1975-1989

Date	Airline**	Aircraft**	Seating Capacity	Load Factor*	Death Rate
6/24/75	EA	72S	134	86.6(%)	91.4(%)
4/4/77	SO	DC9	85	95.3	76.5
9/25/78	PS	72S	157	81.5	100
5/25/79	AA	D10	258	100	100
7/9/82	PA	72S	137	100	100
8/2/85	DL	L10	302	50.7	83.6
8/16/87	NW	M80	150	99.3	99.3
11/15/87	CO	DC9	85	89.4	32.9
12/7/87	PS	146	88	44.3	100
7/19/89	UA	D10	281	100	39.9
Average			167.7	84.7	

Notes:

*Load Factor is percentage of seats occupied; death rate is percentage of passengers killed. Seating capacities refer to the specific aircraft that crashed.

**Airlines: AA-American, CO-Continental, DL-Delta, EA-Eastern, NW-Northwest, PA-Pan Am, PS-PSA, SO-Southern, UA-United

***Aircraft: DC9-DC-9 Series 10, 72S-Stretch Boeing 727, D10-DC10, L10-L-1011, M80-DC-9 Series 80,126-BAC 146

A crash is defined as major if it killed at least 20 percent of the passengers on board. Major crashes cause 98 percent of all domestic jet passenger deaths in 1975-89.

tic jet flights from 1975 to 1989[5] (the mean load factor for established carriers only is within a fraction of a percentage point of this last figure[6]). Thus, jet aircraft with major crashes had load factors that averaged *more than 25 percentage points higher* than the overall domestic jet load factor. Even when account is taken of the sampling error in data with only 10 observations, the probability of setting a 25-point excess by chance alone is well below one in 1,000 (see Appendix).

The second approach starts with a histogram (see Table A1 in Appendix) of load factors for domestic jet flights for the period of 1975 to 1989 (we estimated this histogram from the actual distribution of load factors on recent domestic Delta Air Lines jets, making some slight adjustments to achieve a mean of 59.4 percent). The test arises from the question, "If 10 flights were chosen at random, what is the chance that their load factors would fall as heavily towards the upper tail of the histogram as did the 10 load factors in Table 1?" The answer, once again, is less than one in 1,000.

In other words, whether the test starts with the load factors of aircraft involved in major crashes or with the overall load-factor distribution, very high statistical significance attends the higher seat occupancy rates on flights in Table 1. Table 2 amplifies on this pattern by portraying the death risk per flight as a function of load factor. Although the statistics are subject to considerable imprecision, the table suggests that the mortality risk on flights with load factors above 75 percent was more than five times as high as that on aircraft less than three-quarters full.

Aircraft Size and Capacity Related

The number of passengers aboard a flight depends not only on the fraction of seats occupied but also the number of seats available. The seating capacities of aircraft in the U.S. domestic jet fleet vary from 60 (Fokker F28) to 400 (Boeing 747). If there is any correlation between aircraft size and the risk of a major crash, then, quite apart from any load-factor effects, the percentage of flights involved in major crashes will diverge from the percentage of passengers involved. Hence, it is worthwhile to explore the possibility of such correlation.

The 10 aircraft in Table 1 had an average seating capacity of 167.7. Within the full set of domestic jet flights from 1975 to 1989, the average aircraft that took off had approximately 135 seats available. (This estimate is derived by weighting the usual seating capacity of each type of jet by the percentage of flights performed by the jet.) Thus, flights involved in major crashes had roughly 25 percent more seats than flights in general, a difference corresponding to about two standard deviations. In its own right, this outcome is of borderline statistical significance (see next to last paragraph of Appendix).

The reason for the high average capacity in

Table 2
Approximate Death Risk Per Flight as a Function of Load Factor, Domestic Jets on Established U.S. Carriers, 1975-89

Load Factor Range	Percentage of Flights in Range	Death Risk Per Flight
0 - 50%	40(%)	1 in 26 million
50 - 75%	26	1 in 18 million
75 - 100%	34	1 in 4 million

Notes: These "death risk per flight" statistics assume a random choice among flights in the corresponding load factor range. The calculations take account of all fatal incidents, even those with small numbers of deaths that were not included in Table 1.

Table 1 is that three of the 10 crashes (30 percent) involved widebody jets (two DC-10s and one L-1011). Yet, an analysis of schedules indicates that, during the 1975-1989 period, widebody jets (747s, DC-10s, L-1011s, 767s, and Airbuses) performed only about seven percent of U.S. domestic jet flights by established carriers. The discrepancy between 30 percent and seven percent implies that widebody jets suffered roughly six times as many major crashes per million flights as did smaller jets. Even after taking account of such relevant considerations as the higher-than-average survival rate during these widebody crashes (25 percent vs. 14 percent for the others), a factor-of-five difference persists between the fraction of widebody jet passengers who perished in crashes and the corresponding fraction for other jets.

... but those that suffered major crashes had five-sixths of their seats occupied.

Passenger Loads Put Into Perspective

On average, U.S. domestic jet flights from 1975 to 1989 were three-fifths full, but those that suffered major crashes had five-sixths of their seats occupied. Thus, the aircraft that crashed had 1.4 times the load factor of those that did not. Furthermore, the seating capacity on high-casualty flights was 1.25 times the average for all flights. Although the average domestic air carrier jet had 80 passengers on board between 1975 and 1989, those in Table 1 averaged 142, i.e., about 80 percent more. To put it another way, the 10 aircraft that suffered major crashes had as many passengers on board as 18 jets with average loads.

Calculations reveal that, if 10 domestic jet flights operated during the years 1975-1989 were chosen at random, the total number of passengers aboard would on average be 800. The chance that the 10 flights would carry more than 1,400 passengers would only be one in 5,000. Yet the flights in Table 1 carried a total 1,418 passengers. Under the circumstances, it would seem farfetched to dismiss the high Table 1 loads as a statistical "fluke."

On the other hand, one would not necessarily expect the same pattern to prevail in all places at all times. During 1975 to 1989, established U.S. domestic air carriers amassed the best aggregate safety record in the history of civil aviation.[7] Certain kinds of crashes (such as collisions with mountains) had all but disappeared from domestic jet operations. Since such crashes bear little obvious relation to passenger load, their more frequent presence in less-safe national air transportation systems might act to weaken the linkage between major crashes and high load factors.

