IS PROFICIENCY ERODING AMONG U.S. NAVAL AIRCREWS? A QUANTITATIVE ANALYSIS USING THE HUMAN FACTORS ANALYSIS AND CLASSIFICATION SYSTEM

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With shrinking military budgets and the inevitable drawdown after the Cold War, the potential erosion of aircrew readiness/proficiency has been a source of concern within the U.S. Department of Defense. Unfortunately, it has been difficult to quantify proficiency using traditional performance measures. However, an analytic tool, the Human Factors Analysis and Classification System (HFACS) was recently developed that has enabled those within the Department of Defense and civilian aviation communities to examine pilot proficiency using accident data. An analysis of U.S. Navy/Marine Corps Class A aviation accidents occurring between fiscal years 1991 and 1998 was conducted using HFACS to determine what, if any, trends were evident that would indicate an erosion of pilot proficiency. Notably, a steady increase in the percentage of accidents associated with skill-based errors was observed beginning in 1991. To the degree that skill-based errors reflect a lack of proficiency, they provide an objective indicator of pilot ability. Several explanations have been suggested for this apparent trend including a reduction in flight hours, changes in aircrew training, and/or pilot retention. By employing HFACS, safety professionals can gain a better understanding of previously nebulous topics such as pilot proficiency.

INTRODUCTION

Throughout the last century mankind has witnessed a remarkable evolution among military aircraft as propeller driven aircraft made from cloth and wood have evolved into today's advanced jet aircraft. Yet, improvements in aircraft provide only half of the story. The aircrew must also evolve with each succeeding generation of aircraft. In effect, the days of the barnstorming pilot who flew by the seat-of-his-pants are gone. Those pilots have been replaced by college-educated engineers and technicians armed with state-of-the-art systems and tactical skills the likes of which their predecessors could only dream of.

Yet, at what price has this evolution among aircrew taken place? Some military leaders have argued that while aircrew today are better trained and perhaps superior decision makers, that this improved cognitive ability has come at the cost of basic flight skills and proficiency. Furthermore, this perception has been exacerbated by a shrinking military budget and the inevitable draw-down after the Cold War, resulting in reduced flight hours, training and retention. It is not surprising then that aircrew proficiency has been a source of concern among members of the Department of Defense.

Unfortunately, while some have questioned the proficiency of our military aircrews, deciding how best to quantify it has been difficult using traditional measures. One solution may be the Human Factors Analysis and Classification System (HFACS), an accident investigation and analysis tool, which enables those within military and civilian aviation to examine human error trends (Shappell & Wiegmann, in press).

HFACS

It is generally accepted that aviation mishaps, like most accidents, do not happen in isolation. Rather, they are the result of a chain of events often culminating in the unsafe acts of aircrew. From Heinrich's (Heinrich, Peterson, & Roos, 1931) axioms of industrial safety, to Bird's (1974) "Domino theory" and Reason's (1990) "Swiss cheese" model of human error, a sequential theory of accident causation has been embraced by many in the field. Particularly useful in this regard has been Reason's (1990) description of active and latent failures within the context of his "Swiss cheese" model of human error.

In general, Reason described four levels of human failure, each one influencing the next. Those levels include: 1) Organizational influences, 2) Unsafe supervision, 3) Preconditions for unsafe acts, and 4) The unsafe acts of operators. Unfortunately, while Reason's seminal work revolutionized the way aviation and other accident investigators view the human causes of accidents, it did not provide the level of detail necessary to apply it in the real world. Consequently, HFACS was developed to fill that need.

Drawing upon Reason's (1990) original work then, Shappell & Wiegmann, (in press) developed a comprehensive human error framework was developed - the Human Factors Analysis and Classification System (HFACS). Included in HFACS are 16 causal categories within Reason's (1990) four levels of human failure. Unfortunately, a complete description of all 16 causal categories is beyond the scope of this brief manuscript. However, a complete description of all 16 causal categories is available elsewhere (Shappell & Wiegmann, in press).

HFACS indices of proficiency and decision making

Particularly germane to any investigation of aircrew proficiency and decision-making are the unsafe acts of operators (i.e., aircrew when considering aviation) as contained in HFACS. These unsafe acts have been loosely classified by Reason (1990) and within HFACS as either errors or violations.

In general, errors represent the mental or physical activities of individuals that fail to achieve their intended outcome. Not surprising, given the fact that human beings by their very nature make errors, these unsafe acts dominate most accident databases. Typically, much less common however, violations refer to the willful disregard for the rules and regulations that govern the safety of flight. While violations in their own right are the bane of many organizations, it is the errors that aircrew commit that yield a better understanding of pilot proficiency and decision making.

Even so, there are different types of errors, not all of, which were relevant to this study. For example, within HFACS, the category of errors was expanded to include three basic error types (skill-based, decision, and perceptual). Yet only the first two error forms, skill-based errors and decision errors, are directly influenced by pilot proficiency and decision making skills. Consequently, these will be briefly described below.

