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Beneath the Tip of the Iceberg: A Human Factors Analysis of General Aviation Accidents in Alaska Versus the Rest of the United States

Cristy Detwiler, Carla Hackworth, Kali Holcomb[1]
Albert Boquet[2]
Elaine Pfleiderer[1]
Douglas Wiegmann[3]
Scott Shappell[4]

[1]Civil Aerospace Medical Institute
Federal Aviation Administration
Oklahoma City, OK 73125
[2]Embry-Riddle Aeronautical University
Daytona Beach, FL 32114
[3]Mayo Clinic
Rochester, MN 55905
[4]Clemson University
Clemson, SC 29634

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16. Abstract

Historically, general aviation (GA) accidents have been overlooked and their impact under-appreciated when compared with those in the commercial or military sector. Recently however, the Federal Aviation Administration and other governmental and civilian organizations have focused their attention on one piece of this proverbial "iceberg," that being GA accidents occurring in Alaska. This study examines more than 17,000 GA accidents using the Human Factors Analysis and Classification System. Comparisons of Alaska to the rest of the U.S. (RoUS) included traditional demographic and environmental variables, as well as the human errors committed by aircrews. Overall, categorical differences among unsafe acts (decision errors, skill-based errors, perceptual errors, and violations) committed by pilots involved in accidents in Alaska and those in the RoUS were minimal. However, a closer inspection of the data revealed notable variations in the specific forms these unsafe acts took within the accident record. Specifically, skill-based errors associated with loss of directional control were more likely to occur in Alaska than the rest of the U.S. Likewise, the decision to utilize unsuitable terrain was more likely to occur in Alaska. Additionally, accidents in Alaska were associated with violations concerning Visual Flight Rules into Instrument Meteorological Conditions. These data provide valuable information for those government and civilian programs tasked with improving GA safety in Alaska and the RoUS.

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Beneath the Tip of the Iceberg: A Human Factors Analysis of General Aviation Accidents in Alaska Versus the Rest of the United States

INTRODUCTION

Considerable effort has been expended over the last several decades to improve safety in both military and commercial aviation. Even though many people have died and millions of dollars in assets have been lost, the numbers pale in comparison to those suffered every year within general aviation (GA). For example, according to the National Transportation Safety Board (NTSB), there were 1,741 GA accidents in 2003 that resulted in 629 fatalities (NTSB, 2005). While the numbers may not register with some, when considered within the context of commercial aviation, the losses suffered annually by GA are roughly equivalent to the complete loss of three commercial passenger Boeing 727s.

Why, then, has GA historically received less attention? Perhaps it is because flying has become relatively common as literally millions of travelers board commercial aircraft daily. Not surprising then, when a commercial airliner crashes, it instantly becomes headline news, shaking the confidence of the flying public.

In contrast, GA accidents happen virtually every day, yet they receive little attention and seldom appear on the front page of *USA Today*. Perhaps this is because they happen in isolated places, involving only a couple of unfortunate souls at a time. In fact, unless the plane crashed into a school, church, or some other public venue, it is unlikely that anyone outside the local media, government, or those intimately involved with the accident even knew it happened.

Over the last couple of years, general aviation has deservedly received increasing attention from the Federal Aviation Administration (FAA Flight Plan 2004-2008) and other safety professionals. Indeed, several groups from the government (e.g., the FAA's Civil Aerospace Medical Institute, National Institute of Occupational Safety and Health), private sector (e.g., the Medallion Foundation), and universities (e.g., University of Illinois, Johns Hopkins University) have conducted a number of studies examining GA accident causation.

Alaskan Aviation

It is of note that many of these efforts have focused on Alaska, where aviation is the primary mode of transportation. It has been said that people in Alaska fly private aircraft like those in the lower 48 take taxis. As can be seen in Figure 1, when taking into account the size of the state, it is no wonder that air travel is a must. In fact, some parts of Alaska are only accessible by air.

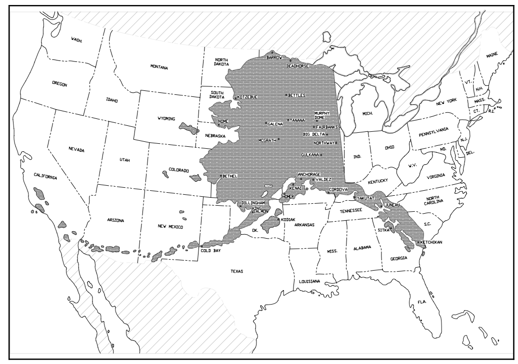

Figure 1. Relative size of Alaska to the continental United States. (Taken from a briefing from the FAA Alaska Region.)

Alaska is known for its varied and often unique landscape, including but not limited to, seemingly endless mountain ranges, glaciers, lakes, long coastlines, volcanoes, and fjords. When this veritable obstacle course is considered, along with temperamental weather and seasonal lighting conditions, even the most experienced pilot would have to agree that Alaskan aviation represents some of the most difficult flying in the U.S., if not the world. The combination of factors mentioned above, the number of GA accidents that are occurring in Alaska, and the FAA's accident reduction goal (FAA Flight Plan 2004-2008) were factors in our decision to implement this study.