In this connection, it is interesting to note that data such as that in Table 1 but for 1965-74 — when major crashes per million U.S. domestic jet flights were three times as numerous as for 1975-89 — would show that the average load factor on jets that crashed was only modestly higher than the mean for all jets (61 percent vs. 53 percent) during that earlier period.

If U.S. jet load factors were more uniform, the unhappy juxtaposition of disasters and heavy crowding would presumably arise less often. If, to pick an extreme example, all flights operated at load factors of 60 percent (roughly the present national mean), then the planes that suffered major crashes would necessarily be 60 percent full. Even it the number of major crashes did not decline at all, having seat occupancy rates of 60 percent on ill-fated planes rather than 85 percent could cut the number of passengers killed by nearly one-third.

Indeed, reducing the variance of jet load factors (while keeping the mean constant) might do more than any innovation in technology or training to reduce the minimal death risk that remains in the domestic jet system. One must be realistic, however; business travelers will not fly at 2:00 a.m., and trips home for Christmas will not be replaced by visits at Halloween. But the possibility that off-peak flights may be safer as well as cheaper could increase their attractiveness to some passengers. And even a limited reduction in load-factor variance could save some lives.

On a more immediate matter, we should adjust the introductory statistic in this article "26,000 years until a fatal crash" to reflect the tendency of doomed planes to have unusually high numbers of travelers on board. Assuming that passenger loads on aircraft involved in major crashes are 80 percent above average, we reach an alternative statement: A traveler who chose one domestic U.S. jet flight each day under present travel patterns would on average go 14,000 years before perishing on an airplane. Given our expected natural lifespans of seventy years, even this revised prognosis should not alarm U.S. air passengers[8].

Appendix: Statistical Significance of the Pattern Concern Load Factors

Suppose that the risk patterns of 1975 to 1989 were to prevail, and let L be the long-term average of load factors on U.S. domestic jets with major crashes. Although we do not know L, we do know that the load factors for the 10 crashes in Table 1 averaged 84.7 percent and had a sample standard deviation of 20.7 percent. According to traditional sampling theory, 84.7 percent is an unbiased estimate of L, and the standard error assigned to the estimate is $20.7/\sqrt{(10)} = 6.6$. The 59.4 percent average load factor for all domestic jet flights for 1975-89 was $(84.7 - 59.4)/6.6 = 3.8$ standard deviations below the estimate of L. Whether under a normal or a t-distribution (used for smaller samples) approximation, the chance that statistical fluctuations could generate such a large discrepancy is far below one in 1,000.

Table A1 presents estimates of various percentiles of the distribution of domestic jet load factors for 1975-89. The chart indicates the fraction of U.S. jet flights with load factors at or below a particular threshold number. For example, 20 percent of such flights had load factors of 32 percent or less, while 80 percent had factors exceeding 32 percent. Thus, in statistical parlance, 32 percent is the 20th percentile of the load-factor distribution.

If a jet flight were picked at random, then on average its load factor would fall at the 50th percentile of the distribution, with about half of all flights having higher load factors and the other half lower ones. But the 10 flights in Table 1 tend to have high percentile scores reflecting their unusually-high levels of seat occupancy. The Eastern jet that crashed in 1975, for example, had a load factor of 90.6 percent, which is approximately the 78th percentile of the distribution.

The average percentile score for the 10 flights in Table 1 was 79, fully 29 points above the average of 50 that one would expect for 10 randomly-chosen flights. Exact calculations (based on the relevant sum of uniform random variables) reveal that, for such an excess to arise by chance alone, an event with the probability of one in 2,300 must take place. Such an outcome works strongly against the

Table A1
Approximate Distribution of Load Factors, 1975-89, Domestic Jet Flights on Established U.S. Carriers

Percentile	Corresponding Load Factor
(0)	(0)
10	23
20	32
30	42
40	50
50	59
60	68
70	80
80	88
90	96
(100)	(100)

This chart indicates, for example, that roughly 40 percent of the domestic jet flights had 50 percent or fewer of their seats occupied, while 50 percent had 59 percent or fewer. (Thus, 50-40-10 percent of all flights had load factors between 50 percent and 59 percent.)

hypothesis that no relationship exists between load factor and major-crash risk.

From detailed explorations of airline schedules in the *Official Airline Guide*, the authors estimated that, during the 1975-1989 period, the number of seats on U.S. domestic jet flights had a mean of 135 and a standard deviation 47. Thus, if 10 such flights were selected at random, their average number of seats would have a mean 135 and a standard deviation of $47/\sqrt{(10)}$, which is about 15. Thus, the sample mean of 167.7 is slightly more than two standard deviations above the population mean.

The point of these calculations is that dismissing the difference between 84.7 percent and 59.4 percent or 167.7 seats and 135 seats because "only" 10 major crashes were studied would be inconsistent with usual standards of statistical inference.

Footnotes

1. By "established U.S. jet carriers," we include those U.S. airlines with extensive jet operations prior to the Airline Deregulation Act of 1978: Aircal, Alaska, Aloha, American, Braniff, Continental, Delta, Eastern, Hawaiian, National, Northwest, Ozark, Pan Am, Piedmont, PSA, Republic, Southern, Southwest, Texas International, TWA, United, USAir, and Western.

2. Barnett and Higgins (see Reference) found that, in a statistically-significant discrepancy, death risk per jet flight in 1979-86 averaged 13 times as high on the new entrants as on established carriers (these new entrants are listed on page 14 of that paper). However, the two main survivors among the new carriers — Midway and America West — have had no major crashes thus far.

3. We are grateful to Steve Cohen of the U.S. Federal Aviation Administration (FAA) for making this point, as well as many other insightful points that helped us in our research.

4. In the remainder of this paper, all references to domestic jet operations should be understood as pertaining only to established airlines.

