

Trends and Analyses of General Aviation Fatalities

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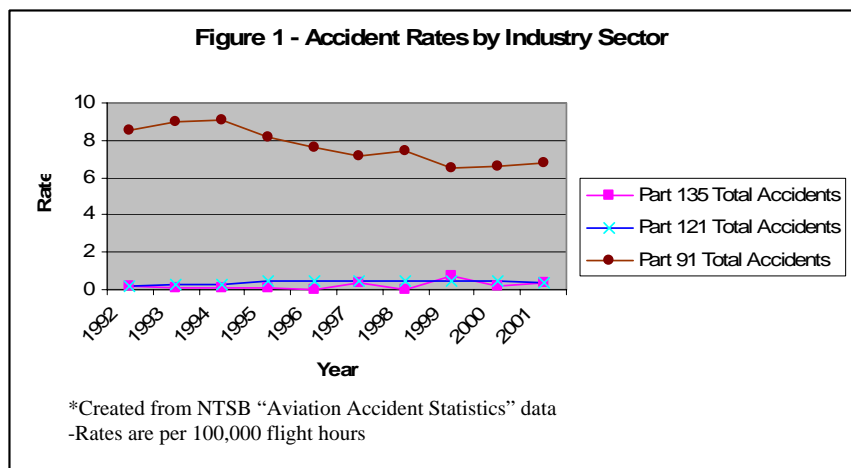
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ABSTRACT

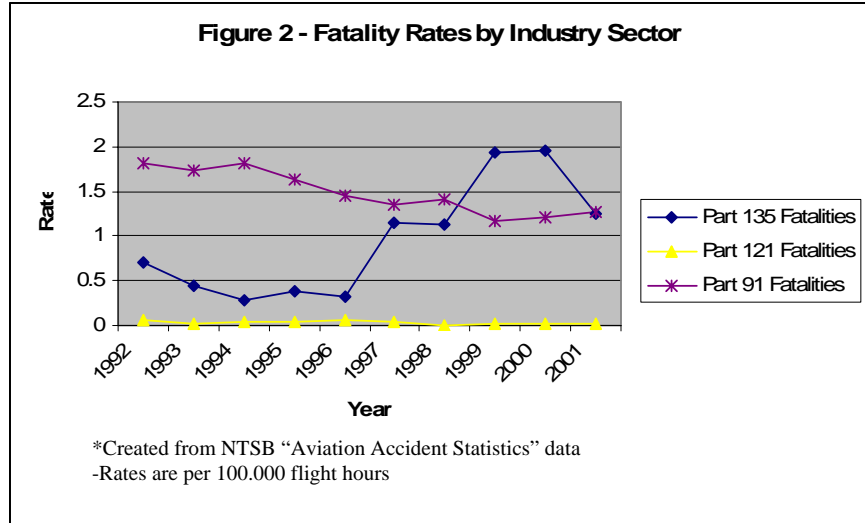
Recent publications have shown that general aviation accident rates in the United States are decreasing, though they remain much higher than other segments of aviation. What is behind this safety improvement? Are all types of accidents decreasing or are certain types of accidents driving the overall decrease? This study provides the preliminary results of an in depth analysis of the causes of fatal general aviation accidents from 1992 through 2002. First a database of all fatal Part 91 accidents during this timeframe was created by examining the NTSB accident report for each accident and determining the initial cause of the accident. Forty-four different cause categories were used and 1305 individual accidents were analyzed. Both the absolute and relative change of the causes of Part 91 fatal accidents from 1992 through 2002 were considered. This study provides the findings from four years from this time period (1992, 1997, 1999, and 2001) in order to evaluate initial results and trends and to develop some initial hypotheses for later testing. Preliminary analyses of the data reveal that the distribution of fatal general aviation accidents by flight phase differs from commercial aviation accidents. The data also reveals that while pilot error remains a significant cause of fatal accidents, the rate of pilot error accidents is decreasing and CFIT accidents, which are thought to be a particular area of concern within general aviation, are actually not a significant cause of accidents within this sector.

