Fatal and Serious Injury Accidents in Alaska

A Retrospective of the years 2004 through 2009 with Special Emphasis on Post Crash survival

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December, 2010

Executive Summary

A team was chartered by the Alaskan Region Flight Standards Division, in the late winter of 2009, to study the last six years of Fatal and Serious Injury (FSI) accidents in Alaska and make recommendations to reduce the number of FSI's. The study period chosen was Calendar Year 2004 through the end of Calendar Year 2009. During that period, there were 649 accidents, of which 97 were FSI accidents. The team's review determined that only 33 accidents, or 5 percent of the total accidents, were not survivable as equipped. Based on the autopsy results, 40 % of those deaths could have been prevented by enhanced aircraft crashworthiness. This equates to 45 peoples lives being saved, even without improvements in accident prevention.

The leading cause of FSI accidents was stall/spin with 29 accidents, followed by Controlled Flight into Terrain with 23 occurrences. Next was Visual Flight Rule (VFR) flight into Instrument Meteorological Conditions (IMC) with 19 FSI accidents. Many of the stall/spin accidents were the result of low level turning maneuvers, commonly referred to in Alaska as Moose Stalls. Eighteen of the FSI accidents involved an off-field takeoff or landing and 23 involved a willful violation of the regulations.

A major focus of this study was post-crash survival. The team studied all of the National Transportation Safety Board (NTSB) reports and available autopsy reports. The reports were evaluated by doctors at the Civil Aviation Medical Institute. Witnesses and Flight Standards Principal Investigators were interviewed. Accident histories were extensively discussed with the NTSB. After this review, the team investigated many post-crash intervention strategies to determine how many lives could have been saved with various strategies. The team selected seven of the most effective strategies to discuss in this report:

- 38 lives might have been saved through the installation of air bag seat belts
- 33 lives might have been saved through the use of helmets in tandem seat airplanes, such as Super Cubs
- 22 lives might have been saved with the use of shoulder harnesses, primarily in passenger seats
- 21 lives might have been saved through survival training
- 21 lives could have been saved through the proper use of personal floatation devices in float planes
- 18 lives could have been saved through the use of rescue air bottles to prevent drowning in float plane accidents
- 12 lives could have been saved if the airplane had been equipped with an effective emergency location device, such as a 406 MHz Emergency Locator Transmitter

(Lives saved may appear in multiple categories)

The team has developed 29 specific intervention recommendations that we feel are practical and cost effective. Because no new rulemaking activity is contemplated as a result of this study, outreach activities must be accelerated, targeting improved, and existing resources must be leveraged with industry groups, such as the members of the Alaska Aviation Industry Council, to reach the goal of improving aviation safety in Alaska.

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Definitions

Fatal Injury: Any injury that results in death within 30 days of the accident. Note: This is consistent with both the ICAO and the NTSB definition.

Serious Injury: An injury which is sustained by a person in an accident and which:

- Requires hospitalization for more than 48 hours, commencing within seven days from the date the injury was received; or
- Results in a fracture of any bone (except fractures of fingers, toes, or nose); or
- Involves lacerations which cause severe hemorrhage, nerve, muscle, or tendon damage; or
- Involves injury to any internal organ; or
- Involves second or third-degree burns, or any burns affecting more than five percent of the body surface; or
- Involves verified exposure to infectious substances or injurious radiation.

This definition is consistent with the ICAO definition. It is also consistent with the NTSB's definition except for the last bulleted item. (Not relevant in the study database)

Airbag Seat Belt - Airbag seat belts, also referred to as inflatable restraint systems, are inflatable cushions that are triggered by deceleration in an accident. They reduce the acceleration felt by the occupants in a crash; reduce flail injuries, as well as head and neck injuries. Automotive air bags are typically located in the vehicle's structure or steering column, whereas aviation air bags are typically mounted on the seat belts.

PFD – Personal Flotation Device refers to any device designed to keep a person afloat in the water, such as life preservers and life jackets. When used in seaplanes, they are typically inflated by a carbon dioxide cylinder triggered by the wearer.

HEEDS Bottle - Helicopter Emergency Egress Device (Rescue Air Bottle), refers to a compact lightweight breathing apparatus, which provides for underwater breathing to enable the user to exit an aircraft under water.

406 ELT - 406 MHz Emergency Location Transmitters (ELTs) work specifically with the Cospas-Sarsat System. These ELTs dramatically reduce the false alert impact on search and rescue (SAR) resources, have a higher accident survivability success rate, and decrease the time required to reach accident victims by an average of 6 hours

Spot Messenger - The SPOT Satellite GPS Messenger provides a satellite link through a commercial satellite provider. The signal for help routes to the GEOS Rescue Coordination Center. The system does not utilize the government Sarsat system.

Part 91 Commercial - 91C is Part 91 Commercial. These are flights that are undertaken principally for commercial reason under Part 91 rules. These include hunter guide operations, rental flights with an instructor, and support flights for wilderness lodges

Introduction: An Analysis of Fatal and Serious Injury Accidents in Alaska, 2004-2009

In 2009 the FAA directed that accident information across the country be expressed as a rate per 100,000 hours of flight. In Alaska, implementation of this metric across all aircraft accidents was considered to be misleading because of the large number of "fender-benders" that occur[1]. Therefore, to get a clearer picture of accidents that had a major effect on pilots and passengers, only accidents in which a Fatal or Serious Injury (FSI) had occurred were included in the accident rate. According to the National Transportation Safety Board (Part 830.2, Definitions), a serious injury is any injury that:

(1) Requires hospitalization for more than 48 hours, commencing within seven days from the date of the injury was received;
(2) Results in a fracture of any bone (except simple fractures of fingers, toes, or nose);
(3) Causes severe hemorrhage, nerve, muscle, or tendon damage;
(4) Involves any internal organ; or
(5) Involves second- or third-degree burns, or any burns affecting more than five percent of the body surface.

In December 2009, a team was formed with the intent of reviewing FSI accidents in GA aircraft in Alaska. The team's goal was to develop interventions and mitigation strategies to reduce the number of accidents or their severity. A total of 97 accidents were analyzed, covering all Alaska FSI accidents during the years 2004-2009. Both Part

135 and Part 91 accidents were included in the analysis. The Code of Federal Regulations, Title 14 (14CFR), Part 91, covers operating requirements for GA flights within the US. Part 135 of the code further covers operating requirements for commuter and on-demand operations and rules governing persons onboard such aircraft. The primary difference between Part 91 and Part 135 operations is Part 135 operations are for the purpose of conducting business with the public for compensation. Therefore, they have more stringent operational requirements than operations conducted under Part 91. However, there are a number of flights that are operated as a Part 91 operation but are conducted on behalf of a business, such as a wilderness lodge. In this dataset, these flights are classified as Part 91 commercial or 91c. The dataset included 55 Part 91 accidents, 18 Part 91c accidents, and 24 Part 135 accidents[1]. In addition, accidents were characterized by whether there was at least one fatality or not. Of the 97 accidents, 56 had at least one fatality, 41 had at least one serious injury (but no fatalities).

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[1] Some of the accidents included as Part 135 were actually Part 133 – Rotorcraft external-load operations, but were moved because the operation was similar in professionalism and requirements to Part 135.

Summary of the Accident Dataset

The accident database included all fatal and serious injury accidents that occurred in the State of Alaska from January 1 2004 through October 14, 2009. During the study, some of the accident investigations for accidents that occurred late in 2009 were completed, resulting in some changes in the conclusions as the study was being completed. During the study period, there were 97 accidents in Alaska. 113 people were killed and 75 people suffered serious injuries.

The leading cause of accidents was Stall Spin with 29 accidents followed by Continued VFR flight into IMC with 19 accidents.

Eighteen accidents involved an intentional off field takeoff or landing. **Figure 1** illustrates the distribution of FSI accidents by type of operation.

Figure 1.Types of Operations

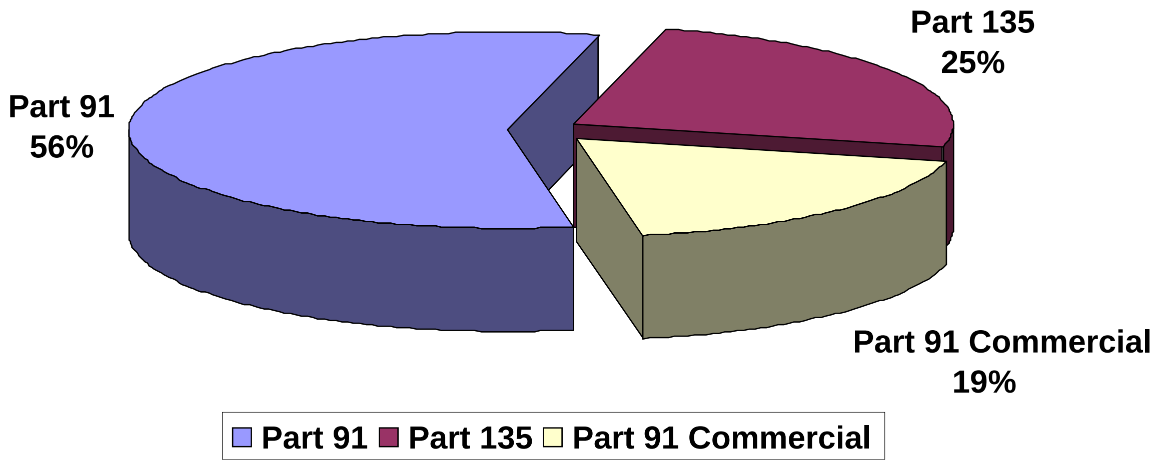
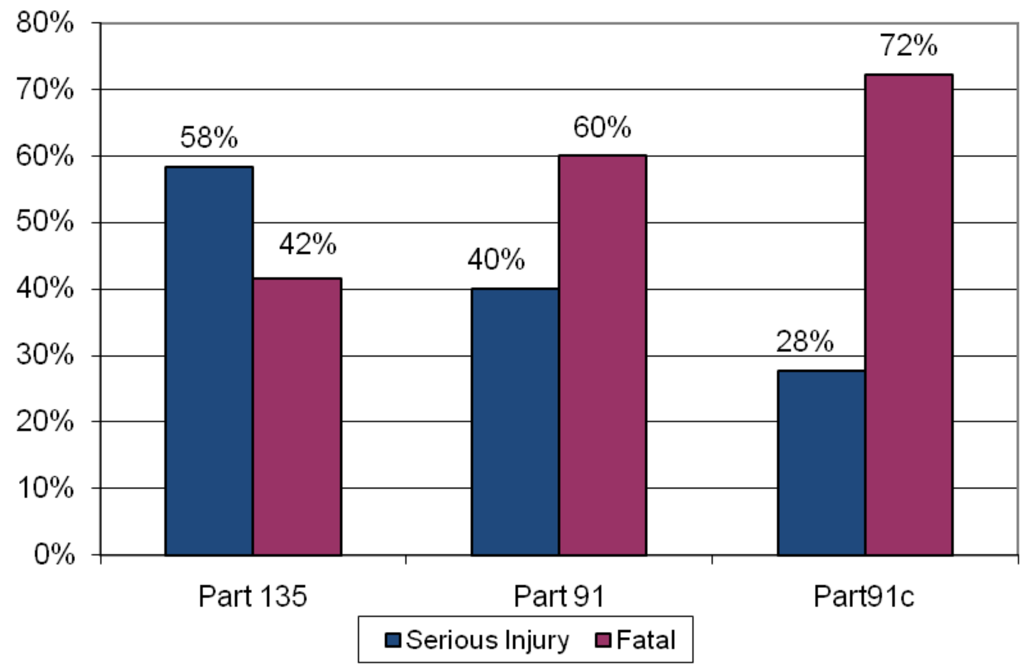


Table 1. FSI Accident Demographics

	Number of Accidents	Mean Pilot Total Experience in hours	Mean Pilot Experience Last 90 Days	Mean Pilot Age
Part 91	**55**	**4,168**	**52**	**53**
Part 91 (Commercial)	**18**	**6,396**	**126**	**52**
Part 135	**24**	**8,330**	**200**	**43**
Serious Injury Accidents	**41**	**5,964**	**125**	**50**
Fatal Accidents	**56**	**5,422**	**110**	**50**
All Accidents	**97**	**5,649**	**118**	**50**

Looking at **Table 1** we find that the average flight experience is fairly extensive, with a mean flight experience of over 5,600 hours across all of the accident pilots. When accidents are divided according to severity (serious injury and fatal) we do not see much difference between the groups in terms of experience or age. However, when divided by operation (Part 91, Part 91c, and Part 135), we see that Part 91c pilots have over 50% more flight hours than Part 91 pilots and Part 135 pilots have over twice the flight experience of Part 91 pilots. In addition, when looking at flight experience in the last 90 days before the accident, Part 91c pilots had more than twice as many hours as Part 91 pilots and Part 135 pilots had almost four times as many hours. An interesting finding from this table is the ten year lower average age of the Part 135 accident group from their Part 91 and 91C counterparts, even though the Part 135 group has a much larger average flight hour total. In addition to the difference in experience levels between Part 135, Part 91c, and Part 91 accident pilots, there is also a difference in accident severity. **Figure 2** (See page 12) shows the breakout of FSI accidents by Part categories.

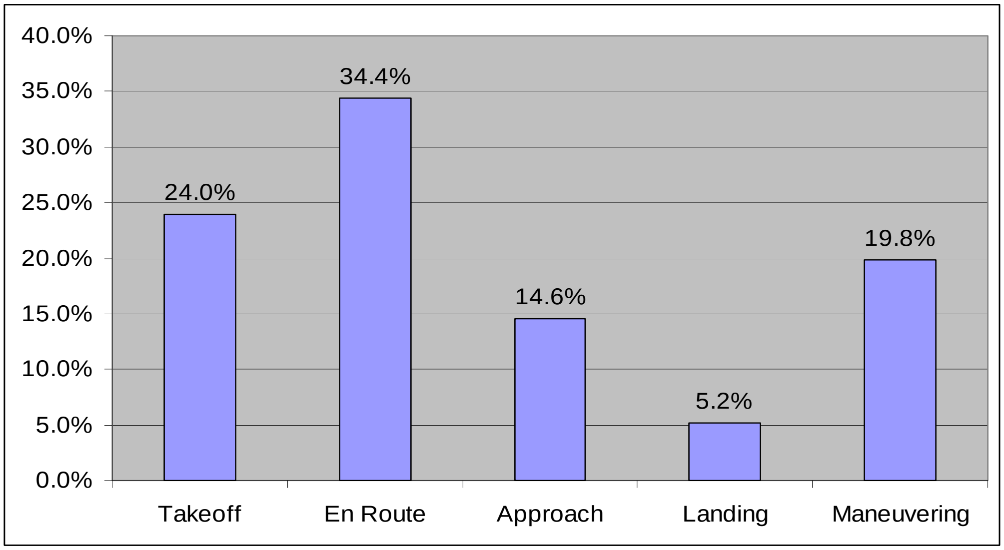
Figure 2. Accident severities by type of operation comparison (Part 135 vs. 91 vs. 91c).



As **Figure 2** shows, the majority of Part 135 accidents in the dataset were serious injury accidents. On the other hand, Part 91 accidents had a majority of fatal accidents. In addition, Part 91c accidents had an even larger percentage of fatal accidents, with over 72% of the accidents including at least one fatality. Differences in the ratios of fatal and serious injury accidents across Parts are likely attributable to differences in the types of operations, experience levels, and professionalism of the pilots. Another way to look at the dataset is by phase of flight in which the accident occurred.

Figure 3 shows a breakout of the percentage of accidents that occurred during a specific phase of flight.

Figure 3. Accident Percentages by Phase of Flight

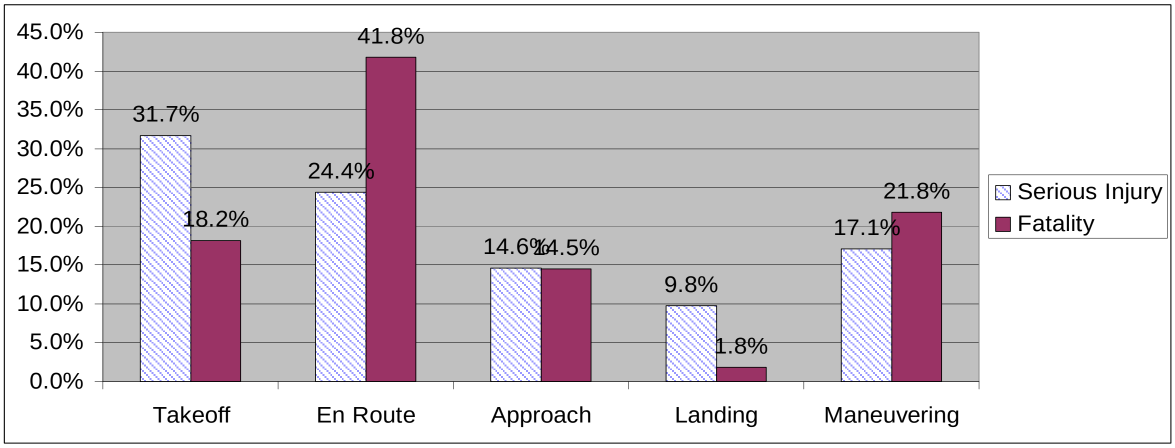


The phase listed on the right side of **Figure 3** “Maneuvering”, refers to a flight that was not traveling from point A to point B, as would occur during the en route phase of flight, but was engaged in some other activity such as looking at a particular point of interest (e.g., animals, camp site, etc.) or perhaps simply flying around for fun. Also included in the maneuvering phase for this analysis were helicopters hovering over a location.

Figure 4 (See page 14) shows that the takeoff and en route phases account for the most accidents. The maneuvering phase is third, followed by approach and then landing. It is interesting to note that the landing phase accounts for only 5.2% of the accidents in the dataset. Other reviews of accidents have shown a much higher percentage of landing accidents. For example, in 2006 Detwiler et al.[2], a published report from the FAA Civil Aero Medical Institute, found almost 40% of the accidents occurred during landing. The Detwiler dataset did not have the FSI only focused data approach, but was a review of all accident severity levels. Part 135 operations were not included in the Detwiler report analysis either, only part 91 operations.

We can also look at the percentage of accidents across phases of flight as they relate to accident severity (serious injury vs. fatality). **Figure 4** (See page 14) shows these results.

Figure 4. Percent of Accidents across Phase of Flight by Accident Severity



If the accident occurred during takeoff or landing it was much more likely to involve only a serious injury. However, if the accident occurred during the en route phase, it was more likely to involve a fatality. Approach phase accidents were divided equally, while maneuvering accidents slightly favored fatalities.