5. The statistic 59.4 percent is based on annual domestic jet load factors for the years 1975-89 in "Air Carrier Traffic Statistics," distributed in early years by the U.S. Civil Aeronautics Board (CAB) and later ones by the U.S. Department of Transportation (DOT). Individual years were weighted by their number of flights. Although official load-factor calculations consider the lengths of individual flights, their little evidence that load factors on long flights differ substantially from those on shorter ones. In the Delta Air Lines data we used, the distance-weighted seat occupancy rate was slightly higher than the unweighted one; that outcome hints that 59.4 percent might overstate the load factor for a flight chosen at random.

6. During 1975-89, established carriers (as listed above in Footnote 1) performed 95 percent of all U.S. Federal Aviation Regulation (FAR) Part 121 scheduled jet flights. Most of the remainder were performed by Midway and America West, which had load factors close to the industry average. Although Midway and America West data contributed to the DOT load-factor data, eliminating them would only alter the mean of 59.4 percent by a few-tenths of a percentage point.

7. By this we mean that no sizable homogeneous group of airlines (e.g., Western European flag carriers) has ever achieved a better cumulative record than did established U.S. domestic airlines during 1975-89. Of course, small individual airlines can go for decades without any crashes.

8. The first major domestic jet crashes of the 1990s occurred on 2/1/91 and 3/3/91. We lack full data to expand the observation period to cover these crashes (in any case, the length of that period should not be determined by events in the process under study); for completeness, however, we briefly discuss these crashes below:

The first took place in evening rush hour at Los Angeles International Airport. The Boeing 737-300 involved had a load factor of 65 percent. Given the drop of air travel in early 1991 because of recession and fears of terrorism, the average domestic load factor around the time of the crash was perhaps 10-15 points below that on the ill-fated jet. The accident seems consistent with the general pattern discussed in the paper.

The second occurred in Colorado Springs on a Boeing 737-200 with a load factor of only about 17 percent. Obviously, that crash does not epitomize the pattern found in 1975-89; as Table 2 suggests, however, there was never any implication that sparsely-crowded planes were invulnerable to disaster.

Even if the two crashes were included in Table 1 (as if they had occurred 1975-89), the average load factor on planes with major crashes would be more than three standard deviations above the mean for all flights. Moreover, the average number of travelers on the crashed planes would be more than three standard deviations above the all-flight average. Thus, the statistical significance of the overall pattern remains high even if the new major crashes are fully included in the calculations.

Reference

Barnett. A. and M.K. Higgins, "Airline Safety: The Last Decade," *Management Science*, 35(1), pp. 1-21 (1989).

Research for this article was supported in part by Contract DTRS57-88C-00078TD28, U.S. Federal Aviation Administration (FAA) and Volpe National Transportation Systems Center (VNTS), Cambridge, Mass., U.S. Additional assistance was provided by Robert Machol, FAA and Don Wright, VNTSC. Points of view expressed in this document should not be ascribed to the individuals just cited or to either FAA or VNTSC.

About the Authors

Arnold Barnett, Ph.D., is professor of operations research/statistics at the Massachussetts Institute of Technology (MIT) Sloan School of Management. An applied statistician, Barnett has been involved for many years in data analyses involving air safety. The results of his research have appeared in publications ranging from professional journals such as Management Science and Risk Analysis *to the op-ed page of The New York Times. Barnett holds a B.A. degree in physics and a Ph.D. in applied mathematics.*

Todd Curtis is a systems safety engineer with the Boeing Commercial Airplane Group. While earning his masters degree in management at MIT, he performed research in the areas of airline safety and air traffic control. Previously, Curtis was a flight test engineer for the U.S. Air Force. He also is a licensed private pilot and holds degrees in electrical engineering from Princeton University and the University of Texas.

Aviation Statistics

U.S. Transportation Fatalities Calendar Year 1990

by
Shung C. Huang
Statistical Consultant

The U.S. National Transportation Safety Board (NTSB) recently reported that U.S. transportation systems, which include highway, rail, aviation, marine and pipeline operations, recorded a total of 46,858 fatalities in calendar year 1990 (Figure 1). Fatalities involving highway traffic account for almost 95 percent of the total fatalities; followed by two percent involving marine operations; and approximately 1.5 percent each involving rail and aviation traffic. The accompanying charts illustrate the 1990 transportation-related fatalities by all transportation modal categories.

Graphic not available

Figure 1

Graphic not available

Figure 2

The 46,858 fatalities reported in 1990 were three percent lower than the 48,334 reported in 1989 and 11 percent lower than the 49,904 reported in 1988. The number of people who died in highway traffic last year dropped by 2.5 percent from 1989, deaths reduced by five percent in marine and 28 percent in aviation, but there was a 15 percent increase in rail. The decrease of fatalities in aviation in 1990 was significant because from 1989 to 1990 fatalities

Graphic not available

Figure 3

involving airlines declined from 278 to 39, fatalities involving commuter air carriers dropped from 31 to four (equal to the previous lowest year recorded in 1986), fatalities for air taxis were down from 88 to four and general aviation fatalities declined from 757 to 742, a record annual low.

The reduction in highway traffic-related fatalities in the last two years is encouraging. However, an analysis of the transportation fatalities during the past seven years, as shown in Figure 2, reveals that the uptrend of highway fatalities over the period has scarcely changed. Rail fatalities were on the rise; only the fatality trends involving marine, aviation and pipeline, which account for only about 3.5 percent of total fatalities, remained in a downward direction.

Figure 3 shows the annual distribution and a seven-year trend of highway related fatalities. The downtrend in fatalities related to pedestrians, large trucks/vans, motorized and pedal cycles continued to improve, but the fatalities involving pickup trucks and vans, however, continued to increase. Although the fatalities involving passenger cars show signs of improving in the past two years, this category's uptrend remains unchanged. The annual frequency distribution of rail fatalities is shown

Graphic not available

Figure 4

Graphic not available

Figure 5

in Figure 4. Except fatalities involving rapid transit, which recorded a seven-year downtrend, the fatality trend involving grade crossing and intercity rail are on the rise.

Figure 5 shows the annual fatality trends for all marine and aviation operations. The annual improvement trends for marine and general aviation fatalities have been the most significant in transportation safety. ♦

Safety Changes in Canada, 1990

by

Shung C. Huang
Statistical Consultant

Before 1990, Canadian aviation accident investigation and related safety activities were performed by the Canadian Aviation Safety Board (CASB). In June 1989, the Canadian Transportation Accident Investigation and Safety Act received Royal Assent; the Act was proclaimed on March 29, 1990, and the new independent multi-model agency was established. The new board is now called the Transportation Safety Board of Canada (TSB).

