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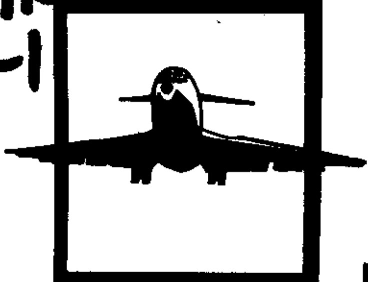

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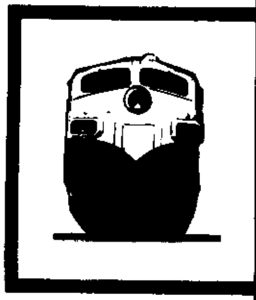

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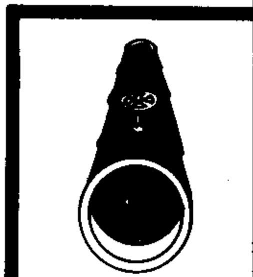
SPECIAL STUDY

REVIEW OF ROTORCRAFT ACCIDENTS 1977-1979



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16. Abstract

The National Transportation Safety Board has reviewed the data on the 890 rotorcraft accidents that occurred from 1977 through 1979 which are in its automated aviation accident data system. This report contains accident data on the rotorcraft, pilots, and operating environment which the Safety Board believes may be most useful to designers, manufacturers, operators, and regulators. The report includes tables and graphs presenting accident statistics, cause/factors, rotorcraft make and model data, pilot experience, weather conditions, and other data.

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NATIONAL TRANSPORTATION SAFETY BOARD
WASHINGTON, D.C. 20594

SPECIAL STUDY

Adopted: August 11, 1981

REVIEW OF ROTORCRAFT ACCIDENTS, 1977-1979

INTRODUCTION

The use of rotorcraft (helicopters and gyroplanes) in general aviation in the United States has increased significantly. From 1970 through 1979, the compound annual rate of growth of hours flown in rotorcraft was more than 11 percent. 1/ The last 3 years of the decade showed an even greater increase in rotorcraft activity. Annual time flown increased from 1.55 million hours in 1976 to 2.56 million hours in 1979--an increase of almost 65 percent in 3 years. In contrast, hours flown annually in general aviation as a whole increased by only 28 percent during the same 3 years.

The bulk of the increase in hours flown annually in rotorcraft was in air taxi, aerial application, industrial operations, and corporate/executive flying--all categories involving professional pilots. By 1980, air taxi flying accounted for 40 percent of the hours flown annually in rotorcraft while accounting for less than 9 percent of the fixed-wing aircraft activity. In fact, rotorcraft accounted for about 75 percent of the increase in air taxi activity from 1976 through 1979.

The increase in rotorcraft activity was accompanied by a decrease in the accident rate per 100,000 hours flown. The rate of occurrence of rotorcraft accidents decreased from 30.5 in 1970 to 11.3 in 1979. The rate of occurrence of all general aviation accidents decreased from 18.1 in 1970 to 9.3 in 1979. The rotorcraft accident rate has been steadily approaching that of fixed-wing aircraft even though rotorcraft are often used for more difficult tasks and operated in worse environments than fixed-wing aircraft. However, rotorcraft still have a higher accident rate than fixed-wing aircraft.

The increased significance of rotorcraft activity in general aviation and the higher rate of occurrence of accidents involving rotorcraft, when compared with the general aviation rate, prompted this review of the data on rotorcraft accidents contained in the Safety Board's automated aviation data system. The object of the review was to provide a summary of data on rotorcraft accidents which would be useful to government and industry in their pursuit of increased safety through improvements in the design, use, and regulation of rotorcraft. This report of the review includes tabular and graphic presentations of data on the rotorcraft, their pilots, and the environments in which they operated.

1/ Based on flight-hour data provided by the Federal Aviation Administration (FAA).

ACCIDENT LOSSES

1970-1979

The number of accidents involving rotorcraft varied from year to year during 1970 through 1979 but displayed an upward trend overall during that period. (See figure 1.) This upward trend also was shown by the number of fatal accidents and fatalities. The number of accidents averaged over the second 5 years of the decade was 294 annually compared with an average of 261 annually over the first 5 years of the decade--an increase of about 13 percent. The number of fatal accidents increased about 15 percent during the second half of the decade and the number of fatalities increased by almost 27 percent during that period.

In 1970, only 8.3 percent of rotorcraft accidents were fatal; in 1979, 13.5 percent of rotorcraft accidents were fatal. (See figure 2.) Because this indicated that the percentage of rotorcraft accidents that were fatal increased during the 1970's, a linear regression of the percentage of accidents that were fatal was performed. The linear curve fit of the data resulted in a positive slope to the straight line through the data. Thus, the annual percentage of rotorcraft accidents which were fatal increased about 0.7 percent per year through the 1970's.

Table 1 shows the number and seriousness of injuries received by persons onboard the rotorcraft and on the ground who were involved in fatal rotorcraft accidents during the 1970's.

Table 1.--Total fatalities and injuries in fatal accidents.

	Severity of Injury					
Year	Fatal	Serious	Minor	None	Total persons involved	Fatalities as a percentage of total persons involved
1979	63	8	3	5	79	79.7
1978	86	22	8	10	126	68.3
1977	56	12	8	4	80	70.0
1976	64	17	4	4	89	71.9
1975	52	7	5	2	66	78.8
1974	72	18	9	5	104	69.2
1973	48	11	1	15	75	64.0
1972	66	9	2	9	86	76.7
1971	35	6	6	8	55	63.6
1970	32	1	1	6	40	80.0
Total	574	111	47	68	800	71.8

Table 2 shows the number and seriousness of injuries received by only those persons onboard the rotorcraft in fatal accidents. Approximately 74 percent of the total persons onboard the rotorcraft were killed in accidents during the second 5 years of the decade compared with about 70 percent for the first 5 years. There were 5.2 fatalities for each serious injury and 3.8 fatalities for each injury of any kind.

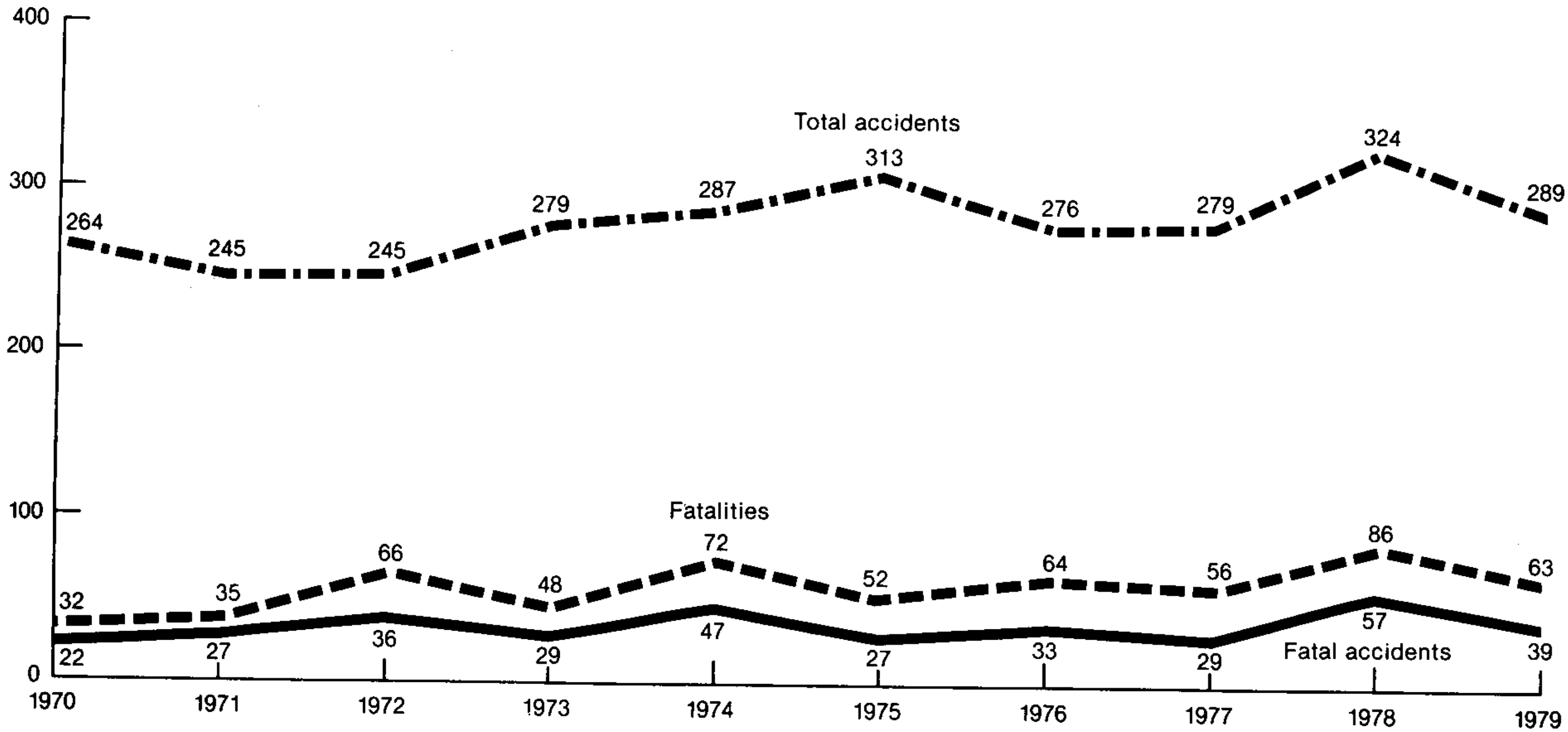

Figure 1.--Total accidents, fatal accidents and fatalities involving rotorcraft, 1970-1979.

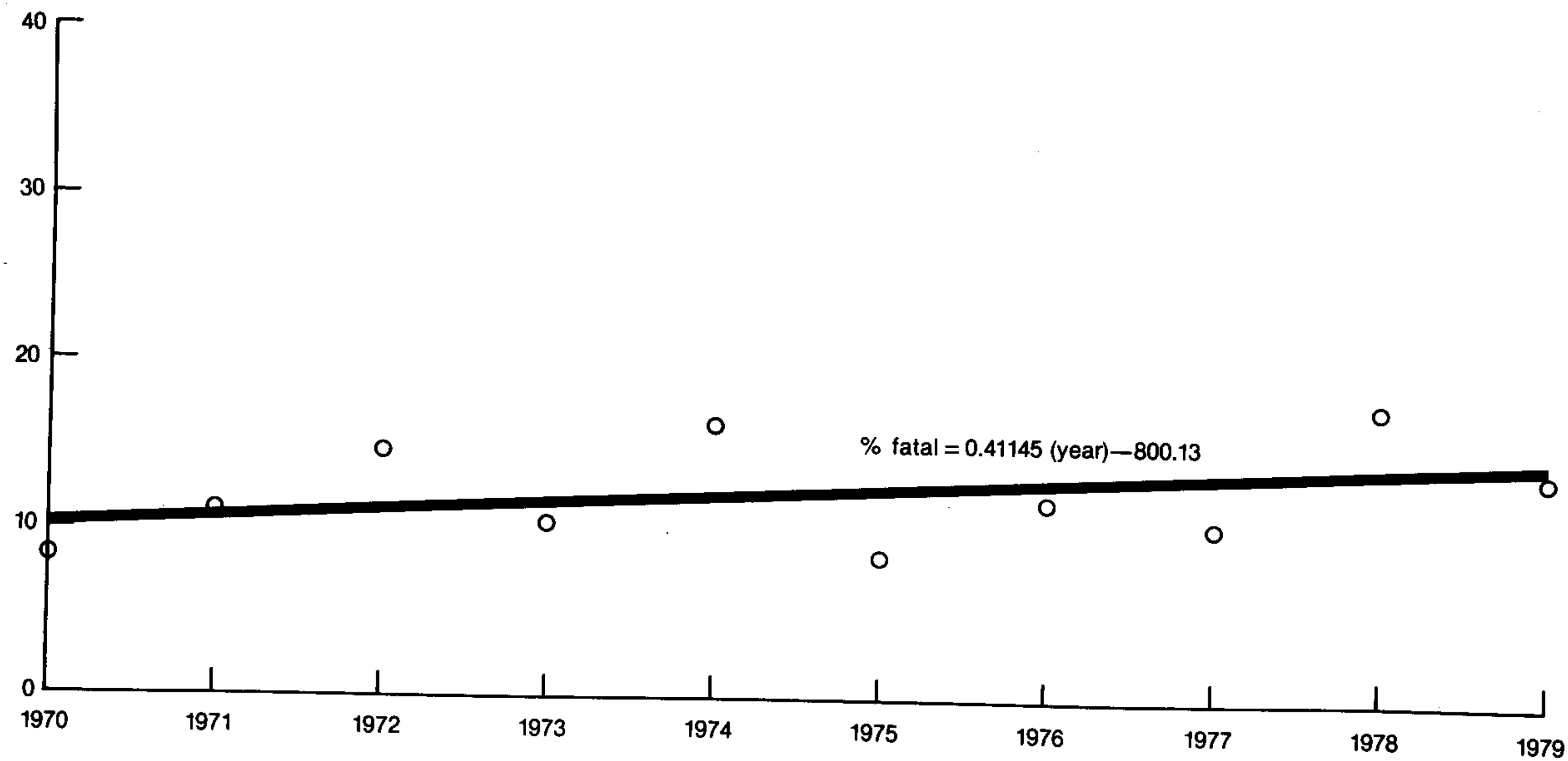

Figure 2.--Percentage of fatal rotorcraft accidents, 1970-1979.

Table 2.--Fatalities and injuries to persons onboard rotorcraft in fatal accidents.

Year	Severity of injury				Total persons involved	Fatalities as a percentage of total persons involved
	Fatal	Serious	Minor	None		
1979	60	6	1	3	70	85.7
1978	78	22	8	10	118	66.1
1977	53	8	8	4	73	72.6
1976	64	17	4	4	89	71.9
1975	50	7	4	2	63	79.4
1974	67	16	5	3	91	73.6
1973	45	11	1	14	71	63.4
1972	64	9	2	9	84	76.2
1971	30	6	6	8	50	60.0
1970	29	1	1	6	37	78.4
Total	540	103	40	63	746	72.4

The ratio of the number of persons onboard the rotorcraft to the number of fatal accidents varied irregularly:

Total	Fatal accidents	Total persons onboard	Mean number of persons onboard per fatal accident
1979	39	70	1.8
1978	57	118	2.1
1977	29	73	2.5
1976	33	89	2.7
1975	27	63	2.3
1974	47	91	1.9
1973	29	71	2.4
1972	36	84	2.3
1971	27	50	1.9
1970	22	37	1.7

These data show the increasing use of rotorcraft in passenger service. During the second half of the 1970's, there was an average of 2.23 persons onboard each rotorcraft involved in a fatal accident, compared with 2.07 for the first half. Although this difference is small, it does indicate a trend toward an increasing number of persons being carried onboard these aircraft. The increase probably reflects the increasing use of rotorcraft in air taxi flying.

In contrast to the upward trend in the number of total accidents and fatal accidents, the rate of occurrence of all rotorcraft accidents per 100,000 hours flown 2/ shows a significant downward trend during the 1970's. (See figure 3.) The fatal accident rate also reflects a downward trend, but not as large as the downward trend for total accidents.

2/ Flight-hour data were provided by the FAA. The FAA changed its procedures for collecting flight-hour data in both 1971 and 1976. Thus, the rates presented in figure 3 should not be used for direct comparison, although the magnitude of any differences caused by the procedural changes would not alter the basic trend of the data.