Pilot/Operational Demographics

Pilot Age

The average pilot age in the study group was 55 years old with 5,649 hours total flight time. (See **Table 1** page 11 for a distribution of these statistics). The average pilot age for Visual Flight Rules (VFR) into Instrument Meteorological Conditions (IMC) accidents was 51 years old. This compares with the statistics in the study of VFR into IMC accidents of 38 from the study done by George Kobelnyk[3] that covered the time period 1983 to 2000. **Figure 5** (See page 15) compares the distribution found in the Kobelnyk study with that from the present study. One possible conclusion is that the accident pilot population is aging at a substantial rate; however the Kobelnyk study looked at all accidents, not just FSI accidents so a data bias is quite likely.

Figure 6 (See page 15) examines the effect of pilot age with flight hours. This data set indicates that as pilots in the study group age they acquire an average of 120 hours per year based on a linear least squares curve fit. As is evident in **Figure 5** (See page 15) there is a great deal of variability in the data, especially in younger pilots.

The rate of pilot aging found in the analysis calls for future scrutiny of pilot medical issues, which were a causal factor in four accidents. The average pilot age was 66 years in this sub group, including two pilots with unreported diabetes, one pilot that had failed his medical due to multiple strokes, and one that had failed his medical due to a heart condition. Both diabetic pilots had a current medical certificate, but the other two did not.

Figure 5. Distributions of Pilot Ages Involved in Accidents in Alaska

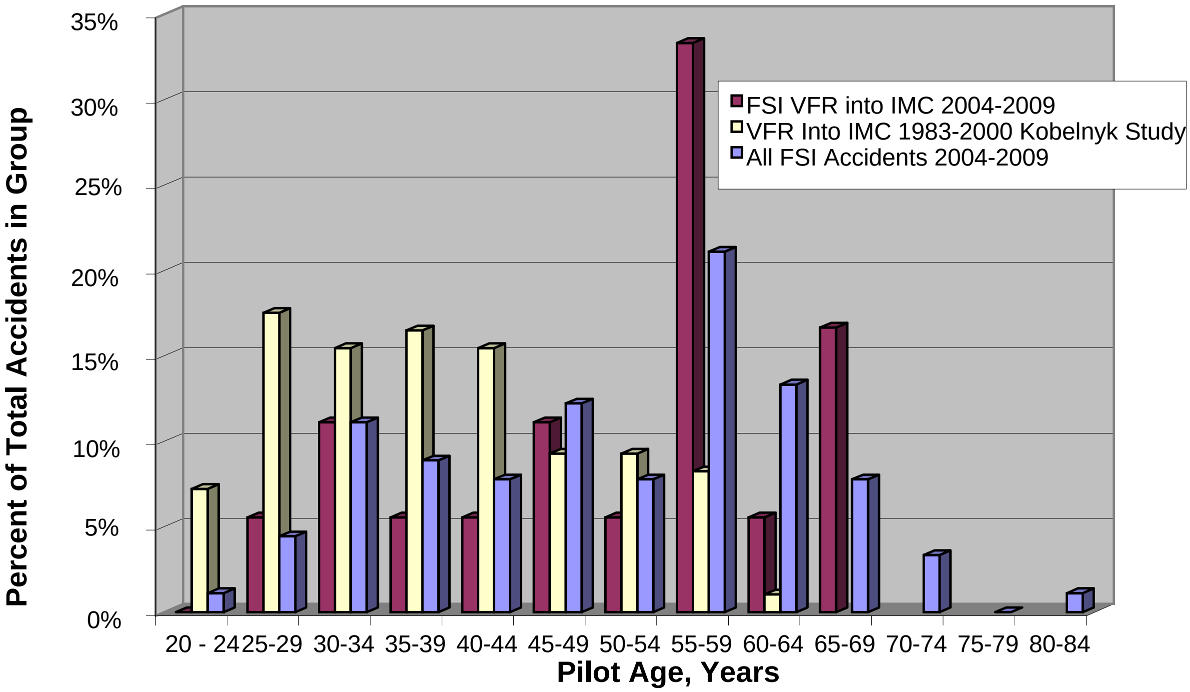
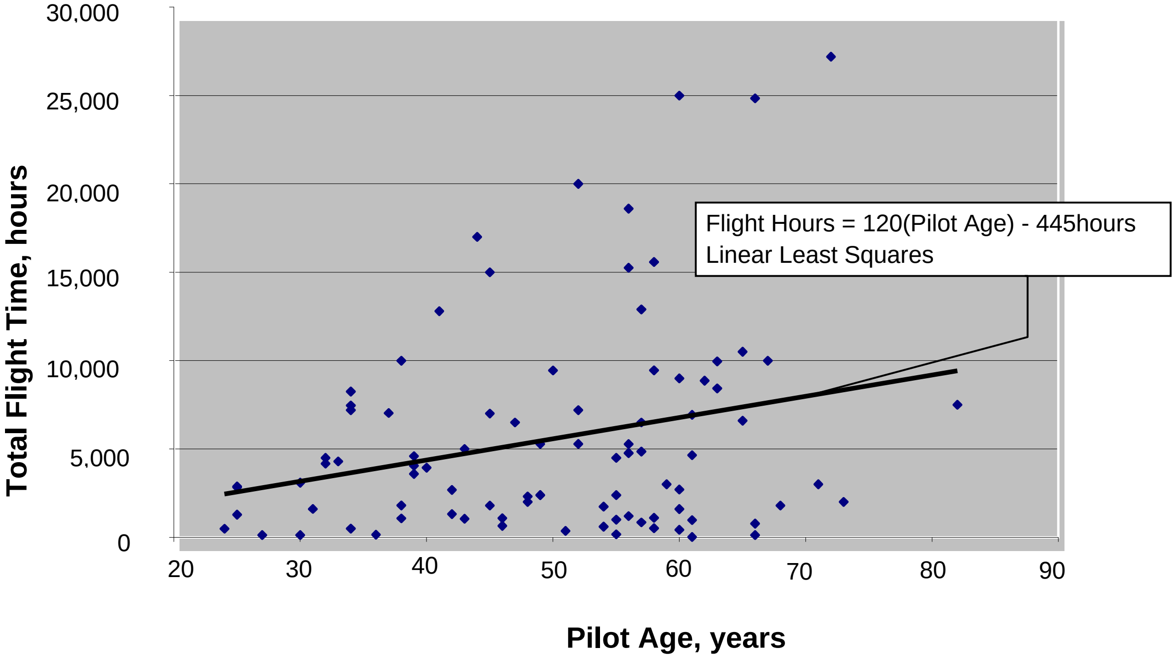


Figure 6. Pilot Age with Total Flight Hours, all FSI Accidents



Accident Causes

Analysis Discussion

The team reviewed the accident causes and interviewed several of the FAA Flight Standards inspectors. The NTSB report of probable cause was the starting point, and in other cases additional information was brought to bear in the team's activities. The team's categorization allows for the existence of multiple causes for accidents. For this reason, one accident may be listed in multiple categories. Several of the leading categories should be viewed as factors in the accident instead of causes. As an example, the team used the term "Willful Violation" and "Rogue Pilot" to describe pilot actions that were significantly outside of the regulations. These terms do not appear in the NTSB categorization of accident causes.

Figure 7 (See page 17) describes the initial breakdown of accident causes/factors. This depicts all the causes that were identified. Because some causes were only present in a single accident, they don't warrant an entire category. For this reason the team consolidated the less common accidents into the "Other" category. That data is presented in **Figure 8** (See page 18) this addresses the most common causes. The next sections will go through the various causes/factors and discuss the team's observations regarding each pie slice, starting with "Pilot Medical Issues." In addition, **Figure 8b** (See page 20) breaks out the causal factors according to the type of operation (Part 91, 91c and 135).

Figure 7. Accidents by Cause/Factors

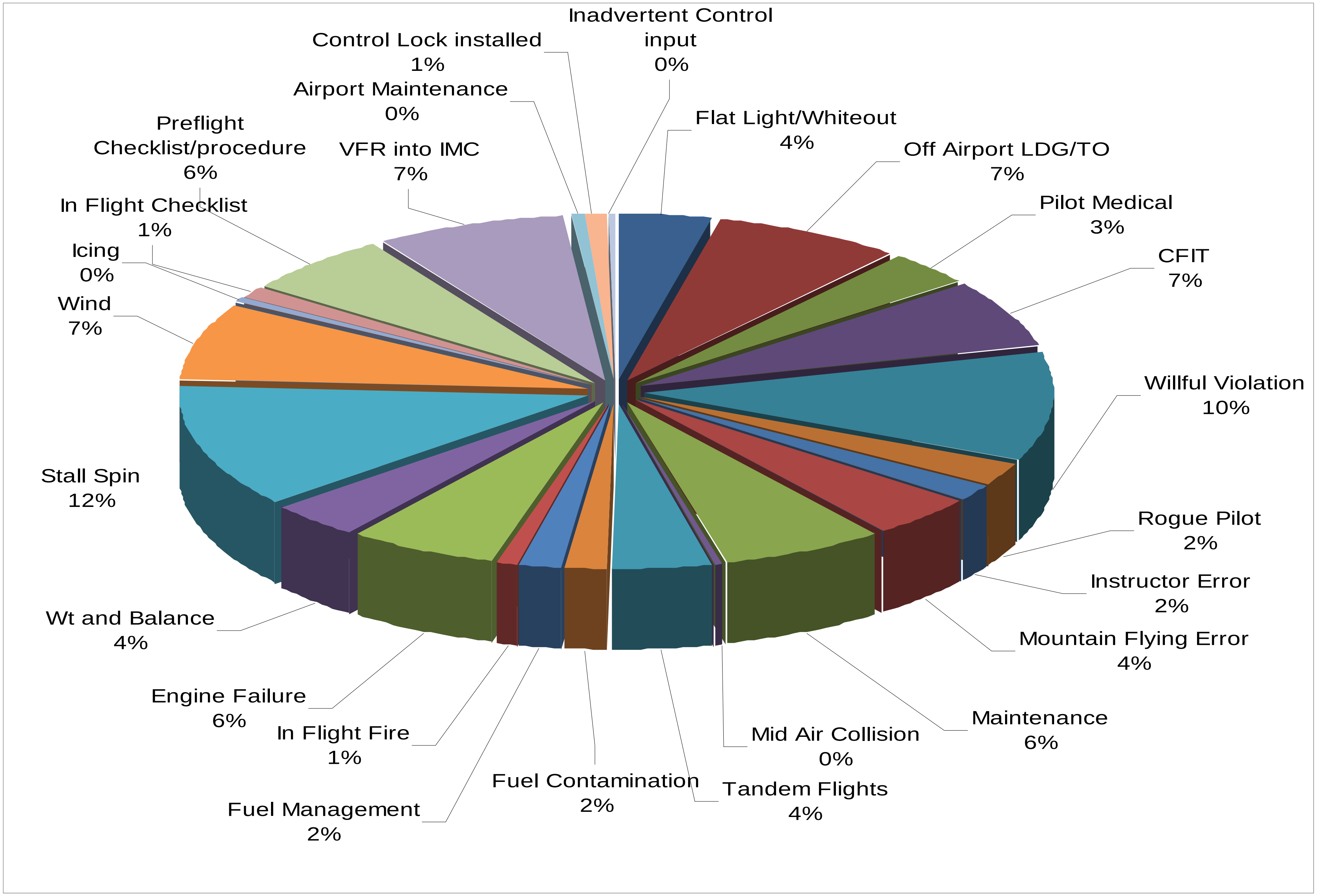


Figure 8. Leading Causes of Fatal and Serious Injury Accidents in Alaska from 2004-2009. Note: Accidents frequently have multiple causes. Therefore, the total in the chart reflects the % of causes, not accidents.

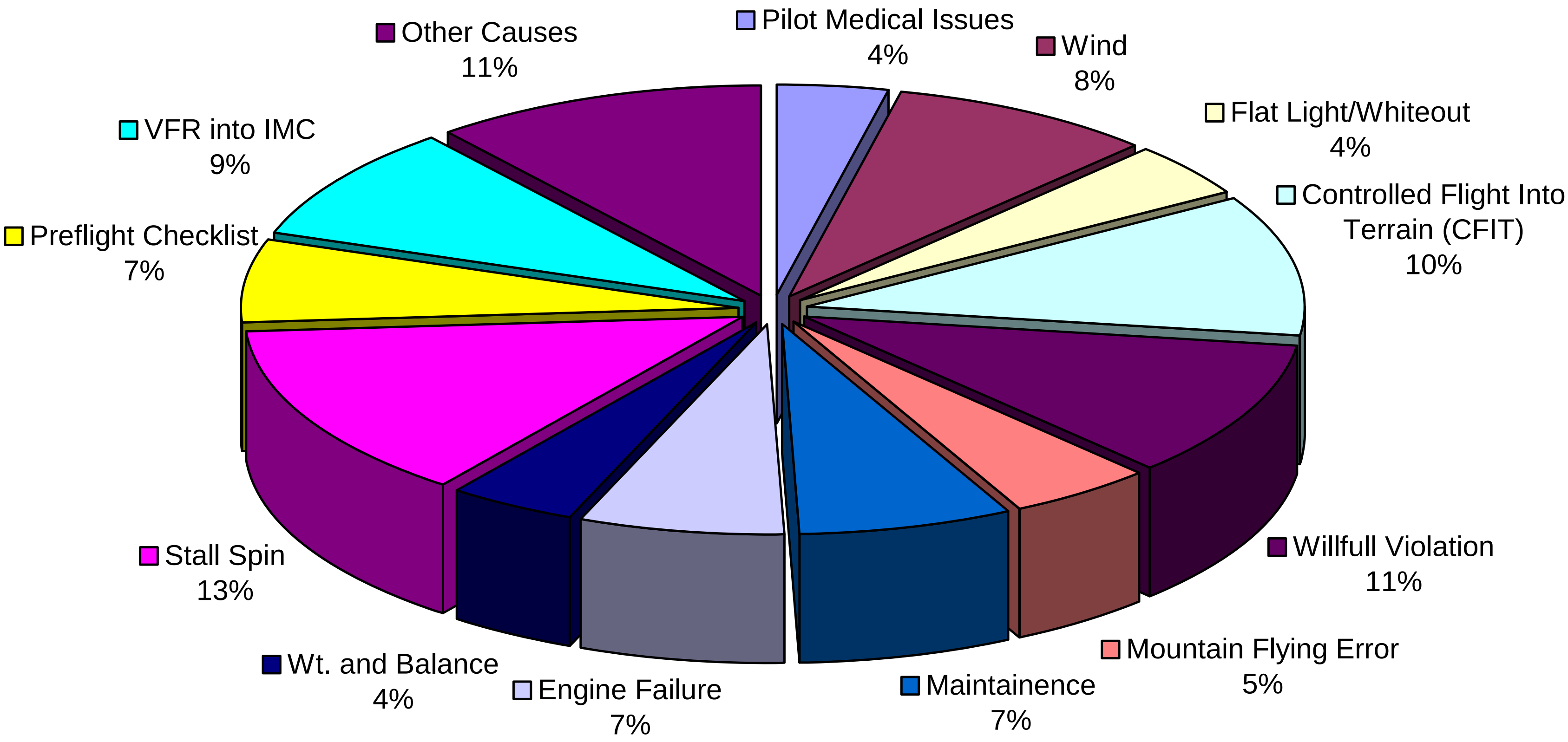
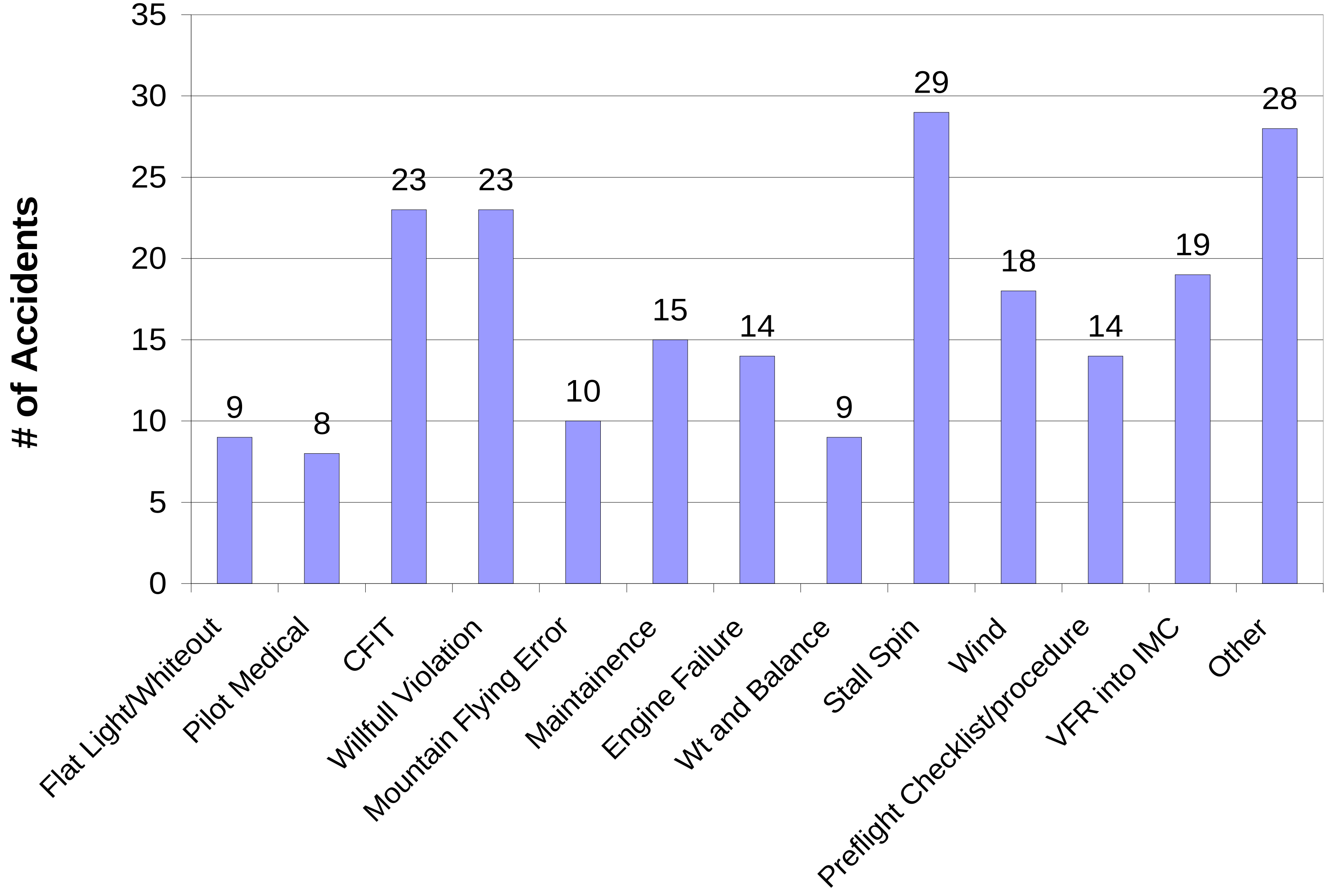