INTRODUCTION

Although aviation safety is widely researched, general aviation, general aviation activity that falls under Part 91 regulations, has received little attention by aviation safety researchers. Most research done on aviation safety focuses on scheduled commercial aviation; Part 91 is generally only covered when a celebrity is



involved an air crash such as JFK Jr. or Senator Paul Wellstone. However, general aviation activity accounts for more flight hours flown each year than all other flight categories combined, accounting for almost 26 million flight hours per year. Part 91 activity also has a higher accident rate than both part 135 and



part 121; a 1995 study completed by the General Accounting Office states "The safety of general aviation has been improving. The total number of accidents declined from 3,233 in 1982 to 1,989 in 1998—a decrease of 41 percent—while the accident rate fell from about 10 to about 7 accidents for every 100,000 flight hours. Even with these improvements, general aviation's accident rate remains about 24 times higher than the accident rate of scheduled commercial aviation."(Dillingham, 5) The general trend of improvement, in both fatal and nonfatal general aviation accidents, as well as the higher rate associated with general aviation accidents, continues through the 2001 data, although there seems to be a bit of an increase in 2000 and 2001. As such greater research is warranted into the factors contributing to the decreasing accident rates in general aviation. Are accidents attributed to certain causes driving the decreasing rates more than others or is the improvement across the board of all general aviation accidents? In order to shed light on this question it is necessary to discern and evaluate the causes of general aviation accidents.

Table 1 - General Aviation Accident Rates per 100,000 Flight Hours

Year	Fatalities	Accidents
1992	1.82	8.51
1993	1.74	9.03
1994	1.81	9.08
1995	1.63	8.21
1996	1.45	7.65
1997	1.36	7.19
1998	1.41	7.44
1999	1.16	6.5
2000	1.21	6.57
2001	1.27	6.78

*NTSB "Aviation Accident Statistics"

A recent study on the importance and impact of general aviation, which includes an analysis of the causes of general aviation safety statistics, has been done by the United States General Accounting Office using National Transportation Safety Board (NTSB) data. In order to analyze general aviation safety they used the cause listed in the NTSB final report of the accident. When more than one cause was listed they chose the first cause listed. They assembled this information for all accidents between 1994 and 1998. They then categorized the causes according to a framework which distinguished between "deficiencies in procedural knowledge, perceptual and motor skills, and

decision-making.” (Dillingham, 23) The results of their study conclude that 80% of all fatal and 72% of all nonfatal accidents are caused by pilot error and that among pilot error nonfatal accidents 52% were attributed to skill error, 6% to procedural error, and 42% to decisional errors.(54)

In 1992, Oster, Zorn, and Strong also conducted an evaluation of general aviation safety which provided a more in depth look at the causes of general aviation accidents that allowed for further delineation of accident causes but for an earlier time period. They found that among general aviation accidents, 19% could be attributed to equipment failure, 7% to the environment, and 65% to pilot error. They also broke these down further into more detailed categories. Within the pilot error category they found that 20% of all pilot error accidents are due to a preflight judgment error while 18% could be attributed to in-flight judgment errors. This study will conduct a similar analysis using the most recent time frame and provide information on a few additional variables.

METHODS

For this study, all fatal general aviation accidents from 1992 to 2002, 1305 accidents total were examined using NTSB final report data. Rather than list each contributing cause, the focus has been to determine the initial cause in the sequence of events that led to the accident. The entirety of every report is read in order to make this determination. For example if an engine fails and the pilot fails to properly execute an emergency landing which could have saved the aircraft or passengers, the accident is classified as an engine failure, since that is the initial event that precipitated the accident. However if the pilot was flying the aircraft with known mechanical deficiencies in the engine, then the accident would be classified as On Ground Pilot judgment. Making these distinctions can be difficult but the classification scheme used has been refined over the past decade to reduce subjectivity as much as possible. The primary aim has been to achieve consistency in like cases so that the trends amongst categories can be compared over time, and eventually with other sectors of the aviation industry. Since every fatal accident for each year is analyzed the resulting data represents the universe of fatal accidents for this time period as opposed to a sample.