Human Error and General Aviation

A variety of studies have been conducted in an attempt to understand the causes of GA accidents. Most have focused on contextual factors or pilot demographics, rather than the underlying causes of the accidents. Past research has shown factors like weather [e.g., Instrument Meteorological Conditions (IMC) versus Visual Meteorological Conditions (VMC)], lighting (e.g., day versus night), and terrain (e.g., mountainous versus featureless) play a part in these accidents; however, pilots have little control over them. Other studies have found that a pilot's gender, age, occupation, or flight experience contribute to the accidents (Baker, Lamb, Grabowski, Rebok, & Li, 2001; Li, Baker, Grabowski, & Rebok, 2001; Urban,

1984) and aid in the identification of target populations for the dissemination of safety information.

However, when the leading cause of accidents, human error, has been addressed, it is often only to report the percentage of accidents associated with aircrew error in general or to identify those in which alcohol or drug use occurred. What is needed is a thorough human error analysis. Previous attempts to do just that have been met with limited success (O'Hare, Wiggins, Batt, & Morrison, 1994; Wiegmann & Shappell, 1997). This is primarily because human error is influenced by a variety of factors that are usually not addressed by traditional classification schemes (Shappell & Wiegmann, 1997). Yet, with the development of the Human Factors Analysis and Classification System (HFACS) previously unknown patterns of human error in aviation accidents have been uncovered (Shappell & Wiegmann, 2001; Wiegmann & Shappell, 2001a).

HFACS

Drawing upon Reason's "Swiss-cheese" model of human error, Wiegmann and Shappell developed HFACS. The HFACS framework includes 19 causal categories within Reason's (1990) four levels of human failure, of which the Unsafe Acts of Operators are most germane to this study (Figure 2). For a complete description of the HFACS framework, see Wiegmann and Shappell, 2003.

In general, the unsafe acts of operators (in the case of aviation, the aircrew) can be classified as either errors or violations. Within HFACS, the category of errors was expanded to include three basic types (decision, skill-based, and perceptual errors) that, in simple terms, refer to errors of "thinking," "doing," and "perceiving." To be more specific, decision errors represent conscious decisions/choices made by an individual that are carried out as intended but prove to be inadequate for the situation at hand. In contrast, skill-based behavior within the context of aviation is best described as "stick-and-rudder" and other basic flight skills that occur without significant conscious thought. As a result, these skill-based actions are particularly vulnerable to failures of attention, memory, or simply poor technique. Finally, perceptual errors occur when sensory input is degraded or "unusual," as is often the case when flying at night, in weather, or in other visually impoverished conditions.

By definition, errors occur while aircrews are behaving within the rules and regulations implemented by an organization. In contrast, violations represent the willful disregard for the rules and regulations that govern safe flight. The key word is "willful" in this definition. That is, the individuals knew that what they were doing was unauthorized but elected to continue anyway.

While there are many ways to distinguish between types of violations, two distinct forms have been identified, based on their etiology. The first, routine violations, tend to be habitual by nature and are often tolerated by the governing authority. The second type, exceptional violations, appear as isolated departures from authority and are not necessarily characteristic of an individual's behavior nor are they condoned by management.

PURPOSE

The present study set out to uncover the types of human error, as identified by HFACS, that contributed to GA accidents in Alaska and compare those results with the rest of the United States. Both the human error findings and contextual factors are presented here to obtain a more complete picture.

METHODS

General aviation accident data from calendar years 1990-2002 were obtained from databases maintained by the National Transportation Safety Board and the FAA's National Aviation Safety Data Analysis Center (NASDAC). In total, 24,978 GA accidents were extracted for analysis. These so-called "GA" accidents actually included a variety of aircraft being flown under several different operating rules: 1) 14 CFR Part 91 – Civil aircraft other than moored balloons, kites, unmanned rockets, and unmanned free balloons; 2) 14 CFR Part 91F – Large and turbine-powered multiengine airplanes; 3) 14 CFR Part 103 – Ultralight vehicles; 4) 14 CFR Part 125 – Airplanes with seating capacity of 20 or more passengers or a maximum payload capacity of 6,000 pounds or more; 5) 14 CFR Part 133 – Rotorcraft external-load operations; 6) 14 CFR Part 137 – Agricultural aircraft operations. In addition, the database contained several accidents involving public use aircraft (i.e., law enforcement, state owned aircraft, etc.) and a few midair accidents involving military aircraft.

It is difficult to envision that large commercial aircraft being ferried from one airport to the next (operating under 14 CFR Part 91F) or aircraft being used to spread chemicals on a field (operating under 14 CFR Part 137) can be equated with small private aircraft being flown for personal or recreational purposes (operating under 14 CFR Part 91). Therefore, we selected only 14 CFR Part 91 accidents for our analyses (22,987) to obtain a more discrete GA sample.