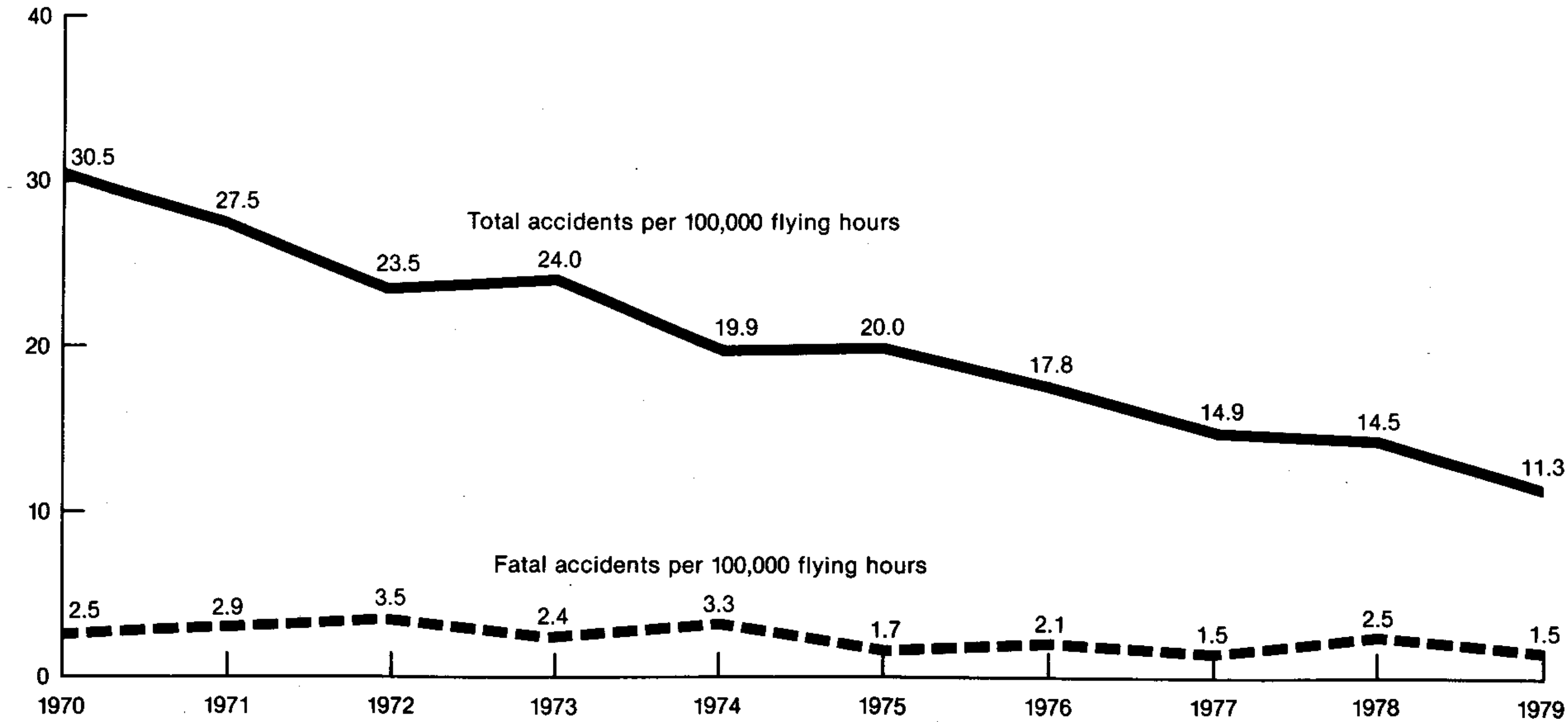

Figure 3.--Total and fatal rotorcraft accidents per 100,000 flying hours, 1970-1979.

1977-1979

The remainder of this review will examine accident data for only the years 1977 through 1979 because the data for this period are the most recent and complete data available and because, as a result of changes in the FAA procedures for collecting flight-hour data, it is the most complete and recent period for which rate calculations can be compared meaningfully.

During the years 1977 through 1979, there were 890 3/ rotorcraft accidents including 125 fatal accidents in which 205 persons died. The following tabulation shows the degree of damage to the rotorcraft involved in the accidents and the severity of injury in the accidents:

	Severity of injury				
Rotorcraft damage	Fatal	Serious	Minor	None	Total
Destroyed	103	45	45	64	257
Substantial	18	51	128	427	624
Minor	3	3	0	0	6
None 1/	2	2	0	1	5
Total rotorcraft	126	101	173	492	892

1/ The fatal and serious injury accidents with no damage to the rotorcraft involved rotor strikes to persons.

Although fatalities occur more frequently in rotorcraft that are destroyed, in 154, or 60 percent, of the 257 accidents in which the rotorcraft was destroyed, there were no fatalities.

There was fire after impact in 79 accidents (8.9 percent of all rotorcraft accidents), of which 32 were fatal. The following tabulation compares the severity of injury to persons involved in rotorcraft accidents in which there was no fire after impact with accidents in which there was fire after impact:

	Severity of injury				
	Fatal	Serious	Minor	None	Total
Fire after impact	32	15	12	20	79
No fire after impact	92	86	160	472	810
Other	2	0	1	0	3
Total rotorcraft	126	101	173	492	892

The 8.9 percent of rotorcraft accidents with fire after impact is slightly greater than the 8.0 percent for all general aviation accidents.

3/ Although there were only 890 accidents, the Safety Board has records on 892 rotorcraft because two accidents were midair collisions, each involving two rotorcraft. One of these midair collisions was a fatal accident in which there were fatalities onboard each aircraft. Thus, there are 126 rotorcraft records for the 125 fatal accidents.

More than 40 percent of the rotorcraft accidents with fire after impact were fatal while only 11 percent of the rotorcraft accidents with no fire after impact were fatal. As a 1980 Safety Board special study pointed out, 4/ fire after impact significantly increases loss of life in general aviation accidents. That study reported that 59 percent of all general aviation accidents (fixed-wing aircraft and rotorcraft) involving postcrash fire resulted in fatalities while only 13.3 percent of the accidents with no postcrash fire were fatal.

These statistics indicate that a lower percentage of rotorcraft accidents result in fatalities than do fixed-wing aircraft accidents, both with and without postcrash fires. This is possibly caused, in part, by the lower impact forces of rotorcraft crashes resulting from generally slower air speeds than fixed-wing aircraft at the time of the accident.

ACCIDENT TYPES

Table 3 (page 9) presents the major types of accidents in which rotorcraft were involved during 1977 through 1979. The most frequent accident type was engine failure or malfunction (256), which includes accidents that occurred after a power loss for any reason. The power losses were most often the result of powerplant mechanical problems (181) or fuel exhaustion (45), fuel starvation (17), or fuel contamination (8). The next most frequent accident types were collisions with obstacles and controlled or uncontrolled collisions with the ground or water. The accident types which most often resulted in a fatality were collisions between aircraft in flight (66.7 percent fatal), airframe failures in flight and propeller 5/ failures (both 50.0 percent fatal), uncontrolled collisions with the ground or water (37.8 percent fatal), and main rotor failure (26.3 percent fatal).

Table 4 shows the rates of occurrences per 100,000 flying hours of rotorcraft accidents among certain kinds of flying. These specific groupings of kinds of flying were chosen for study because they were the most compatible with the categories of types of use of aircraft by which the FAA currently stratifies flight exposure data (flying hours). The FAA is the only known collector of such data.

Table 4.--Rotorcraft accident rates by kinds of flying.

Kind of flying	Hours flown	Percentage of hours	Accidents	Accident rate
Instructional	366,684	5.5	80	21.82
Personal/business	623,001	9.4	196	31.46
Corporate/executive	689,191	10.4	38	5.51
Aerial application	734,389	11.0	225	30.64
Air-taxi-type operations	2,558,639	38.5	148	5.78
Other	1,679,238	25.2	203	12.09
Total	6,651,142	100.0	890	13.38

4/ Special Study--"General Aviation Accidents: Postcrash Fires and How to Prevent or Control Them" (NTSB-AAS-80-2).

5/ Gyroplanes such as the Benser Gyrocopter use propellers to obtain forward thrust.

Table 3.--Total and fatal rotorcraft accidents by major types of accidents, 1977-1979.

Accident type	Total accidents	Fatal accidents	Percentage of fatal to total
Hard landing	80	0	0.0
Rollover	53	2	3.8
Collision between aircraft			
Both in flight	3	2	66.7
Both on ground	1	0	0.0
Collision with ground/water			
Controlled	88	14	15.9
Uncontrolled	56	22	39.3
Collision with obstacles			
Wires/poles	82	9	11.0
Trees	24	2	8.3
Other	53	5	9.4
Airframe failure			
In flight	34	17	50.0
On ground	6	1	16.7
Engine failure/malfunction	256	18	7.0
Prop/rotor failure			
Tail rotor	58	7	12.1
Main rotor	38	10	26.3
Propeller	2	1	50.0
Other	56	15	26.8
Total	890	125	14.0

The NTSB categories of pleasure, practice, and business flying were combined into the category of personal/business flying because of the incompatibility between accident data and exposure data and because this grouping is relatively homogeneous from the standpoint of aviation safety; that is, the pilots and aircraft involved in pleasure, practice, and business flying are more similar than different. This is especially true when this grouping is compared with other kinds of flying such as corporate/executive flying, air taxi flying, and aerial application flying, all of which involve professional pilots who fly considerably more hours, on average, than pilots involved in personal/business flying.

The air-taxi-type operations category of kind of flying, which accounts for almost 40 percent of rotorcraft flying, include the NTSB categories of air taxi passenger and cargo operations, construction work, scheduled and nonscheduled intrastate passenger and cargo service, and domestic and international passenger and cargo contract or charter operations. These categories were combined also because of the similarities in their operations and because this combination provided the accident category believed to be the most compatible with FAA air taxi flight exposure data.

Aerial observation flying includes the NTSB categories of aerial survey, aerial mapping, hunting, fish spotting, power and pipeline patrol, police patrol, search and rescue, and highway traffic advisory. This grouping was made because of the similarities in the nature of the flying activities. Because there is no similar exposure data category by which the FAA categorizes its flight-hour data, accident rates could not be calculated for this group and therefore these accidents have been included in the "other" category in table 4. Based on safety issues, additional categories of accidents by kinds of flying might be developed but, again, exposure data are not currently available. 6/

Table 4 shows that personal/business flying and aerial application flying have the highest accident rates. Aerial application flying, however, unlike personal/business flying, involves pilots who are flying as an occupation. The fact that the rate of occurrence of aerial application flying accidents is so much higher than that of corporate/executive or air taxi flying, both of which also involve professional pilots, is an indication of the often difficult and dangerous nature of aerial application flying.

Major accident types are shown in table 5 (page 11) as a function of major categories of kind of flying. The data show that aerial application flying accounts for almost 60 percent (49 of 82) of all in-flight collisions with wires and poles (the third largest category of accident type). This also is, in large measure, a reflection of the difficult, low-level flying demanded in aerial application flying.

Table 6 shows that despite the very high rate of occurrence of rotorcraft accidents in aerial application flying, this kind of flying has the lowest percentage (4 percent) of accidents that are fatal. The reasons for this low percentage of aerial application flying accidents that are fatal are not immediately apparent from the accident data. However, one likely reason is the relatively low flying speeds and low altitudes of aerial application flying which result in accidents with relatively low impact forces.

Table 6.--Injuries in relation to kinds of flying.

	Severity of Injuries					
Kind of flying	Fatal	Serious	Minor	None	Total	Percentage of fatal
Instructional	10	10	9	51	80	12.5
Personal/business	33	18	39	106	196	16.8
Corporate/executive	5	5	5	23	38	13.2
Aerial application	9	22	42	152	225	4.0
Air-taxi-type operations	32	18	36	62	148	21.6
Aerial observation	16	6	12	24	58	27.6
Other	20	22	30	73	145	13.8
Total accidents	125	101	173	491	890	14.0

6/ The FAA and the NTSB are reconciling differences in groupings and developing a compatible and meaningful categorization system.

Table 5.--Rotorcraft accidents in relation to kinds of flying, 1977-1979.

	Kind of flying							
Accident type	Instructional	Personal/Business	Corporate/Executive	Aerial Application	Air-Taxi-Type Operations	Aerial Observation	Other	Total Accidents
Hard landing	26	22	3	5	6	6	12	80
Rollover	5	13	4	9	8	2	12	53
Collision between aircraft								
Both in flight	1	1	1					3
Both on ground					1			1
Collision with ground/water								
Controlled	7	22		25	14	7	13	88
Uncontrolled	6	13	1	12	8	2	14	56
Collision with obstacles								
Wires/poles	3	9	6	49	3	6	6	82
Trees	1	9	1	8	1	1	3	24
Other	3	8	5	15	10	3	9	53
Airframe failure								
In flight	1	8	1	9	4	2	9	34
On ground	2	3					1	6
Engine failure/malfunction	15	58	7	66	31	21	58	256
Prop/rotor failure								
Tail rotor	3	7	3	12	13	2	18	58
Main rotor	4	4	2	9	5	5	9	38
Propeller		2						2
Other	3	17	4	6	11	1	14	56
Total accidents	80	196	38	225	115	58	178	890

The categories of kinds of flying with the largest percentage of accidents that were fatal was "aerial observation" flying, with almost 28 percent of its accidents fatal, and air taxi flying, with over 21 percent of its accidents involving fatalities. Again, the reasons why these kinds of flying involve relatively more fatal accidents has not been determined, but the higher speed at which the rotorcraft involved in these kinds of flying are normally operated may be a factor.

As shown in table 7 over half of the accidents occurred during the in-flight phase of operation of the rotorcraft and half of these accident involved either engine failures or malfunctions or in-flight collisions with wires or poles. Engine failure or malfunction was also the most frequently occurring accident type in takeoff, and hard landing was the most common accident type during the landing phase of operation.

Table 7.--Phase of operation in rotorcraft accidents, 1977--1979.

	Phase of operation						
Accident type	*Static*	*Taxi*	*Takeoff*	*In-flight*	*Landing*	*Unknown*	*Total*
Hard landing		3	4	7	66		80
Rollover	6	7	20	8	12		53
Collision between aircraft			1	1	1		3
Both on ground	1						1
Collision with ground/water							
Controlled		7	18	50	13		88
Uncontrolled		2	18	25	11		56
Collision with obstacles							
Wires/poles		4	9	63	6		82
Trees			4	16	4		24
Other	2	6	12	18	15		53
Airframe failure							
In flight			3	29	2		34
On ground	1		2		3		6
Engine failure/malfunction		1	44	186	25		256
Prop/rotor failure							
Tail rotor			6	49	2	1	58
Main rotor			8	24	6		38
Propeller				1	1		2
Other	6	3	9	21	13	4	56
Total accidents	16	33	158	498	180	5	890

Table 8 shows the rotorcraft accidents distributed according to broad phase of operation and the severity of injury to persons in the accident. The data indicate that accidents which occurred during the in-flight phase of operation resulted in fatalities most often. Almost 26 percent of the accidents occurring in flight were fatal. Only 10.5 percent of the accidents that occurred during the landing phase of operation were fatal. Further, aerial application flying accidents were among the least fatal and the special category of "in-flight, aerial application" further demonstrates this.

Table 8.--Severity of injury during phase of operation.

	Injury				
Phase	Fatal	Serious	Minor	None	Total
Static	2	4	3	9	18
Taxi	1	3	3	25	32
Takeoff	7	18	36	97	158
In-flight	86	38	60	148	332
In-flight, aerial application	5	16	35	110	166
Landing	19	22	36	103	180
Unknown	6				6
Total accident records	126	101	173	492	892

The 86 fatal accidents which occurred during the in-flight phase of operation represent more than 68 percent of all the fatal accidents.

ACCIDENT CAUSAL FACTORS

Pilot

The pilot is a major factor in rotorcraft accidents. During 1977 through 1979, the pilot was cited as a cause or related factor in 573 rotorcraft accidents--more than 64 percent of the 889 total rotorcraft accidents in which the NTSB cited a probable cause. (See appendix A.) The pilot was cited as a cause or related factor in 74, almost 60 percent, of the 124 fatal rotorcraft accidents in which a probable cause was determined.