The key feature of the TSB is its independence from all federal departments and agencies, especially from the departmental authorities responsible for regulating the transportation industries. Its mission includes, among other things, a mandate to perform the accident investigation and related activities formerly carried out by the CASB, the Rail and Pipeline Investigation Directorate from the National Transportation Agency, the National Energy Board (NEB), and the Marine Causality Investigation Branch from Transport Canada.

The objective of the TSB is to advance transportation safety. The board can function in a number of ways, chiefly by conducting independent accident investigations and studies to identify transportation safety deficiencies and make recommendations to eliminate or reduce the deficiencies. The TSB consists of five full-time members, including the chairperson, appointed by the governor in council and supported by a public service staff. The board is required to report annually to Parliament through the president of the Queen's Privy Council for Canada.

Activity and Safety Statistics Collected

Among its various functions, the TSB maintains an automated information system for recording and analyzing accident data for each of the marine, pipeline, rail and air transportation modes. Historically, the definition of what constituted a reportable incident or accident has differed widely among modes. Although the new TSB regulations will bring more commonality to the types of occurrences to be reported in the future, the accident statistics for calendar year 1990 were based on the reporting requirements that have existed under other regulations. In all cases, the 1990 statistics are preliminary and subject to changes due to late reporting, and re-categorization of occurrence. The Canadian transportation system is one of the most complex transportation systems in the world. The magnitude of Canadian transportation activities and safety performance in 1990 are summarized as follows:

Marine

Canada has more than 42,300 registered vessels, including 20,300 fishing vessels. There were 1.6 million vessels licensed, the majority of which are for pleasure purposes. In one year, approximately 390 million tons of cargo

Table A
Marine Occurrences (pleasure craft excluded) 1981-1990

Year	Shipping Accidents				Accidents Aboard Ship			Incidents
	Accidents	*Fatalities*	*Injuries*	*Vessels Lost*	*Accidents*	*Fatalities*	*Injuries*	
1981	1,075	38	15	201	146	32	126	120
1982	1,127	140	29	212	159	41	144	155
1983	1,098	20	37	220	165	27	154	87
1984	1,050	30	29	215	174	22	163	156
1985	1,040	32	34	154	224	32	213	123
1986	1,043	19	55	130	209	17	195	151
1987	1,008	44	51	114	242	23	233	176
1988	1,062	28	43	97	264	25	256	184
1989	1,172	64	76	112	359	26	355	234
1990	1,171	35	55	148	322	22	320	243

Preliminary: Subject to change
Source: Transportation Safety Board of Canada
1. The large increase in deaths in 1982 was due to the sinkings of the American registered semi-submersible drill rig *Ocean Ranger*, with the loss of 84 lives, and the Russian cargo vessel *Mekanik Tarasov*, with the loss of 32 lives, in February.
2. The large increase in deaths in 1989 was due to the loss of three vessels and their crews in a winter storm along the east coast in December. They were the Canadian fishing vessels *Johnny and Sisters II* (8), the Vanatu-registered general cargo vessel *Capitaine Torres* (23) and the Panamanian general cargo vessel *Johanna* B (16).

were loaded and discharged and 51 million passengers traveled on ferries or passenger vessels. Marine accident reports include commercial vessels of Canadian flag and foreign vessels operating in Canadian waters. Vessels for pleasure purposes were not normally included. In 1990, an estimate of 1,493 marine accidents were recorded, accounting for 148 vessel losses and 90 fatalities. This is essentially unchanged from the 1989 total of 1,531 accidents, but the vessel losses and fatality counts are much higher than the previous five-year average (Table A).

Commodity Pipelines

In Canada, there are 23 oil companies under federal jurisdiction with more than 8,000 miles of mainlines and gathering lines for oil, and 27 gas companies with more than 11,000 miles of mainline transmission and distribution lines for gas. Approximately 2.15 million barrels a

Table B
Commodity Pipeline Accidents and Fatalities by Type by Year 1981-1990

Year	Defective Welds	Material Failures	Third Party Damage	Corrosion	Other*	Total Accidents	Total Fatalities
1981	1	3	5	17	5	31	1
1982	3	1	8	8	11	31	1
1983	6	2	4	7	14	33	1
1984	4	10	5	6	9	34	0
1985	5	4	6	5	11	31	3
1986	0	5	3	10	10	28	0
1987	3	4	8	8	15	38	0
1988	3	7	6	4	18	38	0
1989	5	12	2	3	26	48	3
1990	0	16	3	1	27	47	0

Preliminary: Subject to change
Source: 1990 Transportation Safety Board of Canada
Pre-1990 — National Energy Board of Canada
* Other accidents: Includes workplace and construction accidents, operator error, earth movements and other miscellaneous/undetermined causes.

Table C
Railway Accidents and Incidents by Type — 1981-1990

Year	Main-track Train Collisions/ Derailments	Other Collisions/ Derailments	Railway Grade Crossing Accidents	Persons/Other Struck By Rolling Stock	Total Accidents	Millions of Train-miles	Total Accidents Per Millions of Train-miles	Dangerous Goods Related Incidents*	Other	Total Incidents
1981	315	212	763	137	1,427	82.0	17.4	157	157	314
1982	296	193	691	120	1,300	70.4	18.5	105	172	277
1983	231	168	567	145	1,111	72.6	15.3	288	188	476
1984	230	190	595	138	1,153	77.4	14.9	593	155	748
1985	190	199	606	132	1,127	75.4	14.9	408	160	568
1986	162	199	525	107	993	75.1	13.2	465	160	625
1987	142	224	458	115	939	76.3	12.3	488	128	616
1988	111	222	502	129	964	78.1	12.3	488	85	573
1989	121	193	469	97	880	74.5	11.8	424	64	488
1990	107	247	386	95	835	70.1	11.9	466	106	572

Preliminary: 1990 data includes estimates for late accident reporting
Source: Transportation Safety Board of Canada
* In 1990, the classification of dangerous goods leakage incidents was changed. Formerly "multiple" leakers found on the same train were grouped into a single incident. These are now classified as individual incidents. The data from 1984 to 1989 have been revised from earlier statistical presentations to conform to the current classification. It was not possible to revise pre-1984 data.

day of crude oil are produced in Canada and distributed by pipeline. The TSB has an accident investigation mandate for oil and gas pipelines under federal jurisdiction. In 1990, there were 47 pipeline accidents, which were nearly the same as the total of 48 accidents reported in 1989. There were no fatalities and only 12 persons involved in the accidents were injured (Table B).