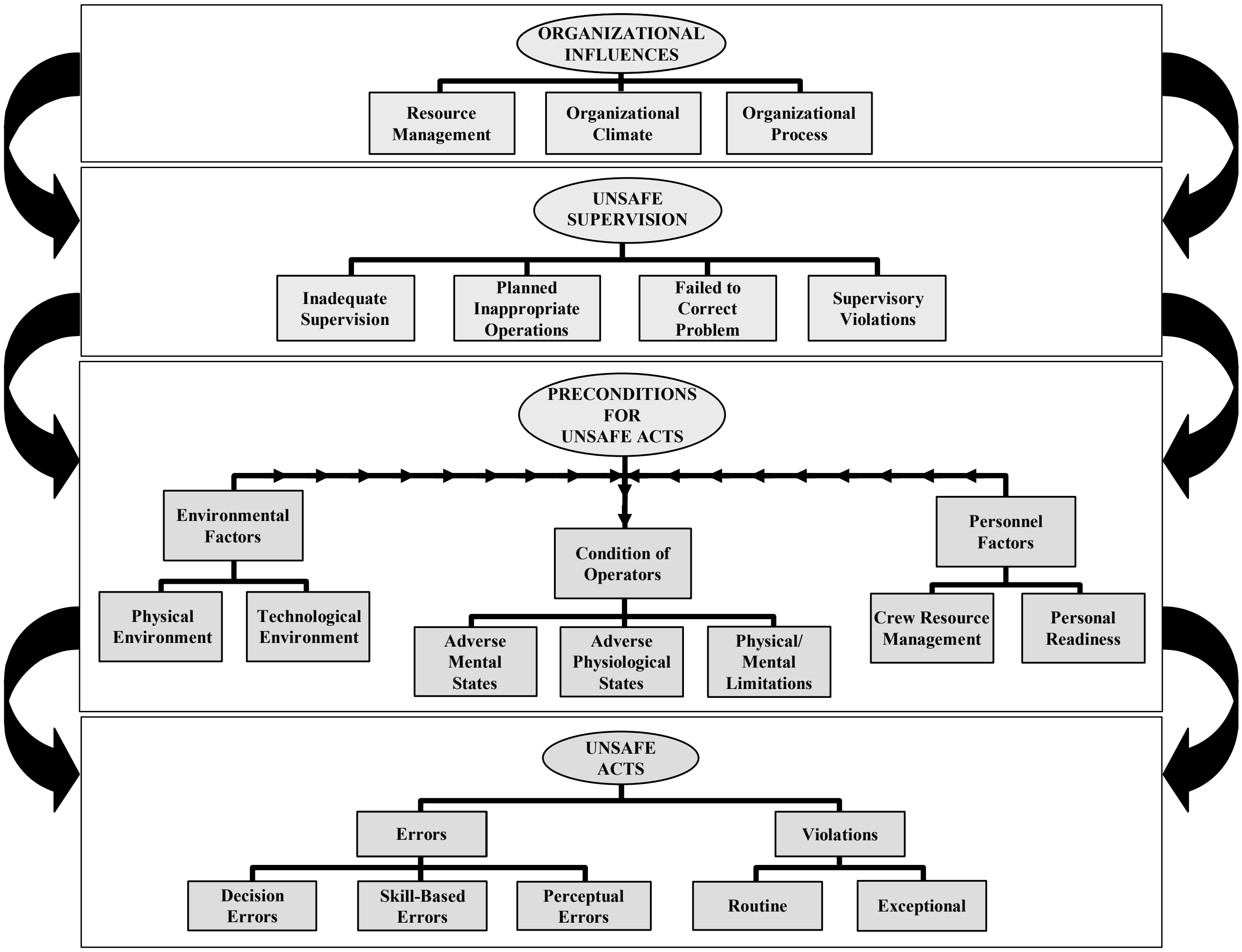

Figure 2. The HFACS framework.

This analysis was primarily concerned with powered aircraft and thus the data were further restricted to include only accidents involving powered fixed-wing aircraft, helicopters, and gyrocopters. The remaining 22,248 accidents were then examined for aircrew-related causal factors. Since we were only interested in those accidents involving aircrew error, not those that were purely mechanical in nature or solely attributable to other human involvement, a final reduction of the data was conducted. Note, this does not mean that mechanical failures or other sources of human error did not exist in the final database, only that some form of aircrew error was also involved in each of the accidents included. Figure 3 depicts the frequency of GA accidents associated with human error from 1990 to 2002. In the end, 17,808 accidents were included in the database that were associated with some form of human error and were submitted to further analyses using the HFACS framework.

Causal Factor Classification Using HFACS

Six GA pilots were recruited from the Oklahoma City area as subject matter experts and received roughly 16 hours of training on the HFACS framework. All seven were certified flight instructors with a minimum of 1,000 flight hours in GA aircraft (mean = 3,530 flight hours) when the study began.

After training, the six GA pilot-raters were randomly assigned accidents, so at least two separate pilot-raters analyzed each accident independently. Using narrative and tabular data obtained from both the NTSB and the FAA NASDAC, the pilot-raters classified each human causal factor using the HFACS framework. Note, however, that only those causal factors identified by the NTSB were classified. That is, the pilot-raters were instructed <u>not</u> to introduce additional casual factors that were not identified by the original investigation. To do so would be presumptuous and only infuse additional opinion, conjecture, and guesswork into the analysis process.

After the pilot-raters made their initial classifications of the NTSB causal factors using HFACS (i.e., skill-based error, decision-error, etc.) the two ratings were compared. Where differences existed between the ratings, the two pilots were asked to reconcile their differences and an agreed-upon "consensus" classification was included in the database for further analysis. Overall, the independent pilot-raters agreed on the classification of human causal factors within the HFACS framework more than 85% of the time. More important, all human causal factors identified in the NTSB records were accommodated using the HFACS framework, and the data were ultimately submitted to a final quality assurance analysis by the authors.

RESULTS

When using HFACS to examine the GA accident data, the majority of the accidents are coded with either a precondition for unsafe acts or an unsafe act. This is due primarily to the fact that there is less of an organizational or supervisory influence on the majority of GA pilots, as compared with their counterparts conducting commercial or "for hire" operations.