The 573 rotorcraft accidents involving the pilot as a cause or related factor occurred at the rate of 8.6 per 100,000 hours flown in rotorcraft. This is identical to the rate of occurrence of fixed-wing aircraft accidents in which the pilot was cited as a cause or related factor. The major reason for the greater overall accident rate for rotorcraft (13.4 compared with 10.5 for fixed-wing aircraft) is the greater rate of occurrence of accidents in rotorcraft due to mechanical failures. (See discussion of aircraft beginning on page 25.)

Table 9 lists the cause/factors involving the pilot-in-command (see appendix A) in four groups. More than one cause/factor was cited in some accidents and, thus, within a group the number of cause/factors generally exceeds the number of accidents to which these cause/factors were assigned.

Table 9.--Detailed pilot cause/factors in rotorcraft accidents.

Major pilot-in-command cause/factors	Fatal accidents	All accidents
Operational/technique		
Failed to maintain rotor rpm or flying speed	13	122
Improper use of flight controls, etc.	16	109
Failed to see and avoid obstacles	10	73
Failed to maintain directional control	1	21
Other	3	6
Total	43	331
Decision/judgment		
Inadequate preflight preparation	7	91
Inadequate supervision of flight or diverted attention from flight	5	47
Mismanagement of fuel	4	39
Improper in-flight decisions	8	30
Initiated or continued VFR flight into adverse weather	11	22
Selected unsuitable terrain	1	22
Failed to follow approved procedures	5	21
Other	14	48
Total	55	320
Perceptual		
Misjudged speed, altitude, clearance, distance	10	114
Physiological		
Spatial disorientation, lost or disoriented	7	15
Physical impairment	3	4
Total	10	19

The cause/factor group most frequently assigned is that which involved the actual manipulation of controls or the technique of operating the aircraft. Cause/factors in this group were assigned 341 times in all accidents and 44 times in fatal accidents. Within this group, the pilot's failure to maintain adequate rotor rpm or flight speed was the most prevalent cause/factor, followed closely by the pilot's improper use of flight, powerplant, and brake controls. The third most frequently cited cause/factor within this group was the pilot's failure to see and avoid obstacles or other aircraft. This detailed cause/factor was put into this group because it is a failure of basic flying technique and generally not a perceptual failure.

The second most frequently cited group is that in which the detailed cause/factors generally indicated inadequate or poor judgment or decisionmaking. The cause/factors in this group were cited 321 times in all accidents and 55 times in fatal accidents. Thus, decisionmaking appears to be a more important factor in fatal accidents than aircraft-handling techniques. The most frequently cited cause/factor within this group related to inadequate preflight preparation or planning. The next most frequently cited cause/factor was inadequate supervision of flight or diverting attention from operation of the aircraft. Fatalities occurred often in accidents involving the continuation of VFR flight or initiation of flight into adverse weather. Cited 22 times in all accidents, this cause/factor was cited 11 times in fatal accidents.

The third group is composed of cause/factors involving pilot perceptual error or misjudgment of one or a combination of speed, altitude, clearance, or distance. The cause/factors in this group were cited 114 times in all accidents and 10 times in fatal accidents.

The group least cited is that involving pilot physiological problems such as disorientation or physical impairment. Although cause/factors in this group were cited only 19 times, 9 of these accidents were fatal.

Table 10 shows the number of pilots involved in rotorcraft accidents in relation to the pilot certificate which they held and the major categories of kind of flying in which they were engaged. The data show that 760 pilots (more than 85 percent of the rotorcraft pilots) held commercial or airline transport pilot certificates. Of these 760 pilots, 596 were engaged in corporate/executive, aerial application, air taxi, aerial observation, or "other" flying. Most of these pilots were being paid to fly, or required special skills to perform their tasks. Thus, as many as two-thirds of the pilots involved in rotorcraft accidents were flying in a professional capacity.

Table 10.--Type of certificate of pilot in rotorcraft accidents by kind of flying.

	Certificate					
Kind of flying	Student	Private	Commercial 1/	Airline transport 1/	Other	Total
Instructional	11	4	53	12		80
Personal/business	30	60	81	18	7	196
Corporate/executive			25	12	1	38
Aerial application		1	211	13		225
Air-taxi-type operations			130	19		149
Aerial observation		4	49	5		58
Other	3	7	109	23	4	146
Total	44	76	658	102	12	892
(Business	3	16	19	3		41)

1/ Commercial and airline transport pilot certificate categories also include those with flight instructor ratings.

Business flying accidents are shown in table 10 to demonstrate that the distribution of accidents by pilot certificate for business flying is more similar to the distribution of accidents in the combined personal/business flying category than to the distribution of accidents in the professional flying categories.

Table 11 shows how rotorcraft accidents are distributed among pilot certificate and pilot age. Most of the accidents involved pilots between the ages of 26 and 45, and almost half involved pilots between the ages of 26 and 35. The study could not determine whether a particular age segment of the pilot accident population had accidents beyond its expected level, because the distribution of the nonaccident pilot population by age and flight time is not available to compare with the distribution shown in table 11 to make such a determination. The NTSB has previously recommended that the FAA collect pilot "exposure" data, and the FAA and the NTSB are currently developing a system to collect such data.

Table 11.--Type of certificate of pilots in rotorcraft accident by age.

Pilot Age	Certificate: Student	Private	Commercial	Airline transport	Other	Total pilots
19-20	2	2	4			8
21-25	5	5	33	1		44
26-30	4	6	162	23	3	198
31-35	11	11	190	26	2	240
36-40	7	7	86	22		122
41-45	5	18	77	9		109
46-50	3	9	46	9		67
51-55	4	8	41	6		59
56-60	1	6	8	4	1	20
61-65	1	1	6	1		9
66-70		3	1		2	6
Over 70			1			1
Other		1	4	1	3	9
Total pilots	43	77	659	102	11	892

Table 12 shows the number of accidents as a function of the pilot's total flight time and the pilot's flight time in the type of aircraft in which the accident occurred. The data show that about 77 percent of the pilots involved in these accidents (for which these data were available) had more than 500 total hours and 50 hours in type. About 64 percent had more than 1,000 total hours and 100 hours in type. Although the exposure data necessary to determine which segments of pilot flying time had more accidents than expected is not available, these data do indicate that most of these accident pilots were not "low time" pilots. In fact, about half of the pilots had over 1,000 total hours flying time and over 250 hours in the accident type of aircraft, an indication that at least these pilots should have been reasonably familiar with the aircraft.

Table 12.--Total time of pilots in rotorcraft accidents by time in type.

Time in type (hours)	Total time (hours): 0-100	101-500	501-1,001	1,001-3,000	3,001-5,000	5,001-10,000	Over 10,000	Total Records
0-50	20	20	13	36	22	15	7	133
51-100	9	16	16	25	16	10	2	94
101-250		28	13	51	41	21	10	164
251-500		9	11	52	32	36	10	150
501-750			14	22	26	14	8	84
751-1,000			3	9	17	11	6	46
1,001-3,000				32	39	49	19	139
Over 3,000					9	22	13	44
Total accident records	29	73	70	227	202	178	75	854

Table 13 provides some insight into the accident pilot's familiarity with the type of rotorcraft and the recency of the pilot's flying time. More than 55 percent of the pilots had more than 100 hours in type and had flown more than 50 hours during the last 90-day period.

Table 13.--Pilot's time in last 90 days by time in type.

	Time in last 90 days (hours)						
Time in type (hours)	0-10	11-25	26-50	51-100	101-200	Over 200	Total Records
0-50	23	28	25	24	21	7	128
51-100	7	9	15	28	25	2	86
101-250	11	17	26	36	49	19	158
251-500	3	7	22	36	49	27	144
501-750	4	2	11	17	33	12	79
751-1,000	2	3	3	3	19	14	44
1,001-3,000	3	7	21	33	47	27	138
Over 3,000	1		5	12	14	9	41
Total accident records	54	73	128	189	257	117	818

Table 14 shows the number of accidents in relation to the pilot's total flying time and the kind of flying being performed when the accident occurred.

Table 14.--Pilot flying time by kind of flying.

	Pilot total flying time (hours)							
Kind of flying	0-100	101-500	501-1,000	1,001-3,000	3,001-5,000	5,001-10,000	Over 10,000	Total Pilots
Instructional	7	13	5	17	18	15	5	80
Personal/business	21	40	25	42	27	20	15	190
Corporate/executive			3	10	9	14	2	38
Aerial application		11	22	69	55	43	25	225
Air taxi			3	38	52	38	16	147
Aerial observation		2	2	22	13	15	4	58
Other	4	9	10	35	35	36	14	143
Total accident pilots	32	75	70	233	209	181	81	881

The following tabulation is useful in analyzing the data in table 14. It compares the percentage of accidents in which the pilots had less than 500 total hours or more than 1,000 and 3,000 total hours by kind of flying category:

Kind of flying	Percentage of accidents per total pilot flying time: Under 500 hours	Over 1,000 hours	Over 3,000 hours
Instructional	25.0	68.8	47.5
Personal/business	32.1	45.8	36.6
Corporate/executive	0	92.1	65.8
Aerial application	4.9	85.3	54.7
Air-taxi-type operations	0	97.3	72.1
Aerial observation	3.4	93.1	55.2
Other	9.1	83.9	59.4
Total	12.1	79.9	53.5
(Business	22.0	58.5	36.6)

The NTSB kind of flying category of "business," which is a subcategory of "personal/business flying" in the preceding tabulation, is shown for comparison. The distribution of the total flying time of business pilots is more similar to personal/business flying than it is to the categories of aerial application, air taxi, or aerial observation, all of which involve pilots flying as a profession. For example, 22 percent of rotorcraft business accidents involved pilots with less than 500 hours total flying time, compared with 32 percent for the personal/business flying accidents. However, none of the pilots involved in corporate/executive or air-taxi accidents had less than 500 hours total time, and less than 5 percent of the aerial application accidents involved pilots with less than 500 hours total experience. Further, only 36.6 percent of the accident pilots in business flying and personal/business flying had more than 3,000 hours total flying time. In the accidents involving the "professional" flying categories, at least half of the pilots had more than 3,000 hours total time and 72.1 percent of the air taxi accident pilots had 3,000 hours or more.

The accident distribution as a function of pilot time in the accident type of aircraft (a measure of the pilot's familiarity with the aircraft) and by the kind of flying is shown in table 15.

Table 15.--Total accidents by time in type by kind of flying.

Kind of flying	Time in type (hours): 0-50	51-100	101-250	251-500	501-1,000	1,001-3,000	Over 3,000	Total Pilots
Instructional	26	13	12	9	9	8	1	78
Personal/business	43	34	50	21	18	15	7	188
Corporate/executive	2	4	13	7	3	7		36
Aerial application	15	11	41	48	40	49	16	220
Air-taxi-type operations	16	7	23	19	34	34	10	143
Aerial observation	8	5	5	19	5	9	4	55
Other	26	20	21	25	21	19	7	139
Total pilots	136	94	165	148	130	141	45	859

The following tabulation aids the review of the data in table 15 by comparing the percentages of accidents by kinds of flying for pilots with less than 100 hours in type and greater than 250 and 500 hours in type:

Kind of flying	Percentage of accidents per time in type: Under 100 hours	Over 250 hours	Over 500 hours
Instructional	50.0	34.6	23.1
Personal/business	22.9	32.4	21.3
Corporate/executive	16.7	47.2	27.8
Aerial application	11.8	69.5	47.7
Air-taxi-type operations	16.1	67.8	34.5
Aerial observation	23.6	67.2	32.7
Other	33.1	51.8	33.8
Total	26.8	54.0	36.8
(Business	30.0	40.0	12.5)

The preceding tabulation shows that in the accidents involving professional flying, pilots have more time in type than in the personal/business and instructional flying categories. In more than half of the accidents with professional pilots, the pilots had more than 250 hours in type. Certainly most pilots involved in rotorcraft accidents have flown in the accident-type aircraft enough to be generally familiar with the aircraft. However, it is possible that their previous experience did not expose them to the unique demands of the accident flight.

Table 16 shows the number of accidents in relation to pilot flying time in the last 90 days and the kind of flying being performed at the time of the accident.

Table 16.--Pilot's time in last 90 days by kind of flying.

	Pilot flying time in last 90 days (hours)						
Kind of flying	0-10	11-25	26-50	51-100	101-200	Over 200	Total Pilots
Instructional	6	11	10	17	24	8	76
Personal/business	33	33	41	34	24	6	171
Corporate/executive	1	1	3	10	16	6	37
Aerial application	2	10	32	57	69	48	218
Air-taxi-type operations	2	5	12	32	70	19	140
Aerial observation	3	1	12	14	16	9	55
Other	12	13	19	31	41	20	136
Total accident pilots	59	74	129	195	260	116	833

The following tabulation aids the review of the data in table 16 by comparing the percentage of accidents by kinds of flying for pilots with less than 50 hours flown in the last 90 days with more than 100 hours in the last 90 days:

Kind of flying	Percentage of accidents per time in type: Under 50 hours	Percentage of accidents per time in type: Over 100 hours
Instructional	35.5	42.1
Personal/business	62.6	17.5
Corporate/executive	13.5	59.5
Aerial application	20.2	53.7
Air-taxi-type operations	13.6	63.6
Aerial observation	29.1	45.5
Other	32.4	44.9
Total	31.5	45.1
(Business	58.8	20.6)

The preceding tabulation shows a distinct difference in the time flown in the last 90 days between pilots engaged in personal/business flying and pilots substantially engaged in professional flying. The percentage of accidents involving pilots engaged in "business" flying with under 50 hours and those with greater than 100 hours in the last 90 days is shown to demonstrate further that this type of flying is more similar to the category of personal/business flying than to the professional kinds of flying such as aerial application and air taxi flying. In the professional flying categories, 30 percent or fewer of the accident pilots had less than 90 hours in the previous 90 days and about half had more than 100 hours in the previous 90 days. In the personal/business flying category, the percentages are quite different. Also, the percentages of pilots involved in instructional accidents were in-between the accident percentages of pilots in the personal/business and "professional" categories.

Table 17 shows the number of accidents for kinds of flying as a function of pilot time in the last 24 hours. This is another measure of pilot activity and a potential measure of pilot fatigue or overwork. Only 5.1 percent of the 728 accidents in which pilot time in the last 24 hours was available involved pilots who had flown 9 hours or more in the last 24 hours. However, fatigue could have been a problem in these 37 accidents, especially in the 6 aerial application accidents where the pilots had flown for more than 11 out of the previous 24 hours. More than 67 percent of the pilots involved in personal/business flying accidents had flown 2 hours or less in the last 24 hours. About 66 percent of the pilots involved in aerial application accidents and about 63 percent of the pilots involved in air taxi accidents flew between 3 and 8 hours in the last 24 hours.

Table 17.--Pilot time in preceding 24 hours by kind of flying.

	Pilot time flown in the last 24 hours (hours)					
Kind of flying	0-2	3-5	6-8	9-11	Over 11	Total Pilots
Instructional	38	22	4	1	1	66
Personal/business	92	32	11	1	1	137
Corporate/executive	18	13	1	1		33
Aerial application	49	75	50	10	6	190
Air-taxi-type operations	44	54	27	3	1	129
Aerial observation	26	11	13	2	2	54
Other	51	38	22	7	1	119
Total accident pilots	318	245	128	25	12	728

Again, without "exposure" data, it is not possible to determine if specific segments of the pilot population were having accidents beyond their expected levels. Therefore, care must be used in interpreting or drawing conclusions from these or any of the other data involving pilot flying time.