Figure 8a. Accident Causes for FSI accidents in Alaska from 2004-2009



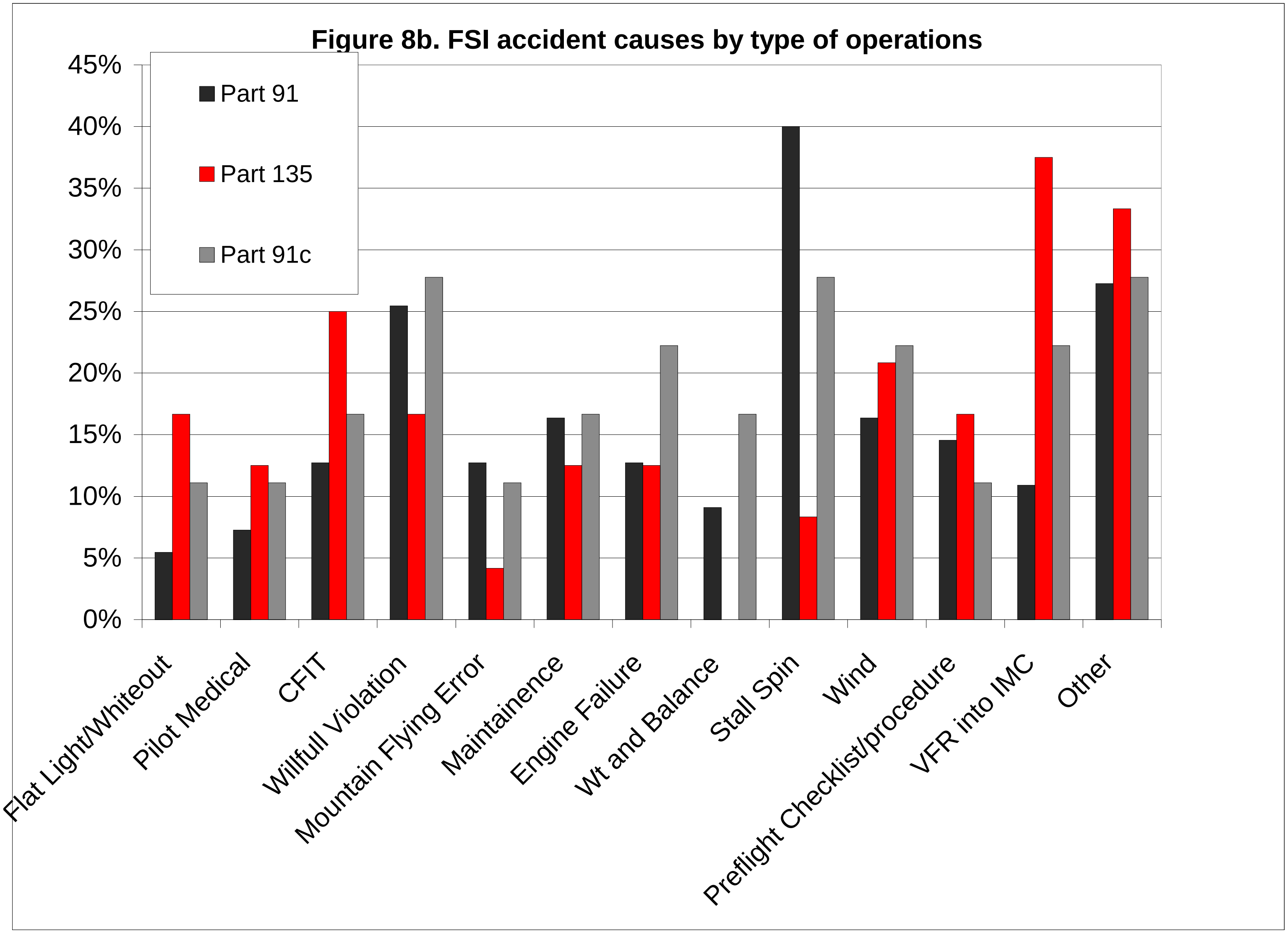


Figure 8b. FSI accident causes by type of operations
45%
40%
35%
30%
25%
20%
15%
10%
5%
0%
Part 91
Part 135
Part 91c
Flat Light/Whiteout
Pilot Medical
CFIT
Willfull Violation
Mountain Flying Error
Maintainence
Engine Failure
Wt and Balance
Stall Spin
Wind
Preflight Checklist/procedure
VFR into IMC
Other

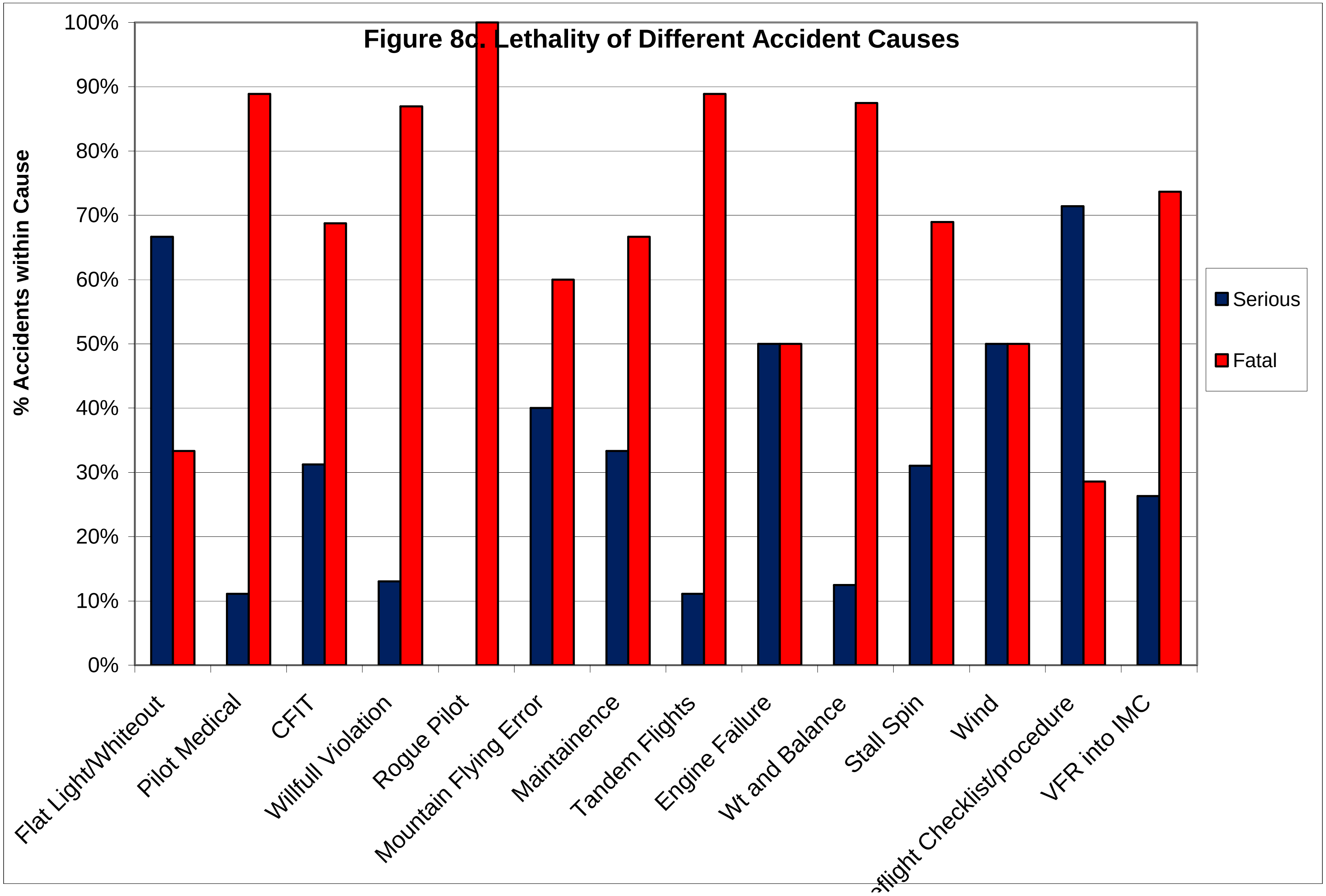


Figure 8c. Lethality of Different Accident Causes

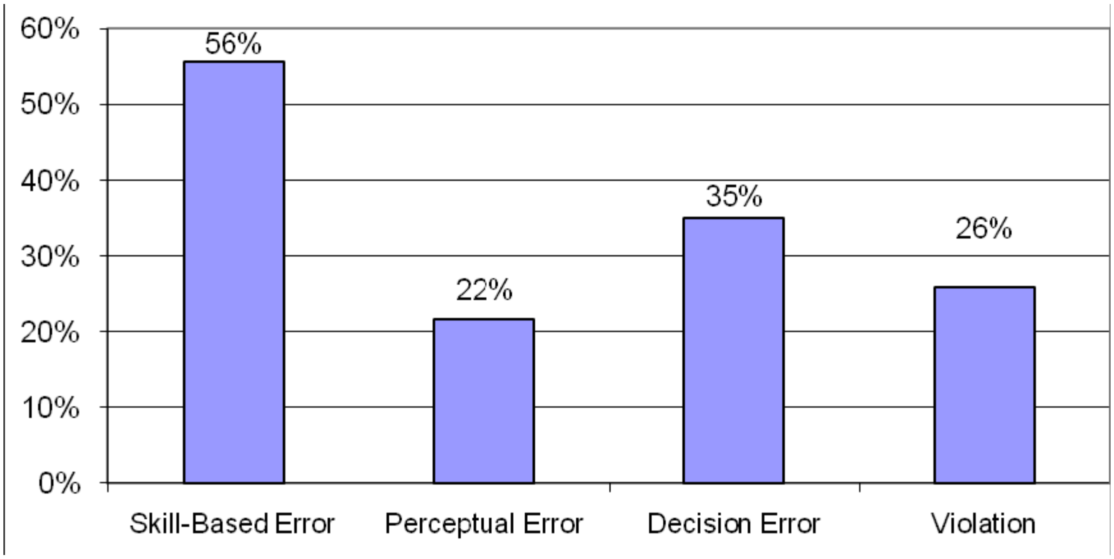
Human Factors Causal Analysis

Only ten of the 97 accidents, or approximately 10%, were not associated with human factors errors. In fact, several of those had errors associated with the maintenance or inspection of the aircraft, but these errors were not examined for this analysis. To better understand the root human factors causes of these accidents, the team reviewed each accident and assigned one or more causal factors, based on the Human Factors Analysis and Classification System (HFACS) taxonomy.[4] The full HFACS taxonomy uses four levels of causal categories. The highest levels are “Organizational Influences” and “Unsafe Supervision.” Because the accidents included Part 91 operations, these levels were of little use in the analysis and were not included. The third level of categories is “Preconditions for Unsafe Acts.” While potentially useful, the limited time frame for conducting the analysis led to the elimination of this level from the analysis as well. Only the lowest level of categorization, “Unsafe Acts,” was used. “Unsafe Acts” are divided into five factors: 1) skill-based error; 2) perceptual error; 3) decision error; 4) routine violation; and 5) exceptional violation. A brief description of each of these factors follows:

- **Skill-based error** - occurs with little or no conscious thought, and is particularly susceptible to attention and/or memory failures. Examples include breakdown in visual scan patterns, inadvertent activation/deactivation of switches, forgotten intentions, and omitted items in checklists. Even the manner (or skill) in which one flies an aircraft (aggressive, tentative, or controlled) can affect safety.
- **Perceptual error** - occurs when sensory input is degraded or “unusual,” often the case when flying at night, in weather, or in other visually impoverished environments, causing misjudgment of distances, altitude, and descent rates, as well as incorrect responses to a variety of visual/vestibular illusions.
- **Decision error** - represents conscious, goal-intended behavior that proceeds as designed, yet the plan proves inadequate or inappropriate for the situation. They manifest as poorly executed procedures, improper choices, or simply the misinterpretation or misuse of relevant information.
- **Routine violation** - tends to be habitual by nature, and is often enabled by a system of supervision and management that tolerates such departures from the rules. Often referred to as “bending the rules,” the classic example is the individual who drives his/her automobile consistently 5-10 mph faster than allowed by law.
- **Exceptional violation** – is an isolated departure from authority, neither typical of the individual nor condoned by management. For example, driving 105 mph in a 55 mph zone would not be typical of drivers in general, and would not be condoned by authorities.

Figure 9 shows the percentage of accidents that have a particular causal factor. Keep in mind that each accident could have more than one causal factor associated with it, so the percentages will not add up to 100% across all causal factors.

Figure 9. Percentage of accidents across causal factors



As stated in the Detwiler,[2] study skill-based errors were the most prevalent accidents, followed by decision error accidents. In the Detwiler study, both routine and exceptional violations were grouped together. Doing so for this data, would rank it third, as was found in Detwiler, making perceptual errors the least prevalent category.

Skill-Based Error Accidents

There were 54 accidents in which a skill-based error by the pilot occurred. When we take a closer look at the accidents involving skill-based errors, we find three general types: 1) critical error accidents; 2) beyond ability accidents; and 3) distraction accidents. We will look at each of these types below.

Critical Error Accidents

The first type is an accident in which a single critical error led to the failure of the flight. There were 11 critical error accidents, accounting for approximately 21% of the total skill-based accidents. The nature of these accidents varied; however, most of them included the improper performance of a flight, or preflight, procedure. One accident occurred when the pilot failed to switch fuel tanks, leading to fuel starvation. Seven of the accidents were related to an improper preflight procedure:

Table 2. Improper pre-flight procedures

Number of Accidents	Pre-Flight Error
1	Not removing the gust locks
2	Not checking the fuel correctly
1	Not deicing the aircraft sufficiently
2	Not verifying correct control surface movement
1	Incorrect hand-propping of the aircraft Which resulted in the propeller striking the pilot on the leg

Finally, three critical error accidents occurred when the pilot failed to maintain proper situation awareness. One of these was a helicopter flight in which the pilot did not remember that he was hovering underneath a power line. A second pilot failed to continue monitoring the position of a truck crossing the end of the runway. The last pilot failed to monitor aircraft altitude during landing and misperceived the distance to the surface of the water.

Beyond Ability Accidents

The second type of skill-based error can be characterized as a flight situation that is beyond the ability of the pilot. Thirty-one accidents, or approximately 57% of those involving a skill-based error, were classified as a “beyond ability” accident. The reason that a particular flight situation was beyond the flight ability of the pilot varied from accident to accident. However, there were five factors in particular that were identified as contributory. These five factors were:

Table 3. Beyond Ability Accidents

Five Skill Based Errors	Number of Accidents
Overloading the aircraft	3
Encountering unexpected wind conditions	12
Mechanical Malfunction with the aircraft	5
Training flight task that proved to be beyond the ability of the student pilot and the beyond the ability of the instructor pilot to monitor or correct	5
Adverse medical condition for the pilot	4

For a few of these accidents, more than one adverse condition was present. For several other “beyond ability” accidents, no adverse condition could be identified for certain, but the outcome of the accident suggested that the pilot’s flying ability was exceeded. One pilot was attempting to perform an acrobatic maneuver and stalled the aircraft. One accident was a mid-air impact. This accident was classified as “beyond ability” in the sense that the pilots were unable to see each other and/or unable to maneuver the aircraft in such a way as to avoid impact. Two accidents occurred during approach to a difficult landing area. Both of these ended with the aircraft stalling at too high an altitude above the ground. The final two “beyond ability” accidents involved a pilot that was unable to complete an instrument approach procedure. In the entire dataset, there were four accidents involving a failed instrument approach. However, it was unclear for two of them whether they involved a lack of skill or simply poor decision-making. One of these may have involved cognitive impairment due to medical issues.

One suggestion for preventing pilots from flying beyond their ability would be to improve training. However, the problem for improving training is how to train for extreme conditions that are rarely encountered during actual flight. Simulator training might be of some use, but there is a question about the realism of simulator training for extreme conditions, especially simulations of smaller GA aircraft. The Medallion foundation has had success in this area in the past, particularly with the part 135 operators.

Airline pilots receive almost no hands-on training in how to recover from aerodynamic stalls and other extreme scenarios, according to the NTSB [8]. The reason is that current flight simulators cannot accurately reproduce such conditions. A USA TODAY review of NTSB accident reports over the past decade found that 317 of the 433 airline fatalities on U.S. carriers since 2000 - or 73% - could have been prevented with better simulator training. [5]

Distraction Accidents

The third type of skill-based error occurred when a distraction, either inside or outside the aircraft, led to the pilot failing to “fly the aircraft.” Twelve of the 53 skill-based error accidents (22%) involved the pilot not flying the aircraft first. During the analysis, these were sometimes referred to as “moose stalls.” All but one of these accidents ended when the aircraft stalled and struck the ground. Most of them occurred as the pilot was distracted from flying because of something happening outside of the aircraft; although, to be fair, moose-watching was not the only distraction. Several of these accidents did involve looking at wildlife (sheep, wolves, a whale bone, as well as moose). For some of the accidents, pilots were looking at a campsite, or investigating a potential landing area. As with the “beyond ability” accidents, some of them involved exacerbating factors such as being over gross weight (3 accidents), mechanical problem (1 accident), or medical problem (1 accident), however, the primary cause was the failure of the pilot to first fly the aircraft.

The one accident that was not a stall accident involved a pilot with an unreported case of diabetes. The pilot, while flying on a perfectly clear day, impacted a hill along the route of flight. Toxicological analysis did not find evidence that the diabetes was a contributing factor, but it is impossible to say whether it was or was not. The NTSB investigation concluded that the plane was likely being flown on autopilot at the time of the accident, leading to the speculation that the pilot was simply not monitoring where the aircraft was flying. Whether the pilot was sightseeing, sleeping, or engaged in some other activity is unknown and unknowable because the lone pilot was killed in the accident.

Decision Error Accidents

Thirty-two accidents, approximately 33% of the dataset, involved a decision error on the part of the pilot. Twenty-four of these decision errors were faulty judgments regarding the weather.