Rail

There are approximately 51,000 miles of track in 19 railways under Canadian federal jurisdiction. Approximately 800 million passenger-miles and more than 300 billion ton-miles of freight, about 70 million train-miles, are performed in a year. Rail accidents have averaged 981 per year during the past five years. There were 835 such accidents in 1990, a 5.1 percent decline from the 1989 total of 880. The 100 fatalities reported in 1990 were 28 percent less than the 1989 total 139 and 15 percent lower than the 1985-1989 five-year average of 118. Although the number of accidents and rates over the years show a substantial decrease, the dangerous goods-related incidents have tripled since 1981. The details are shown in Table C.

Civil Aviation

Canada has one of the highest levels of aviation activity in the world. In 1990, there were approximately 28,000 registered aircraft and more than 90,000 civil aviation personnel in Canada, including pilots, navigators, flight engineers, flight attendants, air traffic controllers and aircraft maintenance engineers. In commercial flying, 66 million passengers were deplaned and enplaned a year at Canadian airports. Canadian registered aircraft in 1990 were involved in 503 accidents, 46 of which were fatal, accounting for 87 fatalities. The level one carriers (Air Canada and Canadian Airlines) and level two carriers (25 small airlines) account for some 95 percent of fare-paying passengers and more than 30 percent of the total hours flown — but only 2.5 percent of the total accidents. Level One Carriers have not had a single fatal accident in the past two years. Other commercial operations performed by aircraft including charter, contract and special operations.

As shown in Table D, although total accidents involving Canadian-registered aircraft increased over the year, the number of fatal accidents and resulting fatalities declined. There were 46 fatal accidents and 87 fatalities in 1990, compared with 59 fatal accidents and 150 fatalities in 1989.

The average annual number of accidents decreased by about 30 percent between 1981 and 1990; fatal accidents and fatalities recorded decreased even more (about 40 percent). During the same period, the accident rate declined from 17 accidents to almost 14 accidents per 100,000 aircraft flight hours — a decrease of 20 percent. The decrease in the fatal accident rate was even greater. The accident statistics

Table D
Accidents & Fatalities, By Year 1981-1990 — Canadian-registered Aircraft

Year	Accidents	Fatal Accidents	Fatalities	Total Hours Flown	Total Accident Rate	Fatal Accident Rate
1981	695	88	172	4,123,288	16.9	2.1
1982	539	62	123	3,688,713	14.6	1.7
1983	510	63	148	3,447,277	14.8	1.8
1984	458	58	120	3,322,200	13.8*	1.7
1985	438	40	71	3,256,280	13.5	1.2
1986	471	65	113	3,172,506	14.8	2.0
1987	472	53	97	3,321,519	14.2	1.6
1988	502	50	95	3,500,000	N/A*	N/A*
1989	487	59	150	3,600,000*	N/A*	N/A*
1990	503	46	87	3,600,000*	N/A*	N/A*

Accident and Fatal Accident Rates are per 100,000 flying hours.
Hours data are as supplied by Statistics Canada.
* Confirmed hours flown data for 1988 to 1990 are not available. Best estimates indicate that the hours will be as shown. If these estimates are confirmed, the accident rate will remain steady at about 14 and the fatal accident rate will also be steady at about 1.5.
Preliminary: 1990 data includes estimates for late accident reporting.
Source: Transportation Safety Board of Canada

for Canadian-registered aircraft as shown in Table D clearly demonstrate that the past decade was one of significant improvement in Canadian aviation safety. ♦

Was 1990 a "Good" Year?

by
Capt. Heino Caesar
General Manager
Flight Operations Inspection and Safety Pilot
Lufthansa German Airlines

From 1986 onwards, the number of jet aircraft weighing more than 44,000 pounds (20,000 kg) that were lost in normal worldwide operations had increased steadily from 11 to 26 by 1989, while in 1990 we counted "only" 13, the long-term average since 1959. In fact, 14 large jets were written off, but one — a Boeing 747 — was not counted among the losses since it was repairable (it was not rebuilt). In these operational losses of 13 Western-built aircraft, there were eight fatal accidents in which 33 crew members and 221 passengers died, well below the average annual loss of 556 passengers plus crew since 1959. However, we cannot regard the number of lives lost as a good parameter regarding safety since fatalities in most cases are a matter of chance. So, is the relatively moderate number of lives lost in 1990 merely due to the fact that three losses were ferry flights and three were freighter aircraft? Regardless, excluding the exceptional year of 1984 (three passengers killed), 1990 resulted in the smallest number of jet passenger deaths for a quarter of a century. Corresponding with this was the cost for total losses and substantial damages with US $345 million, well down from the 1989 level of $501 million.

Another three Western-built jets were lost in the Peoples Republic of China, where an attempted hijack with a subsequent forced landing resulted in the destruction of three aircraft at the airport with 121 passengers and seven crew members killed.

Half the aircraft lost in 1990 compared with the previous year is not indicative of a reversed trend; these numbers are within statistical expectation. Furthermore, the number of near-catastrophes among substantial damages and reported significant events was too high to feel comfortable about the situation. In effect, the 13 operational total losses are accompanied by nearly the same number of almost identical incidents, each only a fraction away from disaster, which did not end in accidents of a similar nature.

Regarding the losses, it was a normal year. The travelling public will probably accept one loss per month. Two will likely provoke raised eyebrows and more than that could very well result in media coverage and negative economic effects on the industry. An underlying reason for this is the dramatization of absolute loss numbers without comparing them with related productivity data. Nearly 22 million flight hours were flown by Western-built jets with more than 1.2 billion passengers transported in nearly 14 million estimated sectors or flights.