Indeed, with few exceptions (e.g., flight instructors and flight training institutions), the top two tiers of HFACS (unsafe supervision and organizational influences) remained sparsely populated when examining the GA accidents, leaving the majority of causal factors within the bottom two tiers of HFACS. Consequently, the balance of this report will focus only on the unsafe acts of the operator level of the HFACS framework.

Unsafe Acts of Operators (Aircrew)

An overall review of the GA accident data yielded the following results (see Figure 4). The most prevalent error noted in the accident data over the past decade was skill-based errors (73%), followed by decision errors (28%), violations (13%), and perceptual errors (7%). The relatively flat lines in the types of unsafe acts across the years suggest that past intervention strategies have had little differential impact on any particular category of error.

To obtain a better sense of how human error differences between Alaska and the rest of the United States (RoUS) are represented in the data, the error types were broken out accordingly (Figure 5). The analysis of the unsafe acts revealed that there were slightly more decision errors, fewer skill-based errors, perceptual errors, and violations in Alaska than there were in the RoUS.

Note, the following analyses did not distinguish between those pilots who were native to Alaska and were involved in an accident versus those who were less familiar with the state. Accordingly, the statistics for Alaska reflect the accidents that occurred within the physical boundaries of the state.

Skill-Based Errors. Differences that existed between Alaska and the RoUS were fairly consistent across the years of study, with slightly more skill-based errors associated with accidents in the RoUS (see Figure 6). The only exception involved 1991, 1996, and again in 2002, where the percentages were nearly equal.

Differences between Alaska and the RoUS were more distinct when the actual types of skill-based error were compared (Table 1). For instance, directional control was the most frequently cited skill-based error for both Alaska (19%) and for the rest of the U.S. (13%). Pilots in

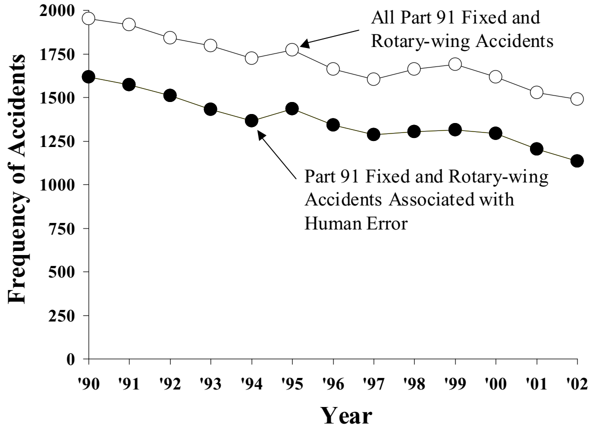

Figure 3. All 14 CFR Part 91 fixed and rotary-wing (Helicopters & Gyrocopters) accidents and the influence of human error in those accidents.

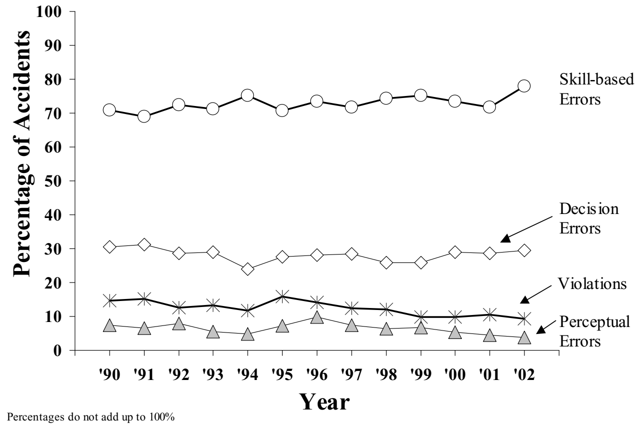

Figure 4. Overall review of general aviation data for HFACS unsafe acts.

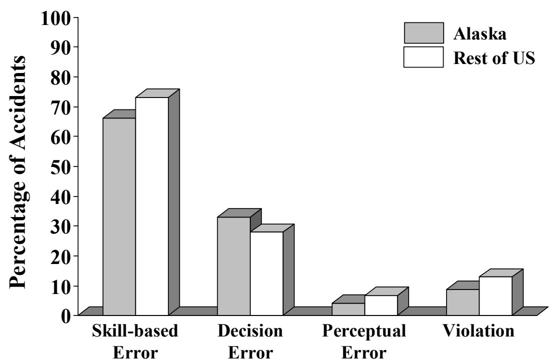

Figure 5. Percentage of accidents associated with each of the unsafe acts of the operator.

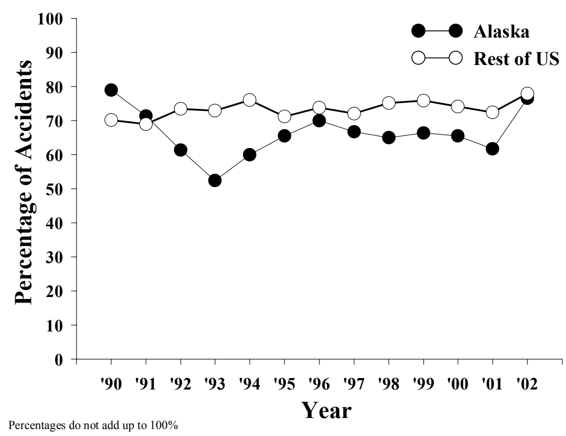

Figure 6. Skill-based errors broken out by Alaska versus the rest of the U.S.