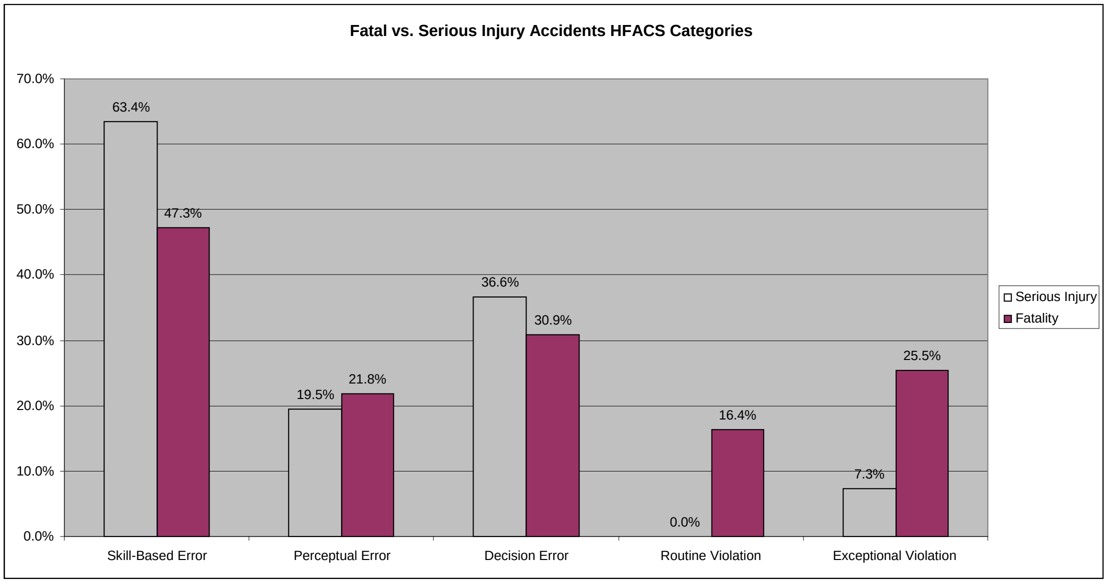
Violation Accidents

Twenty-three accidents, approximately 24% of the dataset, involved the pilot committing either a routine or exceptional violation of FAA regulations. These violations are discussed later in the section of willful violations.

Perceptual Error Accidents

Perceptual error accidents are discussed in a later section entitled, Flat Light/Whiteout.

Figure 10. Fatal vs. Serious Injury Accidents HFACS Categories



Pilot Medical Issues

Pilot medical issues account for 4% of the accident causes. These are broken down further into three areas: diabetes, the use of illegal drugs, and cardiovascular disease. This is an area where the medical evidence and the connection between the medical condition and the cause of the accident may be suspect.

Diabetes

Pilot incapacitation due to the pilot entering a diabetic coma is suspected as being a cause in two accidents. In one, the pilot was flying from Kenai to Fairbanks in an airplane that was equipped with autopilot on a day with unlimited ceiling and visibility, and impacted the highest terrain up to that point in the flight. The point of impact was on the flight path and should have been clearly visible for at least 20 miles. The pilot was an insulin dependent diabetic and had not reported it when renewing his medical certification.

The risk of pilot incapacitation due to the pilot entering a diabetic coma is increasing for two reasons. First, the rate of diabetes in the population is increasing in the nation as a whole. In a comparison of two similar studies, one from the time period 1994 to 1998 and the other from 1999 to 2000, the prevalence of diabetes in the United States went from 8.2% to 8.6%.[6]

The more statistically significant increased risk factor for aviation is the increasing age of the pilot population. In addition, the same Center for Disease Control (CDC) article estimates the population with undiagnosed diabetes in the age group 40-50 at 3.3%, and over 60 at 4.2% [6], a 33% increase.

Table 4. Prevalence of Diabetes and Impaired Fasting Glucose in the US population (Data from reference 6)

Age & Gender Groups	% of US Population with Diabetes and Impaired Fasting Glucose
Age Group 20 to 39	4%
Age Group 40 to 59	15%
Age Group Over 60	34%
All Age Groups	14%
All Males	18%
All Females	13%

Use of Illegal Drugs

Evidence of illegal drug use was found in blood or urine samples taken post-accident from the pilots of four accidents. Of these pilots, one was privately operated under Part 91, and the other three were being operated commercially.

The privately operated airplane was a Cessna 170 where the metabolites of both marijuana and hydrocodone were found in the pilot's blood and urine. In this case, the pilot did not conduct an adequate preflight, and fuel contamination caused the engine to quit on takeoff, according to the NTSB report.

Of the three airplanes that were operated for commercial purposes, one serviced a lodge operation, operating under Part 91, and two were operated under Part 135. Of the Part 135 airplanes, one was an air tour operator and the other was flying cargo.

The cargo flight pilot, operating a Beech C-45H under Part 135, had an extensive past history of drug and alcohol abuse. This included fraud and FAA enforcement action. Metabolites of cocaine, alcohol, and an antihistamine known to impair cognitive functions were found in the pilot's system, according to the NTSB report. In this case, various representatives of different law enforcement bodies and the FAA had information that could have led to preventing the pilot from flying, but no agency had all the information.

The use of Illegal drugs was mentioned in the NTSB reports in the cases cited above because either the active ingredient in the drug or its metabolites was found in samples that were taken post-accident. Determining if the presence of illegal drugs was a cause of the accident by altering the pilot's cognitive abilities was not addressed in any of the reports where drugs were found. Our team discussed this issue with CAMI Doctors and several issues were uncovered:

1. Frequently, the samples are taken in such a way that obtaining quantitative concentrations in the blood or urine is not possible. In the case of marijuana, this relates to where a blood sample is taken from. In the case of other substances, the psychoactive compound is difficult to detect or has a very short half-life in the blood, so a metabolite is tested for instead.
2. The other significant issue is whether or not concentration of either the primary psychoactive compound or its metabolite is indicative of impaired judgment or cognitive ability. (i.e. did the drug cause the accident) Many studies are available to determine this concentration for blood alcohol levels that are both scientifically and legally defensible. This established criterion does not apparently exist for illegal drugs so it is difficult to establish a causal link in most cases.

Cardiovascular Disease

Cardiovascular disease was not a cause of any accidents in the study group but was suspected in one case. In this case the pilot elected not to renew his medical certification after cardiac surgery but continued flying. The aircraft was found to have impacted terrain for no known reason, but the post crash fire destroyed much of the medical evidence. The autopsy report did indicate between 50% and 90% blockage of the coronary arteries.

Moderate or severe atherosclerosis or other pre-impact cardiovascular disease was noted in five of the 27 (18%) autopsy reports that were received for review from CAMI. Discussion of these autopsy reports occurs in a later section.

Continued VFR into IMC

In the Study Group, 20 out of 97 accidents involved continued visual flight rules (VFR) flight into instrument meteorological conditions (IMC). In these accidents, there were 29 fatalities, seven serious injuries, and 15 minor injuries. Accidents involving VFR flights into IMC (VFR into IMC) have been of major interest to aircraft accident investigators and researchers for a number of years. One reason is that, while such accidents account for a small number of the total accident count, a large percentage of VFR into IMC accidents usually prove fatal to the aircraft occupants. Statistics over the last 30 years have placed the percentage of VFR into IMC accidents that resulted in a fatality between 70% and 80%.[7] [8] [9] In the current accident database, the number of fatal and serious injury accidents attributed to VFR into IMC was 19, or approximately 20% of the total. Of those 19 accidents, 15 (79%) involved at least one fatality. While it is critical to focus on preventing VFR into IMC accidents, it is important to note from a post crash survivability standpoint, these accidents are frequently survivable. The study database shows that 27 people lost their lives, nine survived with serious injuries, and 20 suffered only minor injuries. ***Therefore; the majority of the people involved in VFR into IMC accidents within the current accident database survived.***

Previous analyses of VFR into IMC accidents have focused on faulty pilot decision making as a major contributor to the accident. [9] The current dataset supports this notion, with all of the accidents involving either poor decision making or a willful violation (which is a special type of poor decision making), or both. In only a single accident from the database was it likely that the pilot was totally unaware of the presence of dangerous weather conditions along the route of flight.

Weigmann and Goh list four factors associated with poor pilot decision making in VFR into IMC accidents. [9] The first factor is poor situation assessment, either because the pilot lacks experience interpreting changing weather conditions, due to the difficulty in discriminating slowly changing weather, or because tiredness, fatigue, and increased workload can increase the likelihood of an inaccurate assessment of the weather, or some combination of all of these.

The second factor associated with poor pilot decision making is faulty risk perception of the dangers involved in flying in marginal weather conditions. Contributing to this perception is the fact that many pilots might have successfully navigated during marginal conditions in the past, and so, have gained confidence in their ability to succeed again in similar circumstances. While we have accident statistics regarding unsuccessful flights in marginal conditions, we do not have statistics on the success rate of flights in these types of conditions. Even if these pilots have no experience in marginal weather conditions, it is likely that their risk perception is faulty. Previous research has demonstrated that pilots tend to exhibit low levels of risk awareness and a high perception of their skill and judgment in flying.[10]

The third factor associated with poor pilot decision making is inappropriate motivations that bias the decision making process. The term “get-home-itis” refers to the motivation of the pilot to complete the journey. In addition, pilots that fly for companies have financial and professional pressures that motivate their decisions[11;12] such motivations can sometimes outweigh weather considerations when deciding when and where to fly.

The fourth factor associated with poor pilot decision making is called “decision framing.” Decision framing refers to the idea that a person’s choice between a risky or safe course of action depends on whether the choice is framed in terms of a gain or a loss. When the safer course of action is framed in terms of a loss, the decision tends to be risk-seeking. When framed in terms of a gain, the decision tends to be risk-averse. In the case of VFR flight into IMC, research has shown that framing the decision to not fly into marginal weather conditions as a loss (i.e., wasted time, money, and effort) leads to a greater likelihood of continuing the flight, but framing the decision to not fly as a gain (i.e., it is safer) leads to a greater likelihood of diverting the flight.[13]

A fifth factor, one that is not discussed by Weigmann and Goh,[9] is what is referred to as problem-solving set.[14] Problem-solving set refers to the tendency to repeat a solution process that has been previously successful. In addition to altering one’s perception of risk, successfully conducting a flight in marginal conditions by using a specific strategy (e.g., following a river while flying underneath the clouds) will increase the likelihood that the strategy will be used again under similar circumstances. Memory plays a crucial role in problem-solving, and repetition plays a crucial role in memory. So when faced with a problem (how do I make it through this weather?), humans tend to adopt a strategy that has been used successfully in the past, even if the current situation does not quite match previous events.

While it is not known whether these pilots had previously flown in similarly marginal weather conditions, it does seem likely, given the fact that the average flight hours for these pilots was 7,604, and the average flight hours in the 90 days before the accident was 137. In addition, eight of the flights (42%) were Part 135 operations, which tend to fly more regularly than Part 91 flights.

One question that can be asked in regard to these accidents is whether the pilots actually intended to fly into IMC, or were hoping to fly under (scud run) or around the clouds while maintaining a visual reference to the ground. While we cannot know for sure, the analysis of the accident reports and other available information suggests that in only one of the 19 accidents did the pilot fully intend to fly into IMC. In that accident, the pilot was apparently using a handheld GPS (Garmin 295) to fly through the IMC. Unfortunately, there was an island that did not appear in the Garmin database. The aircraft collided with the island, killing all of the aircraft occupants. For the other 18 accidents, it is believed that the pilots thought they could avoid flying into IMC but were unsuccessful.

It might easily be concluded that pilots under these circumstances try to avoid flying into IMC as long as possible because they lack the skills to fly in instrument conditions. This may be true for some of the pilots; however, 12 (63%) of the pilots in the dataset were instrument rated, which means that, at some point in the past, they could competently fly in IMC.

Another question that must be asked is why some of these pilots did not simply transition to instrument flight rules (IFR) flight when it seemed obvious that they would no longer be able to avoid IMC. Reasons probably vary; some possibilities include the potential that those that were not instrument rated felt they might get into trouble with the FAA, or the time between losing ground reference and actual impact was too short to make a decision, or they lacked the skills to fly in IMC, or they never thought about doing so. This last possibility is a reference to problem-solving set discussed above.

Given these possibilities, there are several potential ways to reduce the number of VFR into IMC accidents. They all involve getting the pilot to make better decisions regarding the flight, both before and during the flight. Improving pilot awareness of changing weather conditions would allow better go/no-go decisions before the flight. Preflight planning by the pilot could include specific locations along the flight route to assess weather conditions. These locations should also be accompanied by specific plans for diverting. For example, if the pilot chooses to turn around and come back at a specific point, the pilot needs to be aware of all potential obstructions to be avoided during the turn. Training programs such as the Medallion Foundation Cue-Based Weather Training program would be useful for selecting locations and planning divert procedures.

Another approach is to seek ways to allow a non-punitive entry into IFR under certain circumstances. The lack of ability for flying in IMC could be addressed with training. The training would need to include transitioning from VFR into IMC during the flight. This training would help to overcome problem-solving set by providing the pilot an alternative solution to complete the flight safely. Such a transition could be assisted through the use of a terrain display similar to those used in the Capstone program.

A significant amount of discussion has surrounded the issue of getting better weather information into the cockpit in Alaska. In the contiguous US, XM Satellite weather is available on many handheld GPS units now. Due to the orbits of the satellites providing that information, and the limited availability of ground based weather radars, that data is not available in most of Alaska. Alaska does have the highly successful weather camera program and if a technological solution could be developed to improve accessibility of that data in the cockpit that might enhance pilot decision-making. Currently, Flight Service does provide information to pilots through the Remote Communication Outlets (RCO) that allows pilots to ask the fight service briefer for information, but no graphical product. One easy enhancement might be to add a symbol on sectional charts to indicate the location of the weather cameras so that pilots would at least know when to ask for weather.

Reducing VFR into IMC accidents requires that pilots make better decisions, both before and during a flight. Assisting the pilot in making those decisions requires a combination of policy changes, technology, and training. The challenges are great, but the payoff would be a reduction in the number of fatal aircraft accidents.

Other Causes

The “other causes” category was used to capture causes that did not occur frequently enough to form a trend. The causes/factors that were included were rogue pilot, mid-air collision, fuel contamination, in-flight fire, tandem flights, control lock left in, and icing. While these causes did not occur frequently enough to warrant additional attention, a few things can be learned.

Two accidents occurred when the control locks were left installed. In both cases, the locks used were not the ones that the manufacturer recommended; in one case it was a screwdriver installed through the yoke. This accident, when viewed in concert with the accidents in the maintenance categories where pre flight issues were present and not detected during the preflight procedure, indicate that pilots are not performing effective preflight inspections.

Fuel contamination occurred in two cases, but the circumstances varied significantly. In the first occurrence, foreign material was found in the fuel tank of a helicopter, probably due to ground fueling operations not being performed carefully. The other is more likely to be a systemic problem in Alaska. That airplane had water contamination in the tanks, and the pilot did sump the tanks prior to takeoff. In this case, the water probably flowed outboard from the fuel tanks because the airplane rolled when the pilot stepped on the float, moving the water away from the sump drain. This is a well known issue among experienced float plane pilots, but many pilots new to float flying are unaware of it.

The sole icing accident occurred when a Cessna Caravan was not properly deiced prior to takeoff. An Airworthiness Directive (AD) has been issued to address this problem; however it does not prevent the situation from continuing to occur in other airplanes. (Advisory circulars do exist and are adequate if read and applied by the pilot.)

Tandem Flights

Tandem flight was not included as a causal factor, but the team tracked flights where two airplanes were on the same route and in communication with each other. These were all incidents where two pilots knew each other, one turned back or went IFR, and the accident airplane did not. Nine accidents out of 97 involved tandem flights. Of the nine, five were VFR into IMC accidents. The other four included a tail rotor strike on take off, a missing DHC-2 Beaver in bad weather, a V-tail Bonanza that committed a mountain flying error, and a Cessna 180 where the pilot's seat slid back during takeoff. In addition, eight of the nine (89%), involved at least one fatality.

The psychological aspects of tandem flights are of interest. If you include the Beaver that disappeared in bad weather, six of nine were continued VFR into IMC. While making conclusions from a small dataset is not statistically supported, it remains interesting that 66% of the tandem accidents are VFR into IMC, whereas for the rest of the data base, VFR into IMC only represents 19%. The team read all the accident reports, discussed the accidents at length, and talked to the FSDO Inspectors in Charge (IIC) and to the NTSB. Of the five VFR into IMC tandem flights, three were in the lead position. Our conclusion is that there are psychological factors behind the data that are real and should be recognized by pilots flying in tandem. Some of these are:

1. In a tandem flight in deteriorating weather, one pilot has to make the decision to turn around first. There is a perceived risk to ego and reputation by being the first to make the decision, especially if the other pilot does not share the perception that the weather has deteriorated to the point where turning back is necessary.
2. In commercial operations, there may be either self-imposed or externally imposed pressure to continue into marginal weather if other pilots are still flying. Smaller operators may face significant economic consequences by not completing the flight.
3. A lead pilot that flies into weather that is below VFR weather minimums and has been flying in it for some period of time has to admit to the other pilot over the radio that they have both been violating the regulatory minimums. This may make them reluctant to turn back in marginal conditions.

Wind

Strong or gusty winds were a factor in 18 of 97 accidents. Of these 18 accidents, seven occurred during an off field landing or takeoff. A previous study cites this as a leading cause of accidents in Alaska as well. (Site Reference NTSB Study), The NTSB study analyzed data from the five year period 1989 to 1993. For that time period there were 142 air taxi accidents and wind/turbulence was cited as a causal factor in 18 cases. Of these only one was fatal. The closest equivalent data from this study's five year interval is five accidents involving 14 CFR Part 135 operators that involved strong or gusty winds of which three involved fatalities. While this comparison is probably not statistically significant the record appears to be getting worse. (This study includes only FSI accidents, so there is no equivalent to the 18 accidents cited in the NTSB Study available.)

We believe this is important because in these situations, a wind sock or other source for wind information is frequently unavailable. This means that pilots must understand how to read other wind cues from the environment, a skill that is only touched on in the private pilot training syllabus. Several flight training operations in Alaska provide off-airport training, and in discussions with these operators, reading wind cues is a part of the training. This is particularly emphasized in seaplane training. Five accidents in this category were floatplanes engaged in water takeoffs or landings.

Seven of the 18 accidents that involved strong or gusty winds were stall/spin accidents. The most common airplane in this group is the DHC-2 Beaver with two accidents that were stall/spin accidents in the presence of strong or gusty winds.