This study uses the same categories developed by Oster, Zorn, and Strong study. However they have been slightly expanded in order to delineate more categories in an attempt to answer new questions on the causes of general aviation accidents. This includes additional categories for Controlled Flight Into Terrain (CFIT), unstabilized approaches, and acts of terror. The accidents are also analyzed by the phase of flight in which the accident occurred and the number of pilot hours acquired by the pilot in command during the accident. The information presented here are the preliminary results from this research endeavor. Only the data from 1992, 1997, 1999, and 2001 are provided. A summary of trends across different categories is presented as an initial method of analyzing the results.

ANALYSES

The first step was to evaluate fatal accidents within general aviation by the phase of flight. At what stage of flight do most accidents occur and is this pattern changing over time? It is an important area of analysis because a great deal of the training and safety seminars provided for general aviation pilots focuses on particular phases of flight. In commercial aviation the majority of accidents take place during the phases of takeoff and landing. It is during these phases that the pilot workload is the highest and the opportunity for distractions is the greatest. However, as Table 2 illustrates this does not seem to be the case within general aviation. Combined, accidents occurring during the takeoff and landing phases of flight account on average for only 18.47% of all fatal

Table 2 - Part 91 Fatal Accidents by Flight Phase

	1992		1997		1999		2001		Average	
	Rate	Percent	Rate	Percent	Rate	Percent	Rate	Percent	Freq	Percent
Takeoff	0.22	13.33	0.20	15.92	0.12	11.7	0.1652	14.63	181	13.87
Climb	0.09	5.68	0.06	4.78	0.05	4.68	0.0629	5.57	68	5.21
Cruise	0.26	16.05	0.31	25.16	0.15	14.72	0.1691	14.98	231	17.7
Maneuvering	0.42	25.68	0.25	20.7	0.17	16.39	0.3303	29.27	302	23.14
Descent	0.21	12.84	0.09	7.32	0.02	2.34	0.1337	11.85	116	8.89
Approach	0.26	15.8	0.14	11.46	0.11	11.04	0.1494	13.24	171	13.1
Landing*	0.08	5.19	0.08	6.37	0.02	1.67	0.0551	4.88	60	4.6
Other	0.09	5.43	0.10	8.28	0.38	37.46	0.0629	5.57	169	13.49

*Includes those cited as emergency landing

-Author's calculations based on NTSB accident reports

-Rates are per 100,000 flight hours

general aviation accidents. When the approach and climb phases are included this figure does increase to approximately 37%, however it still does not equal the percentage of accidents which can be attributed to the cruise and maneuvering stages of flight, which account for approximately 45% of all fatal general aviation accidents. The differences between the two sectors of aviation can perhaps be explained by the more varied range of activities in which general aviation pilots are involved. Typically part 121 aircraft fly from point A to point B. Part 91 pilots on the other hand are often involved in a variety of maneuvers from aerobatics to aerial photography, to pleasure flights in which many maneuvers are performed. A general aviation flight is much more likely to include steep turns, stall maneuvers, etc., than a part 121 flight. This may suggest then that greater attention be given to illustrating the potential risks of these stages of flight for the continued training of general aviation pilots.

It is also important to examine these accidents by their cause. This is the reason that a more detailed analysis of these accidents and their causes was necessary. Table 3 provides the distribution of causes amongst accident categories for each of the years analyzed. The category equipment failure includes all types of equipment failure (in categories 11-17,) with the exception of homebuilt equipment failure accidents which are included in the homebuilt category. (See Appendix A for full category descriptions.) Likewise the pilot error category includes all accidents attributed to a pilot error, whether it is due to skill or judgment (categories 41-47, & 49).