Table 1. *Top 5 Skill-based errors occurring for Alaska and the rest of the U.S.*

Alaska	N (%)	RoUS	N (%)
Directional Control	206 (18.6%)	Directional Control	2139 (12.6%)
Compensation for Wind Conditions	170 (15.4%)	Airspeed	1932 (11.3%)
Stall	88 (8.0%)	Stall	1312 (7.7%)
Airspeed	76 (6.9%)	Aircraft Control	1310 (7.7%)
Ground Loop/Swerve	50 (4.5%)	Compensation for Wind Conditions	1009 (5.9%)

Alaska were more likely to experience a loss of directional control of their aircraft than those in the rest of the U.S. (odds ratio = 1.593, X^2 = 33.400, p <.001). Additionally, inadequate compensation for wind conditions was almost three times more likely to occur in Alaska (odds ratio = 2.884, X^2 = 150.893, p <.001). Conversely, pilots in the rest of the U.S. were almost two times more likely to commit airspeed errors than those in Alaska (odds ratio = 1.733, X^2 = 20.652, p <.001).

Decision Errors. To better understand the complexity of the decision errors that were occurring in the accidents for both Alaska and the rest of the U.S., a fine-grained analysis of the data was conducted. Figure 7 illustrates the decision error trends for Alaska and the rest of the U.S. across the 13-year period from 1990-2002. With the exception of 1990, 1991, and 2002, any difference that did exist was remarkably consistent across years of the study.

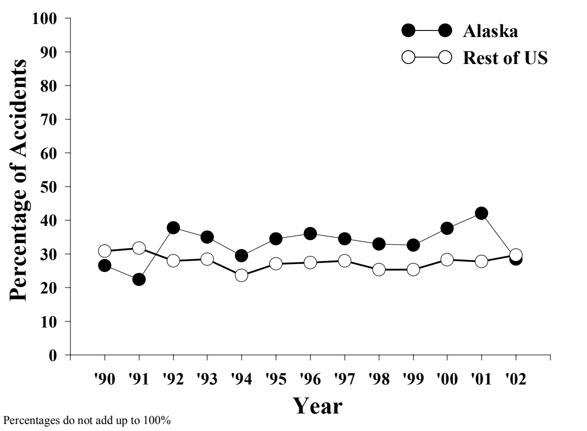

Figure 7. Decision errors broken out by Alaska versus the rest of the U.S.

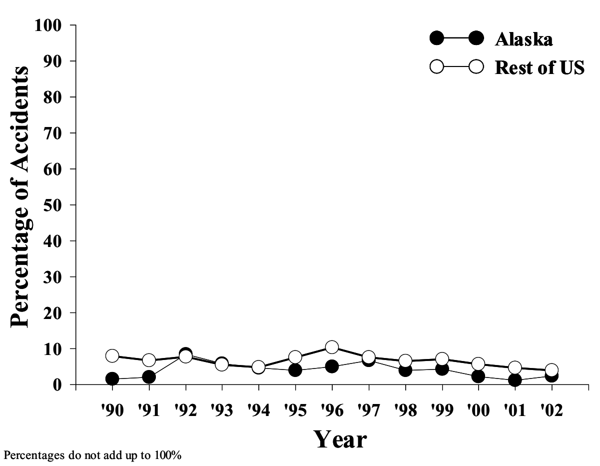

Figure 8. Perceptual errors broken out by Alaska versus the rest of the U.S.

Upon closer examination, the largest proportion of decision errors in the rest of the U.S. involved in-flight planning/decision making, accounting for 19% of those observed. However, the top decision error for pilots flying in Alaska dealt with decisions to utilize unimproved landing, takeoff, taxi areas, or unsuitable terrain. As a matter of fact, those flying in Alaska were almost 15 times more likely to take off from and land on unsuitable terrain than those in the rest of the U.S. (odds ratio = 14.703, X^2 = 829.461, p <.001). A break-out of the top five decision errors for Alaska and the rest of the U.S. are presented in Table 2.

Perceptual Errors. Generally associated with less than 10% of the accidents, perceptual errors in Alaska occurred with a similar frequency as those in the rest of the U.S. (see Figure 8). Moreover, there were few, if any, reliable differences between Alaska and the RoUS when the type of perceptual error was examined (Table 3). Indeed, given the very small cell size for specific types of perceptual errors occurring in Alaska, it was difficult to draw any defensible conclusions.

Violations. In general, violations were associated with less than 20% of GA accidents (Figure 9). For the entire U.S. population, nearly 50% of these accidents resulted

Table 2. *Top 5 Decision errors occurring for Alaska and the rest of the U.S.*

Alaska	N (%)	RoUS	N (%)
Unsuitable Terrain	193 (40.5%)	In-flight Planning/ Decision	1002 (18.7%)
In-flight Planning/ Decision	59 (12.4)	Planning/ Decision	374 (7.0%)
Aborted Takeoff	28 (5.9%)	Refueling	351 (6.5%)
Planning/ Decision	19 (4.0%)	Remedial Action	339 (6.3%)
Go-around	18 (3.8%)	Go-around	336 (6.3%)

Table 3. *Top 5 Perceptual errors occurring for Alaska and the rest of the U.S.*

Alaska	N (%)	RoUS	N (%)
Flare	12 (21.1%)	Flare	246 (20.1%)
Aircraft Control	6 (10.5%)	Aircraft Control	201 (16.4%)
Altitude	5 (8.8%)	Altitude	121 (9.9%)
Clearance	5 (8.8%)	Distance/ Speed	98 (8.0%)
Proper Touchdown Point	5 (8.8%)	Distance/ Altitude	87 (7.1)

