General Aviation Safety: Where Can Safety Improvements Be Made?

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In an attempt to improve general aviation safety, the causes of the 9,245 general aviation accidents that occurred from 1983 to 1986 are analyzed and summarized. During this period, general aviation accidents were responsible for 8 of every 10 aviation-related deaths. The leading causes of general aviation accidents over the 4-year period are identified, and apparent trends are noted. Although the safety record of general aviation improved from 1983 to 1986, the circumstances in general aviation in which safety improvements are most urgent are identified. The leading cause of general aviation accidents is pilot error, but specific causes of accidents include failure to conduct preflight procedures properly, inadequate flying skills, and poor in-flight procedures or in-flight judgment.

General aviation is civil aviation under the *Code of Federal Regulations* (14 CFR 91) and includes business flying, recreational flying, instructional flying, agricultural applications, and a host of other flying activities. Although the media and the public focus on jet aviation, most aviation is general aviation. In 1986 general aviation logged four of every five civil aviation flight hours and accounted for 9 of every 10 U.S. civil operations (*1*).

The majority of aviation fatalities and accidents occur in general aviation. From 1980 to 1985, general aviation accidents accounted for 8 of every 10 fatalities in U.S. civil operations (*2*). Between 1980 and 1985, general aviation aircraft were involved in 9 of every 10 accidents (*3*). Although general aviation comprises the majority of civil aviation operations and accidents, it is often overlooked by Congress, the press, and the public when the safety of the national airspace system is discussed. (One may speculate that the focus on jet aviation safety results from the large number of people who fly in jets, the catastrophic nature of jet aviation accidents, and the amount of media coverage.)

In this analysis, each general aviation accident that occurred in the United States between 1983 and 1986 was reviewed individually and categorized by accident cause. The accidents then were summarized by cause to examine recurrent patterns.

OVERALL GENERAL AVIATION ACCIDENT TRENDS

Between 1983 and 1986, there were 9,245 general aviation accidents in the United States. In this analysis, general aviation accidents that occurred in Alaska are reviewed separately from those in the remaining 49 states. This distinction is made because of the possibility that Alaskan weather results in a different mix of accidents. Thus, in the discussion of overall accident trends, the data include only 49 states.

As shown in Table 1, a downward trend in the total number of general aviation accidents occurred between 1983 and 1986, both in absolute numbers and in the accident rate per 100,000 flight hours. Table 2 provides the distribution of accidents over the 4-year period by the causal categories used in this analysis. During this period, the frequency of aviation accidents by cause appears nearly constant. The three most common accident categories—Pilot Error, Equipment Failure, and Environment—maintain a consistent ranking over the 4 years. The consistency of general aviation accident causes may be seen as an indication of the use of a consistent methodology to categorize the accidents.

As Table 2 indicates, pilot error clearly prevails as the leading accident cause, with an average 64 percent of the accidents. On average during the 4-year period, pilot error

TABLE 1 GENERAL AVIATION ACCIDENT TRENDS: ALL ACCIDENTS

	1983	1984	1985	1986	Total
Total number of accidents	2,511	2,116	2,047	1,952	8,626
Accident rate per 100,000 flight hours	10.64	8.72	8.57	8.10	9.00
Annual flight hours (*8*)					
General aviation (hr 000s)	28,879	29,629	28,552	28,718	115,778
Executive (91d) (hr 000s)	4,473	4,422	3,868	3,424	16,187
Alaska (%)	3.3	3.8	3.3	4.7	
GA adjusted[a] (hr 000s)	23,601	24,261	23,882	24,102	95,847

[a]GA adjusted is the general aviation flight hours minus the Executive 91d flight hours and the FAA estimate of the percentage of Alaskan general aviation flight hours.

TABLE 2 FREQUENCY OF ALL ACCIDENTS

	Percentage by Year				
Accident Category	1983	1984	1985	1986	Total
Equipment Failure	16.3	16.4	23	19	18.5
Environment	7.3	7.5	9.8	8.2	8.1
Pilot Error	69.4	66.8	56.4	63.1	64.2
ATC	0.1	0.1	0.1	0.3	0.2
Ground Crew Error	0.4	0.7	0.5	0.1	0.4
Other Aircraft	2.1	2.6	2.8	2.7	2.5
Other	4.4	6	7.3	6.6	6

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accounted for 6 of every 10 accidents. This statistic should be compared with pilot error accidents of domestic jet carriers, which account for only 2 of every 10 accidents between 1979 and 1985 (*4*).

The second and third leading general aviation accident categories—Equipment Failure and Environment—account for an average of 19 and 8 percent of the accidents, respectively. Although Equipment Failure is the second leading accident category, it accounts for only 2 of every 10 accidents. Environment, which includes weather-related accidents, accounts for less than 1 of every 10 accidents.