The long-term average of flight hours per aircraft loss was 809,000 since 1959. The hours flown per loss has increased to a significantly higher number in the past 10 years and was 1,685,000 hours per loss in 1990. Approximately 10 years ago, the ultimate goal was to lose not more than one aircraft in one million hours. We are well on our way to doubling that goal. The real risk comparison, however, can better be described by taking into account takeoffs or landings, or sectors. The operational losses per million sectors flown decreased in 10-year intervals from five to 1.3 jets. During the past 10 years, the industry lost between one and two aircraft per million flights. Flying became safer, but the investments to achieve this goal also steadily increased. We will approach the point in which a certain — hopefully low — number of losses will be regarded as inevitable.

During the last two decades, the phase of flight with most accidents shifted from approach to landing. Better airport and aircraft instrumentation, ground proximity warning systems (GPWS), more sophisticated procedures, radar and more reliable navigation aids led to a remarkable decrease of "controlled flight into terrain" accidents. These still occur, though, as documented in 1990 by several aircraft in marginal weather conditions that impacted the ground prior to reaching the runway.

In the decade 1981-1990, 31 percent of operational losses of heavy Western-built jets occurred during landing, 24 percent during takeoff.

During the past decade, the number of total losses decreased by eight percent, as did the number of passengers and crew on board ill-fated aircrafts. But, with the enormous increase in productivity, estimated at seven percent per year (more seats offered and sold), a corresponding fatality rate did not occur. On the contrary, while the absolute number of total airframe losses decreased by eight percent, the number of fatalities decreased by 35 percent. The percentages of individual survivals and fatalities actually reversed. Although the percentage of survival between 1961 and 1980 was 41 percent of all on board aircraft, that were finally written off due to the accident, this survivability rose to 59 percent during the last decade. To a certain degree, this may be attributable to better equipment, increased training, more sophisticated means of passenger information and less dangerous aircraft interior. A significant factor is the decrease in approach accidents from 41 percent between 1971 and 1980 to 24 percent since 1981.

The cause is evident. The "controlled flight into terrain" accidents during the approach phase of flight were hardly survivable by the very nature of these mishaps, while landing accidents normally offered the occupants a fair chance to leave the aircraft, although injured and/or shocked. Between 1981 and 1990, the industry experienced 24 aircraft losses during approach with 1,906 fatalities, but there were 44 landing losses in which “only” 176 persons were killed.

Accidents during the takeoff phase, were the leading cause of fatalities in the United States but the second leading phase worldwide. Thirty-eight large jets were lost worldwide during this phase of flight since 1981 and 1,101 fatalities were counted.

The low survivability rate resulted from high-speed accidents, sometimes shortly after lift-off. The most prominent ones with heavy losses occurred in the United States, making the picture of this specific geographical area somewhat different from the worldwide one. But, during the last 15 years, the number of passengers killed per million carried, under all circumstances and all risks, dropped to less than one, making flying the safest transport.

When an aircraft is lost, very often the number of persons killed is a matter of pure chance if the accident was at all survivable. So, as a parameter for an airline industry safety standard, a “body-count” is of very limited value. On the other hand, the media seem to weigh the severity of an accident and its publicity almost exclusively by the number of fatalities. Implementation of the latest model of the ground proximity warning system (GPWS), development of vertical profile indication on cathode ray tube (CRT) instrument displays and strict adherence to instrument landing systems (ILS), without putting too much confidence in less precise vertical navigation (V-NAV) or area lateral navigation (R/L-NAV) updates of horizontal navigation, could help us to achieve that goal.

Map-shifts have surfaced as a navigational problem during final approach in glass-cockpit aircraft. These flight management system (FMS) position errors could be the result of software errors, inertial reference system (IRS) problems, improper initialization, inaccurate navigation aid location or survey position, co-located distance-measuring equipment (DME) transmitters, unreliable or malfunctioning navigation aids or operator error. Unfortunately, many flight crews are reluctant to report electronic problems, either because they do not fully understand the system or because they feel they may have caused the problem themselves. This reluctance resulted in recommendations to use “heading select” and “ILS” to ensure a proper line-up with the runway and to avoid an undershoot of minimum safe heights on what was believed to be the right track with flight director and computer-generated magenta line properly centered. Therefore, during departures and approaches, the pilot flying should confirm the computed map with raw data indications.

Airline managements should ensure a non-adversarial atmosphere with their pilots and encourage open reporting of all incidents, including the electronic ones in glass-cockpit aircraft .

The 1990 breakdown of all accidents and incidents into “total losses,” “substantial damages” and “report significant events” indicates that the heavier the damage, the more dominant is the human factor, which is a failure of the cockpit crews only (other human failures are part of the technical or environmental categories). In 1990, 61 percent of all losses were caused by failure of part of the cockpit crew in either mishandling or reacting incorrectly. But, this made also clear that, in 1990, pilots could influence only 61 percent of the outcome in these most costly cases. It reflects a general tendency that in one out of four cases of total losses, pilots cannot do anything to avoid the negative results, but in the remaining 75 percent they are the ones capable of saving the flight. They do what they are supposed to do. Otherwise, we would not be able to perform 14 million flights with 22 million hours in the air and lose only 13 aircraft.♦

Reports Received at FSF Jerry Lederer Aviation Safety Library

Reference

Advisory Circular 61-67B, 5/17/91, Stall and Spin Awareness Training. — Washington, D.C., U.S. : U.S. Federal Aviation Administration, 1991. 14p.

AC 61-67A dated October 8, 1982, and AC 61-92 dated January 25, 1980, are canceled.

Summary: This advisory circular (AC) explains the stall and spin awareness training required under Part 61 of the Federal Aviation Regulations (FAR) and offers guidance to flight instructors who provide that training. In addition, this AC informs pilots of the airworthiness standards for the type certification of small airplanes prescribed in FAR Section 23.221 concerning spin maneuvers and it emphasizes the importance of observing restrictions that prohibit the intentional spinning of certain airplanes. [Purpose]

Advisory Circular 120-26H, 6/21/91, International Civil Aviation Organization Three-Letter and Radiotelephony Designators. — Washington, D.C., U.S. : U.S. Federal Aviation Administration, 1991. 4 p.