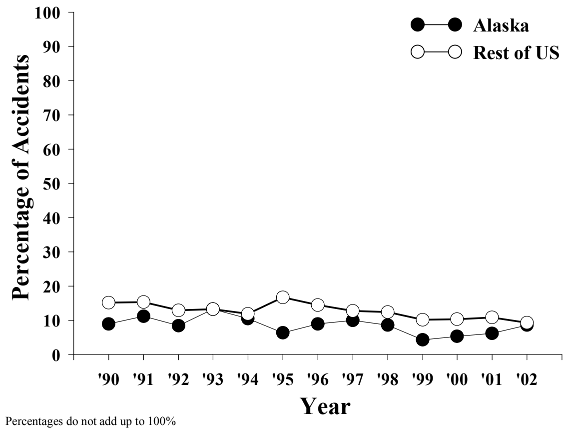

Figure 9. Violations broken out by Alaska versus the rest of the U.S.

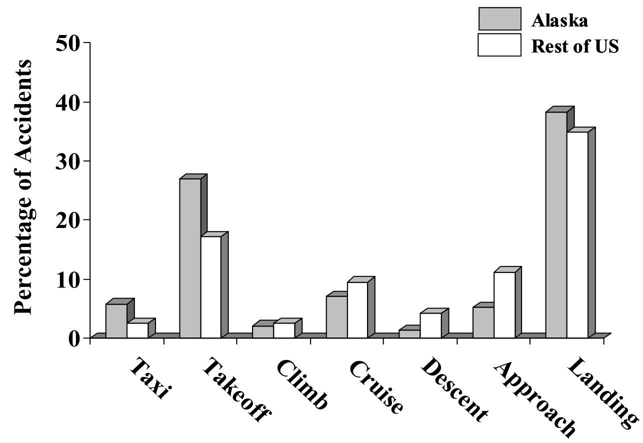

Figure 10. Percentage of accidents occurring in each phase of flight for Alaska and the rest of the U.S.

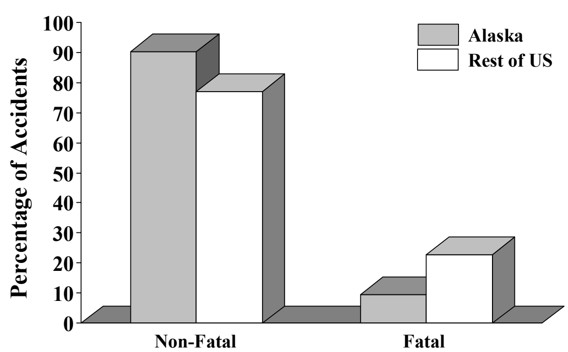

Figure 11. Percentage of fatal versus non-fatal accidents in Alaska and the rest of the U.S.

Table 4. *Top 5 Violations occurring for Alaska and the rest of the U.S.*

Alaska	N (%)	RoUS	N (%)
VFR Into IMC	38 (32.5%)	VFR Into IMC	369 (15.5%)
Aircraft Weight & Balance	13 (11.1%)	Operation with Known Deficiencies	261 (10.9%)
Procedures/ Directives	12 (10.3%)	Procedures/ Directives	248 (10.4%)
Flight Into Known Adverse Weather	11 (9.4%)	Flight Into Known Adverse Weather	212 (8.9%)
Operation With Known Deficiencies	8 (6.8%)	Aircraft Weight & Balance	149 (6.2%)

in a fatality. When examining accidents in Alaska separately from the rest of the U.S., differences were found. Accidents involving violations in Alaska were nine times more likely to result in a fatality (odds ratio = 9.248, X^2 = 127.606, p <.001); whereas those that occurred in the rest of the U.S. were four times more likely to result in a fatality, (odds ratio = 4.410, X^2 = 1054.059, p <.001).

A closer look at the types of violations revealed that the most frequently cited violation for all GA accidents was Visual Flight Rules (VFR) flight into Instrument Meteorological Conditions (IMC), (Table 4). VFR flight into IMC, alone, accounted for one-third of the violations in the Alaska data and was more than two and a half times more likely to occur than in the rest of the U.S. (odds ratio = 2.629, X^2 = 22.467, p <.001). Furthermore, when the weather-related violations were combined (VFR into IMC, flight into known adverse weather, and flight into adverse weather), nearly half of the violations in the Alaska data were represented.

Contextual Data

Phase of Flight. The majority of GA accidents for Alaska and the rest of the U.S. occurred during the landing and takeoff phases of flight (see Figure 10). Note, however, that the accidents in Alaska had a higher occurrence in both of those phases than those in the rest of the U.S., where cruise and approach were higher. Additionally, when takeoff and climb are compared against descent, approach, and landing, across the board, comparatively more accidents occurred during the latter phases of flight.

Fatal vs. Non-Fatal and Injury Level. Curiously, accidents occurring in the RoUS were more likely to include a fatality (23%) than those in Alaska (10%, see Figure 11). Specifically, the accidents in the RoUS were 2.8 times more likely to result in a fatality (odds ratio =2.808, X^2 = 125.090, p <.001). This pattern held across all levels of injury severity (Figure 12) as roughly three-fourths of the GA accidents occurring in Alaska involved no injuries at all.