The remaining four categories account for only 9 percent of the accidents. Midair collisions and on-ground collisions included under the category of Other Aircraft were responsible for 2.5 percent of the accidents. The Air Traffic Control (ATC) and Ground Crew Error categories account for less than 1 percent of the accidents. The miscellaneous accidents falling under Other include 6 percent of the total accidents for the 4-year period.

To understand fully the significance of the statistics in Table 1, a discussion of the methodology that includes the accident category definitions follows. The accident categories must be understood to avoid a misinterpretation of the data.

METHODOLOGY

The National Transportation Safety Board (NTSB) conducts or supervises investigations of all U.S. aviation accidents. NTSB collects and compiles accident information such as the type of aircraft flown, the number of occupants, and the weather conditions at the time of the accident. This analysis uses the NTSB accident data from the 9,245 general aviation accidents that occurred in the United States between 1983 and 1986.

Only accidents involving fixed-wing aircraft operating under 14 CFR 91 as a general aviation operation are included. Aircraft such as helicopters, ultralights, balloons, and gliders are excluded. Because of their exceptional safety record, large and turbine-powered multiengined airplanes operating under 14 CFR 91(d) are also excluded. The analysis includes all U.S. general aviation operations.

Aviation accidents are often viewed as a chain of events that ends in an accident. An example might be an equipment failure that led to a total loss of power and ended in an accident in which the pilot unsuccessfully executed an emergency landing in windy conditions. There are three events, or factors, contributing to the accident: the equipment failure, the pilot's inability to execute an emergency landing, and the weather conditions. Identifying the cause of this accident may be approached in three different ways: by using the initial factor, the final factor, or all factors. This research uses the initial factor to identify the accident cause. In the above example, the initial factor would be equipment failure.

Using the initial factor, however, is not an attempt to deny that accidents are the result of the contribution of a number of interrelated causes. By using the initial factor, the research identifies the first link in the chain of events, and therefore will target those factors that most frequently initiate aviation accidents.

This analysis included the most recent and complete general aviation accident data available, which were compiled in 1986. Because of the detail in the data, there is a delay of over 2 years in data availability. The applicability of the analysis depends on the assumption that today's accident trends resemble those of 1983 to 1986. The general consistency in the causes of aviation accidents suggests that the overall pattern seen from 1983 to 1986 will match that of today.

The analysis only includes 4 years of data, simply because of the large number of accident reports. Over 2,000 general aviation accidents occurred each year. The time-consuming process of reading and categorizing the NTSB data limited the number of years included in the analysis. In addition, changes in the data format for previous years would make comparing years difficult.

The initial factor contributing to the accident was identified for each general aviation accident that occurred from 1983 through 1986. The accident was placed in one of seven categories, each of which is divided into subcategories to gather additional insight on the causes of general aviation accidents. The categories and subcategories are as follows:

1. Pilot Error
   a. Flying Skills
   b. In-Flight Procedures/Judgment
   c. Preflight Procedures/Judgment
   d. Fuel Management
   e. Student Pilot
   f. Home-Built Aircraft
   g. Alcohol/Drug Use
2. Equipment Failure
   a. Engine
   b. Instruments/Electrical
   c. Landing Gear/Tires
   d. Structure
   e. Home-Built
   f. Other
3. Environment
   a. Weather
   b. Wind Gusts
   c. Wind on Landing/Takeoff
   d. Improper Briefing
   e. Animals
4. Air Traffic
   a. En Route
   b. Terminal
   c. Ground
5. Ground Crew Error
6. Other Aircraft
   a. Midair Collision
   b. On-Ground Collision
   c. Evasive Action
7. Other
   a. Aircraft Not Recovered
   b. Apparent Drug Transport
   c. Cause Ambiguous

Before the data are reviewed, the guidelines for the categories and the subcategories will be discussed.

Pilot Error

As mentioned earlier, the leading factor contributing to general aviation accidents is pilot error. The seven subcategories chosen for Pilot Error differentiate among accidents caused by poor judgment, accidents caused by inadequate flying skills, and accidents involving specific circumstances. The subcategories Preflight Procedures/Judgment and In-Flight Procedures/Judgment encompass accidents in which the pilot failed to execute sound judgment or follow expected procedures. Accidents placed in the Flying Skills subcategory are a result of poor flying ability. Separate subcategories for accidents involving alcohol or drug use, student pilots, and home-built aircraft are also included. The distinctions among the Pilot Error subcategories are more subtle than those of the other subcategories and therefore, to ensure clarity, will be discussed in greater detail along with the research results.