Flat Light/Whiteout

Flat light or whiteout conditions occurred as a factor in nine accidents. In these accidents five fatalities and eight serious injuries occurred. Three aircraft were rotorcraft and the other six were fixed wing. Flat light/whiteout conditions are described in a recent FAA publication (FAA, 2009) as follows:

> “A phenomenon called “flat light” can create very hazardous operating circumstances. Flat light is a condition in which all available light is highly diffused, and information normally available from directional light sources is lost. The result is that there are no shadows, which means that the eye can no longer judge distance, depth features, or textures on the surface with any precision. Flat light is especially dangerous because it can occur with high reported visibility. It is common in areas below overcast, and on reflective surfaces such as snow or water. It can also occur when blowing snow or sand create flat light conditions accompanied by “white-out,” which is reduced visibility in all directions due to small particles of snow, ice or sand that diffuse the light” (p. 16 FAA, 2009).

Although flat light appears as a factor in a relatively small number of accidents, the percentage of accidents in which it appears is higher among Part 135 and Part 91c operations than Part 91 operations. This is likely because of the types of operations being flown. Part 135 operations in particular are more likely to fly over glaciers and even land on glaciers and other areas of snow pack while transporting hikers and skiers. This increases the likelihood of encountering flat light/whiteout conditions. In addition, economic pressures may be involved in the decision to fly in marginal conditions that are not present or are present to a lesser degree for recreational pilots.

Once encountered, flat light/whiteout conditions are difficult to deal with, although in the present data set, only one third of these accidents resulted in a fatality. The best way to reduce the number of accidents in which flat light/whiteout plays a role is to improve weather information available to the pilots. There is speculation that the use of specially filtered glasses might allow pilots to see more effectively in flat light/whiteout conditions. However, research is needed to support this speculation.

Southeast Alaska had a rash of flat light accidents prior to and at the beginning of the study period. This includes three rotorcraft flat light accidents in the same location by the same operator on the same day. **Figures 11 and 12** (See page 34) show the results of some of these accidents. The operators worked collaboratively with another operator and the FAA operations inspectors to create a training program for flat light. This program includes ground and flight instruction, evaluation, recognition, avoidance, and strategies to deal with flat light and whiteout. This program was implemented in 2004 and both operators have not encountered a flat light accident since the program was implemented.

Figure 11 Note lack of depth perception of the snow surface. Picture was taken the same day as the accident with similar lighting conditions.

Figure 12 another rotorcraft accident involving flat light. In this case loose snow was blowing up once the rotor down wash impacted the surface. The result was a combination of flat light and whiteout conditions.

In discussion with operators that have experience with flat light and whiteout conditions, the following issues were brought up:

Recognition

It is essential that the pilot be trained to recognize flat light conditions when they occur. Many pilots without experience in snow covered terrain do not have an appreciation for the lack of depth perception that occurs over a featureless snow covered surface. This is a similar perceptive challenge to that encountered in float operations over glassy water, which is addressed in the practical test standard for a sea plane rating. No similar training is required or usually provided for flat light landings in either fixed wing or rotorcraft operating off snow covered surfaces. Currently, operating a ski plane does not require a rating like a seaplane does.

Conscious go/no-go decision

Successful training programs have emphasized that flat light conditions, like VFR weather minimums, must be viewed by the pilot as a go/no-go decision. If the conditions are such that it is not possible to see the surface that you intend to land on, the operation must be aborted. This necessitates that the organization support the pilot’s decision making process. One good way to emphasize this is through formal training for flat light in the context of Part 135 operations manuals for operators that operate on glaciers and other snow covered surfaces.

Use of man made reference points

A great deal of discussion surrounds the use of man made reference points on snow covered surfaces in the literature and in pilot discussions about proper technique for ski operations. Common references are plastic bags with rocks tied in, spruce boughs; small orange snow sleds partially buried in the snow and painted rocks. It is usually emphasized that these objects, whether naturally occurring or man made, must be used in at least two locations to provide depth perception, such as in a line spaced out over a specified distance to mark a runway center line or in a circle to mark a previously identified and evaluated landing location for a helicopter on a glacier.

Experience has shown that these are effective techniques, but all have limitations. Objects may become buried by heavy snowfall or wind, terrain may undulate between reference points and they may not be close enough to provide adequate spatial reference. Environmental concerns have driven the selection of the reference objects and have required the objects to be removed in some locations inside national parks and preserves.

Glasses that enhance contrast (shooting glasses, light rose colored tint)

In discussing the issue with pilots, many emphasize the use of sunglasses for enhancement of features in flat light conditions. There are many opinions regarding the best type of lenses for sunglasses to enhance visual perception, but commonly cited examples are a light rose tint and a yellow tint similar to that found in shooting glasses. The team attempted to find objective research that would either support or refute the efficacy of certain types of lenses, but was unable to find any objective literature that was relevant to the perceptive challenge faced by pilots landing on snow covered terrain in flat light conditions.

Establish a do-not-go-below altitude that is clear of terrain

Some operators have established a method for setting a “do not go below” altitude for operations over snow covered surfaces in mountainous terrain without adequate visual references. This may mean that an altitude is held while man-made objects are dropped over the surface, such as a frozen lake or glacier, to provide visual reference. In the team’s research into this issue, this appears to be one good method of mitigating the inherent risks associated with landing on snow covered surfaces in flat light conditions.

Technological Solutions

Radar altimeters have been proposed as a solution to flat light landing risks for rotorcraft operations. Several operators in Southeastern Alaska have used radar altimeters in helicopters over snow covered surfaces. The operational experience to date is mixed. Some operators have experienced difficulties with getting a reliable signal back from snow covered surfaces. Others have found that while the signal straight down is accurate in some snow conditions, it does not provide visual guidance ahead of the aircraft. When landing or taking off on glaciers, the surface is often not level.

Another technology that has been experimented with is the use of laser lights, or simply high intensity focused colored lights mounted to the rotorcraft at an angle so that, with the aircraft on the ground in a level landing attitude, two beams merge, one from each side of the aircraft. As the aircraft approaches a landing, the colored spots come closer and closer together giving the pilot a visual indication of their height over the ground. This system seems to be effective, but more research is needed before implementation is possible.

Many Super Cub pilots in Alaska have mounted landing lights low down on the landing gear under the aircraft that point straight ahead in the landing attitude. These have the effect of illuminating the landing surface in flat light conditions with low angle light, enhancing the shadows created by surface irregularities such as wind blown hardened snow drifts (Strugee). Given that winter operations in Alaska are also likely to be conducted in the dark and in low light conditions, this modification has been successful at improving visibility both at night and on skis.

Moving map with terrain database

Moving map displays with terrain databases have been successfully used in the Capstone program to reduce VFR into IMC accidents and the resulting CFIT accidents. These systems have been used in emergency situations when pilots become disorientated in low light conditions or in whiteout conditions to successfully navigate away from glaciers. One significant drawback of these systems for glacier operations is the accuracy of the terrain databases.

Significant errors still exist in the terrain databases used in Alaska regarding the location of geographic features in mountainous terrain, but glaciers are particularly susceptible to this type of error. This is caused both by the motion and changes in the elevation contours of the glaciers as well as measurement difficulties in the geographic systems that create the maps. Because the databases contain information on the terrain contours on glaciers, some pilots may be tempted to rely on the depictions on the moving map and have too much confidence in them.

Controlled Flight into Terrain (CFIT)

A category established by the team during analysis was Controlled Flight into Terrain (CFIT). Analysis of the accident data revealed that 23 of the 97 accidents (approx. 24%) involved CFIT. Of the 23 accidents, four of the accidents occurred during good visual meteorological conditions (VMC), and the remaining 11 accidents occurred in IMC. A majority of these flights involved pilots initiating the flight in VFR conditions and pushing into IMC conditions that precipitated the crash. Nine of these accidents were in whiteout or flat light conditions. With the rugged terrain, large remote distances, and large variances in weather in Alaska, the data indicates that pilots often tend to push on, regardless of the regulatory requirements for visibility for VFR flight.

For the Part 135 operations, seven involving CFIT (44% of this category) have tighter VFR standards, 500 ft above ground level and two miles visibility in VFR day conditions with less than 1000 ft ceiling (14 CFR 135.203, 135.205). Obviously, continued flight into conditions that contacted the ground violated these rules. This CFIT accident trend for Part 135 operations indicates a normalcy of deviation that appears to be an accepted risk for some VFR operators in remote Alaska locations. Additional FAA surveillance may detect these deviations from safe practices, but in long periods of marginal conditions, Part 135 operators may push the safety and regulatory envelope. Common use of portable GPS units in many operators' aircraft is being used to enhance terrain avoidance. Recent discussion with a popular portable GPS manufacturer indicates that current GPS technology has evolved to the point that the unit's installed map has full terrain information available. The limiting factor is now in the unit's data processing capability. This limitation keeps the highest resolution display data from making it to the screen. Future enhancements in processing power and unit pricing could have a large impact in CFIT avoidance. Current approved Terrain Awareness Warning Systems (TAWS) are expensive and highly unlikely to be installed in Alaska's VFR commercial fleet.

Part 91 flight operations are even more likely to push the safety envelope into a CFIT situation due to no definitive altitude requirement over “sparsely populated areas” (14 CFR 91.119 (c)). This loose regulatory requirement leaves the door open to low above ground scud running to attempt to push through the weather.

Group discussion during the data analysis involved a long term solution of the formation of an FAA partnership with manufacturing to develop/approve new lower cost, portable terrain avoidance GPS systems for use on the lower end GA aircraft. The question is whether this new technology would encourage unsafe VFR operations in weather that is below minimums for visibility? Intervention 30 discusses possible options for enhancing terrain avoidance in Alaska operations.

Willful Violation

In reviewing the data, our team decided to establish a category called willful violations. In Alaska in the last five years, 23 fatal and serious injury accidents occurred when the pilot committed a willful violation of the rules and that violation contributed to the accident. (This is primarily based on NTSB reports and witness statements.) Thirty-three people were killed and 11 people were seriously injured in these accidents. In addition, for accidents that have a willful violation as a contributing factor, 89% (20 out of 23) resulted in a fatality. This finding is similar to other accident analyses. For example, Detwiler, et al., (2006) found that accidents involving violations were nine times more likely to result in a fatality. The fact that 24% of the accidents involve a willful violation is particularly disturbing. One of the more egregious examples from the data set is a Cessna 180 being flown 287 lb over gross weight with a passenger seated on a bucket and the pilot having failed his medical. Another was a pilot with no license or medical certification, and no annual for the last five years on the airplane. This pilot was advised before takeoff by other pilots and FAA inspectors that flying that day was unwise (he then flew into a thunderstorm.)

All of these accidents involved a decision error on the part of the pilot. In many cases we suspect there may have been routine violations as well, but because the NTSB report typically does not address past violations or the pilot past history, it was not possible to determine if the pilot was in the habit of violating the rules or not. In a few cases, the data did indicate that this was the norm. An example of this is the accident out of Manley Hot Springs where the pilot did not have a license and the local pilots knew he had been flying for some time without one. His former flight instructor, who was also reportedly his uncle, knew as well.

The Medallion Foundation attempts to address these violations through risk management and pilot decision making training. One element of the training is the aeronautical decision making that is taught through the King Schools Practical Risk Management for Pilots program. Due to the self selection of pilots that participate in these programs, while they do appear to be quite effective in helping the pilots that participate in them manage risk more effectively, we believe the Willful Violation subgroup of pilots are not likely to participate.

Examining the data set of willful violators, there were two examples of the flying community attempting to stop an accident from occurring before it did. The pilot out of Manley Hot Springs was one and a pilot that committed a serious mountain flying error near Denali National Park was the other. In both of these instances, members of the community contacted the FAA flight standards office responsible and inspectors were dispatched to talk to the pilots involved in the accident.

In another case, an inspector investigated a previous incident prior to the accident involving a Beech C-45, but did not know of the past history of the pilot involving abuse of illegal drugs. In discussions with the regional flight surgeons staff, they become aware of issues with individual pilot medical certifications frequently due to whistle blower reports, audits of Designated Medical Examiner issued certificates and other issues, but rarely notify Flight Standards.

In other situations, pilots that have a history of special issuances of their medical stop requesting medical certificates. In most cases, this means the pilot is no longer flying, or is flying a light sport aircraft, but in a significant number of cases, this may mean that they are flying without a medical. No systematic mechanism currently exists to identify these pilots.

Cross indexing pilot medical information with aircraft registration information might yield a list of pilots at higher risk for flying without a medical. This approach could be further refined by ramp checks of airplanes and cross indexing with airport tie down records and in some cases fuel sales records where there is evidence of a violation. We believe that a well-formed group could come up with a risk assessment tool that could be used to cross index available databases and other information to identify high risk pilots. That database output could be used to better target ramp check activities for maximum effectiveness.

Many of these issues are heavily intertwined with medical privacy issues and issues involving the role of the federal government and the limits of that authority. In addition, there are sources of information, such as weather briefings at flight service and airplane activity reports that, if used, would discourage the use of those services, and would therefore be counterproductive to safety.

Mountain Flying Error

Mountain flying errors accounted for ten of 97 fatal and serious accidents. In these 10 accidents, five occupants experienced minor injuries, seven serious injuries and eight received fatal injuries. All of these errors are discussed in various texts on mountain flying, such as (Reference: Mountain flying by Sparky Imeson[15]) This book, and others, discuss issues such as ridge crossing, not flying up the center of a valley, giving yourself room to turn around, etc. All ten of these accidents occurred when the pilot violated one of these commonly accepted rules of mountain flying.

Eight of the ten accidents were the result of flying into rising terrain without the necessary performance to out climb the terrain. In several of these situations, flat light conditions contributed to the pilot not realizing that the aircraft was getting dangerously close to the terrain until too late for evasive maneuvering. The pilots in these accidents were quite experienced, with an average of 10,700 flight hours.

The other two accidents were maneuvering accidents in mountainous terrain with people on the ground that knew the pilot. The result was a maneuver in a confined area at low altitude above the ground that resulted in a stall followed by impact with the ground. Both of these pilots were relatively low time pilots with 135 and 361 hours each.

The FAA and AOPA Aviation Safety Foundation both have mountain flying training available online and all the errors made are covered in that training. There is solid information available that one of the pilots had formal mountain flying training prior to the accident. Other factors were present in these accidents that indicate that these pilots had a willful disregard for safety for themselves and of their passengers. The flight leader in this accident advised the FAA of these issues prior to the accident and FSDO inspectors attempted to talk to the pilot and addressed mountain-flying topics with him days prior to the accident.

In most of these accidents, mountain flying training might have been effective in preventing the accident, especially if the pilot in question followed the training. Our team did not find any accidents that were the result of poor training. In the case of the mountain flying accidents due to rising terrain, the errors were perceptual errors, or pilot attitude issues, that were made by experienced pilots.

Maintenance

There were 15 accidents that involved a maintenance error. These accidents cost 22 lives and resulted in 11 people suffering serious injuries. In two cases, post-crash survival was affected by maintenance errors. In one, a fire extinguisher did not contain any retardant and impeded extinguishing a post-crash fire. The fire subsequently destroyed the other survival gear.

Four mechanical failure accidents resulted in stall spins. Two accidents in Cessna 170s occurred when the cowling came open in flight. The Cessna 170 cowling opens along two hinges on the upper surface. In one, case the cowling latches were found to be worn and in the other the pilot forgot to latch them. The initial assumption often made is that pilot distraction is the ultimate cause of the accident. Both of these accidents appear to contradict that assumption.

The first one occurred at Lake Hood and the radio conversations were recorded. The pilot elected to return to the airport, but stalled the airplane and the airplane spun at low altitude.

The other one occurred during a flight to a remote airstrip. The NTSB recovered a video tape documenting the flight. The pilot elected to continue to the destination knowing about the cowling. The pilot and a passenger made comments about the cowling and did not seem concerned. The pilot made two passes to evaluate the field and on the second pass, the airplane broke to the right, at which point the tape ended.

Another accident that resulted in a stall spin involved a Cessna 180 when the pilot’s seat slid back on takeoff. The seat tracks were found to be excessively worn and the airplane had not complied with the latest Cessna service bulletin regarding seat track inspections and secondary stops.

The final mechanical failure that resulted in a stall spin was a Taylorcraft that suffered an engine failure on takeoff. This airplane had experienced previous failures that had not been successfully diagnosed. After takeoff the pilot attempted to return to the airfield and stalled the airplane in the process.

Two airplanes in the database experienced crossed flight control cables. Both of these airplanes were returned to service after extensive maintenance activities without a control rigging check that would have revealed the problem. Following prescribed preflight inspection procedures would also have prevented these accidents.

Engine Failure

In-flight engine failures accounted for 14 fatal or serious injury accidents. In these accidents, eight people died, 12 people suffered serious injuries and seven people suffered minor injuries. Of these 14 accidents, nine could have been prevented by proper preflight actions.

Five of the engine failures were caused by either fuel contamination or fuel mismanagement. One of the fuel management accidents illustrates another danger of “scud running.” The airplane in question was being flown at an altitude of approximately 500 ft from Aniak to Crooked Creek over the Kuskokwim River. The visibility at Aniak was one mile and the ceiling was reported as 600 ft broken. According to the NTSB report, the pilot noted that his fuel pressure began fluctuating three miles outside of Aniak during marginal VFR conditions. The pilot changed tanks, at which time the engine returned to full power, the pilot applied forward control pressure on the controls and the airplane collided with the frozen surface of a river.

When a pilot is forced to switch tanks at low altitude, there is limited time to complete the action, so what would be a minor occurrence in other circumstances in this case turned into a serious injury. There is very little margin for error, when pilots are flying low over inhospitable terrain.

In four cases, the engine problem was known to the pilot prior to takeoff. In one case, the pilot had experienced low oil pressure the flight before. He then elected to takeoff and fly over Cook Inlet at a low altitude before the engine had the opportunity to warm up and manifest the problem. His body was never recovered, but the airplane was found floating after overrunning an ice flow in an attempted engine-out landing. The temperatures were quite cold at the time. Examinations revealed that the bearings had spun.

Another incident occurred when the engine failed suddenly on takeoff previously but the problem had not been diagnosed. The pilot's response was seeking additional assistance at another field from another mechanic. The engine was serviced by the new mechanic. Afterwards, the engine quit on takeoff resulting in an unsuccessful attempt to turn back to the runway. A post-accident investigation was unable to determine the cause of the engine failure.