From the evidence in the table it appears that while pilot error remains the largest cause of fatal accidents, the percentage decreases during this time frame. Weather related accidents, a small portion of total accidents, seems to be decreasing as well. It appears that homebuilt accidents may be increasing as a percentage of total accidents however it is unclear what is driving this increase. It could simply be that a greater proportion of general aviation activity is with homebuilt aircraft but more data would be necessary to draw any conclusions. In order to evaluate whether or not the decrease in the percentage of accidents attributed to pilot error is actually driven by a decrease in the rate of pilot error accidents we need to analyze the rate changes over this time frame as well as is done in Table 4. The data shows that in fact the rate of pilot error accidents has decreased substantially as well. A closer look at the types of pilot error causes that these accidents are attributed provides even more insight as to the decrease in these types of accidents.

Table 3 - Part 91 Fatal Accident Rates by Flight Cause

Cause	1992	1997	1999	2001
	Percent	Percent	Percent	Percent
Equipment Failure	7.66	6.38	9.69	8.72
Weather	0.74	0.64	0.33	0.35
Wind	0.25	0	0	0
Animals	0	0	0	0.35
Pilot Error	53.32	52.22	52.18	48.43
Student	2.72	2.55	0	3.14
Midair Collision	2.72	6.37	4.01	2.09
On Ground				
Collision	0.49	0	0	0
Company	0	0	0.33	0
Hijack	0	0	0	0.35
Homebuilt*	10.37	14.33	17.06	18.12
Other**	43.44	35.04	32.78	36.96

*Homebuilt includes all homebuilt accidents including both equipment failure and pilot error.

**Other includes categories 81-87, categories for which there were no incidents are unlisted.

-Author's calculations based on NTSB accident reports

Table 5 - Part 91 Fatal Pilot Error Accidents

Cause	1992	1997	1999	2001
	percent	percent	percent	percent
Pilot Skills	7.65	4.46	9.7	11.5
Unstabilized				
Approach	1.23	1.27	0.67	0.35
Pilot Error				
CFIT	0.99	1.27	0.67	0.35
In Flight				
Judgment	18.02	17.52	16.39	11.5
On Ground				
Judgment	17.53	17.83	14.38	14.98
Fuel				
Management	3.21	3.18	3.68	1.74
Alcohol/Drug	4.69	6.69	6.69	8.01
Total	53.32	52.22	52.18	48.43

-Author's calculations based on NTSB accident reports

Table 4 - Part 91 Fatal Accident Rates by Flight Cause

Cause	1992	1997	1999	2001
	Rate	Rate	Rate	Rate
Equipment Failure	0.125	0.078	0.099	0.098
Weather	0.012	0.008	0.003	0.004
Wind	0.004	0.000	0.000	0.000
Animals	0.000	0.000	0.000	0.004
Pilot Error	0.872	0.641	0.533	0.547
Student	0.044	0.031	0.000	0.035
Midair Collision	0.044	0.078	0.041	0.024
On Ground Collision	0.008	0.000	0.000	0.000
Company	0.000	0.000	0.003	0.000
Hijack	0	0	0	.004
Homebuilt*	0.169	0.176	0.174	0.204
Other**	0.710	0.430	0.335	0.417

*Homebuilt includes all homebuilt accidents including both equipment failure and pilot error.

**Other includes categories 81-87, categories for which there were no incidents are unlisted.

-Author's calculations based on NTSB accident reports

-Rates are per 100,000 flight hours

Tables 5 & 6 break down the pilot error category into the seven separate categories of which it is composed. By doing so we are able to distinguish accidents attributed to pilot skills, in essence the ability to handle the aircraft, and pilot judgment. We are also able to distinguish between types of pilot judgment such as whether the error in judgment occurring in flight or on the ground. The categories for Fuel Management and Alcohol/Drugs are considered to be distinct types of on ground pilot judgment error. As a share of fatal general aviation accidents, those attributed to

pilot skills have increased during this time frame. Conversely those attributed to In Flight judgment have decreased substantially. The share of accidents as well, as the rate of accidents attributed to pilot judgment errors as a whole, seem to be decreasing with the exception of Alcohol and Drug related accidents which have increased from 4.69% of all fatal general aviation accidents to just over 8%. Also of interest within these tables is the particularly low rate and share of accidents represented by the CFIT category. Despite a great deal of attention to the hazard CFIT accidents pose to the industry and general aviation in particular, when presented with the numbers it appears to be a relatively insignificant cause of fatal general aviation accidents.