Equipment Failure

The Equipment Failure category includes all accidents in which the failure of the aircraft's equipment triggered the accident. Equipment failure was the second leading cause of general aviation accidents between 1983 and 1986, accounting for 18.5 percent of all accidents. To distinguish among the types of equipment failure accidents, the category contains six subcategories: Engine, Instruments/Electrical, Landing Gear/Tires, Structure, Home-Built, and Other.

The Engine subcategory includes accidents that occurred because of the failure of the internal engine parts, the carburetors, the magnetos, the exhaust system, the propellers, or fuel contaminates other than those detectable during the preflight check, for example, water. This subcategory also includes situations in which a pilot or witness claimed that engine failure initiated the accident and the postaccident investigation failed to determine another likely cause. In this situation, however, if the engine operated without difficulty during the postcrash investigation, the accident was categorized under Cause Ambiguous.

The Instruments/Electrical subcategory includes accidents that resulted from malfunctions in the aircraft's instruments or any electrical failure other than a magneto failure. An inaccurate fuel gauge, however, is not considered an instrument or electrical failure. Because of the inherent inaccuracy of fuel gauges, instructors urge pilots to mistrust fuel gauge readings. Instructors request that pilots calculate fuel consumption rates before and during flight. Thus, running out of fuel becomes a Pilot Error accident.

The subcategory of Landing Gear/Tires includes accidents in which the structural or mechanical failure of the landing equipment led to the accident. For instance, in Oklahoma in 1986 an aircraft flipped over during the landing roll after the left brake locked. The accident is classified under Landing Gear/Tires because postaccident investigation revealed that the brake shoe return spring failed.

The Structure subcategory includes failure of wings, flight control surfaces, or other structural components of the aircraft. The Home-Built subcategory contains all home-built aircraft accidents in which equipment failure initiated the accident. A separate subcategory exists for home-built aircraft because they are often considered experimental. Experimental aircraft are subject to airworthiness regulations, which differ from those observed by other aircraft when operating under 14 CFR 91. The Other subcategory includes all accidents resulting from faulty equipment that was excluded from previous subcategories, for example, seats.

Environment

Environmental factors were the third leading cause of general aviation accidents, containing 8 percent of all accidents that occurred between 1983 and 1986. The five Environment subcategories are Weather, Wind Gusts, Wind on Landing/Takeoff, Improper Briefing, and Animals.

The Weather subcategory covers accidents resulting from adverse meteorological conditions, such as in-flight thunderstorm turbulence and icing, and slippery runways. However, if a pilot failed to obtain a weather briefing before the flight and an accident resulted because of adverse weather, the accident falls under Pilot Error—Preflight Procedures/Judgment, not Weather.

Wind-gust accidents result from strong winds during taxiing, landing roll, or takeoff roll. An example of a wind-gust accident occurred in October 1984 in Oklahoma. As the pilot taxied from the active runway, the aircraft overturned because of strong, gusting winds. The subcategory Wind on Landing/Takeoff includes accidents caused by strong winds just before runway contact or immediately after take-off.

Weather-related accidents in which pilots obtained an incorrect weather briefing are categorized under improper briefing. The Animal subcategory includes accidents caused by striking an animal in-flight or while on the ground. Accidents resulting from evasive action taken to avoid animals also qualify for this category. For example, in December 1984, in an attempt to avoid four deer running across the runway, a Texas pilot landed his aircraft to the left of the runway, causing the landing gear to collapse.

Air Traffic Control

Any accident resulting from air traffic controller mismanagement is included under the ATC category. The three subcategories for ATC accidents are En Route, Terminal, and Ground. The accident falls under the Ground subcategory if the aircraft was misguided by a controller operating from the airport tower. Terminal accidents occur if the controller was located in the terminal radar approach control facility, which means that the controller was responsible for airborne aircraft immediately surrounding the airport. The En Route subcategory involves accidents precipitated by a controller at an air route traffic control center while the aircraft was en route.

Ground Crew Error

Situations in which actions of individuals on the ground lead to accidents fall under the Ground Crew Error category. For instance, if a maintenance vehicle hit the wing of an aircraft, causing damage, it would be a Ground Crew Error accident.

Other Aircraft

Midair collisions and on-ground collisions are included in this category. A midair collision occurs when two planes collide while one or both of the planes are airborne. For instance, in Indiana in October 1985, a pilot landed his Cessna 150 on top of a Cessna 152. Although the Cessna 152 was taxiing on the ground, a midair collision occurred because the Cessna 150 was airborne. An on-ground accident occurs when neither aircraft is airborne. The third subcategory, Evasive Action, is used when damage to an aircraft occurs as a result of attempting to avoid a midair or on-ground collision.