Stall/Spin

The leading causal factor involved in accidents in the study group was stall/spin. The reference to stall/spin, instead of two separate maneuvers, is largely due to the fact that most GA aircraft do not have flight data recorders and there may not be any reliable witnesses available to precisely determine the aircraft's flight condition prior to impact. There were 29 fatal or serious injury stall/spin accidents. Almost 70% of these accidents involved at least one fatality. This resulted in the deaths of 36 people, with 26 experiencing serious injuries and ten only minor injuries. There is a higher likelihood of fatalities in stall/spin accidents due to the way the aircraft crashes. If an aircraft crashes in a normal landing attitude, it can dissipate a lot of the energy associated with the crash and therefore increase the likelihood of it being a survivable event. However, in a stall/spin scenario, the impact occurs in a nose down attitude at a high rate of descent where the g forces, and therefore, the crash energy, tend to be much higher, resulting in a higher chance of fatality.

A stall occurs when the aircraft's angle of attack is greater than the angle of maximum lift. The result is a loss of lift and increase in drag. A spin is an aggravated stall resulting in an autorotation about the spin axis. All spins are preceded by a stall on at least part of the aircraft's wing. The stall speed is influenced by a number of factors. These include the aerodynamic properties of the wing's airfoil, the airspeed, the aircraft configuration (flap and gear positions), the load factor, weight, contaminated wing surfaces (snow, ice and/or frost), and turbulence.

As discussed in the weight and balance section below, there is a strong correlation between stall/spin accidents and weight and balance accidents. Seven out of 29, or 24% of stall/spin accidents were demonstrably out of the weight and balance envelope. This compares to nine out of 97 (9%) total FSI accidents. This statistically argues that in addition to the aerodynamic causal link between stall/spin and weight and balance, there is an increased likelihood of having a stall/spin accident if the airplane is loaded outside of the weight and balance envelope. These statistical relationships reveal that, based on the study database, a stall/spin accident is 2.6 times more likely to occur if the airplane is loaded outside of weight and balance than would be predicted by chance.

The most common airplane type to have a stall/spin accident is the PA-18 Super Cub. Including the PA-12, there were six stall/spin accidents in Super Cub family airplanes. Since these are common airplanes in Alaska, this is not surprising, especially given the nature of these accidents. It is interesting to note that none of the Super Cub family airplanes that had FSI stall/spin accidents had an artificial stall warning system. Piper did not install an artificial stall warning system into the Super Cub fleet until the last year of production in Lockhaven, Pennsylvania. The result is that most airplanes in the fleet do not have a stall warning system, but due to a series of accidents and the ensuing litigation, the last of the Lockhaven airplanes and all of the Vero Beach airplanes do have stall warning systems. None of these airplanes were involved in these accidents. Given the availability of data, it is not possible to determine if this is statistically significant without further data collection and reduction.

None of the Super Cub family of airplanes in the stall spin accident category was being operated under 14 CFR part 135 rules, but a guide was operating one for commercial purposes at the time of the accident.

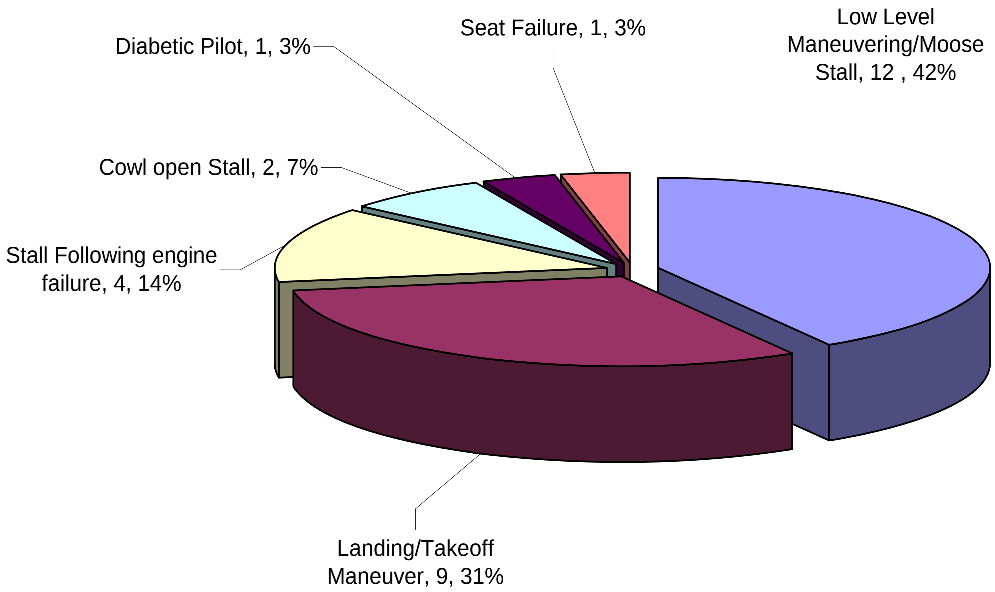
Twenty-nine accidents included a stall/spin of the aircraft as a contributing factor. One of these accidents occurred when the pilot attempted to perform an acrobatic maneuver in the aircraft and was unsuccessful. Eleven of these accidents involved the pilot not maintaining proper awareness of aircraft performance.

A common scenario occurs when the aircraft is already low and enters a turn. A banked turn increases the load factor of the aircraft which in turn increases the stall speed. In a 60 degree banked turn, the aircraft experiences 2 g's, and the stall speed increases by approximately 40%. Failure to understand the effect of load factor can result in a stall. If the turn is not coordinated and a stall occurs, there is an increased potential for spinning the aircraft. The uncoordinated condition is usually the result of the pilot concentrating on something on the ground instead of the airplane.

Though stalls and spins are closely related, the altitude required to recover from a stall is much less than that required for recovery for spins. This is not due to the experience level of the pilot but rather the nature of the two maneuvers. Typical GA aircraft manuals estimate the average altitude loss during a stall to be between 100 and 350 ft. However, in a spin there is a loss of altitude due to entry into the spin, stopping the turn, and then recovering from the stall. Because of this, recovery from spins can easily exceed 1,000 ft to recover.

It is interesting to note (See Figure 8b page 20) that stall/spin was a factor in 40% of Part 91 accidents, but only 8% of Part 135 accidents. Stall/spin was a factor in 27% of Part 91c accidents.

Figure 13. Causes of Stall/Spin Accidents in Alaska



Again the types of operations being flown probably account for much of these differences, although differences in skill level between the pilots also must come into play.

As mentioned previously, the leading cause of accidents as well as fatalities in the study group was stall/spin. As seen in the preceding pie chart, 73% of the stall/spin accidents occurred while in low altitude flight; takeoff, landing, and low level maneuvering. Since it is not possible to eliminate maneuvering while in low altitude, other mitigations must be considered to reduce this type of accident. There are at least two types of mitigations; education based and technology based.

Some sort of education based-intervention may help reduce the number of stall/spin accidents. Many pilots still revert to an overly simplistic view of stalls and spins that can be best summarized by the belief that an airplane won’t stall until it reaches the published stall speed. It is very important that this education-based intervention must correctly inform pilots that a stall or spin can occur at any airspeed and at any altitude. The FAA has produced guidance material (AC 61-67A, Stall and Spin Awareness Training) specific on this topic and should be considered when designing the framework for this intervention.

There are a wide range of technological-based interventions that may also help in the reduction of stall/spin accidents. Much of the GA fleet, were certified prior to the requirement for a stall warning system. Installing a stall warning system that has compelling audio and visual annunciations would provide additional feedback to the pilot. There are a multitude of different designs with varied levels of complexity and costs that specifically address stall warning systems. The least complex solution is the implementation of a stall sensor switch. By sensing the stagnation pressure on the wing, a cockpit warning can be generated prior to the actual stalling of the wing. A slightly more complex design is an angle of attack indicator. Instead of only providing a discrete indication, an angle of attack system provides a real-time indication of the wing's angle of attack. This real-time indication can additionally assist the pilot with trends of going into a stalled state which may be beneficial while maneuvering near stall. Finally, at the most complex levels, several GA avionics manufacturers have or are developing "envelope protection" systems that leverage the current autopilot capabilities.

Weight and Balance

There were eight accidents where the airplane was demonstrably outside of the weight and balance envelope at the time of the accident. These accidents resulted in 15 fatalities and five serious injuries. Our team suspects that the number of airplanes that were loaded outside the envelope may have been significantly higher, but the reports do not address the weight and balance configuration in many cases.

Of the eight accidents that were out of weight and balance, seven resulted in a stall spin accident. The only FSI accident that was out of weight and balance that was not categorized as a stall/spin accident was a Cessna 180 that was overloaded with supplies to service a remote lodge and carried as a passenger a mechanic to work on the lodge's heavy equipment. The passenger was seated on a bucket, the pilot did not have a medical due to cardiac issues, and the airplane was at least 281 pounds over gross. Due to extensive post crash fire, it was not possible to determine the cause of this accident, but there are many possible causes.

As an aircraft's weight increases, the stall speed increases with the square root of the ratio of the new weight to the reference gross weight. This means that the Cessna 180 referenced above with a stall speed of 55 knots would stall at approximately 58 knots when it was 281 lb over gross. This is further aggravated by the center of gravity. In most cases in the database, as airplanes are over loaded, the additional weight is carried in the baggage compartments or the rear seat. This tends to drive the center of gravity aft. This results in lower control forces, poorer stall characteristics, increased tendency to spin with a stall due to lower directional stability, and poorer spin recovery characteristics. Unfortunately, it is frequently not possible to estimate the center of gravity as part of the accident investigation without making significant assumptions due to cargo shifting during the accident.

Preflight Checklist/Procedure

Fourteen out of 97 accidents could have been prevented by proper preflight actions. In these accidents, there were 12 fatalities and 16 serious injuries. In addressing this topic, the team used either the manufacturers recommendations in the aircraft flight manual, or the preflight commonly taught in primary flight training if the model of aircraft did not contain a preflight checklist as the basis for determining if the preflight was adequate. This category does not include accidents where weight and balance issues were a causal factor. 14 CFR Part 91.7 states that the pilot in command is responsible for determining whether that aircraft is in a condition for safe flight. All 14 of these accidents violated this rule.

With this relatively high number, the team was curious about experience level of the pilots involved. The average pilot in this subgroup had 5,341 flight hours and was 51 years old. The least experienced pilot had 428 hours and the youngest pilot was 34 years old. Based on the experience and the fact that the large majority of the errors committed were very basic, the problem does not seem to be training or lack of experience. Rather, it is more likely complacency in the majority of these accidents.

Four accidents in this group were caused by in flight engine failures while the engine was not behaving normally before takeoff. These are discussed more thoroughly in the engine failure section.

Two airplanes experienced accidents because the controls were locked and the pilot did not complete a control check as part of their preflight inspection. In both of these cases the control locks used where not “idiot resistant” designs as would be required by modern certification regulations. Title 14 CFR Part 23.679 states in part that control locks must “Give unmistakable warning to the pilot when the lock is engaged or the device must be installed to limit the operation of the airplane with the device engaged, the pilot receives unmistakable warning at the start of the takeoff.” Many people erroneously believe that this is a new requirement in the regulations. In both of these cases, essentially the same requirement was in place in CAR 3.341. These control locks did not comply with the applicable certification regulations.

Two accidents occurred because the controls were improperly rigged” coming out of maintenance and neither the pilot nor the mechanic adequately checked the movement of the control surfaces. Title 14 CFR Part 23.685 states in part that “Each element of the flight control system must have design features or must be distinctively and permanently marked to minimize the possibility of incorrect assembly that could result in malfunction of the control system.” An equivalent regulation is present in CAR 3.344 in the 1956 revision, but is not present in the 1949 revision.

Four Accidents in this group were being operated under Part 135 and three were being operated under Part 91 for commercial purposes, for a total of seven commercial accidents. Of these seven accidents, it appears that a supervisory error may have been a contributing factor in four of them. (The term “Supervisory Error” in this usage refers to human factors categorization of the error.) In three of the four accidents, it was believed that management pressure contributed to the accident. In the other, company management did not provide the training to the pilot that might have prevented the accident.

Post Crash Survivability

Discussion

Addressing post crash survivability was one of the most challenging parts of our charter, due to limited data quality. Autopsy report availability and quality of data was an additional limiting factor in the analysis.

One of the most frequently asked questions of the authors of these types of studies is “how many accidents are survivable”? Answering this question involves several “what if” questions. In addition, it is often easy to play “Monday morning quarterback” and come up with a way to allow people to survive, given the now known set of circumstances. Ultimately, you must ask “to what extent are the suggested interventions possible and/or practical”.

One simple way to answer the question that avoids many “what if” questions is to look at how many accidents had at least one survivor. In our data set, 33 out of 97 accidents had no survivors. By this measure, 66 % of all fatal or serious injury accidents in this study group are survivable by evidence that some occupants of the aircraft did indeed survive. This way of looking at the data however neglects that many accidents only have a single occupant, the pilot, and they may have survived with relatively simple existing technological improvements in the airplane or its equipment. Of the 33 accidents where no one survived, there were 11 where the only fatality was the pilot.

It is critical to keep this number in context by remembering that this study group only looked at the fatal and serious injury accidents. During the study period from January 1, 2004 to December 31, 2009, there were 649 accidents in Alaska, of which only 97 were FSI accidents. Using the above measure, only 33 of 649 accidents (5%) were not survivable.

Another way to ask this question is to look at the totality of the circumstances and ask the question “could X technology have affected the outcome”? The team looked at many different potential solutions to enhance post crash survival and settled on seven to evaluate against the dataset. The team then asked the question, debated the available data, and reached a consensus on each accident. This is an attempt to quantify the effectiveness of a possible safety improvement.

The team believes that one or more of the seven solutions could have affected the outcome for 52 out of 97 accidents studied. The next seven sections will discuss each of the seven post-crash survival possibilities. The team was conservative in determining if there was a reasonable possibility that a given technology could have changed the outcome, coupled with the fact that in some accidents some of the proposed strategies were already in place.

Survival Training: Possible Lives Saved 19

In Alaska, many companies and governmental agencies require that personnel engaged in aviation activities attend and pass a survival training course. These courses frequently involve dunker training and outdoor survival training in simulated or actual Alaska winter conditions. The depth and breadth of these courses vary, but one typical provider offers a course that is five days long and includes an overnight simulated emergency scenario in the winter as well as basic first aid and dunker training.

In evaluating the training the team asked the question, “If the primary flight crew, typically the pilot, had been through the training, could it have affected the outcome”. We believe that adequate survival training, properly implemented, could have affected the outcome in ten accidents with an opportunity to save 19 lives.

Rescue Air Bottle: Possible Lives Saved 18

In the last five years, 18 lives might have been saved if they had not drowned as a result of sudden immersion in the water. Given the circumstances, deaths may not have been prevented, even with proper use of a rescue air bottle. In Alaska these accidents are typically float plane accidents. All the US Military services and the US Coast Guard use rescue air bottles, and their experience with them has resulted in technological enhancements in the equipment and improved training. The acronym commonly used by the military services is HEEDS, which stands for Helicopter Emergency Egress Device. The first generation of devices had to be armed prior to takeoff and closed after landing. In the general aviation environment, that would probably be impractical, but the newest version, the HEEDS III, eliminates the need for arming; the operator can simply put the bottle in their mouth, exhale, and then start breathing. In one documented case, a Naval aviator in an emergency situation forgot to exhale, and was still able to successfully use the bottle and egress.[16] Another acronym for the same type of device is EBD which stands for Emergency Breathing Device. Another trade name for essentially the same device that is used extensively in the recreational diving world is Spare Air.

Table 5. Technological Developments in HEEDS Bottles

	HEED II	HEED II Mod.1	HEED III
Model No.	171	271M1	175MT
Length (in.)	13.5	11.75	8.75
Diameter (in.)	2.0	2.25	2.25
Weight (lbs)	1.5	1.75	1.3
Pressure (psi)	1,800	3,000	3,000
Air Capacity (cu. ft.)	1.7	2.7	1.7
Surface Breaths	30	48	30
Valve Actuation	Knob	Knob	Check Valve
Pressure Indicator	Pin	Pin	Pin

Figure 14. HEEDS III Bottle Example

A particularly poignant example of the effectiveness of a Rescue Air bottle is the case of a Coast Guard HH 60 Helicopter that went down out in the Aleutian Chain attempting to rescue the survivors of the wreck of the cargo Ship Selendang Ayu. After the seventh of nine crewmembers from the ship had been hoisted on board the helicopter, and while the Selendang Ayu master and the Coast Guard rescue swimmer waited on the freighter’s exposed bow, a wave larger than any yet encountered, according to witnesses, struck the bow of the freighter, sprayed up, and engulfed the HH-60. The helicopter’s engines stalled, the helicopter descended, and its tail and main rotor blades struck the side of the Selendang Ayu. The helicopter then fell into the sea close to the freighter’s forward port side, overturned, and sank. None of the Selendang Ayu’s crewmembers had a HEEDS bottle, or were wearing survival suits. They were wearing life jackets.

The Coast Guard Cutter Alex Haley’s other helicopter then went into rescue mode and was able to rescue all three of the HH-60’s three crew members, but only one of the eight Selendang Ayu’s crew members. A member of our team interviewed one of the three coast guard crewmen regarding the role of the HEEDS bottle in their survival. He said that all three of them had used and needed the HEEDS bottle to egress the rotorcraft underwater. We believe that the survival training the Coast Guard provided the flight crew played a part in their survival. (All three of the aircrew in this accident received the Distinguished Flying Cross for their action that day)

Figure 15. Coast Guard HH-60 Jayhawk helicopter hovering above Alex Haley's deck during rescue of Selendang Ayu crew

(Reference Selendang Ayu NTSB Report NTSB/MAB-06/01)

For HEEDS bottles to be effective, training is essential. Experience in the training environment demonstrates that the first attempt to egress underwater is rarely successful, especially when other aggravating factors are present, such as being upside down or in darkness. With training, the person has greater opportunity for success.

HEEDS bottles have been used for many years by several government agencies and large private companies, confirming their cost effectiveness and affectivity. However, they are largely unused in the general aviation environment. Our team believes it is impractical for air tour operators to equip passengers with HEEDS bottles, but we do believe it is cost effective and practical for pilots of float planes to have them and be trained in their use. This will result in an increased likelihood of the pilot rescuing passengers in the event of an accident. In addition, if the pilot survives, they are better trained and equipped to be able to notify search and rescue and aid in the survival of the passengers until assistance can arrive.

