A human factors analysis of general aviation accidents in Alaska versus the rest of the United States

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General aviation (GA) accidents that occurred in Alaska versus the rest of the United States were compared using the Human Factors Analysis and Classification System (HFACS). 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 rest of the U.S. were minimal. However, a closer inspection of the data revealed notable variations in the specific forms of unsafe acts 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 VFR into IMC. These data provide valuable information for those government and civilian programs tasked with improving GA safety in Alaska and the rest of the US.

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 727's.

Why then has GA historically received less attention? Perhaps it has something to do with the fact that flying has become relatively common as literally millions of travelers board commercial aircraft daily to get from place-to-place. Not surprisingly 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, GA has deservedly received increasing attention from the FAA (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. Alaska is known for its varied and often unique landscape and when this is considered 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. 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 where alcohol or drug use occurred. What is needed is a thorough human error analysis. Previous attempts to do just that have 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).

METHOD

GA accident data from calendar years 1990-2002 were obtained from databases maintained by the NTSB and the FAA's National Aviation Safety Data Analysis Center (NASDAC). In total, 24,978 GA accidents were extracted for analysis. Only accidents occurring during 14 CFR Part 91 operations were included (22,987 cases). 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. In the end, 17,808 accidents were included in the database that were associated with some form of human error and submitted to further analyses using the HFACS framework.

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 typically not much of an organizational structure or supervisory influence on the majority of GA pilots, as compared to 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 1). 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%).[1] 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.

[1] These percentages do not add up to 100 because an accident could be assigned more than one HFACS code (i.e., DE, SBE, PE, etc..).

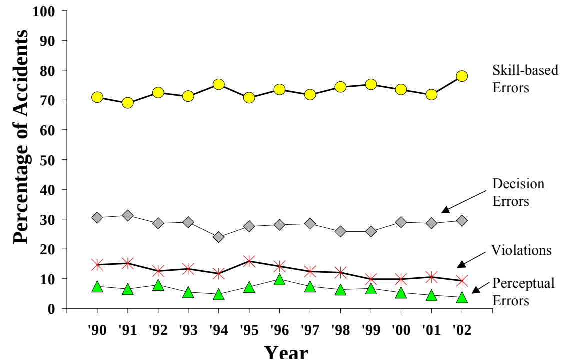

Figure 1. Overall review of general aviation data for HFACS unsafe acts.

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 2). 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. That being said, the numbers for Alaska reflect the accidents that occurred within the physical boundaries of the state.

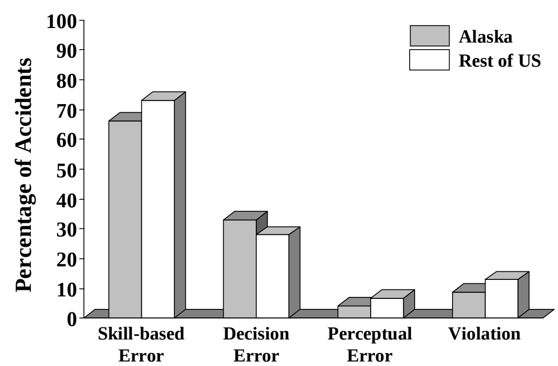

Figure 2. Percentage of accidents associated with each of the unsafe acts of the operator.

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 3). The only exception involved 1991, 1996, and again in 2002 where the percentages were nearly equal.

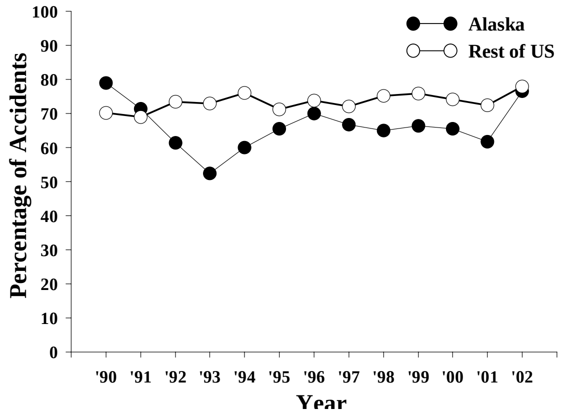

Figure 3. Skill-based errors broken out by Alaska versus the RoUS.