Skill-based Errors. 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 and/or memory. In fact, attention failures have been linked to many skill-based errors such as the breakdown in visual scan patterns, task fixation, the inadvertent activation of controls, and the misordering of steps in procedures, among others. Likewise, memory failures such as omitted items in a checklist, place losing, or forgotten intentions have adversely impacted the unsuspecting aircrew.

Equally compelling yet not always considered by investigators, is the manner or technique one uses when flying an aircraft. Regardless of one's training, experience, and educational background, pilots vary greatly in the manner in which they control their aircraft. In fact, such techniques are as much an overt expression of ones personality as they are a factor of innate ability and aptitude. More important, these techniques can interfere with the safety of flight or may exacerbate seemingly minor emergencies experienced in the air.

Decision Errors. The second error form, decision errors, represent intentional behavior that proceeds as intended, yet the plan proves inadequate or inappropriate for the situation. Often referred to as "honest mistakes", these unsafe acts represent the actions or inactions of individuals whose heart is in the right place, but they either did not have the appropriate knowledge or just simply chose poorly.

Decision making and associated errors have been studied, debated, and reported extensively in the literature. In general however, decision errors can be grouped into one of three categories: procedural errors, poor choices, and problem solving errors. Procedural decision errors (Orasanu, 1993) or rule-based mistakes as referred to by Rasmussen, (1982) occur during highly structured tasks of the sorts, if X, then do Y. Aviation, particularly within the military, by its very nature is highly structured, and consequently, much of pilot decision making is procedural. That is, there are very explicit procedures to be performed at virtually all phases of flight. Unfortunately, on occasion these procedures are either misapplied or inappropriate for the circumstances culminating in a mishap.

However, even in aviation, not all situations have corresponding procedures to deal with them. Therefore, many situations require a choice be made among multiple response options. This is particularly true when there is insufficient experience, time, or other outside pressures that may preclude a correct decision. Put simply, sometimes we chose well, and sometimes we do not. The resultant choice decision errors (Orasanu, 1993), or knowledge-based mistakes (Rasumussen, 1982) have been of particular interest to the U.S. Navy/Marine Corps over the last several decades.

Finally, there are instances when a problem is not well understood, and formal procedures and response options are not available. In effect, in these situations aircrew find themselves where no one has been before and textbook answers are no where to be found. It is during these ill-defined situations that the invention of a novel solution is required. Unfortunately, individuals placed in this situation must resort to slow and effortful reasoning processes where time is a luxury rarely afforded. Consequently, while this type of decision-making is more infrequent then other forms, the relative proportion of problem-solving errors committed is markedly higher.

Research objectives

The purpose of the present study was to examine the U.S. Navy/Marine Corps accident record to determine what, if any, evidence exists that would either support or refute assertions that aircrew decision making has improved at the cost of proficiency – an effect exacerbated by the recent military draw-down. Likewise, and to the extent aviation accidents associated with aircrew error accurately portray a lack of proficiency and decision making ability, it would seem reasonable to begin any investigation with associated skill-based and decision errors.

METHOD

Between fiscal years (FY) 1991 and 1998, the U.S. Navy/Marine Corps experienced 323 Class A mishaps for a variety of reasons. However, the purpose of this study was to examine aircrew proficiency and decision making not an omnibus study of human error. Therefore, only a subset of these accidents was included in the analyses. Consequently, mishaps involving training aircraft were excluded because training flights presumably involved aircrew who had not yet become proficient. This reduced the number of mishaps examined to 292. Of these, only 170 were associated with the unsafe acts of aircrew. It was this final subset of the data that was submitted to further analyses.

Using the final Naval Safety Center report, each causal factor associated with the 170 mishaps described above was classified by a panel of experts into one of 16 HFACS causal categories (i.e., this study was a piece of a much larger investigation) of which skill-based errors and decision errors are a part. Note however, that only those causal factors identified by the original mishap investigation board and subsequently endorsed by the chain-of-command, were included. In other words, the mishaps were not "reinvestigated," nor were any causal factors added to the final report. In this study, the panel of experts consisted of U.S. Navy Flight Surgeons, Aviation Psychologists, and designated Naval Aviators. A group consensus was reached on all classifications before submitting the data to further HFACS analyses.

RESULTS

All human causal factors associated with the 170 U.S. Navy/Marine Corps Class A mishaps were successfully classified into the 16 causal categories of HFACS. However, only data associated with the skill-based error and decision error categories are reported here.

Of the 170 mishaps, roughly half (89) were associated with skill-based errors while 100 were associated with decision errors. While this finding is interesting and provides objective and quantifiable data, the fact that 50-60% of the human error mishaps were associated with skill-based and decision errors was not particularly surprising.