One question that has been asked is how long a rescue air bottle lasts underwater. The answer is difficult, because many factors are at work. These include the temperature, the training level of the user, lung capacity of the user, the extent to which panic sets in, and the depth the user. While these variables exist, some general comments can be made. Bottles are available in several different sizes, but one of the most common ones will provide 30 breaths underwater. One of our team members took a similar bottle to the bottom of a pool and was able to stretch it for 30 minutes. Because this person was a trained former Coast Guardsman and the environment was much more controlled than a real accident, this should be viewed as an outside limit estimate.

An adult's respiration rate during strenuous exercise is about 35-45 breaths per minute. This means that an inside estimate is between 40 to 50 seconds. Even this short time can be critical in the event of an underwater egress event.

Seat Belts with Shoulder Harnesses: Possible Lives Saved 28

The FSI team completed an analysis of the database accidents in relation to the use of shoulder belts for securing the occupants of the aircraft. In reviewing these data, the main source was the Shoulder Harness Used field on the NTSB factual accident reports. This field has a simple yes or no answer to it. It does not tell us if the belts are three, four, or five point harnesses. A three point harness is the minimum installation included for this field. The four and five point harnesses are a great improvement to the security of the user due to the geometry of the belts installation. Since we have only the single NTSB data field we are left with a lot of questions for each analyzed accident.
Some of the questions are:

- What were the positions of the shoulder belts?
- Pilot position?
- Front Seat Passenger?
- Rear Seat Passengers?
- What types of shoulder belts were used?
- Three point?
- Four point?
- Five point?

Surprisingly in a review of the 97 accidents, 73 of them, or 75%, indicated that shoulder belts were installed. This high percentage of indicated Shoulder Belt usage is encouraging. Of the 73 accidents involving some form of Shoulder Harness use, 30 were fatal to the pilot (41%). Of the 30 fatal accidents, 20 of them involved a high angle of impact during the accident. Certainly the energy/speed of the accident and the angle of impact can have a very large effect on the survivability of the accidents. Of the 24 remaining accidents in which we have no indicated usage of Shoulder Belts, 12 or 50% were fatal to the pilot, eight of these involving a high angle of impact. Statistically we know that a better restrained occupant has an improved survival chance during an accident. In analysis of the data, some other questions were posed, and attempted to answer through the available data, they were:

- Were the aircraft analyzed likely to have shoulder belts for the aft seated passengers/occupants?
- Would harnesses for the aft seated passengers/occupants have improved the outcome of the accident?

Using available autopsy reports for the accidents, and NTSB/FAA accident data, we selected 15 accidents of the 97, or 15% that could have improved their outcome if all onboard occupants had shoulder belts to secure them. Nine of these 15 selections were within the group of accidents indicated to have Shoulder Belts Used in the NTSB report.

There were 17 fatalities in six accidents in Beavers and Otters. In these accidents, the pilot frequently survived and the passengers did not. The pilot in these airplanes is often equipped with a shoulder harness and the passengers are typically not. We believe that equipping the passenger seats with either lap belt airbags or shoulder harness seat belts would significantly improve the number of people killed in accidents in the future.

As a result of this analysis, the FSI Team believes that shoulder belts make a large difference in the survivability of all aircraft accidents. The team also believes that a new area of focus to encourage the installation of aft passenger shoulder belts would make a large impact on crash survivability.

Airbag Seat Belts: Possible Lives Saved 38

Aircraft airbags, in our study, had the greatest potential to save lives of any of the post crash survival technologies. We believe that if airbag seat belts had been installed in the correct seats, there existed the potential to have saved 38 lives. In addition, airbags are very effective in preventing injuries. We believe that the installation of airbags would have greatly reduced the number of serious injuries as well.

The group studied the available autopsy reports as well as the accident reports and associated photographs. We then made a determination regarding whether or not the accident would have been survivable if airbag seat belts were installed.

Airbags have been installed in airplanes beginning with the change to dynamic seats in Part 23 and Part 25 aircraft. In 14 CFR Part 23, this occurred in 1988. Initially, airbags were used as a means to comply with the new certification basis for the aircraft, but as experience was gained an independent market began to develop as a safety enhancement retrofit in the existing fleet.

As airbags have emerged in the automotive fleet and been incorporated into the general aviation fleet, some experience has been gained in service. Admittedly the experience to date is anecdotal. One incident that occurred in Florida involves a Cirrus SR 22 that suffered an engine failure due to a throttle cable issue. The pilot, an experienced flight instructor with 4500 hours, decided that the altitude was too low to deploy the ballistic parachute and believed that he could glide to a close by airport. Due to the winds present that day, the glide was unsuccessful, and the airplane struck the tops of trees approximately 100 foot tall and fell to the ground ¼ mile short of the runway. The airplane apparently struck the ground in an area of low brush at a high vertical angle and came to an inverted rest.

The airplane was equipped with airbag seat belts and on impact they deployed as designed. Although the airplane was destroyed, all three people on board walked away and the most critical issue facing them post crash was avoiding poisonous snakes. The pilot attributes their survival to the airbags. **Figure 16** (See page 52) below is a picture taken at the accident site and shows the damage to aircraft

Figure 16. Florida Cirrus SR-22 Accident

In **Figure 16** notice the nose of the aircraft is showing the point of impact. Note the soil on the landing gear and belly indicating a relatively high angle of impact, but still low enough to show impact damage to the underside of the cowling.

Anecdotal stories such as the one above are supported by extensive sled testing of prototype airbag seat belts using anthropomorphic test dummies. These tests show significant reductions in head injuries, improvements in the decelerations experienced by the heart, and reductions in head injuries.

Airbag seat belts are available for over 105 airplane models including many commonly flown in Alaska. The Cessna 170, 172, 175, 180, and 185, are all included. A kit has been developed for Light Sport Cubs and experimental Super Cubs but it is not on the approved model list yet. The cost of the seat belts, airbags and associated system is $1000 per seat in most airplanes plus installation. There are currently four facilities in Alaska that can install airbag seat belts.

Helmets: Possible Lives Saved 33

In the State of Alaska, several state and federal agencies now require helmets to be worn by all occupants of small aircraft during the performance of their official duties. This requirement is mainly for small aircraft performing low level surveys and off-airport work. Of 27 relevant autopsy results, all listed moderate to severe injury to the head. While the team recognizes that not all 27 lives would have been saved by the use of helmets, we do believe wide-spread use of helmets, particularly in tandem seat aircraft, would have a significant positive impact on reducing FSI accidents in the State of Alaska.

In the past, fixed wing aircraft helmets were heavy, cumbersome and had little or no crash attenuation. Their primary purpose was to provide a platform for oxygen masks and other equipment necessary for flying military type aircraft. Today's technology has transformed the industry. Flight helmets are now light (weighing mere ounces), quiet and have crash attenuation. Pilots, who regularly wear the newer style helmets for government contracts and private use, prefer them to traditional headsets.

Helmet Overview

A helmet consists generally of a rigid head covering and a retention system composed of flexible straps and hardware. The rigid covering consists of a stiff outer shell and a crushable liner. The stiff outer shell protects by its capacity to spread a concentrated load at its outer surface over a larger area of the liner and the wearer's head. The crushable liner protects the head from direct impact by its capacity to manage impact energy. Other general features of helmets may include eyeshades and accommodations for goggles, and visibility enhancements such as bright colors and reflective surfaces. These features all deal with matters of safety and comfort.

The capacity for impact protection is determined by direct measurement of the shock delivered through the helmet to a headform when the helmeted headform is dropped in a specified manner onto any of three unyielding anvils. The helmet must also resist penetration by sharp edged and pointed projections and projectiles.

Most helmets are intended to accommodate a range of head sizes and shapes. Various thicknesses of resilient padding are sometimes placed within otherwise identical helmets during production or during fitting to configure the helmet to several different ranges of head sizes. This resilient padding does not significantly affect the way the helmet absorbs and attenuates impact.

Manufacturing Standards

Helmets are manufactured to many standards. In this section we will only discuss two of the more popular standards, Military specification (MILSPEC) MIL-H-27856D and Snell Memorial Foundation (SMF) Standard M2005.

MIL-H-27856D applies to the MILSPEC flying helmet HGU-7/P. This is one of the most common standards referenced by manufacturers of flight helmets. This MILSPEC states requirements for preproduction testing, materials, design, construction, accessories, performance, identification markings, inspection, and testing methods.

SMF M2005 is a motorcycle helmet standard, yet is frequently utilized in the production of flight helmets. It generally states the same requirements as MIL-H-27856D.

Common Objections to Flight Helmets

Some pilots consulted during this activity stated several objections to wearing flight helmets. Some of the more common objections were lack of visibility, lack of head movement, weight, cost and comfort (overheating while wearing helmet). Two other objections, not related to those stated above, were vanity (it's not cool to wear a helmet) and a lack of knowledge of a helmet's capabilities during a crash.

It seemed most pilots were familiar with the older style flight helmets which validates several of the objections listed above. Newer style helmets have mostly fixed the problems noted, except for cost (discussed below). A pilot's lack of knowledge of helmet safety features can be fixed through training at aviation functions such as Aviation North Expo. While vanity is a personal issue, it could be hoped that through proper training and exhibition, pilots could overcome this issue and be persuaded the safety issues outweigh the "cool factor".

Cost Analysis

There are several dozen manufacturers of flight helmets in the market today. Two typical helmet examples are discussed below:

Helmet 1, Fixed Wing Helmet:

- Weight 37 ounces
- Pre-formed thermoplastic liner
- One-piece integrated chin and nape strap
- Available in custom (for eyeglasses) or standard fit
- Leather ear pads
- Standard or comfort liner system
- Optional system for oxygen masks
- Sizes are medium, large, extra-large
- Cost: $1268 +shipping + options

Helmet 2 Fixed Wing Helmet:

- Approximately 35 ounces
- Carbon fiber and aramid shell
- Polystyrene inner padding with high density
- High degree of passive noise protection
- Sun Visor for low visibility
- Cost: $1243 + shipping + options

All helmets researched were in the same general price range, the two listed were the lightest and most well known among pilots.

406 ELT/Personal Locator Beacon/Spot Messenger: Possible Lives Saved 12

Current Federal regulations require only that the installed aircraft Emergency Locator Transmitter (ELT) is "not" a TSO C91 unit. This regulatory standard, by exclusion, forces aircraft to currently install at a minimum, a TSO C91a unit, which by design is an upgraded unit dependent on the 121.5 MHz locating frequency. Existing units are grandfathered at their TSO status until replaced in the aircraft. Two of the most important differences between C91 and C91a units are an improved g switch and the requirement for a pilot activated remote activation switch.

With elimination of 121.5 MHz COSPAS-SARSAT satellite monitoring on February 1, 2009, use of the minimum mandated TSO C91a ELTs has made crash notification and locating with these devices highly unlikely. The newest TSO, C126a ELTs and the new features of 406 MHz technologies are the obvious choice to ensure satellite recognition of ELT based distress signals. The FSI workgroup team found that due to the remote terrain encountered after departing from all Alaska locations, use of a 406 MHz capable ELT is the minimum installed equipment recommended for flight in this state.

Personal Locator Beacons (PLBs) are 406 MHz devices that are registered to their personal owners for emergency distress notification. FSI workgroup discussion focused on new and existing technologies that could have an impact on flight survivability. PLBs were believed by the group to add another level of safety to flight in Alaska since it adds a backup distress notification system to aircraft crashes. The drawback of these devices is that they are manually actuated.

SPOT Messenger personal locator devices were also discussed for their ability to improve accident survivability in aircraft accidents. SPOT devices are registered to a private company for distress notification and have message capabilities that can give status updates concerning the owner/user of the device. SPOT devices use very low transmitting power output to their receiving satellite network. FSI workgroup members feel that carriage of these devices can also add a backup distress callout capability in an accident situation for a minimum cost.

In summary, the FSI workgroup highly recommends all aircraft operations in the state of Alaska operate with a 406 MHz ELT. This installation would provide early remote activation during a crash event, and provide standard G-force activation with no human input as designed and installed. 406 MHz PLBs are a great addition to crash distress notification if the operator can get a clear view of the sky and activate the device. The SPOT devices are a lesser addition to survivability due to their lower power output and higher need of a clear sky view. Regardless, the SPOT devices are considered a valid addition to onboard distress equipment.

Inflatable Personal Floatation Device with Minimal Survival Gear: Possible Lives Saved 21

Using data compiled from the FSI workgroup findings, 14 accidents of the 97 accidents, 14%, involved water based situations where Personal Flotation Devices (PFDs), (Float vests, float coats, etc) would have made a major change in the survivability of each person. Twenty-one people were killed in these accidents, and 12 suffered serious injuries.

A large percentage of operations in the state of Alaska are water based operations. In addition, a large percentage of the land based aircraft operations fly over remote water areas.

In the group’s analysis of data, it became clear that a simple method of increased survivability operating around water would mean crew and passengers wearing PFDs. This recommendation is a large change in culture from past practices.

For float-based aircraft operations, the accident data reveals that on-water emergencies evolve rapidly with little time to don safety equipment. From a safety perspective, the normal practice for boating operations in the state is for all to **wear** a PFD. This requirement is in force on stable personal watercraft for good reason. Residents of this state learn quickly the inherent dangers and short survival times of the cold water and climate conditions.

From an aircraft on floats perspective, (which is a very unstable boat); it would make sense for all aircraft occupants to be wearing a PFD for water based operations. At a very minimum, the pilot should be equipped and wearing a PFD, and available to then quickly assist others in an evacuation event.

Of the 14 water related accident sites, only three had any use of PFDs involved. Four of the water related accident sites had no fatalities even though they had the conditions for this to occur. In one of the accidents, into a glacial lake, the accident happened with three of the passengers wearing their PFDs. The pilot and one passenger were not wearing theirs. All survived the crash impact and evacuation. Everyone exited the aircraft OK, and the two not wearing their PFDs did not manage to don theirs, or even maintain possession of them. One of these two was fatal as a result. (Accident #23, FSI Accident Data Set).

PFDs have evolved to smaller, lighter, less intrusive equipment that can be worn on a daily basis by those operating in this environment. Their use is recommended during all float based aircraft operations.

Autopsy results

It must be noted that under current law, the NTSB only has the authority to order an autopsy for the pilot and required crew. This means that we do not have autopsy results for any passengers except in one case (a student pilot where there was initial confusion regarding who was pilot in command). In several cases, because the pilot's body was not recovered or out of respect for the wishes of the family, no autopsy was performed.

Out of 53 accidents where the pilot was killed we have 28 autopsy reports, one of which indicated that the body was so badly burned that little evidence of the pre-fire condition of the pilot was available. All 27 viable reports listed moderate or severe injuries to the head. Seventeen accidents listed moderate or severe injuries to the chest.

Moderate or severe atherosclerosis or other pre-impact cardiovascular disease was noted in five of the 27 (18%) autopsy reports. This study did not assess if this is representative of the pilot population as a whole, or if a causal link exists to the causes of the accidents. The team is confident that in at least one instance, a causal link probably does exist because the pilot's medical had been denied due to cardiovascular disease, which was confirmed in the autopsy results. In another case, the pilot's medical was also denied due to cardiovascular disease, but a causal link between the cardiovascular disease and the accident is weak at best. In any event, the trend toward older pilots and the apparent incidence of cardiovascular disease in the autopsy set is of concern as a risk factor that may be increasing.

One representative of the FSI team reviewed the results of the autopsy reports in an effort to determine, if it was possible that enhancements in the crashworthiness of the aircraft could have improved the chances of survivability. The information quality made this a difficult deduction. This finding is that eight of 27 pilots might have survived if enhanced crashworthiness features had been incorporated into the restraint systems, they had been able to successfully egress the aircraft, or medical attention had been available sooner.

A second review was undertaken by a medical doctor at the FAA Civil Aerospace Medical Institute (CAMI) in Oklahoma City, Oklahoma, Dr. Nicholas Webster. Although results are similar, the conclusions of Dr. Webster were that 11 of the 27 pilots might have survived if enhanced crashworthiness features had been incorporated in the restraint systems of the aircraft. In particular, the use of airbag seat belts was considered to be the most effective enhancement. In conducting the review, ten of the accidents were classified as non-survivable because of the severe energy involved in the crash. Key words in the autopsy reports were clear indicators of the amount of force involved in the crash. Body fragmentation, "pulpified" liver, and aortic separation are all terms that indicate a non-survivable crash. In one accident, a passenger in the aircraft survived the crash. However, it was determined that enhanced crashworthiness features would still not have been useful because a tree limb had entered into the cockpit, causing the fatal injuries to the pilot. In another accident, the plane broke apart in mid-air, which would have rendered any safety enhancements useless.

In conducting this investigation, researching the autopsy reports was impaired for several reasons. Four autopsies could not be conducted because the pilot's body was never found. Ten autopsy reports on pilots are missing from the CAMI database for no recorded reason. Of the 113 people that died in the study period, we have viable information on the causes of death for only 24% of the fatalities. Even so, the estimation that over 40% of the fatal injuries that were reviewed in the autopsy reports may have been prevented is significant.

Recommendations for Improving Data Collection

Review of the FSI accident data set brought forth the following recommendations to improve this process in the future.

1. Flight Standards accident investigators should be provided an appropriately secured location on the Flight Standards Local Area Network to store data collected related to accidents, including things like photos, scans of applicable documents and other ad-hock data relevant to the accident.
2. When possible, Flight Standards accident investigators or the NTSB should record the restraint systems used in the airplane and the location in the aircraft. This could be done by simply attaching a copy of the aircraft's flight manual weight and balance page with annotations regarding the seats occupied and the restraint system used.
3. When available, the nature of the serious injuries and the nature of the injuries that caused the fatalities should be recorded. As an example "The pilot seated in the left front seat with a four point shoulder harness was killed as a result of impact to the skull by the instrument panel"
4. Record the type of ELT installed **and** if it did not assist in search and rescue, **why** not.
5. Do a retrospective weight and balance on each aircraft accident or state that it is not possible and give reason.
6. For all VFR into IMC accidents, record the avionics and instruments installed in the aircraft that relate navigation and attitude reference.
7. In the narrative of the accident, state the nature of the serious injuries and the specific cause of death. (Current practice is typically a phrase such as multiple

Interventions

Discussion

There are three areas where the team believes additional focused work is necessary by an appropriately assembled group of representatives from industry groups, NTSB and FAA. Our suggestion is that the Alaska Aviation Industry Council should form these teams.