Environment

The following tabulation shows the number of fatal and total rotorcraft accidents which occurred from 1977 through 1979 in which weather, terrain, and airport/airway/facilities were cited as a cause or related factor (for more details see appendix A):

Environmental cause/factors	Fatal accidents			Total accidents		
	Cause	Factor	Totals	Cause	Factor	Totals
Weather	0	22	22	6	114	116
Terrain	0	17	17	31	185	216
Airport/airway/ facilities	0	0	0	0	3	3

There were no fatal accidents in which these environmental factors were cited as a cause of the accidents. Terrain was cited in 31 nonfatal accidents as a cause, and weather was cited in 6 nonfatal accidents as a cause. However, terrain was cited as a cause or factor in 216 total accidents and weather was cited as a cause or factor in 116 total accidents. These data indicate that while environmental factors are not often the cause of rotorcraft accidents, they are frequently factors in these accidents.

Weather.--The following tabulation shows the most frequent weather cause/factors (see appendix A for more details):

Weather cause/factors	Fatal accidents	Total accidents
Unfavorable wind conditions	4	40
High-density altitude	1	26
Fog	9	17
Low ceiling	8	18
Downdrafts and updrafts	1	10
Rain	6	7
Snow	2	7
Icing conditions, conditions conducive to carburetor icing	2	7
Other	7	23
Total weather cause/factors	40	155

Although unfavorable wind conditions, updrafts and downdrafts, and high-density altitude contributed to a significant number of rotorcraft accidents, most of these were not fatal. Conditions affecting pilot visibility such as low ceiling, fog, and rain were the factors most often contributing to fatal accidents. Table 18 shows the visibility and the conditions of light at the time of the rotorcraft accidents. At the time of 14 rotorcraft accidents, visibility was 1/2 mile or less, and at the time of 21 accidents, the visibility was 1 mile or less. Most accidents (814) occurred during daylight and in 757 of these the visibility was 5 miles or more. Only 37 accidents occurred during night conditions.

Table 18.--Conditions of light in relation to visibility.

	Conditions of light						
Visibility	Dawn	Day-light	Dusk	Night (dark)	Night (light)	Unknown	Total accidents
Zero			3	2			5
Zero to 1/4 mile			3	1			4
1/4 to 1/2 mile	2	2		1			5
1/2 to 1 mile		5	1	1			7
1 to 2 miles		6		4			10
2 to 5 miles		30					30
5 miles or more	11	757	16	22	6		812
Unknown	1	14	1			1	17
Total accidents	14	814	24	31	6	1	890

Of the 21 accidents with visibility of 1 mile or less, only 3 (14.3 percent) were fatal, as shown in table 19. About 12.7 percent of the accidents that occurred with visibility of more than 5 miles were fatal, whereas 30 percent of the accidents with visibility of between 1 and 5 miles were fatal. However, the relationship between visibility and accident severity is not obvious from these data since the accidents in which the visibility was the least did not result in the greatest percentage of fatal accidents.

Table 19.--Severity of accidents in relation to visibility.

	Severity of accident				
Visibility	Fatal	Serious	Minor	None	Total
Zero		2	3		5
Zero to 1/4 mile	1	1		2	4
1/4 to 1/2 mile	1		1	3	5
1/2 to 1 mile	1		1	5	7
1 to 2 miles	5		2	3	10
2 to 5 miles	7	1	4	18	30
5 miles or more	103	95	160	454	812
Unknown	7	2	2	6	17
Total accidents	125	101	173	491	890

The following tabulation shows the certificate held by the pilots involved in the accidents which occurred in VFR (visual flight rules) and IFR (instrument flight rules) conditions:

	Weather conditions				
Certificate	VFR	IFR	Below minimums	Unknown	Total
Student	43	1			44
Private	73	3			76
Commercial	631	23	1	3	658
Airline transport	100	2			102
Other	12				12
Total pilots	859	29	1	3	892

Of the 29 accidents which occurred during IFR conditions and the 1 accident in below-minimums conditions, 24 of the pilots held commercial certificates. One pilot was a student and three held private certificates. The following tabulation shows that 18 of the 29 pilots involved in rotorcraft accidents in IFR conditions did not have instrument ratings.

	Weather conditions				
Pilot rating	VFR	IFR	Below minimums	Unknown	Total
Rotorcraft	463	18		2	483
Rotorcraft with instrument rating	257	9	1	1	268
Other	139	2			141
Total pilots	859	29	1	3	892

It was not possible to determine whether 141 of the pilots involved in these rotorcraft accidents had a rotorcraft and/or instrument rating because of the method by which data on pilot ratings are collected and stored in the computer system.

The following tabulation shows that almost 38 percent of the accidents which occurred in IFR conditions were fatal:

Severity of accident	Weather conditions: VFR	IFR	Below minimums	Unknown	Total
Fatal	113	11		1	125
Serious	96	4		1	101
Minor	166	6	1		173
None	482	8		1	491
Total accidents	857	29	1	3	890

By way of comparison, only about 13 percent of the accidents which occurred in VFR conditions were fatal. These data demonstrate the increased degree of severity of accidents in instrument weather conditions, that is, weather conditions which combine low ceiling with poor visibility.

As shown in the following tabulation, the 519 accidents which occurred during the 5 months from May through September accounted for 58 percent of all rotorcraft accidents. This relatively high number of accidents during the summer months probably reflects the higher level of rotorcraft activity during these months.

Month	Weather conditions: VFR	IFR	Below minimums	Unknown	Total
January	46	2			48
February	35	3			38
March	62	1		1	64
April	69	1			70
May	95	3			98
June	98	2			100
July	116	2			118
August	105	3		1	109
September	90	2		1	93
October	55	3			58
November	34	2	1		37
December	52	5			57
Total accidents	857	29	1	3	890

Terrain.--The following tabulation shows that high obstructions is the terrain-related cause/factor most frequently cited in total and fatal rotorcraft accidents:

Terrain cause/factors	Fatal accidents	Total accidents
High obstructions	13	102
Rough, uneven ground	2	40
Wet, soft ground	0	27
High vegetation	0	21
Other	3	30
Total	18	220

Airport/Airway/Facilities.--Table 20 shows the severity of injuries to persons in rotorcraft accidents in relation to the distance the accidents occurred from an airport. About 20 percent of all rotorcraft accidents occurred on an airport or other prepared landing facility. Of these 176 accidents, only 15, or about 8.5 percent, were fatal. In comparison, of the 466 rotorcraft accidents which occurred beyond 5 miles from an airport, 69, or 14.8 percent, were fatal. The accidents that occurred between 1/4 and 5 miles from an airport were the most fatal. Of 96 such accidents, 27, or almost 28 percent, were fatal.

Table 20.--Severity of injury in relation to distance from airport.

Distance from airport	Severity of injury				
	Fatal	Serious	Minor	None	Total
On airport	12	16	29	85	142
On seaplane base			1		1
On heliport	1	3	4	13	21
On barge/ship platform	2	1	3	6	12
In traffic pattern	2	3	1	5	11
Within 1/4 mile	2	1	7	6	16
1/4 to 1/2 mile	6		4	5	15
1/2 to 1 mile	5	4	4	3	16
1 to 2 miles	5	1	5	14	25
2 to 5 miles	11	5	7	17	40
Beyond 5 miles	69	53	92	252	466
Other	10	14	16	85	125
Total accidents	125	101	173	491	890

Table 21 (page 26) shows the kind of flying at the time of the accident by the distance the accident occurred from an airport. The data do not provide any insight into why accidents occurring between 1/4 and 5 miles from an airport are more often fatal than others.

Aircraft

The following tabulation shows the major mechanical or aircraft cause/factors that were cited in the total and fatal rotorcraft accidents that occurred from 1977 through 1979:

Mechanical or aircraft cause/factors	Fatal rotorcraft accidents			Total rotorcraft accidents		
	Cause	Factor	Totals 1/	Cause	Factor	Totals 1/
Airframe	1	1	2	2	1	3
Landing gear				4		4
Powerplant	10		10	178	13	188
Systems				2	1	3
Instruments/equipment				3	3	6
Rotorcraft	29	1	30	128	3	131

1/ If an accident includes both a cause and a related factor in the same causal category, the accident is represented once under the total for that category.

Table 21.--Kind of flying in relation to distance from airport.

Distance from airport	Instructional	Personal/business	Corporate/Executive	Aerial Application	Air-Taxi-Type Operations	Aerial Observation	Other	Total Accidents
	Kind of Flying							
On airport	38	42	8	9	12	2	31	142
On seaplane base							1	1
On heliport		3	2	3	6	1	6	21
On barge/ship platform		1	1	2	6		2	12
In traffic pattern	2	5		2	1		1	11
Within 1/4 mile	2	7	1	2	1		3	16
1/4 to 1/2 mile	2	7			2	1	3	15
1/2 to 1 mile	3	5		3	3	2		16
1 to 2 miles	2	4		9	2	1	7	25
2 to 5 miles	4	11	1	5	8	5	6	40
5 miles or more	24	86	21	132	96	40	67	466
Other	3	24	4	58	11	6	19	125
Total accidents	80	195	38	225	148	58	146	890

The two most important major mechanical cause/factors relate to the propulsion and control of the aircraft. Powerplant was cited as a cause/factor when failures or malfunctions of the engine, fuel system, and auxiliary systems caused or contributed to the accident. Rotorcraft was cited as a cause/factor when failures or malfunctions of the main and tail rotor assemblies, the transmission and rotor drive system, and the flight control systems caused or contributed to the accident. These two cause/factors were almost always a cause and not just a related or contributing factor. The detailed aircraft-related cause/factors can be found in appendix A.

The following tabulation compares the mean rates of occurrence per 100,000 flying hours of accidents involving the major mechanical cause/factors for rotorcraft and fixed-wing aircraft:

Mechanical or aircraft cause/factors	Rotorcraft Total accidents	Rotorcraft Accident rate	Fixed-wing aircraft Total accidents	Fixed-wing aircraft Accident rate
Airframe	3	0	123	0.1
Landing gear	4	0.1	469	0.4
Powerplant	188	2.8	1,677	1.5
Systems	3	0	178	0.2
Instrument/equipment	6	0.1	53	0.1
Rotorcraft	131	2.0	0	0.0
Total accidents with cause/factors assigned	889	13.4	11,640	10.5

Since more than one cause or factor can be cited in a given accident, the rates of occurrence of accidents with specific cause/factor assignments cannot be added directly. However, it is still evident from the preceding data that the mean rate of occurrence per 100,000 flying hours of accidents involving mechanical cause/factors is significantly greater for rotorcraft than for fixed-wing aircraft. These data indicate that the major difference between the overall mean accident rates of 13.4 for rotorcraft and 10.5 for fixed-wing aircraft is the greater rate of occurrence of mechanically caused rotorcraft accidents.

The following tabulation shows the number of total accidents and fatal accidents which occurred from 1977 through 1979 and their mean rate of occurrence per 100,000 flying hours for various rotorcraft makes and models:

Rotorcraft make and model 1/	Hours flown	All accidents	Accident rate 2/	Fatal accidents	Fatal accident rate 2/
Aerospatiale 315/316/319	107,953	22	20.38	1	0.93
Aerospatiale 341	63,641	6	9.43	2	3.14
Bell 47	1,180,728	250	21.17	25	2.18
Bell 204/205	156,554	7	4.47	2	1.28
Bell 206	2,741,889	97	3.54	17	0.62
Bell 212	274,756	6	2.18	2	0.73
Brantly B-2	30,101	15	49.83	4	13.29
Enstrom F-28	191,270	69	36.07	5	2.61
Hiller UH-12	311,547	103	33.06	6	1.93
Hiller FH-1100	58,270	16	27.46	2	3.43
Hughes 269/300	452,518	129	28.51	13	2.87
Hughes 369/500	511,865	63	12.31	12	2.34
MBB BO-105	90,879	8	8.80	3	3.30
Sikorsky S-55	17,871	9	50.36	2	11.19
Sikorsky S-58	14,591	8	54.83	0	0.00
Sikorsky S-58T	14,028	3	21.39	2	14.26

1/ Sikorsky models S-61 and S-62 were not included because of the lack of flight-hour data and the small number of accidents involving them.
2/ Accident rates are the number of accidents per 100,000 flying hours.

The tabulation includes all FAA-certificated makes and models for which it was possible to match FAA make and model fight-hour data with NTSB make and model accident data. Accident rates varied from about 2 per 100,000 flying hours to more than 50 per 100,000 flying hours. The number of flying hours also varied greatly with one rotorcraft make and model flying less than 15,000 hours and another flying more than 2 1/2 million hours during 1977 through 1979.

Many factors can affect the accident rates of aircraft makes and models including global factors such as exposure (hours flown), design concepts, manufacturing techniques, and kind of use of the aircraft. The rates also can be affected by specific factors such as pilot experience and capabilities, aircraft maintenance and condition, and the environment in which the aircraft is flown. Although it was not possible in this review to determine how all of these factors affected the accident rates shown in the preceding tabulation, it was possible to explore some of the relationships.

In an attempt to assess the relationship of these rotorcraft makes and models to flight exposure, the accident rates were plotted as a function of hours flown on semilogarithmic graph paper (graph paper on which the lines are evenly spaced on one side and spaced in a logarithmically graduated scale on the other side). Distinct differences were noted between the piston-powered rotorcraft data and the turbine-powered rotorcraft data. (See figure 4.) The piston-powered rotorcraft accident rates and flight-hour data points were in a nearly straight line on the semilogarithmic paper. These data fell substantially above the data for turbine-powered rotorcraft, indicating generally higher accident rates for piston-powered rotorcraft. The data for turbine-powered rotorcraft displayed much greater disarray.

Several different attempts were made to curve-fit the data. The logarithmic curve:

$$\text{Accident rate} = 123.73 - 7.27 \text{ X } \log(\text{flight-hours})$$

fit the piston-powered rotorcraft data almost exactly. The correlation coefficient was 0.99. It was not possible to find a curve fit for the turbine-powered rotorcraft data as precise as the curve fit for the piston-powered data, which would be expected because of the data disarray. However, the power curve:

$$\text{Accident rate} = 748.21\,(\text{flight-hours})^{-0.37}$$

did fit the data with a correlation coefficient of 0.65.

The results of this effort to curve-fit the aircraft make and model accident rate and flight-hour data were twofold. First, a considerable difference in accident rates between piston- and turbine-powered rotorcraft was revealed. Second, it appears that flight exposure correlates highly in an inverse manner with piston-powered rotorcraft accident rates. That is, the more flight-hours associated with a given rotorcraft make and model, the lower its accident rate. The same high degree of correlation did not exist with the turbine-powered rotorcraft. The data review did not reveal the significance of this fact.