Differences between Alaska and the RoUS were more distinct when the actual type of skill-based error was 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 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 demonstrate airspeed errors than those in Alaska, (odds ratio = 1.733, X^2 = 20.652, $p < .001$).

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%)

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 4 illustrates the decision error trends for Alaska and the rest of the U.S. across the thirteen-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.

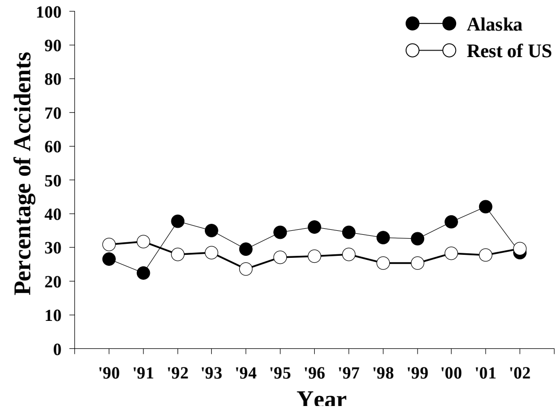

Figure 4. Decision errors broken out by Alaska versus the rest of the U.S.

Upon closer examination, the largest proportion of decision errors in the RoUS 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 takeoff and land from unsuitable terrain than those in the RoUS (odds ratio = 14.703, X^2 = 829.461, $p < .001$). A break-out of the top 5 decision errors for Alaska versus the rest of the U.S. is presented in Table 2.

Table 2. Top 5 Decision errors occurring for Alaska and the RoUS.

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%)

Violations. In general, violations were associated with less than 20% of GA accidents (Figure 5). For the entire U.S. sample, nearly 50% of these accidents resulted in a fatality. When examining accidents in Alaska separately from the RoUS, differences were found. Accidents involving violations in

Alaska were 9 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 4 times more likely to result in a fatality, (odds ratio = 4.410, X^2 = 1054.059, p <.001).

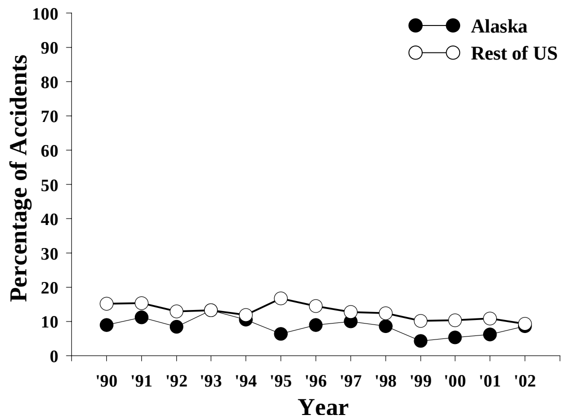

Figure 5. Violations broken out by Alaska versus the RoUS.

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 3). VFR flight into IMC alone accounted for one-third of the violations in the Alaska data and was over two and a half times more likely to occur there than in the RoUS (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.

Table 3. 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%)

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).

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 there would be adequate transfer of training for these specific tasks to make simulation training viable. Therefore, before utilizing simulation to address these issues, research needs to be conducted to determine the best role simulators might play. In the meantime however, it appears necessary 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 RoUS, 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 a classification imposed by the NTSB investigators after the fact, and 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 during flight, pilots are often under pressure to be right the first time while using limited information. Scenario-based training along these lines like that 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, behaviors like 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 RoUS, 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 weather changes that often occur, especially around mountainous areas.

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 pilot training using high-resolution flight simulators capable of producing simulated weather and lighting conditions and terrain depictions which are all appropriate to Alaska. 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 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 situation 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.

CONCLUSIONS

In recent years, a growing concern has been directed toward GA accident rates. 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. Only then can any great strides in improving the GA accident rate be achieved.

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