It seems reasonable to expect that as a pilot's flight experience increases their propensity to commit an error whether it be in flying skills or judgment would decrease. In order to evaluate this hypothesis pilot hours, as reported in NTSB reports, are used as a measure of flight experience. Then mean pilot hours for pilots involved in accidents attributed to pilot error are compared to those in all other categories. Table 7 shows that in fact it appears that there is not a significant difference in mean pilot hours for those involved in pilot error

Table 6 - Part 91 Fatal Pilot Error Accidents

Cause	1992	1997	1999	2001
	rate	rate	rate	rate
Pilot Skills	0.125	0.055	0.099	0.130
Unstabilized				
Approach	0.020	0.016	0.007	0.004
Pilot Error				
CFIT	0.016	0.016	0.007	0.004
In Flight				
Judgment	0.295	0.215	0.168	0.130
On Ground				
Judgment	0.287	0.219	0.147	0.169
Fuel				
Management	0.052	0.039	0.038	0.020
Alcohol/Drug	0.077	0.082	0.068	0.090
Total	0.872	0.641	0.533	0.547

-Author's calculations based on NTSB accident reports

-Rates are per 100,000 flight hours

accidents from all other types. Both have an average of approximately 2700 flight hours. When analyzed by different types of pilot error accidents it does seem that pilots involved in accidents attributed to pilot skill have a slightly lower average than the other pilot error categories, however pilots involved in accidents attributed to unstabilized approaches, which is considered a distinct type of pilot skill accidents, has a higher average. Ultimately greater research and analysis is needed before conclusions as to the role of pilot experience in fatal general aviation accidents can be made.

Table 7 – Mean Pilot Hours

Mean Pilot Hours for Pilot Error Accidents	2715
Mean Pilot Hours for all other Accidents	2725

-Author's calculations based on NTSB accident reports

Table 8 - Mean Pilot Hours for Causes Attributed to Pilot Error

Cause	Mean Pilot Hours
Pilot Skills	2146
Unstabilized Approach	4854
Pilot Error CFIT	2906
In Flight Judgment	3206
On Ground Judgment	2670
Fuel Management	2668
Alcohol/Drug	2211

-Author's calculations based on NTSB accident reports

CONCLUSION

While this research endeavor is still in its preliminary stages there are some initial results which prove interesting. In the planning of the continual training of general aviation pilots a greater emphasis should be placed on the cruise and maneuvering phases of flight as the share of accidents that occur within these phases are greater than within part 121 operations. This may also help to curb the rise in accidents that are attributed to pilot skill.

Decreased emphasis on the risk of CFIT accidents also seems appropriate since it does not appear to be a significant contributor to fatal general aviation accidents. As previously mentioned these are preliminary results of a larger ongoing research endeavor. The remainder of the years in this time period will be added to the analysis and additional hypotheses will be tested. Further analysis of this data may shed greater light as to the causes of general aviation accidents and to a better understanding of what factors are contributing to the decrease in accident rates as well as to the question of why the rates are so much higher than other sectors within the industry.

Appendix A - Definitions and Rules for Assigning Causes to Accidents

Equipment Failure: Codes 10 – 19 (10 indicates a summary of all in the category)