AC 120-26G, dated 10/1/87, is canceled.

Summary: This AC defines the criteria and procedures required for an International Civil Aviation Organization (ICAO) three-letter and/or radiotelephony designator assignment. [Purpose]

Advisory Circular 135-14A, 06/20/91, Emergency Medical Services/Helicopter (EMS/H). — Washington, D.C., U.S.: U.S. Federal Aviation Administration, 1991. viii, 22 p.

AC 135-14, dated October 20, 1988, is canceled.

Summary: This AC provides information and guidance material which may be used by Air Ambulance and Emergency Medical Service/Helicopter (EMS/H) operators in conducting or planning EMS/H operations. [Purpose]

Reports

Aircraft Accident Report: Northwest Airlines Inc. Flights 1482 and 299, Runway Incursion and Collision, Detroit Metropolitan/Wayne County Airport, Romulus, Michigan, December 3, 1990/United States. National Transportation Safety Board. — Washington, D.C., U.S. : U.S. National Transportation Safety Board; Springfield, Virginia : Available through NTIS*, Adopted June 25, 1991, Notation: 5416B. Report NTSB/AAR-91/05; NTIS PB 91-910405. vii, 169 p.

Key Words
1. Aeronautics — Accidents — 1990.
2. Aeronautics — Accidents — Air Traffic Control Procedures.
3. Aeronautics — Accidents — Airport Lighting.
4. Aeronautics — Accidents — Airport Markings.
5. Aeronautics — Accidents — Evacuation Procedures.
6. Aeronautics — Accidents — Ground Operations.
7. Aeronautics — Accidents — Runway Incursions.
8. Aeronautics — Accidents — Visibility.
9. Cockpit Resource Management.
10. McDonnell Douglas DC-9 Jet Transport — Design.
11. Northwest Airlines — Accidents — 1990.

Summary: On December 3, 1990, at 1345 eastern standard time, Northwest Airlines flight 1482, a McDonnell Douglas DC-9, and Northwest Airlines flight 299, a Boeing 727, collided near the intersection of two runways in dense fog at Detroit Metropolitan/Wayne County Airport, Romulus, Michigan. At the time of the collision, the Boeing 727 was on its takeoff roll, and the DC-9 had just taxied onto the active runway. The Boeing 727 was substantially damaged, and the DC-9 was destroyed. Eight of the 39 passengers and 4 crewmembers aboard the DC-9 received fatal injuries. None of the 146 passengers and 10 crewmembers aboard the B-727 were injured. The NTSB determines that the probable cause of this accident was a lack of proper crew coordination, including a virtual reversal of roles by the DC-9 pilots, which led to their failure to stop taxiing their airplane and alert the ground controller of their positional uncertainty in a timely manner before and after intruding onto the active runway. Contributing to cause of the accident were (1) deficiencies in the air traffic control procedures; (2) deficiencies in the airport marking and lighting; and (3) failure of Northwest Airlines Inc., to provide adequate cockpit resource management training to their line aircrews. Contributing to the fatalities in the accident was the inoperability of the DC-9 internal tailcone release mechanism. Contributing to the number and severity of injuries was the failure of the crew of the DC-9 to properly execute the passenger evacuation. NTSB recommendations A-91-54 through A-91-69 were addressed to the Federal Aviation Administration, the Detroit Metropolitan / Wayne County Airport, and Northwest Airlines Inc. on the five safety issues. [Modified Executive Summary] ♦

*National Technical Information Service (NTIS)
Springfield, VA 22161 U.S.
Telephone: (703) 487-4780

Accident/Incident Briefs

This information is intended to provide an awareness of problem areas through which such occurrences may be prevented in the future. Accident/incident briefs are based upon preliminary information from government agencies, aviation organizations, press information and other sources. This information may not be accurate.

Air Carrier

Descent Below Glidepath Ends in Disaster

McDonnell Douglas DC-9-30: Aircraft destroyed. Fatal injuries to 46.

The aircraft was on a landing approach, at night, on the instrument landing system (ILS) to runway 14 and was cleared to 4,000 feet above sea level (asl). The aircraft was established on the localizer at 10 nautical miles (nm) from the airport, but between 10 nm and 14 nm it had descended through the 4,000-foot altitude clearance limit. According to the approach procedure, this altitude should only be left at the 8 nm point. At 8 nm the aircraft's altitude was at 3,600 feet.

The aircraft collided with the forest on a steep mountain and was destroyed by the impact and subsequent fire. The aircraft impacted at an elevation of 1,660 feet, 5.2 nm from the threshold and 1,460 below the glidepath. The digital flight data recorder (DFDR) indicated a small decrease in sink rate and a small increase of power 20 seconds prior to impact. Fatal injuries were sustained by the six crew members and 40 passengers on board.

Missed Weather, Met Mountain

McDonnell Douglas DC-9-30: Aircraft destroyed. Fatal injuries to 31.

The aircraft was approaching an airport after midnight and was in contact with approach radar. There were four crew members and 27 passengers aboard. The pilot reported visual ground contact and, to avoid an area of weather, deviated from following the published nondirectional beacon (NDB) approach procedure and let down to the west of the weather pattern.

The aircraft crashed into a mountain ridge nine nautical miles southwest of the airport at an altitude of 2,000 feet. The aircraft was destroyed and the four crew members and 27 passengers on board the aircraft received fatal injuries.

The Pilot Who Thought He Could

North American Commander 500: Substantial damage. Minor injuries to one.

The pilot of the cargo flight was unable to start the right engine of the twin piston-engine aircraft using normal procedures. He decided to start the balky engine by allowing the propeller on the inoperative engine to windmill during the take-off run.

The attempt was unsuccessful.

The aircraft rolled off the end of the runway and came to rest just outside the airport perimeter fence. The landing gear collapsed and the aircraft was damaged substantially. The pilot received minor injuries.

The causal events and factors included improper engine start, initiating flight with a known deficiency, directional control not maintained, uncontrollable swerve / ground loop and collision with fence post.