The magnitude of the difference in accident rates between piston- and turbine-powered rotorcraft is shown in the following tabulation:

	Piston-powered rotorcraft	Turbine-powered rotorcraft
Hours flown	2,306,550	4,343,932
Total accident records	626	265
Mean total rate per 100,000 hours	27.14	6.10
Fatal accident records	72	53
Mean fatal rate per 100,000 hours	3.12	1.22

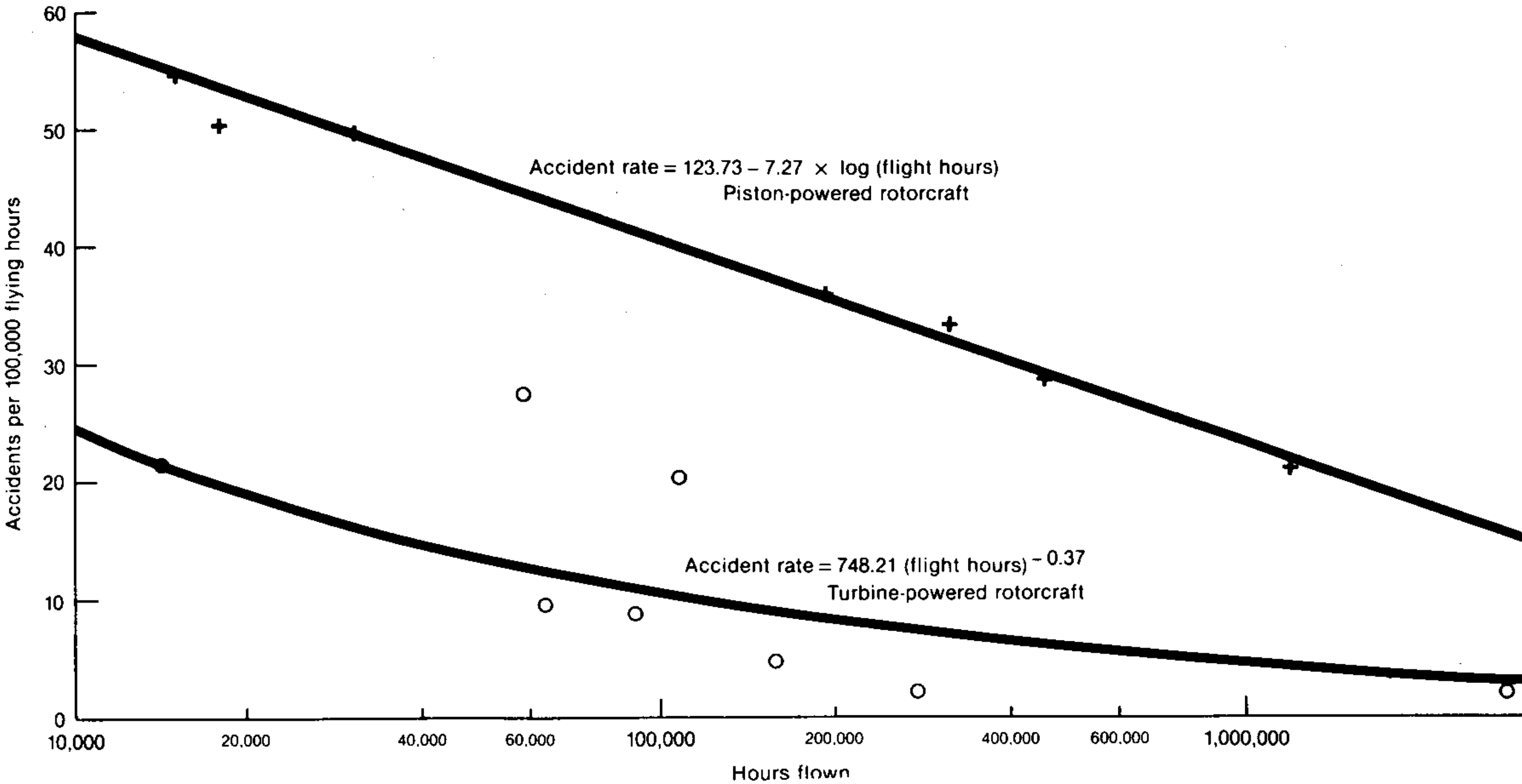

Figure 4.--Rotorcraft accident rates variation with exposure.

Although there were 892 records for each of the rotorcraft involved in the 890 accidents during 1977 through 1979, in the preceding tabulation there are only 891 records because 1 fatal accident involved a rotorcraft that was being towed without an engine in a test program.

The mean total accident rate for piston-powered rotorcraft was almost 4 1/2 times greater than the mean total accident rate for the turbine-powered rotorcraft. The mean fatal accident rate for piston-powered rotorcraft was 2 1/2 times greater than the mean fatal accident rate for turbine-powered rotorcraft. From the preceding data it can be seen that 20.0 percent of turbine-powered rotorcraft accidents were fatal while only 11.5 percent of the piston-powered rotorcraft accidents were fatal.

Many factors could be contributing to the significantly higher rate of occurrence of accidents of piston-powered rotorcraft. A difference in the kind of flying performed in piston- and turbine-powered rotorcraft could be a factor. The kind of flying during which the accidents occurred is shown in the following tabulation for piston- and turbine-powered rotorcraft:

	Piston-powered rotorcraft			Turbine-powered rotorcraft		
Kind of flying	Accidents	Flying hours	Rates 1/	Accidents	Flying hours	Rates 1/
Instructional	73	189,298	38.6	7	178,079	3.9
Personal/business	164	358,530	45.7	31	266,060	11.7
Corporate/executive	10	118,531	8.4	28	568,733	4.9
Aerial application	207	662,480	31.2	18	72,344	24.9
Air-taxi-type operations	42	110,126	38.1	107	2,448,466	4.4
Other 2/	130	860,771	15.1	74	819,738	9.0

1/ Per 100,000 flying hours.
2/ Includes aerial observation flying because flying hours are not available for that category and rates cannot be calculated separately.

The preceding flying hour data show that piston- and turbine-powered rotorcraft are used most often in different types of operations. Piston-powered rotorcraft are used more often then turbine-powered rotorcraft in personal/business flying and aerial application, both of which have previously been shown to have relatively high accident rates. Turbine-powered rotorcraft, however, are used much more frequently in air taxi and corporate/executive flying, both of which have already been shown to have lower accident rates.

The data also show, however, that the accident rates of all categories of kind of flying are lower for turbine-powered rotorcraft than those for the same categories in piston-powered rotorcraft. Thus, although there is a distinct difference in the kinds of flying of piston- and turbine-powered rotorcraft, the fact that turbine-powered rotorcraft have lower accident rates for all categories of kinds of flying indicates that other factors also are involved.

The following tabulation does not show a markedly different distribution of the percentage of accidents as a function of broad cause/factor between piston- and turbine-powered rotorcraft accidents:

Broad cause/factor	Turbine-powered rotorcraft		Piston-powered rotorcraft	
	Accidents	Percentage of all accidents	Accidents	Percentage of all accidents
All	263	100.0	626	100.0
Pilot	157	59.7	416	66.5
Personnel	46	17.5	75	12.0
Powerplant	58	22.1	130	20.8
Rotorcraft	33	12.5	98	15.7
Weather	40	15.2	76	12.1
Terrain	70	26.6	146	23.3

These accident data, if divided by flight-hours, would indicate that accidents occurred at higher rates for piston-powered rotorcraft in all the above cause/factor categories. The tabulation also shows that pilots were cited as a cause/factor in a somewhat larger percentage of accidents involving piston-powered rotorcraft. However, this could reflect the large involvement of piston-powered rotorcraft in aerial application flying. Aerial application flying is difficult and dangerous, but piston-powered rotorcraft are known to be more difficult to fly than turbine-powered rotorcraft since the pilot must manipulate the twist grip throttle on the collective control as power requirements change on piston-powered rotorcraft. Once the pilot sets the throttle into the "fly position" on most turbine-powered rotorcraft, no further throttle adjustment is required.

Tables 22 and 23 (page 32) show the total flying time and the time in the accident type of aircraft for pilots involved in piston-powered rotorcraft accidents and for pilots involved in turbine-powered rotorcraft accidents. It appears from these two tables that pilots involved in turbine-powered rotorcraft accidents are more experienced, in terms of flight time, than the pilots involved in piston-powered rotorcraft accidents. This can be seen from the following tabulation which shows the percentage of rotorcraft accidents for pilots with less than 100 hours time in type and 1,000 hours total time and for the pilots with more than 250 hours time in type and 5,000 hours total time.

Rotorcraft	Less than 100 hours in type and 1,000 hours total time	Greater than 250 hours in type and 5,000 hours total time
Piston-powered	42.1	17.3
Turbine-powered	20.7	28.8

Table 22.--Turbine-powered rotorcraft accidents by pilot total time and time in type.

Time in type (hours)	Total time (hours): 0-100	101-500	501-1,000	1,001-3,000	3,001-5,000	5,001-10,000	Over 10,000	Total Records
0-50	1	1		8	8	5	2	25
51-100			3	10	5	2	2	22
101-250		4		18	15	10	4	51
250-500		1		15	17	18	3	54
501-750			2	7	11	5	3	28
751-1,000				3	8	6	1	18
1,001-3,000				6	14	25	8	53
Over 3,000				1	2	4	2	9
Total accident records	1	6	5	68	80	75	25	260

Table 23.--Piston-powered rotorcraft accidents by pilot total time and time in type.

Time in type (hours)	Total time (hours): 0-100	101-500	501-1,000	1,001-3,000	3,001-5,000	5,001-10,000	Over 10,000	Total Records
0-50	19	19	13	28	14	10	5	108
51-100	9	16	13	15	11	8		72
101-250		24	13	33	26	11	6	113
250-500		8	11	37	15	18	7	96
501-750			12	15	15	9	5	56
751-1,000			3	6	9	5	5	28
1,001-3,000				26	25	24	11	86
Over 3,000					7	18	11	36
Total accidents records	28	67	65	160	122	103	50	595

The percentage of piston-powered rotorcraft accidents involving the lower-time pilots is more than double that for the turbine-powered rotorcraft accidents. Conversely, a much higher percentage of the turbine-powered rotorcraft accidents involved the higher-time pilots. These data could be indicating that turbine-powered rotorcraft are generally flown by pilots with relatively more flying experience than piston-powered rotorcraft. Although it is not likely, these data also could be indicating that the more experienced (in terms of flying time) turbine-powered rotorcraft pilots are having more accidents then the lower-time piston-powered rotorcraft pilots. Nonaccident pilot exposure data are needed to determine which hypothesis is correct. However, it is likely that these data do reflect, to some extent, a generally lower level of pilot flying time among piston-powered rotorcraft pilots.

Data shown previously in this report indicated that a substantial portion of the pilots involved in aerial application accidents had extensive total flying time and time in the accident-type rotorcraft. Since most aerial application flying is performed in piston-powered rotorcraft and aerial application flying accounts for about one-third of the piston-powered rotorcraft accidents, the piston-powered rotorcraft accidents involving the private and "other" categories of kind of flying must have involved pilots with relatively low flying time for the flying hours data of piston-powered rotorcraft pilots to be skewed to the "low time" side.

If the preceding theories are correct, then the higher accident rates of piston-powered aircraft could be the result, in part, of a combination of the following: (1) "lower time" pilots involved in private and "other" flying; (2) extensive aerial application flying; (3) the inherently more difficult operational demands of piston-powered rotorcraft; and (4) higher rates of occurrence of mechanical failures.

As stated previously, 20 percent of the turbine-powered rotorcraft accidents were fatal while only 11.5 percent of the piston-powered rotorcraft accidents were fatal. The following tabulation shows that turbine-powered rotorcraft accidents result in a greater percentage of fatal accidents for all major cause/factors except for powerplant failures:

	Turbine-powered rotorcraft				Piston-powered rotorcraft			
Cause/ factors	Total accidents	Accident rate	Fatal accidents	Fatal accident rate	Total accidents	Accident rate	Fatal accidents	Fatal accident rate
All	263	6.1	52	1.20	626	27.1	72	3.12
Pilot	157	3.6	34	0.78	416	18.0	40	1.73
Personnel	46	1.1	9	0.21	75	3.3	12	0.52
Powerplant	58	1.3	2	0.05	130	5.6	8	0.35
Rotorcraft	33	0.8	11	0.25	98	4.2	19	0.82
Weather	40	0.9	14	0.32	76	3.3	8	0.35
Terrain	70	1.6	9	0.21	146	6.3	8	0.35

However, those turbine-powered rotorcraft accidents involving the pilot and weather as cause/factors showed the greatest difference from piston-powered rotorcraft in the percentage of accidents that were fatal.

Again, differences in the kinds of flying could be a factor contributing to the larger percentage of turbine-powered rotorcraft accidents that are fatal compared with piston-powered rotorcraft accidents. Table 24 shows the severity of accidents as a function of kind of flying for piston- and turbine-powered rotorcraft.

Table 24.--Severity of injury in relation to kind of flying.

	Piston-powered rotorcraft accidents					
	Severity of injury					
Kind of flying	Fatal	Serious	Minor	None	Total	Percentage of fatal to total
Instructional	10	9	8	46	73	13.7
Personal/business	27	15	34	88	164	16.5
Corporate/executive	1	2		7	10	10.0
Aerial application	8	21	37	141	207	3.9
Air-taxi-type operations	7	1	13	21	42	16.7
Aerial observation	11	5	8	18	42	26.2
Other	8	14	18	48	88	9.1
Total accidents	72	67	118	369	626	11.5

	Turbine-powered rotorcraft accidents					
	Severity of injury					
Kind of flying	Fatal	Serious	Minor	None	Total	Percentage of fatal to total
Instructional		1	1	5	7	
Personal/business	5	3	5	18	31	16.1
Corporate/executive	4	3	5	16	28	14.3
Aerial application	1	1	5	11	18	5.6
Air-taxi-type operations	25	17	23	42	107	23.4
Aerial observation	5	1	4	6	16	31.3
Other	13	8	12	25	58	22.4
Total accidents	53	34	55	123	265	20.0

One-third of the piston-powered rotorcraft accidents involved aerial application flying and only 3.8 percent of these accidents were fatal. On the other hand, 40 percent of the turbine-powered rotorcraft accidents involved air taxi accidents of which 23.4 percent were fatal. With the exception of instructional and personal/business flying, accidents in all categories of kind of flying were more often fatal in turbine-powered rotorcraft.

Table 25 (page 35) shows how the rotorcraft type of power is related to accident distribution by broad phase of operation. These data indicate that accidents occurring during in-flight operation of the rotorcraft account for almost 51 percent of the turbine-powered rotorcraft accidents, but only 31.5 percent of the piston-powered rotorcraft accidents. It was shown previously in this report that a larger percentage of the accidents occurring in flight were fatal than the accidents occurring during other phases of operation. Further, almost 25 percent of the piston-powered rotorcraft accidents occurred during the much less fatal, in-flight aerial application phase of operation.

Table 25.--Type of power in relation to broad phase of operation.

Broad phase of operation	Type of power: None[1/]	Piston	Turbine	Total
Static		6	12	18
Taxi		21	11	32
Takeoff	1	116	41	158
In-flight		197	135	332
In-flight, aerial application		152	14	166
Landing		130	50	180
Unknown		4	2	6
Total accident records	1	626	265	892

1/ Rotorcraft had no powerplant and was being towed by an automobile.

The differences in phase of operation and kind of flying of turbine- and piston-powered rotorcraft tend to support a hypothesis that greater flying speeds and higher altitudes resulting in greater impact speeds in turbine-powered rotorcraft accidents accounts for, in part, the larger percentage of turbine-powered rotorcraft accidents that are fatal.

Tables 26 and 27 (page 36) show the accident distribution by detailed phases of in-flight operations according to the severity of injury to persons involved in the accidents and according to the type of power.

Table 26.--Severity of injury in relation to in-flight phase of operation.

In-flight phase of operation	Severity of injury: Fatal	Serious	Minor	None	Total
Climb to cruise	3	1	3	7	14
Normal cruise	41	16	36	82	175
Descending	1		3	5	9
Hovering	9	12	8	28	57
Power-on descent	1	2	1	3	7
Autorotative descent	2	1	1	6	10
Uncontrolled descent	12	1		1	14
Low pass	7	2	2	5	16
Other	10	3	6	11	30
Total accident records	86	38	60	148	332

Table 27.--Type of power in relation to in-flight phase of operation.

In-flight phase of operation	Type of power: Piston	Turbine	Total
Climb to cruise	10	4	14
Normal cruise	102	73	175
Descending	5	4	9
Hovering	28	29	57
Power-on descent	6	1	7
Autorotative descent	5	5	10
Uncontrolled descent	7	7	14
Low pass	11	5	16
Other	23	7	30
Total accident records	197	135	332

Accidents occurring during normal cruise, uncontrolled descent, and low pass were the most often fatal (aside from "other"). Accidents occurring during these three phases accounted for more than 32 percent of the turbine-powered rotorcraft accidents and only 19 percent of the piston-powered rotorcraft accidents.

There were more hovering accidents involving turbine-powered rotorcraft. The relationship of this to the type of use of the aircraft is not explicitly apparent from the data.