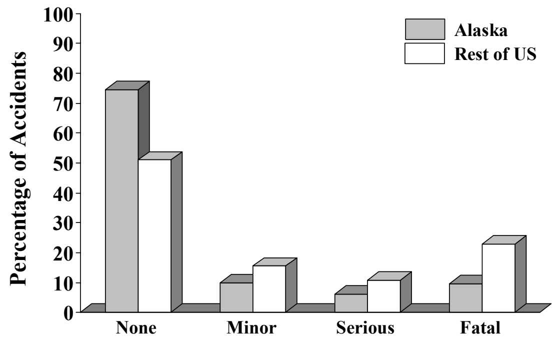

Figure 12. Percentage of accidents associated with the four levels of injury.

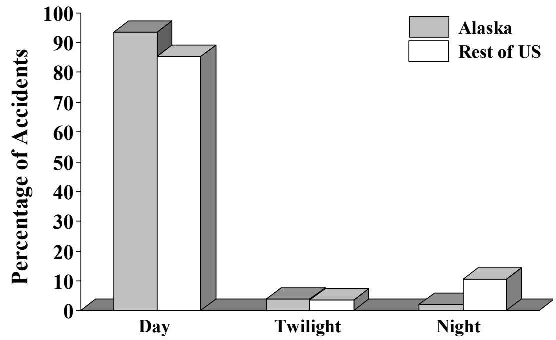

Figure 13. Lighting conditions for accidents occurring in Alaska and the rest of the U.S.

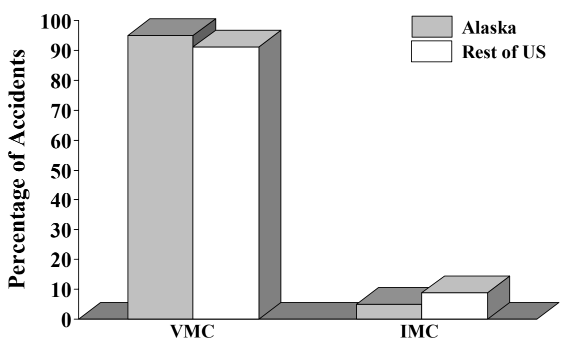

Figure 14. Weather conditions associated with accidents in Alaska and the rest of the U.S.

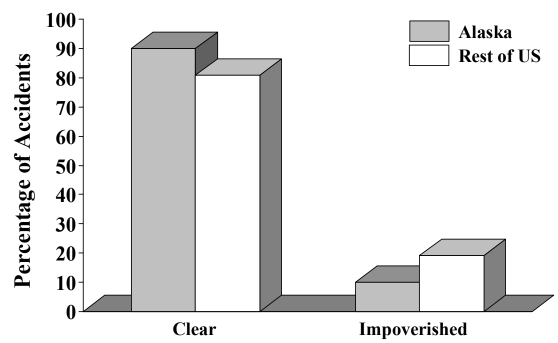

Figure 15. Accidents occurring in clear versus impoverished conditions for Alaska and the rest of the U.S.

Weather and Lighting Conditions. Very few differences between Alaska and the rest of the U.S. were noted with regard to either lighting conditions (day, twilight, and night) or weather (IMC vs. VMC). That is, the vast majority of accidents occurred during the daytime and in VMC conditions (Figures 13 & 14). However, when the two conditions were combined to create a measure of visibility (i.e., clear versus impoverished condition), some small but significant differences emerged (Figure 15). Specifically, accidents were more likely to occur in visually impoverished (at night/twilight or IMC) conditions in the rest of the U.S. than in Alaska (odds ratio =2.160, $X^2 = 68.766$, $p < .001$).

DISCUSSION

On the surface, there were no major differences between Alaska and the rest of the U.S. with regard to the overall pattern of human error. If anything, there were slightly more decision errors associated with accidents occurring in Alaska and fewer skill-based errors, perceptual errors, and violations. This information is similar to research in other aviation operations, which identified skill-based errors as the most commonly occurring type of error (Shappell & Wiegmann, 2003; Wiegmann & Shappell, 2001b; 2003).

Upon closer examination, both Alaska and the rest of the U.S. exhibited similar problems with regards to the specific types of each HFACS causal category. When addressing skill-based errors, the accident data suggest that aircraft handling should be taken into account when determining where interventions should be applied. For instance, any training (both *ab initio* and recurrent) along these lines should include control of the aircraft on the ground (e.g., ground loops), crosswind landings, avoiding and recovering from stalls, and general control of the aircraft in flight. Given the inherent risk associated with some of these maneuvers, it makes sense to utilize modern simulators during this training. Unfortunately, it is unclear whether adequate transfer of training warrants this possibility. Therefore, before utilizing simulations to address these issues, research needs to be conducted to examine the role simulators might offer. In the meantime however, it appears to make sense to emphasize these topics during actual in-flight training.

The only notable exception among the HFACS casual categories involved decision errors. Specifically, pilots in Alaska were more likely to utilize unsuitable terrain for landing, taxi, and takeoff. It would appear that educating aviators on the hazards of utilizing frozen rivers or gravel bars, for example, may reduce these types of errors. However, it may be that there are simply more "improved" areas in the rest of the United States, providing pilots with more options in case of an emergency (i.e., alternate airports, highways, roads, etc.), in which case education in and of itself may not prove successful. Additionally, it is worth noting that "unsuitable terrain" was defined by the NTSB investigators after the fact; the moment to moment judgment of how suitable terrain may be during a flight may be influenced by factors not considered fully in post hoc analyses.