Out of Altitude, on Final and Into the Gusts

De Havilland DHC6 Twin Otter: Aircraft destroyed. Serious injury to one.

The aircraft was on final approach during daylight conditions in a right-hand traffic pattern. Aboard were two pilots and 14 passengers. There was a left-quartering, gusting, 15-knot headwind blowing across the airport.

As the aircraft neared the runway on final approach, the rate of descent accelerated. The pilot applied full power to compensate for the abnormal descent, but the aircraft collided with the ground short of the runway. Both crew members and 13 passengers received minor injuries while one passenger was seriously injured.

Cited were an improper approach, delayed application of power, turbulence and vertical wind gusts and inadvertent stall.

Low on Altitude and Night Experience

Piper PA-31p-350 Mojave: Aircraft destroyed. Fatal injuries to two.

The aircraft, with a pilot and one passenger aboard, had completed an instrument landing system (ILS) approach to Norton Air Force Base, California, U.S., when the pilot received a special visual flight rules (VFR) clearance to proceed to nearby Redlands Airport which had an elevation of 1,572 feet mean sea level (msl). It was night and the weather conditions included one mile visibility and fog.

The aircraft descended below the circling minimum descent altitude (MDA) for the Air Force base of 1,710 feet and was last seen on the radar display flying at 1,600 feet msl one mile from Redlands Airport. The aircraft was last seen by ground witnesses flying low and fast.

There were few ground reference lights in the area and the pilot had accumulated a minimum amount of night flying time. The left wing contacted the ground in a 42 degree left bank and a slight nose-down attitude. The aircraft was destroyed and the pilot and passenger were fatally injured.

Causal factors included the presence of visual illusion, altitude not maintained, poor inflight planning and lack of experience in aircraft type.

Combination of Ingredients Proves Bad Medicine

Cessna 425: Aircraft destroyed. Fatal injuries to one.

The aircraft, with a pilot and one passenger aboard, was cleared for a night instrument landing system (ILS) approach at approximately 2200 hours local time. The pilot had been advised of fog and that the airport was closed.

The aircraft collided with the ground on a grassy area within the airport in a near-level attitude with the landing gear retracted. The wreckage of the aircraft was located the next morning. The pilot was fatally injured in the crash and the passenger was seriously injured.

There was no approach plate for an ILS procedure found in the aircraft after the crash. The toxicology report revealed Dextromethorphan, an ingredient in over-the-counter cold remedies, in the pilot. The dose was 30 times greater than the minimum amount necessary to cause drowsiness.

Other General Aviation

Touchdown Encounter

Mooney Mark 20k: Substantial damage. No injuries.

The Airbus Industrie A320 was on short final approach when the Mooney, with two occupants aboard, taxied onto the runway for takeoff, without clearance. The nose gear of the landing A320 struck the Mooney's right wing. The smaller aircraft's left wing was partly ingested into the left engine of the larger aircraft. The A320 slid down the runway with the nose gear broken for 2,500 feet (750 meters) before stopping.

There was substantial damage to both aircraft, but no injuries were sustained by the occupants of either airplane. Air traffic control (ATC) did not see the Mooney enter the runway because of fog.

Glassy Water Confuses Height Perception

Cessna 310: Aircraft destroyed. Fatal injuries to two.

The aircraft was flying in a loose formation with a Beech J35 Bonanza as part of a videotape filming. The Bonanza was in the lead position and the Cessna, with a pilot and one passenger aboard, had assumed an echelon position.

The aircraft were filming over Utah Lake, Utah, U.S., at low altitude when the Cessna hit the water and sank. Neither the pilot nor the passenger were wearing restraining devices. Both occupants drowned.

Causal factors included misjudged altitude influenced by the glassy water surface that imposed a visual illusion and the pilot's attention being diverted by the filming activities.

Rotorcraft

Tripped by Unseen Wires

Hughes 369HS: Substantial damage. No injuries.

The aircraft was on a sightseeing flight around Niagara Falls, New York, U.S. While flying under visual flight rules (VFR) at the ridge level around the Niagara River gorge, the pilot flew into downflowing air and descended into the vicinity of the of an area called the Whirlpool. The pilot stopped his descent and was, according to the accident report, planning to climb out of the area when the aircraft struck an aerial car support cable.

The cable tore the landing skid gear from the fuselage and control was momentarily lost. A cable car with 17 passengers aboard was jostled as the cable swayed from the helicopter encounter, but no one was injured. The pilot recovered control and made a forced landing approach to a golf course. Since a normal touchdown was not possible because of damage to the landing skids, he kept the helicopter in a hover while the passengers exited. The pilot then allowed the aircraft to touch down on the fuselage and the tail skid; it remained upright. There were three passengers and one crew member on board, none of whom were injured.

The helicopter sustained substantial damage. Both forward struts of the aircraft were severed; both rear landing gear strut assemblies and both skid tubes were missing; the horizontal stabilizer had an outboard puncture through both surfaces; and the right forward strut brace had ruptured the fuselage belly skin.

The pilot routinely flew tour flights around the area of the falls but had only flown around the Whirlpool area on one previous occasion and, according to the accident report, had not visually inspected the area for hazards. The aerial car support cables in the area were not visibly indicated or marked on navigational charts.

The accident report concluded that the pilot operated the helicopter within the river gorge without prior inspection for hazards, and was unaware that the aerial car cables were there. Also cited was the fact that the cables were not visibly marked or indicated on navigational charts.

Weather, Powerlines and Helicopters Do Not Mix

Aerospatiale AS355 Twinstar: Aircraft destroyed. Fatal injuries to two.

The emergency medical service (EMS) helicopter was flying in conditions of deteriorating weather. The fact that it was a life-saving mission, plus the lack of an alternate landing location in case the destination's trauma center landing area was closed, delayed the decision to turn around.

The aircraft collided with power lines suspended 36 feet above a road. Control of the aircraft was lost, it hit a retaining wall, clipped the tops of trees and descended into a 70-foot-deep ravine. The main wreckage came to rest 220 feet from the initial point of impact. The aircraft was destroyed and both the pilot and the passenger were fatally injured.

Among reasons cited as causal factors for the accident were a delayed emergency procedure in poor weather and self-induced and external mental pressure on the pilot. ♦