Table 28 (page 37) shows the frequency of occurrence of total accidents and fatal accidents and the percentage of accidents which are fatal as a function of the type of power by accident type. The distribution of accidents by the type of accident are relatively similar for piston- and turbine-powered rotorcraft. The most significant differences between piston- and turbine-powered rotorcraft accident data is in the percentage of accidents that were fatal. A larger percentage of the turbine-powered rotorcraft accidents were fatal in most accident types. These data do not indicate why a larger percentage of turbine-powered rotorcraft accidents are fatal. However, they do not refute the possibility that higher impact forces of the turbine-powered rotorcraft accidents, because of greater speeds and higher altitudes, contribute to the higher percentage of turbine-powered rotorcraft accidents that are fatal.

Table 29 (page 38) shows the percentage of accidents that are fatal by make and model and the number of such accidents that resulted in fire after impact. The amateur or home-built rotorcraft accidents were fatal most frequently. The Bell 214 had the second highest percentage of fatal accidents during the 1977 through 1979 period. Forty percent of the 79 accidents with postcrash fire involved Bell 47 rotorcraft. These 32 accidents with fire after impact resulted in 13 fatal accidents, over half of all Bell 47 fatal accidents.

Additional data on the type of accidents, phase of operation, and accidents involving the powerplant as a cause/factor for rotorcraft can be found in appendices B through D.

Table 28.--Total rotorcraft accident types as a function of type of power.

Accident Type	Piston-powered rotorcraft: Total Accidents	Piston-powered rotorcraft: Fatal Accidents	Piston-powered rotorcraft: Percent Fatal	Turbine-powered rotorcraft: Total Accidents	Turbine-powered rotorcraft: Fatal Accidents	Turbine-powered rotorcraft: Percent Fatal
Hard landing	60			20		
Rollover	34	1	2.9	19	1	5.3
Collision between aircraft						
Both in flight	1	1	100.0	3	2	66.7
Both on ground				2		
Collision with ground/water						
Controlled	66	6	9.1	22	8	36.4
Uncontrolled	39	14	35.9	17	8	47.1
Collision with obstacles						
Wires/poles	63	6	9.5	19	3	15.8
Trees	19	1	5.3	5	1	20.0
Other	28	2	7.1	25	3	12.0
Airframe Failure						
In flight	23	11	47.8	11	6	54.5
On ground	5	1	20.0	1		
Engine failure/malfunction	185	11	5.9	71	7	9.9
Prop/rotor failure						
Tail rotor	42	6	14.3	16	1	6.3
Main rotor	26	5	19.2	12	5	41.7
Propeller	2	1	50.0	3		
Other	33	6	18.2	19	8	42.1
Total accidents	626	72		265	53	

Table 29.--Rotorcraft accidents involving fire after impact by make and model.

Rotorcraft make and model	Total Accidents	Fatal Accidents	Percent Fatal	Fire After Impact	Fatal Fire After Impact
Aerospatiale 315/316/319	22	1	4.5	2	1
Aerospatiale 341	6	2	33.3	1	
Bell 47	250	25	10.0	32	13
Bell 204/205	7	2	28.6		
Bell 206	97	17	17.5	4	2
Bell 212	6	2	33.3		
Bell 214	7	3	42.9	1	
Brantly B-2	15	4	26.7		
Enstrom F-28	69	5	7.2	6	2
Hiller UH-12	103	6	5.8	10	1
Hiller FH-1100	16	2	12.5	1	
Hughes 269/369	129	13	10.1	8	6
Hughes 369/500	63	12	19.0	7	4
MBB BO-105	8	3	37.5	1	
Sikorsky S-55	9	2	22.2	2	
Sikorsky S-58	11	2	18.2	1	1
Amateur	42	20	47.6	1	1
Experimental	7	1	14.3		

FINDINGS

1. The number of rotorcraft total accidents, fatal accidents, and fatalities increased during the 1970's.

2. The rate of occurrence of rotorcraft accidents per 100,000 flying hours decreased significantly during the 1970's, and in 1979 the rotorcraft accident rate was 11.3 per 100,000 hours compared with a rate of 9.3 per 100,000 hours for all general aviation accidents.

The following findings are based on the 1977 through 1979 accident data:

3. The mean rate of occurrence of rotorcraft accidents was 13.4 per 100,000 flying hours compared with 10.5 per 100,000 flying hours for fixed-wing aircraft. However, only 14.0 percent of the rotorcraft accidents were fatal while 17.3 percent of the fixed-wing aircraft accidents were fatal.

4. The rate of occurrence of rotorcraft accidents where the pilot was determined by the NTSB to be a cause or related factor was 8.6 per 100,000 hours, the same rate of occurrence as that of fixed-wing aircraft accidents.

5. The primary cause of the difference in accident rates between fixed-wing aircraft and rotorcraft was the higher rate of occurrence of mechanical failures in rotorcraft accidents, specifically those failures involving the powerplant and rotor systems.

6. About 8.9 percent of rotorcraft accidents involved postcrash fire compared with 8.0 percent for all general aviation accidents. Only 40 percent of the rotorcraft accidents with postcrash fire were fatal compared with 59 percent for all general aviation. However, only 11 percent of all rotorcraft accidents were fatal and thus the chance of fatalities was significantly greater if fire after impact was present.

7. Rotorcraft accidents involving aerial application flying occurred at the rate of 30.6 per 100,000 flying hours compared with an air taxi rate of only 5.8. However, 21.6 percent of the air taxi accidents were fatal compared with only 4.0 percent of the aerial application accidents having fatalities.

8. Pilots involved in rotorcraft accidents were not generally "low time" pilots, especially those pilots involved in the professional kinds of flying such as corporate/executive, air taxi, and aerial application flying.

9. Pilots involved in turbine-powered rotorcraft accidents generally had more flying experience, in terms of flight-hours, than the pilots involved in piston-powered rotorcraft accidents.

10. The pilot was a cause or related factor in 64.5 percent of all rotorcraft accidents and 59.7 percent of the fatal accidents.

11. Weather was a cause in only 6 of 890 rotorcraft accidents, but it was a related factor in 13 percent of the accidents. Weather was a factor in 17.7 percent of the fatal rotorcraft accidents.

12. Terrain was a cause or related factor in 24 percent of the rotorcraft accidents.

13. Piston-powered rotorcraft accidents occurred 4 1/2 times more frequently than turbine-powered rotorcraft accidents, but 20 percent of the turbine-powered rotorcraft accidents were fatal while only 11.5 percent of the piston-powered rotorcraft accidents were fatal.

BY THE NATIONAL TRANSPORTATION SAFETY BOARD

/s/ ELWOOD T. DRIVER
Vice Chairman

/s/ FRANCIS H. McADAMS
Member

/s/ PATRICIA A. GOLDMAN
Member

JAMES B. KING, Chairman, and G. H. PATRICK BURSLEY, Member, did not participate.

August 11, 1981

APPENDIX A

CAUSE/FACTOR TABLE

ROTORCRAFT
U. S. GENERAL AVIATION
1977 - 1979

INVOLVES 889 TOTAL ACCIDENTS

INVOLVES 124 FATAL ACCIDENTS

(EXCLUDES ACCIDENTS WITHOUT CAUSAL ASSIGNMENT)

BROAD CAUSE/FACTOR	FATAL ACCIDENTS			NONFATAL ACCIDENTS			ALL ACCIDENTS		
	CAUSE	FACTOR	TOTAL*	CAUSE	FACTOR	TOTAL*	CAUSE	FACTOR	TOTAL*
PILOT	71 57.26	12 9.68	74 59.68	491 64.18	44 5.75	499 65.23	562 63.22	56 6.30	573 64.45
PERSONNEL	18 14.52	2 1.61	20 16.13	89 11.63	11 1.44	100 13.07	107 12.04	13 1.46	120 13.50
AIRFRAME	1 .81	1 .81	2 1.61	1 .13	.00	1 .13	2 .22	1 .11	3 .34
LANDING GEAR	.00	.00	.00	4 .52	.00	4 .52	4 .45	.00	4 .45
POWERPLANT	10 8.06	.00	10 8.06	168 21.96	13 1.70	178 23.27	178 20.02	13 1.46	188 21.15
SYSTEMS	.00	.00	.00	2 .26	1 .13	3 .39	2 .22	1 .11	3 .34
INSTRUMENTS/EQUIPMENT & ACCESSORIES	.00	.00	.00	3 .39	3 .39	6 .78	3 .34	3 .34	6 .67
ROTORCRAFT	29 23.39	1 .81	30 24.19	99 12.94	2 .26	101 13.20	128 14.40	3 .34	131 14.74
AIRPORT/AIRWAYS/FACILITIES	.00	.00	.00	.00	3 .39	3 .39	.00	3 .34	3 .34
WEATHER	.00	22 17.74	22 17.74	6 .78	92 12.03	94 12.29	6 .67	114 12.82	116 13.05
TERRAIN	.00	17 13.71	17 13.71	31 4.05	168 21.96	199 26.01	31 3.49	185 20.81	216 24.30
MISCELLANEOUS	7 5.65	2 1.61	9 7.26	37 4.84	6 .78	43 5.62	44 4.95	8 .90	52 5.85
UNDETERMINED	16 12.90	.00	16 12.90	19 2.48	.00	19 2.48	35 3.94	.00	35 3.94

THE FIGURES OPPOSITE EACH CAUSAL CATEGORY REPRESENT THE NUMBER AND PERCENT OF ACCIDENTS IN WHICH THAT PARTICULAR CAUSAL CATEGORY WAS ASSIGNED

* IF AN ACCIDENT INCLUDES BOTH A CAUSE AND RELATED FACTOR IN THE SAME CAUSAL CATEGORY, THE ACCIDENT IS REPRESENTED ONCE UNDER THE TOTAL FOR THAT CATEGORY

DETAILED CAUSE/FACTOR	FATAL ACCIDENTS			NONFATAL ACCIDENTS			ALL ACCIDENTS		
	CAUSE	FACTOR	TOTAL	CAUSE	FACTOR	TOTAL	CAUSE	FACTOR	TOTAL
** PILOT **									
PILOT IN COMMAND									
ATTEMPTED OPERATION W/KNOWN DEFICIENCIES IN EQUIPMENT		1	1	1	1	2	1	2	3
ATTEMPTED OPERATION BEYOND EXPERIENCE/ABILITY LEVEL	2		2	6	2	8	8	2	10
BECAME LOST/DISORIENTED				2	1	3	2	1	3
CONTINUED VFR FLIGHT INTO ADVERSE WEATHER CONDITIONS	10	1	11	5	2	7	15	3	18
DELAYED IN INITIATING GO-AROUND	1		1	4		4	5		5
DIVERTED ATTENTION FROM OPERATION OF AIRCRAFT	2		2	9	7	16	11	7	18
EXCEEDED DESIGN STRESS LIMITS OF AIRCRAFT		1	1					1	1
FAILED TO SEE AND AVOID OTHER AIRCRAFT	3		3	1		1	4		4
FAILED TO SEE AND AVOID OBJECTS OR OBSTRUCTIONS	7		7	62		62	69		69
FAILED TO OBTAIN/MAINTAIN FLYING SPEED				7		7	7		7
MISJUDGED, SPEED, ALTITUDE OR CLEARANCE				2		2	2		2
FAILED TO MAINTAIN ADEQUATE ROTOR RPM	13		13	101	1	102	114	1	115
FAILED TO USE OR INCORRECTLY USED MISC EQUIPMENT	1	2	3	1		1	2	2	4
FAILED TO FOLLOW APPROVED PROCEDURES, DIRECTIVES ETC	5		5	14	2	16	19	2	21
IMPROPER OPERATION OF POWERPLANT + POWERPLANT CONTROLS	3		3	15	1	16	18	1	19
IMPROPER OPERATION OF BRAKES AND/OR FLIGHT CONTROLS				6		6	6		6
IMPROPER OPERATION OF FLIGHT CONTROLS	13		13	69	2	71	82	2	84
IMPROPER LEVEL OFF				7		7	7		7
IMPROPER IN-FLIGHT DECISIONS OR PLANNING	8		8	20	2	22	28	2	30
IMPROPER COMPENSATION FOR WIND CONDITIONS				13	4	17	13	4	17
INADEQUATE PREFLIGHT PREPARATION AND/OR PLANNING	6	1	7	80	4	84	86	5	91
INADEQUATE SUPERVISION OF FLIGHT	3		3	24	2	26	27	2	29
LACK OF FAMILIARITY WITH AIRCRAFT	3	2	5	2	3	5	5	5	10
MISMANAGEMENT OF FUEL	4		4	35		35	39		39
EXERCISED POOR JUDGMENT	4		4	4		4	8		8
OPERATED CARELESSLY				1		1	1		1
SELECTED UNSUITABLE TERRAIN		1	1	17	4	21	17	5	22
IMPROPER STARTING PROCEDURES				2	1	3	2	1	3
INITIATED FLIGHT IN ADVERSE WEATHER CONDITIONS				4		4	4		4
SPONTANEOUS-IMPROPER ACTION	1		1	3		3	4		4
MISJUDGED DISTANCE, SPEED, AND ALTITUDE	1		1	1		1	2		2
MISJUDGED DISTANCE				1		1	1		1
MISJUDGED DISTANCE AND ALTITUDE				13	1	14	13	1	14
MISJUDGED SPEED AND ALTITUDE	1		1	23		23	24		24
MISJUDGED SPEED	1		1				1		1
MISJUDGED ALTITUDE AND CLEARANCE	2		2	9		9	11		11
MISJUDGED ALTITUDE	1		1	11	1	12	12	1	13
MISJUDGED CLEARANCE	4		4	43		43	47		47
IMPROPER RECOVERY FROM BOUNCED LANDING					1	1		1	1
PHYSICAL IMPAIRMENT		2	2		2	2		4	4
SPATIAL DISORIENTATION	7		7	5		5	12		12
LEFT AIRCRAFT UNATTENDED ENGINE RUNNING				2		2	2		2
FAILED TO MAINTAIN DIRECTIONAL CONTROL	1		1	3		3	4		4
FAILED TO INITIATE GO-AROUND				2	3	5	2	3	5
SUBTOTAL	107	11	118	630	47	677	737	58	795

PILOT (CONTINUED)

DETAILED CAUSE/FACTOR	FATAL ACCIDENTS CAUSE	FATAL ACCIDENTS FACTOR	FATAL ACCIDENTS TOTAL	NONFATAL ACCIDENTS CAUSE	NONFATAL ACCIDENTS FACTOR	NONFATAL ACCIDENTS TOTAL	ALL ACCIDENTS CAUSE	ALL ACCIDENTS FACTOR	ALL ACCIDENTS TOTAL
COPILOT									
DELAYED IN INITIATING GO-AROUND	1		1				1		1
IMPROPER COMPENSATION FOR WIND CONDITIONS	1		1				1		1
MISJUDGED DISTANCE AND ALTITUDE	1		1				1		1
SPATIAL DISORIENTATION		1	1					1	1
SUBTOTAL	3	1	4				3	1	4
DUAL STUDENT									
FAILED TO SEE AND AVOID OBJECTS OR OBSTRUCTIONS				1		1	1		1
FAILED TO MAINTAIN ADEQUATE ROTOR RPM				6		6	6		6
IMPROPER OPERATION OF POWERPLANT + POWERPLANT CONTROLS				2		2	2		2
IMPROPER OPERATION OF FLIGHT CONTROLS				11		11	11		11
CONTROL INTERFERENCE				1		1	1		1
SPONTANEOUS-IMPROPER ACTION				1		1	1		1
MISJUDGED DISTANCE, SPEED, AND ALTITUDE					1	1		1	1
MISJUDGED DISTANCE AND ALTITUDE				2		2	2		2
MISJUDGED SPEED AND ALTITUDE	1		1	3		3	4		4
FAILED TO MAINTAIN DIRECTIONAL CONTROL				1		1	1		1
SUBTOTAL	1		1	28	1	29	29	1	30
CHECK PILOT									
INADEQUATE SUPERVISION OF FLIGHT				1		1	1		1
** PERSONNEL **									
RULES, REGULATIONS, STANDARDS PERSONNEL					1	1		1	1
FLIGHT INSTRUCTOR									
INADEQUATE TRAINING OF STUDENT					1	1		1	1
MAINTENANCE, SERVICING, INSPECTION									
IMPROPER MAINTENANCE(MAINTENANCE PERSONNEL)	2		2	12		12	14		14
IMPROPER MAINTENANCE(OWNER PERSONNEL)	2		2	1		1	3		3
IMPROPERLY SERVICED AIRCRAFT(GROUND CREW)				3		3	3		3
IMPROPERLY SERVICED AIRCRAFT(OWNER-PILOT)				3		3	3		3
INADEQUATE INSPECTION OF AIRCRAFT(MAINTENANCE PERSONNEL		1	1	2	1	3	2	2	4
INADEQUATE MAINTENANCE AND INSPECTION	4		4	37	2	39	41	2	43
OTHER				1		1	1		1
UNK/NR				1		1	1		1
OPERATIONAL SUPERVISORY PERSONNEL									
FAILURE TO PROVIDE ADEQ DIRECTIVES, MANUALS, EQUIPMENT				2		2	2		2
DEFICIENCY, COMPANY MAINTAINED EQMT, SERV, REGULATIONS				4	1	5	4	1	5
WEATHER PERSONNEL									
TRAFFIC CONTROL PERSONNEL									
ISSUED IMPROPER OR CONFLICTING INSTRUCTIONS	2		2				2		2
INADEQUATE SPACING OF AIRCRAFT	2		2				2		2
AIRPORT SUPERVISORY PERSONNEL									
AIRWAYS FACILITIES PERSONNEL									
PRODUCTION-DESIGN-PERSONNEL									
SUBSTANDARD QUALITY CONTROL	3		3	3		3	6		6
POOR/INADEQUATE DESIGN	1		1	4		4	5		5
OTHER	1		1	2		2	3		3