Other

The Other category includes miscellaneous accident subcategories such as Aircraft Not Recovered and Apparent Drug Transport. The subcategory of Cause Ambiguous covers the largest number of accidents in the Other category. An example of a Cause Ambiguous accident occurred in 1983: the pilot could not recall the events leading to the accident, there were no witnesses, and the aircraft was destroyed.

CAUSES OF GENERAL AVIATION ACCIDENTS

General aviation accidents are concentrated in the categories of Pilot Error and Equipment Failure: 83 percent of all U.S. general aviation accidents that occurred between 1983 and 1986 were due to these factors. The categories Environment, ATC, Ground Crew Error, Other Aircraft, and Other were responsible for 17 percent of the general aviation accidents and for 25 percent of the fatalities.

Pilot Error

Pilot error was cited as the cause of 5,542 general aviation accidents from 1983 to 1986. The seven subcategories of pilot error were listed earlier.

The data in Table 3 illustrate that accidents in the Flying Skills subcategory occurred most frequently, followed by accidents in the In-Flight Procedures/Judgment and Preflight Procedures/Judgment subcategories. Because pilot error causes 64 percent of all general aviation accidents, each subcategory of Pilot Error will be addressed.

The Flying Skills subcategory includes accidents in which the pilot was unable to maintain control of the aircraft. Stalling the aircraft, landing hard or long, and taxiing into stationary objects fall in this accident category. The Flying Skills category attempts to isolate accidents in which the pilot's ability to fly the aircraft was insufficient. Over the 4-year period, 1,750 accidents of this type occurred; however, only 11 percent of those accidents were fatal.

TABLE 3 FREQUENCY OF PILOT ERROR ACCIDENTS: 1983–1986

Accident Subcategory	Percentage by Severity		
	Fatal	Nonfatal	Total
Flying Skills	11.4	22.4	20.3
In-flight Procedures/Judgment	17.7	10.5	11.9
Preflight Procedures/Judgment	19.9	9.9	11.8
Fuel Management	2.7	8.6	7.4
Student Pilot	3.4	11	9.5
Home-built Aircraft	2.7	1.4	1.7
Alcohol/Drug Use	6.2	0.5	1.6
Total	64	64.3	64.2

The large number of accidents due to insufficient flying skills may suggest a need for additional initial and recurrent pilot training. In June 1985, the Federal Aviation Administrator expressed his concern regarding the large number of pilot-induced accidents. To emphasize the importance of fundamental flight skills, the administrator initiated a 3-year program in January 1986—Back-to-Basics.

The first priority of the Back-to-Basics program was take-offs and landings. Between January and March 1986, FAA and independent aviation organizations sponsored local seminars and clinics on improving pilot take-off and landing skills. FAA does not know the number of pilots who participated in the first quarter of 1986; however, during the 3-year life of the program, over one million pilots attended Back-to-Basics seminars.

Improving a pilot's ability to negotiate take-offs and landings focuses on those skills involved in the Flying Skills accident category. If the seminars produced safety improvements, a decrease in the number of accidents caused by insufficient flying skills might have resulted. Typically, all general aviation accidents increase during the summer. The number of accidents in the Flying Skills subcategory in 1986 did not vary from this typical pattern.

Although the data do not show a reduction in the number of such accidents, the Back-to-Basics program on take-offs and landings was not necessarily unsuccessful. To measure its success accurately, the accident record of individuals participating in the program would have to be reviewed. Perhaps the program successfully reached a limited number of pilots, which was not revealed by the aggregate accident data. The data may also indicate that those who most need accident prevention training do not participate in voluntary programs. Perhaps the Back-to-Basics program should have been mandatory or targeted at pilots who needed recurrent training to decrease the overall number of accidents in the Flying Skills subcategory. Without detailed data on the participants, however, these questions cannot be answered.

In-Flight Procedures/Judgment and Preflight Procedures/Judgment are the next two leading Pilot Error subcategories. The In-Flight Procedures/Judgment subcategory includes accidents resulting from mental errors that led to incorrect procedures or judgment errors that caused the aircraft to be in unnecessarily hazardous situations. Mental errors include failing to complete the landing checklist, unintentional gear-up landing, improper flap settings for flight or landing, and failure to maintain proper fuel mixture. Judgment errors include recreational flying at low altitudes (buzzing, spotting animals, hitting power lines) and choosing to land in uncertain terrain (roads, pastures, and the like) during nonemergency situations.

Preflight Procedures/Judgment errors include failing to perform expected preflight duties and failing to use appropriate judgment before the flight. Preflight errors include failure to obtain a weather briefing, failure to complete the preflight checklist, and failure to detect water in the fuel tank.