1. Stall/Spin Accident Prevention. This group should work on ways to prevent stall spin accidents, primarily in the Part 91 fleet. Technological and training solutions should be addressed.
2. Continued VFR into IMC Accident Prevention Team. This team should look at the success of the Capstone program including all of its elements and formulate new ways to continue to improve the accident rate. Training should be a part of this effort including the Medallion Foundations efforts.
3. Post Crash Survivability. This team would focus on how to improve post crash survivability. Many of the technological solutions exist; the most significant barriers are financial in nature. We believe that by working together, industry groups can lower cost through buying modifications in quantity and amortizing product development and certification costs over a larger number of airplanes.

The team addressed 29 intervention concepts. These were specific to groups that the team believes should address certain items and ideas to enhance safety and post crash survival. Some addressed infrastructure issues that the team believes are barriers to existing programs being more effective. The team believes that in many areas, these recommendations need work with industry stakeholders to maximize their effectiveness and to sort out interventions that won’t work and to suggest additional interventions.

The appendix provides a detailed write-up on each intervention and addresses which accidents that particular intervention might have had a chance to mitigate. Because Stall/Spin accidents are the largest group of accidents, it is believed that creating a Stall/Spin summit or a Stall/Spin working group with industry partners could be effective in addressing this class of accidents.

The team conducted a paired prioritization exercise to evaluate the importance and effectiveness of each proposed intervention. These are ranked as A B and C below. In addition, the team ranked the A priorities 1-12.

Table 6. Interventions in Priority Order

No.	Intervention	Priority
26	Develop and install an enhanced stall warning systems for Cessna 170, Piper PA-18 and DHC-2 airplanes. (170 system may be usable on 180/185 and PA-18 system may be usable on PA12 and PA 22/20)	A1
11	Encourage Shoulder Harnesses installation in all seats. Emphasize passenger seats.	A2

No.	Intervention	Priority
30	A low cost terrain avoidance system (Capstone like) for VFR into IMC accidents in Alaska.	A3
5	Lowering barriers to going IFR when weather deteriorates Non punitive approach to going into IFR when not legal. A program similar to ASAP, however, designed for Part 91.	A4
18	Work with Industry Partners to design and implement rear seat shoulder harness restraint systems and/or airbags in DeHavilland Beaver and Otter Airplanes. (Most of the Beavers and Otters flying in Alaska today only have a lap belt, including the seat that Former Senator Stevens was in at the time of his death.)	A5
6	Anonymous inspector program (Part 135)	A6
9	Concentrated 406 MHz ELT Implementation.	A7
16	Distribute brochure “how to assess your airplane for Survivability” part of GA initiative.	A8
12	Develop Biennial Flight Review Guide to Emphasize causes of accidents. Deploy through CFI/DPE initiative.	A9
19	Enhance participation of targeted pilots in safety seminars. Cross-index existing databases to identify pilots that do not attend seminars and are likely to be high risk pilots. Use info to invite at-risk pilots by personal phone calls, to seminars. Consider offering limited seminars in smaller communities, Willow, Kenai, Port Alsworth, Bethel, Glennallen, Nome, Hanes, Skagway, Wrangel, Petersburg, Kenai, Homer, Kodiak, Kotzebue Yakutat, and Sitka.	A10
21	Get the Helicopter laser light system certified and create an equipage program. Work with operators to evaluate prototype and make suggestions to improvement prior to certification. Identify a company to manufacture systems.	A11
31	Establish a Single Point of Contact phone number for the public to call in of safety issues. Advertise the new simplified phone access for FAA notification.	A12
1	Airplane Safety Check program annually (Like Coast Guard Boat Check) in each FSDO with an OPS and an Airworthiness inspector. Program should include wanted handouts, such as CO detectors, Gust locks, fish scales, Fuel samplers (GATS Jars?) support with FSDO Inspector training in personal interaction. Non punitive, no violations allowed. Participant sticker for airplane. Couple with other aviation events, maybe airplane wash days for CAP cadets.	B
3	Conversations with a Ghost (Youtube posting), Flat Light, Rouge Pilot out of Manley (Model after AOPA Aviation Safety Foundation Videos)	B
4	VFR into IMC transition training at Medallion Foundation.	B
10	Underwater egress training at seaplane seminars.	B
13	Fund instructors for the Medallion Simulators and establish goals for increasing SIM use by Medallion Foundation.	B
14	Expand Cue Based Training in Southeast once prototype is finished and expand Phase II to 135 other areas of the state. (Program will have to change along with operational differences) offer Phase III to Part 91.	B

No.	Intervention	Priority
17	Briefing brochure about how to do a preflight safety briefing of passengers.	B
20	Post Passenger Bill of Rights and (Circle of Safety poster) in passenger lounge for all 135 operators. Add Weather to the Circle of Safety.	B
23	Add Flat light/Whiteout presentations to Safety Seminars. Try to get experienced 135 operators to help train 91 pilots. (Fund travel and honoraria)	B
24	Develop new Mountain flying seminar topic for pilot seminar.	B
25	Encourage Part 91 pilots to get mountain flying training. Have Medallion Foundation develop a mountain flying course and a more thorough class for instructors. Implement the Instructor program through the CFI/DPE initiative.	B
27	Enhance Medallion Foundation PA-18 simulator, add Moose stalls and stall spin awareness training. Make the simulation as realistic as reasonable by giving the pilot a high gain task like counting the brow tines. Simulate a wake turbulence encounter with turbulence turn on include weight and balance. Simulate the impossible turn following the fuel selector, causing engine failure at low altitude.	B
29	Fund a position to be a web master to maintain Aviation Safety outreach data and address branding of old safety information that was eliminated due to branding issues. Allow any interested pilot to access data without password. Include flying to Alaska web site.	B
2	Dramatic reenactments (YouTube posting) VFR into IMC; example, Cub into Lake Hood, Stall/Spin Turn about whale stall/spin accident, Mountain Flying 185 with the bucket as a chair killed mechanic.	C
7	406 ELT Award as a door prize at safety seminars and conventions.	C
15	Weather Cameras to provide Weather cam site/app optimized for Smart Phones. (In prototype stages currently, Weather Camera independently came to the same conclusion as FSI Working group)	C
22	Develop brochure and other more detailed guidance documents to provide guidance to eye doctors and to pilots for the best color sunglasses for flat light conditions and provide the limitations of sunglasses. May need to conduct research for determine the correct information to publish.	C

Conclusions

Discussion

The change to a flight plan goal that addresses fatal and serious injury accidents provides an excellent opportunity to evaluate what we have been doing well and what we can do to improve. In this effort, the team looked at both accident causes and at post crash survivability.

Accident Causes

The leading cause of Fatal and Serious Injury Accidents in the study was Stall/Spin at 29 accidents followed by continued VFR flight into IMC at 20 accidents. The success that the Capstone program enjoyed appears to be responsible for reduction of VFR into IMC accidents and shows us that focused efforts at reducing accidents can be effective.

Because the Capstone program is essentially over, it is possible that many of the safety benefits that the Capstone program provided may begin to decrease over time if other advances do not take their place. This will likely manifest itself as an increase in VFR into IMC accidents unless other action is taken. (Some elements of the Capstone program remain, such as Weather Cameras, so those benefits are likely to continue.)

It is clear from the data involving stall/spin accidents that, efforts to prevent these accidents may have a beneficial effect; more must be done if we intend to meet the flight plan goals established to reduce the fatal and serious injury accident rate by 10% in the next five years. Our team believes that the question of stall warning in these aircraft must be addressed. Many technological improvements are possible in this area, but it is also possible to address some of these issues through training. We encourage a robust discussion with industry stakeholders regarding the solutions to stall/spin accidents.

Demographic trends in the pilot population will likely drive an increase in pilot medical issues. This increase may make it difficult to detect trends in other areas because definitively determining pilot incapacitation is problematic at the present state of technology. It will also make it necessary to reduce the accident rate in other areas further to account for the increase in FSI accidents due to pilot medical issues.

Experience with helicopter operators that have had flat light accidents has shown us that it is possible to improve safety significantly through training and technological improvements. While this is a relatively small part of the total accident causes, it remains a “low hanging fruit” because it is feasible to affect.

Mountain flying accidents and engine failure accidents also represent opportunities to improve the accident rate with relatively simple improvements in training. In mountain flying, much existing information exists that if followed and trained would prevent most of the accidents. The most important conclusion from engine failures is that they can be detected before flight if the pilot pays attention to existing information.

Post Crash Survival

Public perceptions are often that most airplane accidents are not survivable; therefore, enhancements in post crash survivability are not important. The data shows otherwise. Of the 649 total accidents that occurred in the study period, only 33 were not survivable with the technology in place at the time. Of these 33, many would have been survivable if changes were made to the aircraft, equipment, or training programs. We believe that it is critically important that the flying public be made aware of these statistics, otherwise acceptance of post crash survivability enhancements will likely meet resistance.

Another often-overlooked part of the statistics is the rate of serious injury. While preventing death is critically important, it is easy to loose sight of the human suffering that is often associated with serious injuries. In most of these cases, the serious injuries suffered in these accidents substantially changes the life of the individual and can change to remaining life span of these people significantly. Based on the technologies evaluated, the following safety enhancements in airplanes appear possible.

- 31 lives might have been saved through the installation of air bag seat belts
- 33 lives might have been saved through the use of helmets in tandem seat airplanes, such as Super Cubs
- 28 lives might have been saved with the use of shoulder harnesses, primarily in passenger seats
- 19 lives might have been saved through survival training
- 21 lives could have been saved through the proper use of personal floatation devices in float planes
- 18 lives could have been saved through the use of rescue air bottles to prevent drowning in float plane accidents
- 12 lives could have been saved if the airplane had been equipped with an effective emergency location device, such as a 406 Mhz Emergency Locator Transmitter

Team Makeup and Objectives

The team that conducted this study was diverse and had support from many others both inside the Federal Aviation Administration (FAA) and out. The core team members were selected by the Flight Standards Division Manager for Alaska, Angela Elgee.

The core members were:

Team Lead

Dr. David D. Swartz, Anchorage Aircraft Certification Office Senior Engineer

Dr. Swartz is an active pilot, and proud owner of a 1949 Aeronca Sedan. Prior to joining the Anchorage Aircraft Certification Office (ACO), he was a consulting FAA Designated Engineering representative, a former Technical specialist in Composites and in Metallurgy and has worked on the design team for six new general aviation airplanes. He has participated in many general aviation accident investigations as well as in investigation into the Space Shuttle Columbia and the American Airlines accident in New York in 2001. He holds a chair at the University of Washington Aeronautics and Astronautics department and has published many articles on aviation safety and in fracture mechanics. He is currently the Senior Engineer in the Anchorage ACO where he has worked for the past six years.

Team Members

Dr. Kevin Williams, Research Psychologist Human Factors Laboratory FAA Civil Aerospace Medical Institute

Dr. Kevin Williams is a research psychologist at the Federal Aviation Administration's Civil Aerospace Medical Institute (CAMI) in Oklahoma City, Oklahoma. He received his Ph.D. in cognitive psychology from the University of Oklahoma in 1986. Prior to joining the FAA in 1992, Dr. Williams worked in the Human Factors Engineering group at General Dynamics in Fort Worth, Texas where he was involved in pilot/cockpit interface design issues and the incorporation of artificial intelligence systems in the cockpit. After leaving General Dynamics, he was a team leader of MANPRINT evaluation team during the operational test of an unmanned aerial vehicle (Hunter system) for the U.S. Army and Marine Corps. Since joining CAMI, Dr. Williams has been involved in the development of training device specifications for personal computer-based aviation training devices, advanced general aviation cockpit display studies, Global Positioning Systems (GPS) design and development research, and advanced primary flight displays. He was involved in the Alaska Capstone project looking at the implementation of advanced displays into general aviation aircraft. He is currently involved in human factors, training, and pilot qualification issues for unmanned aircraft systems. Kevin is a member of the Human Factors and Ergonomics Society. He holds a private pilot certificate.

David Brice Banning, Operations Inspector, Fairbanks Flight Standards Office

Brice began his commercial flying career in Alaska over 13 years ago and has accumulated over 7,800 hours of flight time (7,200 in the State of Alaska) in all types of aircraft such as Piper Lances, Navajos, King Airs and Lear jets. Brice is an airline transport pilot (ATP) with commercial privileges for single engine land and sea, certified flight instructor, certified instrument instructor, and multi-engine instructor, as well as a certified airframe mechanic. He has served in many required management positions for multiple 14 CFR Part 135 airlines, including Director of Operations for Guardian Flight, Inc., the largest medevac operator in the State of Alaska. He currently serves as an FAA Principal Operations Inspector in Fairbanks, Alaska, for multiple Part 135 Operators. In 2010, Brice was awarded the FAA Alaska Region Mission Possible Award for his outstanding dedication to ensuring the safety of Part 135 operators and his commitment to reducing FSI accidents for Part 91 and 135 personnel. He consistently volunteers the services of his personal aircraft, a Cessna 170B, to accomplish the FAA’s mission of taking the safety message directly to Part 91 General Aviation (GA) pilots.

Richard Ebert, Anchorage Flight Standards District Office Avionics Inspector

Richard began his aviation career in 1980 graduating as an Airframe and Power plant, A/P Technician from Winona Area Technical Institute in Winona, Minnesota. Richard worked two years on general aviation fixed wing and rotorcraft aircraft in Louisiana. Richard spent the next 23 years working air carrier maintenance at Northwest Airlines in Minneapolis, Minnesota, with time spent in hangar heavy maintenance, instrument repair, and aircraft line maintenance. Richard spent the last several years at Northwest

Airlines in the Radio Communications Department, managing areas of the airline's communications infrastructure before taking a position in Anchorage, Alaska, as a lead technician for the B-747 cargo base. In 2005 Richard left Northwest Airlines and worked the next 4 years in the Alaska general aviation avionics repair station industry; first working in Juneau and Ketchikan, Alaska, as an avionics technician for the FAA Capstone project, then in Fairbanks, Alaska, as an avionics technician, and finally in Anchorage, Alaska, as an avionics repair station manager. Richard was hired by the FAA Anchorage Flight Standards District Office (FSDO) as a GA Avionics Inspector in February 2009 and worked as a Primary Avionics Inspector for several carriers within the Anchorage FSDO. Richard is currently working as a Primary Maintenance Inspector with the Fairbanks FSDO.

Ross Schaller, Small Airplane Directorate Flight Test Engineer

After receiving a Bachelor of Science degree in Aerospace Engineer, Ross accepted a position as a stability & control engineer with General Dynamics where he worked on the F-16 Block 40, the Agile Falcon, the National Aerospace Plane, and the US Navy's A-12. He left General Dynamics to work for an independent flight test engineering firm for the next 17 years. As a flight test engineer/program manager he flight tested over 100 aircraft ranging from a Piper Seminole to a C-17. During that same time, Ross completed the requirements and received a Master of Science degree in Engineering Management. For the last two years, he has accepted the position of Flight Test Engineer in the Regulations & Policy Branch of the Small Airplane Directorate and his primary role has been validating foreign aircraft for US type certification.

Dwayne Edwards, Juneau Flight Standards District Office Airworthiness Inspector

Dwayne began his Aviation career during high school in 1983 as a ramp assistant for a small float plane business in Petersburg, Alaska, loading and unloading aircraft, cleaning, and assisting the mechanic at night. Also in 1983, Dwayne joined the Alaska Army National Guard. In 1986 Dwayne joined the US Coast Guard and served 11 years as an Aviation Structural Mechanic/Flight Mechanic on HH3F and HH60J helicopters. He spent seven years at Air Station Sitka; Alaska, during this time Dwayne was involved in responding to multiple aircraft crashes, lost or missing people, and disabled water crafts and boats. He was taught survival tactics for survival on land and sea in Alaska's tough climate. He then spent four years at the US Coast Guard Aircraft Overhaul Facility in Elizabeth City, North Carolina, working on H-65, HH-3F and HH-60J helicopters and HU-25 and HC-130 fixed wing aircraft. Dwayne left the Coast Guard in 1997. Dwayne received his authorization to take the Airframe and Power plant tests and obtained his A&P certificate in April of 1997. Dwayne then moved to Juneau, Alaska, were he worked for Temsco Helicopters a 135/145 Operator as a field mechanic, shop foreman and lead mechanic; where he was involved with the installation of FAA Capstone equipment into their fleet of AS350 helicopter. Dwayne was hired by the FAA Juneau FSDO as a GA Maintenance Inspector in January 2008 and works as a primary maintenance inspector with operators within the Juneau FSDO region.

Varanda L. Huffman, Executive Assistant, Flight Standards Division

Varanda is an Executive Assistant to the Alaskan Region Flight Standards Division Manager and Assistant Manager. Varanda's aviation background consists of a certificated military Air Traffic Controller (ATC), Air Training Command, in Del Rio, Texas. She was Air Training Command's Air Traffic Controller of the Year 1989, and distinguished graduate of Non Commissioned Officer's preparatory course 1989. In 1991 Varanda received a Bachelor of Science in Professional Aeronautics, from Embry Riddle Aeronautical University. She was hired at the Anchorage Flight Standards District Office ANC FSDO as an Aviation Safety Assistant in 2006 and promoted to Regional Secretary in 2008. Her primary duties included management event planning, scheduling, organization and networking. She accomplishes Flight Safety through partnerships with Flight Standards management, anticipating the needs of management and being an administrative professional.

Management Steering Committee

Angela Elgee, FAA, Alaskan Region, Flight Standards Division Manager
August Asay, FAA, Alaskan Region, Anchorage Aircraft Certification Office Manager
Kimberly Smith, FAA, Small Airplane Directorate, Manager
Kevin Clover, FAA, FAASTeam Manager
David Karalunas, FAA, Alaskan Region FAASTeam Field Office Manager

Support Entities

Robert N. Lewis, FAA, Alaskan Regional Administrator
Greg J. Holt, FAA, Alaskan Regional Deputy Administrator
Jim Labelle, National Transportation Safety Board, Anchorage, Manager
Larry Lewis, National Transportation Safety Board, Anchorage, Investigator
Scott Erikson, National Transportation Safety Board, Anchorage, Investigator
Dee Hanson, Alaska Airmen's Association, Executive Director
Val Jokela, FAA, Alaskan Region Community Relations Officer
Jere Hayslett, FAA, Alaska Aviation Industry Council, Chairman
Dennis Ward, Medallion Foundation, Executive Director
Jerry Rock, Alaska Air Carriers Association, President
Harry Keiling, Department of Interior, Alaska Aviation Safety Foundation and Alaska Regional Director of Aviation Management
Alaska State Troopers
Roger Moztko, FAA, Alaskan Region, Runway Safety Program Manager
Leonard F. Kirk, University of Alaska Anchorage Aviation Technology Department, Assistant Director
Kevin Alexander, University of Alaska Fairbanks Community College Division, Aviation Maintenance Technology Department.

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