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|---------------------------|---|
| 11 Engine Failure | Engine failure includes any failure in flight or during the takeoff role of the power plant including propellers, internal engine parts, turbos, magnetos, fuel lines downstream of the fuel tank, engine controls, fuel contamination other than problems that should have been detected during preflight checks (water, misfueling, etc.) If the pilot claims engine failure and post-crash inspection fails to determine a cause of the engine failure, the accident is considered an engine failure. However, if the engine runs without problem in the post-crash Investigation, the accident is considered “cause ambiguous” An accident caused by the failure of the APU is included in this category. |
| 12 Instruments/Electrical | Includes any malfunction of aircraft instruments of any other electrical failure (other than magneto). Inaccurate fuel gauge is not considered instrument failure. |
| 13 Instruments-CFIT | Includes any malfunction of onboard aircraft instruments that results in a CFIT accident in reduced visibility conditions. |
| 14 Landing Gear/Tires | Any malfunction of the landing gear, tires, wheels, or brakes. However, it does not include malfunction from a hard landing or excessive side loads (ground loops). |
| 15 Structure | Includes failure of wings, flight control surfaces, or other structural parts of the aircraft (ailerons, horizontal and vertical stabilizers, etc.) |
| 16 Homebuilt | Includes any mechanical, structural, or electrical failure of a homebuilt aircraft. Homebuilt aircraft are identified either by being designated as a homebuilt in the accident brief or if the manufacturer’s name is the same as the pilot’s name. |
| 17 Other | Includes all other equipment failures, such as the failure of a seat leading to loss of control of the aircraft. |

Seatbelt Not Fastened/Turbulence: Codes 21-29

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|--------------------------|--|
| 21 Seatbelt not fastened | This category is to be used when a passenger injury or death results from not having his or her seatbelt fastened when turbulence is encountered and adequate warning had been given by the flight crew. Adequate warning must include the seatbelt sign being illuminated and, if it had been previously turned off in flight, must include an announcement by a member of the flight deck crew or cabin crew. If the sign had been previously turned off in flight, there must be an announcement by a member of the flight deck crew or cabin crew. |
|--------------------------|--|

22 Turbulence	This category is to be used in accidents involving turbulence other than those in the category above. If a flight attendant is injured by turbulence, it is in this category. If a passenger is injured by turbulence when the seatbelt sign is not turned on, it is also in this category. If the seatbelt sign is turned on but the passenger is injured before or while returning to his or her seat, it is in this category. Damage to an aircraft from turbulence would also be in this category.
Environment: Codes 30-39	
31 Weather	Includes accidents resulting from windshear, slippery runway (unless the pilot lands excessively long), emergency landings due to weather, and icing. Weather encountered during takeoff is considered pilot error preflight judgment. If a weather briefing is not obtained prior to flight, the cause is considered preflight judgment. If a VFR-rated pilot encounters predicted weather beyond his or her capability, it is preflight judgment. Attempting to land at an airport below minimums is weather only if no alternative airport is available. Windy conditions during takeoff or landing while airborne that are corroborated by weather data or witnesses are considered weather. Otherwise such accidents are to be categorized as flying skills or, if high winds are known to the pilot prior to landing as in-flight judgment or prior to takeoff as preflight judgment. Downdrafts in mountainous terrain are considered weather if altitude is 1000 above ground level. Otherwise, the accident is considered in-flight judgment.
32 Wind Gusts	Includes accidents resulting from encountering high winds while the aircraft is on the ground (taxi, landing roll, takeoff roll, parked).
33 Animals	Includes collision with any animals in-flight or on the ground. It also includes accidents due to evasive maneuvers trying to avoid animals.
34 Unimproved runway	Any accident where the cause was an unseen obstruction or flaw in a non-paved runway. Examples would include hitting a submerged log with a float plane or breaking through the ice while landing on a river or lake.
Pilot Error: Codes 40-49	
41 Flying Skills	Includes accidents resulting from deficiencies on the part of the pilot in maintaining physical control of the aircraft. It includes hard landing, landing long, stalls, becoming disoriented, and so on. Failure to correct for a mild downdraft during landing is considered flying skills.
42 Unstabilized approach	Any accident resulting from failure to maintain a reasonably constant airspeed and descent rate during approach and landing. This is a form of flying skills with a separate code.
43 CFIT	CFIT accidents attributed to pilot error.