As shown in Table 3, these two subcategories account for 37.6 percent of the fatal accidents caused by pilot error. The fact that the Preflight Procedures/Judgment subcategory contains the largest percentage of fatal pilot error accidents is surprising. Logically, accidents in this subcategory should be the easiest to avoid because the initial accident factor occurs before departure. A tragic example of such an accident occurred in 1984 when the pilot took off with approximately 170 lb over the maximum allowable gross weight and five passengers on board. The pilot flew into known moderate icing conditions in an aircraft unequipped to operate under such conditions. Shortly after take-off, the plane was sighted falling out of an overcast sky with a failed wing. All six occupants died.

As with the Preflight Procedures/Judgment subcategory, accidents in the Fuel Management subcategory should be avoidable. However, over the 4-year period, 640 general aviation aircraft were involved in accidents stemming from lack of fuel. In many cases fuel was available on the aircraft, but the pilot failed to switch fuel tanks. For instance, in 1985 an aircraft was substantially damaged after the pilot made a forced landing because of a complete loss of power. The investigators found the fuel selector positioned on the right tank, which was empty. The left tank contained 20 gal of fuel.

Although an apparent solution to avoid some accidents due to lack of fuel would be an aircraft designed with one fuel tank, low-wing aircraft do not lend themselves to a balanced single-tank fuel system (*7*). It appears that pilots must know the fuel consumption rate of their aircraft, be aware of the preflight fuel quantity in each tank, and be attentive to the timing of fuel-tank switching. These factors should be stressed during training.

The Alcohol/Drug subcategory includes all accidents in which the pilot was under the influence of alcohol or drugs. This subcategory included less than 1 percent of all nonfatal accidents and 16 percent of all fatal accidents over the 4 years. According to the data, an accident involving a pilot who is under the influence of alcohol or drugs will most probably be fatal. However, it may also be that the number of nonfatal alcohol- or drug-related accidents is under-reported. Because investigations may not occur immediately following an accident, pilots may successfully conceal the involvement of alcohol or drugs. The data may therefore underestimate the number of such accidents that are not fatal.

The remaining two subcategories under pilot error are Student Pilot and Home-Built, isolating accidents in which student pilots or home-built aircraft were involved. Over the 4-year period, both subcategories fluctuated and showed no definite increasing or decreasing trend.

Equipment Failure

Equipment failure accounts for 11.6 percent of the fatal accidents and 20.4 percent of the nonfatal accidents that occurred between 1983 and 1986. As shown in Table 4, the accident rates per 100,000 hr for equipment failure during the 4 years fluctuate. All of the subcategories in Equipment Failure follow the same trend, decreasing from 1983 to 1984, increasing in 1985, and decreasing slightly in 1986.

Equipment failures also increase in the summer and decrease in the winter (see Figure 1). This trend is probably due to an increase in flight hours during the summer. However, this is only a speculation, because hours flown are reported annually, not monthly.

As shown in Figure 1, the number of accidents due to equipment failures usually increases significantly during July

TABLE 4 EQUIPMENT FAILURE ACCIDENTS

	Rate per 100,000 Flight Hours				
All Accidents	1983 (N=409)	1984 (N=348)	1985 (N=471)	1986 (N=371)	Total (N=1,599)
Fatal	0.23	0.14	0.23	0.21	0.20
Nonfatal	1.50	1.29	1.74	1.33	1.47
Total	1.73	1.43	1.97	1.54	1.67