Also of concern in both Alaska and the rest of the U.S. was in-flight planning/decision making. After all, decisions made during flight are often more critical than those occurring on the ground. Thus, when confronted with important decisions in-flight, pilots are often under pressure to be right the first time with limited information. Scenario-based training along these lines as provided within the FAA-Industry Training Standards (FITS) program may improve decision-making in the cockpit, particularly if examples are drawn from the accident record.

Of the unsafe acts that aircrew commit, addressing violations may be the most difficult and complex. Recall that violations are the "willful" disregard for the rules and, as such, are not necessarily something that can be easily deterred or mitigated. Nevertheless, since nearly half of violations involved fatalities, such behaviors as VFR flight into IMC are of great concern to the FAA and other aviation safety professionals.

Even though the percentage of accidents associated with violations did not differ markedly between Alaska and the rest of the U.S., the specific types of violations did differ in meaningful ways. In particular, when intentional VFR flight into IMC and other adverse weather conditions were combined, an alarming 47% of the violations occurring in Alaska were accounted for (27% for the rest of the U.S.). Exactly why a larger proportion was observed in Alaska remains unknown, but one reason may be the rapid climatic changes that often occur, especially around mountainous areas.

So why would a VFR-only pilot fly into such hazardous conditions? This has perplexed safety professionals and aviation psychologists alike. At least one study suggests that pilots' overconfidence in their personal ability and need for goal achievement (too much was already invested in the trip to turn around or deviate from course) may explain this behavior (Goh & Wiegmann, 2002). Other research proposed certain factors that influence the pilot's decision to press into the weather, specifically in Alaska, could be due to the lack of relevant information, ambiguous cues, time pressure, and risk perception, among others (Holbrook, Orasanu, & McCoy, 2003). Batt and O'Hare (2005) have proposed that the decision to fly into degraded conditions could depend on the stage of flight. They hypothesize that in the early part of the flight, pilots will weigh the alternatives of continuing the flight or turning around. Later in flight, pilots debate on whether to perform a precautionary landing (considering the loss and potential damage that can result) or to continue into weather and hope conditions improve, avoiding the potential loss. Regardless of the reasons, it is imperative that pilots be adequately informed and trained on the real dangers that they encounter when they continue or attempt VFR flight into hazardous weather conditions.

Current interventions, like weather cameras in mountain passes and other locations, have proved useful by providing pilots with access to real-time weather information and therefore allowing them to make informed decisions. In addition, the Medallion Foundation has provided GA pilots training using high-resolution flight simulators capable of producing simulated weather and lighting conditions over the Alaskan terrain. With this technology, pilots are able to safely navigate through Alaska and see what flying through places such as Merrill Pass in adverse weather conditions could entail, a difficult task even for a highly experienced pilot to successfully perform in clear conditions.

Alaska, as perhaps the FAA's largest aviation laboratory, has been the testbed for advanced avionics like those associated with the Capstone project. Enhanced weather radar, global positioning sensors, Automated Dependent Surveillance – Broadcast (ADS-B), and other cutting-edge technologies provide a more accurate picture of how the weather, terrain, and traffic situations actually look from inside the cockpit. These technologies have proven useful with 14 CFR Part 135 (commuter) operations (Williams, Yost, Holland, & Tyler, 2002). However, their efficacy within GA remains to be seen.

Although technology has led to a reduction in aviation accidents in Alaska, we cannot rely solely on it as the panacea for GA safety. Being a successful pilot requires basic "stick and rudder" skills. These are particularly important during the critical phases of flight (i.e., takeoff and landing). Similar to previous reports (AOPA, 2005), we found the largest percentage of accidents occurred during takeoff and landing. A larger proportion of these accidents occurred in Alaska than in the rest of the U.S. This is consistent with the observation that in Alaska decisions concerning takeoff and landing from unimproved terrain account for a significant proportion of accidents. Importantly, unlike violations, these types of decision errors typically have not resulted in fatalities (Wiegmann et al., 2005). However, this does not mean that they did not involve significant damage to the aircraft or have a significant economic impact.

CONCLUSIONS

In recent years, a growing concern has been directed toward GA accident rates. Indeed the FAA Administrator has set a goal of a 20% reduction in GA accidents by fiscal year 2008. If this goal is to be realized, interventions that target the underlying human causes as identified in this analysis need to be developed.

The next step in this research effort will be the development of the Human Factors Intervention Matrix (HFIX), which pits the unsafe acts of operators (i.e., skill-based errors, decision errors, perceptual errors, and violations) against several putative intervention approaches (e.g., organizational, human-centered, technology, task, and environment; Figure 16). In addition, other features will be integrated into the model/matrix such as feasibility, efficacy, and acceptance.

	Organizational/ Administrative	Human/ Crew	Technology/ Engineering	Task/ Mission	Operational/ Physical Environment
Decision Errors					
Skill-based Errors					
Perceptual Errors					
Violations					

Figure 16. The Human Factors Intervention Matrix (HFIX).

Once developed, HFIX will be validated and assessed using intervention programs currently in use and planned within the Small Airplane Directorate (ACE-100), the General Aviation & Commercial Division (AFS-800), Alaska Region (AAL), and other FAA offices.

Ultimately, the systematic application of HFACS, coupled with the methodical utilization of HFIX (once fully developed) to generate intervention solutions, should ensure that the aviation industry's personnel and monetary resources are utilized wisely. This should occur because such efforts will be needs-based and data-driven. Together, these tools will allow the true effectiveness of intervention programs to be objectively and impartially evaluated so that they can be either modified or reinforced to improve system performance. Only then can any great strides in improving the GA accident rate be achieved.

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