PERSONNEL (CONTINUED)

DETAILED CAUSE/FACTOR	FATAL ACCIDENTS CAUSE	FATAL ACCIDENTS FACTOR	FATAL ACCIDENTS TOTAL	NONFATAL ACCIDENTS CAUSE	NONFATAL ACCIDENTS FACTOR	NONFATAL ACCIDENTS TOTAL	ALL ACCIDENTS CAUSE	ALL ACCIDENTS FACTOR	ALL ACCIDENTS TOTAL
MISCELLANEOUS-PERSONNEL									
PILOT OF OTHER AIRCRAFT	2		2	2		2	4		4
GROUND SIGNALMAN				1	1	2	1	1	2
GROUND CREWMAN	1		1	2	1	3	3	1	4
PASSENGER	3		3	7		7	10		10
DRIVER OF VEHICLE				1	1	2	1	1	2
OTHER	1	1	2	2	2	4	3	3	6
THIRD PILOT									
FLIGHT ENGINEER									
FLIGHT PERSONNEL									
DISPATCHING (AIR CARRIER ONLY)									
SUBTOTAL	24	2	26	91	11	102	115	13	128
** AIRFRAME **									
WINGS									
FUSELAGE									
OTHER				1		1	1		1
LANDING GEAR									
MAIN GEAR-SHOCK ABSORBING ASSY, STRUTS, ATTACHMENTS, ET				1		1	1		1
SKID ASSEMBLY				3		3	3		3
FLIGHT CONTROL SURFACES									
RUDDER, SURFACES ATTACHMENTS	1	1	2				1	1	2
SUBTOTAL	1	1	2	5		5	6	1	7
** POWERPLANT **									
ENGINE STRUCTURE									
CRANKCASE				1		1	1		1
CRANKSHAFT				1		1	1		1
MASTER AND CONNECTING RODS				10		10	10		10
CYLINDER ASSEMBLY	1		1	5		5	6		6
PISTON, PISTON RINGS				5		5	5		5
VALVE ASSEMBLIES				8		8	8		8
OTHER				2		2	2		2
IGNITION SYSTEM									
MAGNETOES				5		5	5		5
SPARK PLUG				7		7	7		7
COILS				1		1	1		1
LOW TENSION WIRING				1		1	1		1
SWITCHES				1		1	1		1
FUEL SYSTEM									
TANKS				1		1	1		1
LINES AND FITTINGS				8		8	8		8
FILTERS, STRAINERS, SCREENS				1	1	2	1	1	2
CARBURETOR					1	1		1	1
PUMPS	1		1	4		4	5		5
FUEL INJECTION SYSTEM				1		1	1		1
VENTS, DRAINS, TANK CAPS				3		3	3		3
RAM AIR ASSEMBLY				1		1	1		1
OTHER				2		2	2		2

POWERPLANT (CONTINUED)

DETAILED CAUSE/FACTOR	FATAL ACCIDENTS CAUSE	FATAL ACCIDENTS FACTOR	FATAL ACCIDENTS TOTAL	NONFATAL ACCIDENTS CAUSE	NONFATAL ACCIDENTS FACTOR	NONFATAL ACCIDENTS TOTAL	ALL ACCIDENTS CAUSE	ALL ACCIDENTS FACTOR	ALL ACCIDENTS TOTAL
LUBRICATING SYSTEM									
LINES, HOSES, FITTINGS				1		1	1		1
PUMP-PRESSURE	1		1				1		1
OTHER				1		1	1		1
COOLING SYSTEM									
OTHER				1		1	1		1
PROPELLER AND ACCESSORIES									
BLADES				1		1	1		1
BLADE RETENTION MECHANISM					1	1		1	1
OTHER				1		1	1		1
EXHAUST SYSTEM									
MANIFOLDS				1		1	1		1
OTHER				1		1	1		1
ENGINE ACCESSORIES									
OTHER				1		1	1		1
ENGINE CONTROLS									
THROTTLE-POWER LEVER ASSEMBLIES				4		4	4		4
FUEL INJECTION CONTROL				1		1	1		1
POWERPLANT-INSTRUMENTS									
POWER INDICATORS				1		1	1		1
FUEL QUANTITY GAUGE					7	7		7	7
OTHER					1	1		1	1
MISCELLANEOUS									
POWERPLANT FAILURE FOR UNDETERMINED REASONS	7		7	60		60	67		67
FOREIGN OBJECT DAMAGE				2		2	2		2
COMPRESSOR STALLS				2		2	2		2
OTHER				1		1	1		1
REDUCTION GEAR ASSEMBLY									
SHAFT, ACCESSORY DRIVE				1		1	1		1
COMPRESSOR ASSEMBLY									
CASTING				1		1	1		1
BLADE, COMPRESSOR ROTOR				1		1	1		1
BEARING, ROTOR SHAFT				3		3	3		3
SHAFT, ROTOR				1		1	1		1
COMBUSTION ASSEMBLY									
SEALS, EXPANSION				1		1	1		1
TURBINE ASSEMBLY									
WHEEL, TURBINE				1		1	1		1
BLADE, TURBINE WHEEL				2		2	2		2
SEALS, AIR-OIL				1		1	1		1
SHAFT, TURBINE				1		1	1		1
BEARING, SHAFT				3		3	3		3
ACCESSORY DRIVE ASSEMBLY									
EXTENSION SHAFT				1		1	1		1
GEARS, ACCESSORY DRIVE				2		2	2		2
LUBRICATING SYSTEM									
OTHER				2		2	2		2
FUEL SYSTEM									
PUMP, FUEL				3	1	4	3	1	4
FUEL CONTROL				5	1	6	5	1	6
OTHER				2		2	2		2

POWERPLANT (CONTINUED)

DETAILED CAUSE/FACTOR	FATAL ACCIDENTS CAUSE	FATAL FACTOR	FATAL TOTAL	NONFATAL ACCIDENTS CAUSE	NONFATAL FACTOR	NONFATAL TOTAL	ALL ACCIDENTS CAUSE	ALL FACTOR	ALL TOTAL
SAFETY SYSTEM									
IGNITION SYSTEM									
TORQUEMETER									
AIR BLEED									
EXHAUST SYSTEM									
THRUST REVERSER									
PROPELLER SYSTEM									
CONSTANT SPEED DRIVE									
POWER LEVER									
PROPELLER LEVER									
REVERSE THRUST LEVER									
ENGINE INDICATING EQUIPMENT									
TACHOMETER				1		1	1		1
ENGINE INSTALLATION									
OTHER				1		1	1		1
SUBTOTAL	10		10	180	13	193	190	13	203
** SYSTEMS **									
ELECTRICAL SYSTEM									
RELAYS AND WIRING				1		1	1		1
SWITCHES					1	1		1	1
HYDRAULIC SYSTEM									
FLIGHT CONTROL SYSTEMS									
ANTI-ICING, DE-ICING SYSTEMS									
AIR CONDITION, HEATING AND PRESSURIZATION									
AUTO PILOT									
FIRE WARNING SYSTEM									
FIRE EXTINGUISHER SYSTEM									
OXYGEN SYSTEM									
OTHER SYSTEMS									
OTHER				1		1	1		1
SUBTOTAL				2	1	3	2	1	3
** INSTRUMENTS/EQUIPMENT AND ACCESSORIES **									
FLIGHT AND NAVIGATION INSTRUMENTS									
COMMUNICATIONS AND NAVIGATION EQUIPMENT									
OTHER					1	1		1	1
MISCELLANEOUS EQUIPMENT									
SPRAY, DUSTING EQUIPMENT				2	1	3	2	1	3
PICK-UP EQUIPMENT				1	1	2	1	1	2
SUBTOTAL				3	3	6	3	3	6
** ROTORCRAFT **									
ROTOR ASSEMBLIES									
MAIN ROTOR BLADES	4		4	5		5	9		9
TAIL ROTOR BLADES	6		6	10		10	16		16
MAIN ROTOR HEAD ASSEMBLIES	1		1	4		4	5		5
UNIVERSAL JOINTS, COUPLINGS				3		3	3		3
BEARINGS	1		1	3		3	4		4
OTHER	2		2	7		7	9		9

ROTORCRAFT (CONTINUED)

DETAILED CAUSE/FACTOR	FATAL ACCIDENTS			NONFATAL ACCIDENTS			ALL ACCIDENTS		
	CAUSE	FACTOR	TOTAL	CAUSE	FACTOR	TOTAL	CAUSE	FACTOR	TOTAL
TRANSMISSION ROTOR DRIVE SYSTEM									
ENGINE DRIVE SHAFT	1		1	4		4	5		5
MAIN ROTOR DRIVE SHAFT	1		1	4		4	5		5
FREE WHEEL UNIT				1		1	1		1
MAIN ROTOR BRAKE ASSEMBLY				1		1	1		1
MAIN ROTOR GEAR BOX	1		1	1		1	2		2
MAIN ROTOR PULLEYS, BELTS				4		4	4		4
TAIL ROTOR DRIVE SHAFT ASSEMBLY	2		2	8		8	10		10
TAIL ROTOR GEAR BOX				11	1	12	11	1	12
MAIN ROTOR INTERMEDIATE GEARS				1		1	1		1
CLUTCH ASSEMBLY				11		11	11		11
SPRAG SYSTEM				4		4	4		4
OTHER	2		2	7		7	9		9
FLIGHT CONTROL SYSTEMS									
CYCLIC PITCH CONTROL SYSTEM	3		3	2		2	5		5
COLLECTIVE PITCH CONTROL SYSTEM	1		1	3	1	4	4	1	5
TAIL ROTOR PITCH CONTROL SYSTEM	1		1	8		8	9		9
STABILIZING SURFACES-DAMPERS				1		1	1		1
OTHER				1		1	1		1
MISCELLANEOUS UNITS AND ASSEMBLIES									
DUAL TACHOMETER		1	1					1	1
TAIL BOOMS/PYLONS/CONES	3		3	3		3	6		6
OTHER	1		1	1		1	2		2
SUBTOTAL	30	1	31	108	2	110	138	3	141
** AIRPORTS/AIRWAYS/FACILITIES **									
AIRPORT FACILITIES									
OTHER					1	1		1	1
AIRPORT CONDITIONS									
WET RUNWAY					1	1		1	1
OTHER					1	1		1	1
AIRWAYS FACILITIES									
SUBTOTAL					3	3		3	3
** WEATHER **									
LOW CEILING		9	9		8	8		17	17
RAIN		6	6		1	1		7	7
FOG		8	8		10	10		18	18
SNOW		2	2		5	5		7	7
ICING CONDITIONS-INCLUDES SLEET, FREEZING RAIN, ETC		1	1					1	1
CONDITIONS CONDUCIVE TO CARB/INDUCTION SYSTEM ICING		1	1		5	5		6	6
UNFAVORABLE WIND CONDITIONS		4	4	2	34	36	2	38	40
SUDDEN WINDSHIFT				3	2	5	3	2	5
TURBULENCE IN FLIGHT, CLEAR AIR		1	1					1	1
TURBULENCE ASSOCIATED WITH CLOUDS AND/OR THUNDERSTORMS		1	1		2	2		3	3
DOWNDRAFTS, UPDRAFTS		1	1	2	7	9	2	8	10
LOCAL WHIRLWIND		1	1		1	1		2	2
HIGH TEMPERATURE					6	6		6	6
OBSTRUCTIONS TO VISION					1	1		1	1

WEATHER (CONTINUED)

DETAILED CAUSE/FACTOR	FATAL ACCIDENTS			NONFATAL ACCIDENTS			ALL ACCIDENTS		
	CAUSE	FACTOR	TOTAL	CAUSE	FACTOR	TOTAL	CAUSE	FACTOR	TOTAL
HIGH DENSITY ALTITUDE		1	1		25	25		26	26
THUNDERSTORM ACTIVITY		3	3		1	1		4	4
OTHER		1	1					1	1
SUBTOTAL		40	40	7	108	115	7	148	155
** TERRAIN **									
WET, SOFT GROUND				5	22	27	5	22	27
SNOW-COVERED		1	1	2	6	8	2	7	9
HIGH VEGETATION				6	15	21	6	15	21
HIDDEN OBSTRUCTIONS					4	4		4	4
ROUGH/UNEVEN		2	2	4	34	38	4	36	40
ROUGH WATER		1	1	1	2	3	1	3	4
GLASSY WATER		1	1		2	2		3	3
HIGH OBSTRUCTIONS		13	13	12	77	89	12	90	102
SANDY					1	1		1	1
OTHER				2	7	9	2	7	9
SUBTOTAL		18	18	32	170	202	32	188	220
** MISCELLANEOUS **									
BIRD COLLISION	1		1	2		2	3		3
VORTEX TURBULENCE				1		1	1		1
EVASIVE MANEUVER TO AVOID COLLISION	1		1	10	4	14	11	4	15
UNQUALIFIED PERSON OPERATED AIRCRAFT	2	2	4	2	1	3	4	3	7
FOREIGN OBJECT DAMAGE				10		10	10		10
FOREIGN MATERIAL AFFECTING NORMAL OPERATIONS	3		3	13	1	14	16	1	17
UNDETERMINED	16		16	19		19	35		35
SUBTOTAL	23	2	25	57	6	63	80	8	88
GRAND TOTAL	199	76	275	1143	365	1508	1342	441	1783
** MISCELLANEOUS ACTS, CONDITIONS **									
ALTIMETER SETTING-INCORRECT	1		1		1	1	1	1	2
ANTI-ICING/DEICING EQUIP-IMPROPER OPER. OF/FAILED TO US	1		1	6		6	7		7
CREW COORDINATION-POOR				1	2	3	1	2	3
DISREGARD OF GOOD OPERATING PRACTICE				2	1	3	2	1	3
IMPROPER EMERGENCY PROCEDURES	2		2	4	2	6	6	2	8
GUST LOCKS ENGAGED					1	1		1	1
INSTRUCTIONS-MISINTERPRETED				1		1	1		1
INSTRUMENTS-MISREAD OR FAILED TO READ				2	2	4	2	2	4
SEAT BELT NOT FASTENED		1	1					1	1
UNWARRANTED LOW FLYING	3	3	6	5	4	9	8	7	15
INATTENTIVE TO FUEL SUPPLY		1	1	7		7	7	1	8
POORLY PLANNED APPROACH				1	4	5	1	4	5
MISCALCULATED FUEL CONSUMPTION	2		2	3		3	5		5
JETTISONED LOAD		1	1		10	10		11	11
STOLEN OR UNAUTHORIZED USE OF AIRCRAFT					1	1		1	1