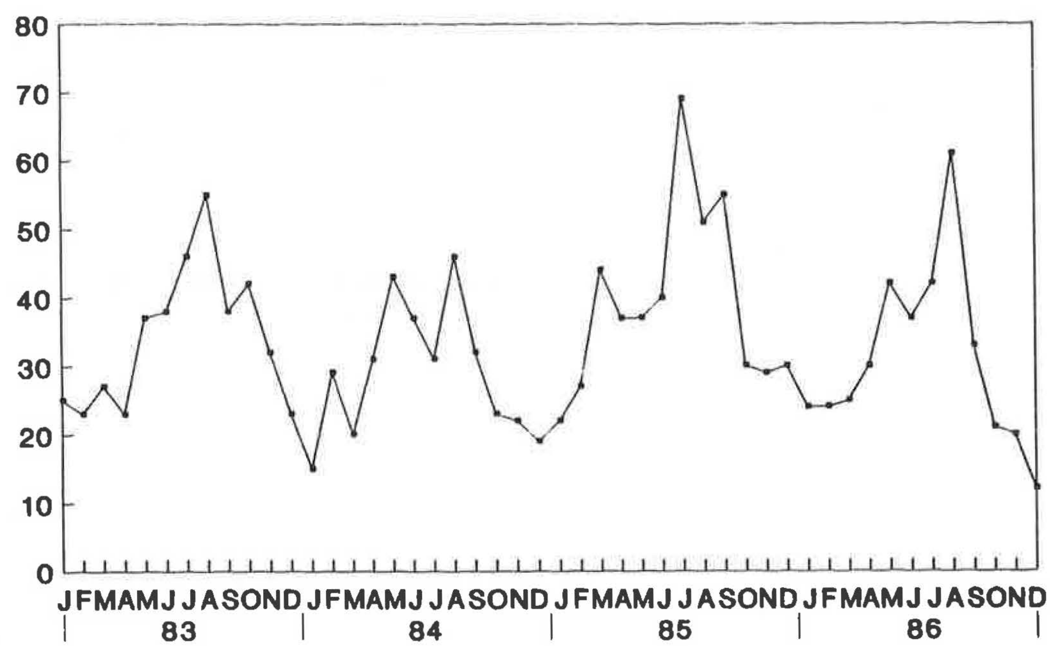

FIGURE 1 Number of equipment failures by month.

and August. However, the number of such accidents in the summer of 1984 is conspicuously low. The accident rate per 100,000 flight hours for equipment failure is also the lowest in 1984, at 1.4. There is no definitive explanation for this decrease; however, it did coincide with an FAA-initiated program, the General Aviation Safety Audit (GASA).

On June 20, 1984, the U.S. Secretary of Transportation requested that the FAA conduct an audit with the goal of (5) "promot(ing) continued safety in the operation and maintenance of aircraft used in the general aviation and commercial environment." GASA included inspections of repair facilities and mechanics with inspection authorization. During the 12-month audit, FAA inspected over 85 percent of the noncertificated maintenance facilities that service single- and multiengine aircraft.

A decreasing trend in accidents due to equipment failure began as early as January 1984, which suggests that the publicity surrounding the initiation of the audit may have caused mechanics and maintenance facilities to operate more cautiously. Detailed information on the aircraft affected by GASA is not available, and thus, proving a causal relationship between GASA and the decline in accidents is impossible. The accident trend, however, is encouraging and suggests that the FAA program possibly improved aviation safety.

If a connection could be established between the timing of GASA and the decreasing number of equipment failure accidents, it might indicate that FAA's announcement of a concern regarding a safety issue, in this case general aviation maintenance facilities, is effective in improving the safety record. If GASA actually caused the reduction of equipment failure accidents in 1984, the program apparently did not provide permanent improvements. The largest number of equipment failure accidents in any single month during the 4-year period occurred 1 year after the initiation of the program.

The short-lived reduction in equipment failure accidents suggests that FAA's maintenance inspections are effective only shortly before and during the inspections, and have little long-term consequence. The lack of detailed data on the aircraft affected by GASA, however, decreases the reliability of this conclusion. If FAA adopts another program to improve general aviation maintenance, the agency should make an effort to collect and examine accident data before, during, and after program implementation. Without detailed data on aircraft that are and are not involved, FAA cannot evaluate the success of the safety program.

Environment

If a decrease occurred in the number of Environment accidents, it might suggest an improvement in weather forecasts or an improvement in pilot judgment. The 4 years of accident rates per 100,000 hr in Table 5, however, show no trends.

Air Traffic Control and Other Aircraft

ATC induced only 13 general aviation accidents during the 4-year period (see Table 6). Few ATC-induced accidents are expected, because most general aviation flights are conducted under Visual Flight Rules (VFR) and operate from airports that do not depend on air traffic controllers to manage traffic.

VFR flights depend on the "see and avoid" concept, which means that the responsibility for aircraft separation falls on the pilot. However, the "see and avoid" concept occasionally fails. During the 4-year period, 218 general aviation aircraft were involved in accidents caused by the inability to "see and avoid." The data in Table 7 show a relatively constant number of total aircraft involved in accidents with other aircraft over the 4-year period. However, the number of aircraft involved in midair collisions appears to be rising.

Between 1983 and 1986, 148 general aviation aircraft were involved in midair collisions, with 101 fatalities. The accident rate per 100,000 flight hours rose from 0.093 in 1983 to 0.195 in 1986. The majority of general aviation midair collisions occurred while in the landing or take-off phase, during the day, and under clear (or VFR) meteorological conditions. Fifty-one percent of general aviation midair collisions occurred during take-off or landing, and 29 percent occurred en route. The remaining 19.5 percent occurred while the aircraft were either preparing to land or had recently left the airport and were no closer than ½ mi from the airport. Only two midair collisions involved a general aviation and a commercial aircraft.

The location of midair collisions in the United States seems to vary from year to year, with the exception of one state. Over the 4-year period, 21 midair collisions occurred in California. As shown in Table 8, the rate of aircraft involved in midair collisions per 100,000 flight hours in California is substantially higher than the average rate for the United States. The majority of the midair collisions in California occurred near Los Angeles or San Francisco, where the airspace is highly congested.