44 In-flight judgment	Includes mental errors such as failure to do the landing checklist, failure to correct for carb icing, failure to maintain proper mixture control, becoming lost, improper flap setting for flight or landing. It also includes errors in judgment that put the plane in a hazardous situation such as flying at low altitude (buzzing, hitting power lines, spotting animals), flying into canyons, flying into rising terrain that exceeds climb capabilities of the aircraft, choosing to land in uncertain terrain (roads, pasture, etc.) and continuing VFR flight into IFR conditions. These are errors in judgment while the plane is airborne.
45 On-ground judgment	Includes errors made prior to the flight that result in an accident such as failure to do preflight checklist, failure to get weather briefing, takeoff for a VFR flight into marginal weather, takeoff into adverse weather or wind conditions, takeoff from uncertain terrain and, starting the plane when it is unoccupied and it isn't chocked and tied down. Failure to detect water in the fuel and misfueling is preflight judgment. Failure to know the fuel consumption rate of the aircraft is preflight judgment. Also use this category for errors in post-flight procedures such as failure to do a checklist when the airplane is safely on the ground or failure to set the parking brake. This category is for mistakes made by the flight crew when the aircraft is safely on the ground.
46 Fuel management	Includes all running out of fuel in flight except for mechanical failures such as leaks and/or defective fuel cells.
47 Student pilot	Includes all pilot error accidents by beginning student pilots up to and including their fourth solo flight.
48 Homebuilt	Includes any pilot error accident in a homebuilt aircraft.
49 Alcohol/Drug	Includes any accident where the pilot is impaired by alcohol or drugs, including equipment failure-related accidents.
Air Traffic Control: Codes 50-59	
51 En route	Includes accidents precipitated by errors by controllers in Air Route Traffic Control Centers as well as errors by personnel at Flight Service Stations.
52 Terminal	Includes accidents precipitated by errors by controllers at Terminal Area Radar Control Centers.
53 Ground	Includes accidents precipitated by errors by tower controllers.
54 Air Nav CFIT	Includes CFIT accidents caused by ground-based navigational equipment errors or malfunctions.
55 TCAS	Includes accidents caused by evasive maneuvers commanded by TCAS.

Ground/Cabin Crew: Codes 60-69

- | | |
|------------------------|---|
| 61 Airline Ground Crew | Includes any accidents from errors by ground crew personnel employed by an airline. |
| 62 Other Ground Crew | Includes accidents by ground crew or other ground-based personnel employed non-airline companies. This would include drivers of catering and fuel trucks. |
| 63 Cabin Crew | Includes accidents caused by cabin crew error. |

Other Aircraft: Codes 70-79

- | | |
|---------------------|---|
| 71 Midair collision | Any accident where two planes collide and either of the planes is in the air. This category takes precedence over all other causes except air traffic control. |
| 72 On ground | Any accident when two moving planes collide on the ground. If a moving plane collides with a stationary plane, the moving plane is a pilot error/flying skills and the stationary plane is this category. |

Other: Codes 80-89

- | | |
|---|---|
| 81 Company Operations | Any accident resulting from systematic application of company-mandated unsafe practices. |
| 82 Aircraft not recovered | Any accident where the aircraft was not recovered or a sufficient portion of the aircraft to allow an effective accident investigation was not recovered. |
| 83 Medical Impairment | Any accident where the pilot error appears to have been induced by a medical impairment, such as a heart attack and so on. |
| 84 Apparent Drug/Illegal Contraband Transport | Any accident that occurs during the apparent transport of illegal drugs, or other contraband (illegal aliens) regardless of the specific cause of the accident. |
| 85 No valid license | Any accident by an unlicensed pilot. A pilot whose license has only recently expired is not included in this category. |
| 86 Cause ambiguous | Any accident where the accident investigation was not able to determine the sequence of events in sufficient detail to determine the cause. |
| 87 Other jurisdiction | Any accident where the responsibility for the accident investigation lies with an authority outside of the NTSB or FAA and information has not been obtained from that jurisdiction. When sufficient information is available in the material from NTSB to determine a cause, that cause may be assigned. Otherwise, use this category. (This category includes when the investigation is conducted by the FBI because of criminal activity.) |

Terrorism/Conflict/Criminal Activity: 90-99

91 Hijacking

92 Bomb

93 Missile

94 Gunfire

95 Other Terrorism/Criminal use this category for accidents caused by unruly or illegal behavior by passengers.

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