MISCELLANEOUS ACTS, CONDITIONS (CONTINUED)

DETAILED CAUSE/FACTOR	FATAL ACCIDENTS			NONFATAL ACCIDENTS			ALL ACCIDENTS		
	CAUSE	FACTOR	TOTAL	CAUSE	FACTOR	TOTAL	CAUSE	FACTOR	TOTAL
IMPROPERLY SECURED	3		3	6	1	7	9	1	10
BOGUS PART	1		1	1	1	2	2	1	3
ELECTRICAL FAILURE					1	1		1	1
ENGINE LOADED UP				2		2	2		2
FATIGUE FRACTURE	14		14	30		30	44		44
FUEL GRADE-IMPROPER				1		1	1		1
IMPROPER GRADE OIL-LUBRICATING SYSTEM				1		1	1		1
RPM-UNCONTROLLABLE-OVERSPEED					1	1		1	1
WINDSHIELD, DIRTY, FOGGY, ETC-RESTRICTED VISION					1	1		1	1
WRONG PART	1		1	4		4	5		5
IMPROPER ALIGNMENT/ADJUSTMENT				4	1	5	4	1	5
FAILURE OF TWO OR MORE ENGINES		1	1					1	1
SEPARATION IN FLIGHT		15	15		20	20		35	35
FIRE IN ENGINE					2	2		2	2
LATERAL IMBALANCE				3		3	3		3
CORRODED/CORROSION	1		1	3		3	4		4
PILOT FATIGUE		2	2		4	4		6	6
FUEL EXHAUSTION	4		4	41		41	45		45
FUEL CONTAMINATION-EXCLUSIVE OF WATER IN FUEL	1		1	6	1	7	7	1	8
ICE-CARBURETOR	1		1	5		5	6		6
IMPROPERLY LOADED AIRCRAFT-WEIGHT-AND/OR CG	1		1	3	2	5	4	2	6
INTERFERENCE WITH FLIGHT CONTROLS	1		1	12		12	13		13
WHITEOUT	1		1	3	2	5	4	2	6
SUNGLARE					7	7		7	7
LACK OF LUBRICATION-SPECIFIC PART, NOT SYSTEM	1		1	5		5	6		6
OIL EXHAUSTION-ENGINE LUBRICATION SYSTEM				3		3	3		3
OIL CONTAMINATION				1		1	1		1
SIMULATED CONDITIONS				1	9	10	1	9	10
WATER IN FUEL				12		12	12		12
AIRCRAFT CAME TO REST IN WATER		16	16	1	34	35	1	50	51
MISSING				8		8	8		8
TOUCH AND GO LANDING					1	1		1	1
OVERLOAD FAILURE	1		1	6	17	23	7	17	24
MATERIAL FAILURE	10	1	11	78	3	81	88	4	92
FUEL STARVATION	3		3	14		14	17		17
OIL STARVATION	1		1	1		1	2		2
IMPROPER CLEARANCE-TOLERANCE	1		1	1		1	2		2
UNAPPROVED MODIFICATION		1	1					1	1
PREVIOUS DAMAGE	2		2	1	1	2	3	1	4
LEAK/LEAKAGE				5		5	5		5
LOW COMPRESSION				4		4	4		4
DOWNWIND					15	15		15	15
CARBON DEPOSITS				5	1	6	5	1	6
LOOSE, PART/FITTING				5	2	7	5	2	7
GROUND RESONANCE	1		1	5	1	6	6	1	7
BURNED				1		1	1		1
DISCONNECTED	5		5	5		5	10		10
DISTORTED				2		2	2		2
ELONGATED				1		1	1		1
EXCESSIVE-WEAR/PLAY				6		6	6		6
ERRATIC				1	3	4	1	3	4
FLUCTUATING					1	1		1	1
FRAYED				2	1	3	2	1	3
FRICTION, EXCESSIVE				2		2	2		2
GROUNDED				4		4	4		4

MISCELLANEOUS ACTS, CONDITIONS (CONTINUED)

DETAILED CAUSE/FACTOR	FATAL ACCIDENTS			NONFATAL ACCIDENTS			ALL ACCIDENTS		
	CAUSE	FACTOR	TOTAL	CAUSE	FACTOR	TOTAL	CAUSE	FACTOR	TOTAL
IMPROPERLY INSTALLED	1		1	7		7	8		8
JAMMED				1	1	2	1	1	2
OBSTRUCTED	1		1	4	2	6	5	2	7
OPEN				2		2	2		2
OUT OF BALANCE				1		1	1		1
OVERHEATED	1		1	6		6	7		7
EXCESSIVE PRESSURE				1		1	1		1
PRESSURE TOO LOW				3		3	3		3
PRESSURE, NONE				1		1	1		1
SCORED				1		1	1		1
SHEARED				1		1	1		1
STRIPPED				2		2	2		2
STUCK				1	1	2	1	1	2
VIBRATION, EXCESSIVE		1	1	7		7	7	1	8
WARPED				2		2	2		2
ICE-INDUCTION				1		1	1		1
LOAD NOT JETTISONED				1	8	9	1	8	9

DIRECT ENTRY CAUSES

MISC-CLAMP SLIPPED CAUSING RIGGING TO HIT WORKMAN
MISC-POWERLINE TOWER STATIC CABLE FELL ON ACFT.

DIRECT ENTRY CAUSES ARE CARRIED UNDER THEIR APPROPRIATE
CAUSAL CATEGORIES AND ARE INCLUDED IN THE TOTALS

APPENDIX B

ROTORCRAFT MAKE AND MODEL BY TYPES OF ACCIDENTS

Rotorcraft make and model	Accident types: Hard landing	Rollover	Collision with ground/water	Collision with obstacles	Airframe failure	Engine failure/ malfunction	Prop/rotor failure	Other	Total Records
Aerospatiale 315/316/319		3	3	3		8	2	3	22
Aerospatiale 341	1			1		2		2	6
Bell 47	18	20	44	50	7	69	31	11	250
Bell 204/205			2		1	1	3		7
Bell 206	5	10	15	19	2	29	5	12	97
Bell 212			1	2		1		1	6
Bell 214					2	3	2		7
Brantly	1	2	5	1			4	2	15
Enstrom F-28	9	2	8	13	2	22	11	2	69
Hiller UH-12	7	2	6	20	4	45	12	7	103
Hiller FH-1100		1	5	4	2	3		1	16
Hughes 269	23	7	27	26	5	26	8	7	129
Hughes 369/500	15	3	7	11	1	15	7	4	63
MBB-BO-105		1	2	2		1	1	1	8
Sikorsky 5-55			1	1	4	1	2		9
Sikorsky 5-88				1		9	1		11
Amateur (Home-built)		2	13	1	5	12	4	4	41
Experimental			2		1	2		2	7

APPENDIX C

ROTORCRAFT ACCIDENTS BY MAKE AND MODEL AND KIND OF FLYING

Rotorcraft Make and model	Kind of flying							
	Instructional	Personal/Business	Corporate/ Executive	Aerial Application	Air-Taxi-Type Operations	Aerial Observation	Other	Total records
Aerospatiale 315/316/319		2	2		10		8	22
Aerospatiale 341		2	3				1	6
Bell 47	20	40	1	110	21	19	39	250
Bell 204/205	1			2	2		2	7
Bell 206	1	11	13	4	46	5	17	97
Bell 212					4		2	6
Bell 214					2		5	7
Brantly	3	5	1	2			4	15
Enstrom F-28	13	36	5	3	4		8	69
Hiller UH-12	5	17		45	14	6	16	103
Hiller FH-1100	1	1		2	8		4	16
Hughes 269	29	26	2	44	4	11	13	129
Hughes 369/500	5	16	9	2	14	6	11	63
MBB-BO-105					7		1	8
Sikorsky S-55				5	1	1	2	9
Sikorsky S-88				1	5		5	11
Amateur (Home-built)	3	32					6	41
Experimental		3					4	7

APPENDIX D

ACCIDENTS INVOLVING POWERPLANT AS A CAUSE/FACTOR FOR VARIOUS ROTORCRAFT MAKES AND MODELS

Aircraft make and model	Accidents with powerplant cause/factor	Accident rate (per 100,000 hours)	Type of powerplant
Aerospatiale 315/316/319	8	7.42	Turbine
Aerospatiale 341	3	4.71	Turbine
Bell 47	42	3.56	Piston
Bell 204/205	1	0.64	Turbine
Bell 206	23	0.84	Turbine
Bell 212	1	0.36	Turbine
Bell 214	2	(Flying hours not available)	Turbine
Brantly	0	0	Piston
Enstrom F-28	19	9.93	Piston
Hiller UH-12	30	9.63	Piston 1/
Hiller FH-1100	2	3.43	Turbine
Hughes 269	19	4.20	Piston
Hughes 369/500	12	2.34	Turbine
MBB-BO-105	1	1.10	Turbine
Sikorsky 5-55	1	5.60	Piston
Sikorsky S-88	7	47.97	Piston
Amateur (Home-built)	9	(Flying hours not available)	
Experimental	0		

1/ Two of these were Soloy conversions.

APPENDIX E

EXPLANATORY NOTES

U.S. GENERAL AVIATION

U.S. general aviation refers to U.S. civil aircraft owned and operated by persons, businesses, corporations, etc., excluding the operations of U.S. air carriers.

U.S. AIR CARRIER

U.S. air carrier operations include the following three operational categories: (1) certificated route air carriers, (2) supplemental air carriers, and (3) commercial operators of large aircraft.

DEFINITIONS

The following definitions contained in 49 CFR 830.2 apply when used in this publication.

Aircraft Accident

An occurrence associated with the operation of an aircraft which takes place between the time any person boards the aircraft with the intention of flight until such time as all such persons have disembarked, and in which any person suffers death or serious injury as a result of being in or upon the aircraft or by direct contact with the aircraft or anything attached thereto, or in which the aircraft receives substantial damage.

Fatal Injury

Any injury which results in death within 7 days of the accident.

Serious Injury

Any injury which (1) requires hospitalization for more than 48 hours, commencing within 7 days from the date the injury was received; (2) results in a fracture of any bone (except simple fractures of fingers, toes, or nose); (3) involves lacerations which cause severe hemorrhages, nerve, muscle, or tendon damage; (4) involves injury to any internal organ; or (5) involves second- or third-degree burns, or any burns affecting more than 5 percent of the body surface.

Substantial Damage

Damage or structural failure which adversely affects the structural strength, performance, or flight characteristics of the aircraft, and which would normally require major repair or replacement of the affected component. Engine failure, damage limited to an engine, bent fairings or cowling, dented skin, small puncture holes in the skin or fabric, ground damage to rotor or propeller blades, damage to landing gear, wheels, tires, flaps, engine accessories, brakes, or wingtips are not considered "substantial damage" for the purpose of this part.

INJURY INDEX

Injury index refers to the highest degree of personal injury sustained as a result of the accident.

TYPE OF ACCIDENT

Type of accident relates to the immediate circumstances of the occurrence. Many accidents involve a series of circumstances and therefore require a second type to more fully describe the sequence of events. Some examples of types of accidents are as follows:

Gear Collapsed

Collapse of the landing gear due to mechanical failure other than malfunction of the retracting mechanism.

Gear Retracted

Retraction of the landing gear due to malfunction or failure of the retracting mechanism or to inadvertent retraction by the crew. Excludes intentional gear retraction and wheels-up landing.

Airframe Failure

Occurrences resulting from failure of any part of the airframe while in flight or in motion on the ground. Excludes failure resulting from contact with another airplane or object, or impact with the ground, or damage from landing gear collapse or retraction.

Engine Failure/Malfunction

Occurrences of engine failure or malfunction for any reason. Includes engine stoppage, power interruption, or power loss, actual or simulated.

PHASE OF OPERATION

The phase of operation relates to the particular segment of the flight or operation during which the circumstances of the accident occur.

KIND OF FLYING

Refers to the purpose for which the aircraft is being operated at the time of the accident. There are four broad categories of kind of flying.

1. Instructional Flying

   Refers to flying accomplished in supervised training under the direction of an accredited instructor.

2. Noncommercial Flying

   Refers to the use of an aircraft for purposes of pleasure, personal transportation, or in connection with a private business, in corporate/executive operations, and in other operations, wherein there is no direct monetary fee charged. It includes the following categories:

Pleasure

Flying by individuals in their own or rented aircraft for pleasure, or personal transportation not in furtherance of their occupation or company business.

Business

The use of aircraft by pilots (not receiving direct salary or compensation for piloting) in connection with their occupation or in the furtherance of a private business.

Corporate/Executive Operations

The use of aircraft owned or leased and operated by a corporation or business firm for the transportation of personnel or cargo in furtherance of the corporation's or firm's business, and flown by professional pilots receiving a direct salary or compensation for piloting.

3. Commercial Flying

Commercial flying includes all general aviation flying normally conducted for direct financial return, except instructional flying. It includes air taxi operations, aerial application, fire control, aerial mapping or photography, aerial advertising, power/pipeline patrol, and fish spotting.

4. Miscellaneous Flying

Includes other kinds of flying not covered under the other three broad categories. In some instances the criterion of direct financial return may or may not be present.

COLLISION BETWEEN AIRCRAFT

Collisions between aircraft are so classified only when both aircraft are occupied. This includes collisions wherein both aircraft are airborne (midair); one is airborne, the other on the ground; and both are on the ground. A collision with a parked, unoccupied aircraft is classified under the broad category of collision with objects (parked, unoccupied aircraft).

CAUSES AND RELATED FACTORS

In determining probable cause(s) of an accident, all facts, conditions, and circumstances are considered. The object is to ascertain those cause-effect relationships in the accident sequence about which something can be done to prevent recurrence of the type of accident under consideration. Accordingly, for statistical purposes where two or more causes exist in an accident, each is recorded and no attempt is made to establish a primary cause. Therefore, in the Cause and Related Factor Table, the figures shown in the columns dealing with Cause will exceed the total number of accidents. The term Factor is used, in general, to denote those elements of an accident which further explain or supplement the probable cause(s). This provision was incorporated in the coding system to increase its flexibility and to provide a means for collecting essential items of information which could not be categorized elsewhere in the system.

AIRCRAFT WEIGHT CATEGORIES

The international Civil Aviation Organization's categories of aircraft weight are used to classify accident data as follows:

0-2,250 kilograms	(0-4,960 pounds)
2,251-5,700 kilograms	(4,961-12,565 pounds)
5,701-27,000 kilograms	(12,566-59,525 pounds)
27,001-272,000 kilograms	(59,526-599,650 pounds)
272,001-kilograms and greater	(599,651 pounds and greater)

SMALL FIXED-WING AIRCRAFT

Fixed-wing aircraft which have a maximum gross takeoff weight of 5,700 kilograms (12,565 pounds) or less.

LARGE FIXED-WING AIRCRAFT

Fixed-wing aircraft which have a maximum takeoff weight greater than 5,700 kilograms (12,565 pounds).

ROTORCRAFT

Aircraft which in all usual flight attitudes are supported in the air wholly or in part by a rotor or rotors; i.e., by airfoils rotating or revolving about an axis.

TYPES OF WEATHER CONDITIONS

The types of weather conditions (VFR/IFR) are determined in accordance with the prescribed minima in Part 91 of the Federal Aviation Regulations. These minima pertain to the ceiling and visibility, in conjunction with the type of airspace, at the accident site. Type of weather conditions are based on surface weather as determined from officially recognized sources. Weather conditions encountered in flight are not necessarily representative of the classifications VFR/IFR as carried under Type of Weather Conditions.

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