TABLE 5 ENVIRONMENT ACCIDENTS

	Rate per 100,000 Flight Hours				
Accident Subcategory	1983	1984	1985	1986	Total
Weather	0.24	0.18	0.20	0.23	0.21
Wind Gusts	0.12	0.15	0.21	0.19	0.17
Wind on Landing/Takeoff	0.36	0.27	0.33	0.17	0.28
Improper Briefing	0.01	0.00	0.01	0.01	0.01
Animals	0.05	0.05	0.09	0.06	0.06
Total	0.77	0.65	0.84	0.67	0.73

TABLE 6 NUMBER OF AIR TRAFFIC CONTROL ACCIDENTS

Accident Subcategory	1983	1984	1985	1986	Total
En route	1	1	0	1	3
Terminal	1	1	0	2	4
Ground	1	1	2	2	6
Total	3	3	2	5	13

TABLE 7 NUMBER OF OTHER AIRCRAFT ACCIDENTS

Accident Subcategory	1983	1984	1985	1986	Total
Midair Collision	22	36	43	47	148
On-Ground Collision	26	14	10	6	56
Evasive Action	5	4	5	0	14
Total	53	54	58	53	218

TABLE 8 MIDAIR COLLISION ACCIDENTS

State or Region	Rate per 100,000 Flight Hours				
	1983	1984	1985	1986	Total
California	0.164	0.273	0.333	0.304	0.268
Eastern Region	0.116	0	0.033	0.227	0.098
New England Region	0	0.351	0	0.254	0.164
Total	0.093	0.148	0.180	0.195	0.154

Table 8 gives the midair collision rates per 100,000 flight hours for the Eastern Region (Virginia, West Virginia, Maryland, Delaware, New Jersey, Pennsylvania, and New York) and the New England Region (Rhode Island, Connecticut, Massachusetts, Vermont, New Hampshire, and Maine). Although East Coast airspace is also congested, the accident rates in these two regions are not consistently above the national average.

Alaska General Aviation Accidents

As mentioned previously, the Alaskan general aviation accident record was separated from those of the remaining 49 states because of the hypothesis that the severe weather conditions and terrain would create different accident trends. In addition, Alaska is unique because aviation may often be the only transportation option.

Predictably, Alaskan general aviation suffers a high occurrence of accidents and a high distribution of fatal and weather-related accidents. Alaskan general aviation accidents occurred at an average rate of 16.5 per 100,000 flight hours between 1983 and 1986, whereas the rate for the remaining 49 states was only 9.0. Fatal accidents make up a small percentage of the total accidents—only 12 percent compared with 19.5 percent in the remaining 49 states.

Weather-related accidents occurred more frequently in Alaska than in the remaining 49 states, accounting for 5.5 percent of all accidents, compared with 2.4 percent in the remaining 49 states. The subcategory Wind on Landing/Takeoff included a larger percentage of Alaskan accidents (6.8), whereas remaining 49 states accounted for 3.1 percent of the total accidents in this subcategory.

Although the Environment category accounts for 14 percent of the Alaskan accidents, Pilot Error is the most common category of accidents in both Alaska and the remaining 49 states (see Table 9). The percentage of Pilot Error accidents in Alaska and that in the remaining 49 states are similar; however, the distribution of Pilot Error accidents is slightly different. Preflight Procedures/Judgment accounts for 19.9 percent of the fatal accidents in the remaining 49 states, but only 8.1 percent in Alaska. Alcohol/Drugs accounts for 16.2 percent of the fatal accidents in Alaska, but only 6.2 percent in the remaining 49 states.

Although the environment in which general aviation operates in Alaska differs from that in the remaining 49 states, the most common cause of accidents—pilot error—is shared. As suggested in the discussion of pilot error, additional pilot training might be warranted. The most common subcategory under Pilot Error in Alaska and the remaining 49 states is Flying Skills. Again, this suggests that the effectiveness of initial and recurrent training in the physical control of the aircraft might be evaluated.

TABLE 9 FREQUENCY OF ALL ACCIDENTS: ALASKA VERSUS REMAINING U.S. STATES

Accident Category	Alaska (%)	United States (%)
Pilot Error	66.2	64.2
Equipment Failure	9.5	18.5
Environment	14.2	8.1
ATC	0.5	0.2
Ground Crew Error	0	0.4
Other Aircraft	2.4	2.5
Other	7.1	6

COMPARING AVIATION SECTORS

Accident rates for U.S. air carrier operations are lower than those for general aviation. During 1983, aircraft operating under 14 CFR 121, 125, and 127, which include large commercial air carriers and helicopters used as scheduled air carriers, had an accident rate of 0.06 per 100,000 flight hours (*6*). In contrast, general aviation's accident rate per 100,000 flight hours was 10.64. The fact that general aviation includes new pilots with limited experience might explain the difference in accident rates. An individual can get a private pilot's license to fly a general aviation aircraft after a total of 40 hr of flight time (Federal Aviation Regulation 61.109). In contrast, jet carrier airline pilots hold Air Transport Pilot licenses, which require a minimum of 1,500 hr of flight time (Federal Aviation Regulation 61.155).

Because of the variety of pilot experience between aviation sectors, a higher percentage of accidents caused by pilot error in general aviation would be expected. As shown in Table 10, which includes data from the Aviation Safety Commission report, this speculation is correct (*4*). The research in the Aviation Safety Commission report includes all the NTSB accident briefs for jet carriers and commuters. All accidents were categorized by the initial contributing factor that led to the accident. The categories of Pilot Error and Equipment Failure used by the Aviation Safety Commission are identical to those defined in this general aviation research. Note, however, that the Aviation Safety Commission report provides the average distribution of accidents by cause for 1979 through 1985.

Table 10 reveals that pilot error is the leading cause of general aviation accidents at 64 percent, but accounts for only

TABLE 10 FREQUENCY OF SELECTED ACCIDENTS BY AVIATION SECTOR

Accident Category	Percentage by Sector		
	General Aviation[a]	Scheduled Jet Carriers[b]	Scheduled Commuters[c]
Pilot Error	64.2	9	27
Equipment Failure	18.5	19	39
Seat Belts	0	28	1

[a]CFR Part 91, 1983–1986.
[b]CFR Part 121, 1979–1985 (*4*)
[c]CFR Part 135, 1979–1985 (*4*)

9 percent of jet carrier accidents. Pilot error accidents for scheduled commuter flights, in contrast, account for 28 percent of the total number of accidents. Failure of passengers to wear seat belts is the most frequent cause of jet carrier accidents. Because an aviation accident includes events ending in serious personal injury, not wearing a seat belt after the pilot has requested that the passengers return to their seats and fasten their safety belts may result in personal injury and be reported to NTSB as an accident.

The different distributions of accident causes for the aviation sectors may also be a function of the types of flights conducted. General aviation flights are typically much shorter than the average jet carrier flight. Shorter flights mean additional takeoffs and landings. Because many pilot error accidents occur during these flight phases, a higher accident rate per 100,000 flight hours for general aviation pilot error accidents might be expected.

RECOMMENDATIONS

Identifying the causes of general aviation accidents is not equivalent to identifying where FAA should concentrate safety programs. The primary causes of general aviation accidents may suggest logical areas for safety improvements, but the information on the FAA aviation safety programs is inadequate to evaluate the success of current or past programs. The recommendations, therefore, include suggestions that FAA carefully evaluate current safety programs and consider focusing additional safety efforts in areas where accidents have frequently occurred in the past.

The safety programs Back-to-Basics and GASA are examples of efforts in which program evaluation could have enlightened the agency on the effectiveness of their safety programs. The Back-to-Basics program included training in pilot decision making. Research published before the program suggested that pilot judgment training improved pilots' decision-making efforts (*7*). Nevertheless, FAA failed to collect detailed information on the program participants, which would have allowed an evaluation of the training program's effectiveness.

The accident data suggest that the GASA program briefly reduced accidents due to equipment failure. Although this is inconclusive, the findings suggest that FAA's maintenance audits enhanced safety. Again, the findings were inconclusive because of the lack of information on the participants. In the case of Back-to-Basics and GASA, if FAA had recorded who participated in the program and surveyed their accident records before and after participation, the effects of the program could have been evaluated. Without program evaluation, an agency cannot determine whether a program should continue to receive support.

FAA should begin evaluation of those programs that target the leading causes of accidents—particularly fatal accidents. The four subcategories containing the largest percent of fatal accidents are Preflight Procedures/Judgment, with 19.9 percent; In-Flight Procedures/Judgment, with 17.7 percent; Cause Ambiguous, with 11.6 percent; and Flying Skills, with 11.4 percent. Nonfatal accidents are also concentrated in these categories.

FAA should also use the leading causes of general aviation accidents identified in this study to design effective safety programs. Designing appropriate safety programs in the future, however, depends on FAA's ability to identify factors most frequently contributing to accidents. To achieve this, FAA and NTSB should coordinate efforts to improve access to NTSB data. The published NTSB data are not always aggregated and presented in a helpful way to shape policies and programs.

FAA has recently formed a new general aviation office, one of the goals of which is to focus on safety. This office should consider working with NTSB to access the general aviation accident data base and use the information to improve safety. An annual assessment of the initial factors contributing to general aviation accidents would help FAA design the most beneficial safety programs.

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