However, what HFACS provides is the ability to examine trends in these error forms over the duration of the study. In particular, two questions were of interest. First, what is the probability that a skill-based error or decision error occurred given an accident was caused by a human error? Second, what is the likelihood that any accident will be caused by either a skill-based or a decision error? These two questions require two separate analyses to answer them. The first requires the calculation of the percentage of human error accidents associated with each error form, while the second requires that a rate based on some exposure measure (e.g., flight hours) be computed.

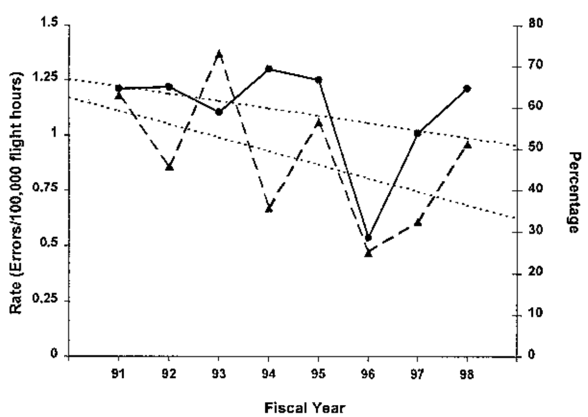

Figure 1. Rate (triangles and broken line) and percentage (circles and solid line) of mishaps associated with decision errors. Linear trends are plotted as a dashed line for both curves.

Both the percentage and rate data associated with decision errors are presented in Figure 1. The percentage of human error mishaps associated with skill-based errors ranged from a high of 69% in FY 1994 to a low of 29% in FY 1996. Similarly, the rate of accidents attributable at least in part to decision errors ranged from a high of 1.37 mishaps/100,000 flight hours in FY 1993 to a low of 0.47 in FY 1996. An examination of the related trends revealed that both the rate of accidents and the percentage human error mishaps associated with decision errors have declined since FY 1991. Notably however, an increase in both was evident in FY 1997 and FY 1998.

In contrast to the overall decline in decision errors observed during the years of this study, skill-based errors associated with the mishaps examined revealed a different picture (Figure 2). Specifically, the percentage of human error mishaps associated with skill-based errors has increased steadily since FY 1991 when roughly 45% of the accidents were associated with this error form. Since then, the percentage of skill-based errors has risen to a high of 67% and 65% in FY 1996 and 1998 respectively. Surprisingly however, the rate at which all mishaps have been associated with skill-based errors showed a great deal of variability but no appreciable change over the years studied.

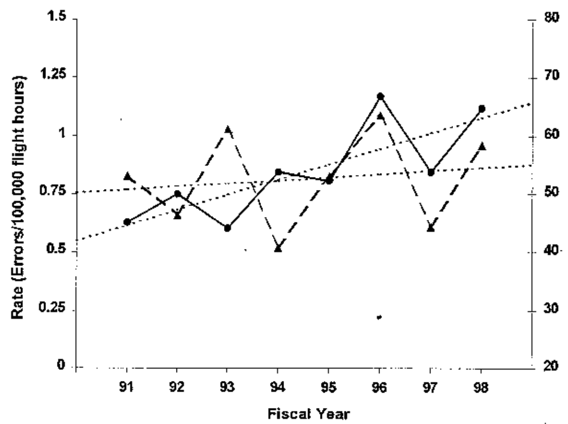

Figure 2. Rate (triangles and broken line) and percentage (circles and solid line) of mishaps associated with skill-based errors. Linear trends are plotted as a dashed line for both curves.

DISCUSSION

Several of the findings presented here require further discussion. First, and foremost however, it should be noted that HFACS provided a quantitative picture of skill-based and decision errors that was not possible prior to its development. In fact, data such as these are transforming the focus of the aviation safety program in the U.S. Navy/Marine Corps.

However, what of the original premise that U.S. Navy/Marine Corps aircrew decision making has improved, perhaps at the cost aircrew proficiency? It would appear from the data presented here that evidence does exist that supports the assertion that aircrew decision making has improved, at least over the 8 years of the study. Yet, even with this apparent improvement, the last two fiscal years of the study (FY 1997 and 1998) showed a marked increase. Should that increase continue into FY 1999 and 2000, the general reduction apparent over the preceding 8 years would all but be eliminated.

What this means is that now is not the time to claim victory over decision errors and suggest that no further improvements in pilot decision making can be made. In fact, nearly 60% of all human error mishaps were associated with decision errors. Instead, what may be needed is a refocus of efforts aimed at specific types of decision errors, rather than decision making in general is warranted. With this in mind, efforts are currently under way to describe the types of decision errors prevalent in U.S. Navy/Marine Corps mishaps so that specific intervention and mitigation strategies can be developed.

But, what of the proficiency issue? The picture is much less positive. At best, the rate of skill-based errors has not changed over the 8 years of this study. Yet, the rate measure only depicts the fact that the overall number of aircraft mishaps associated with skill-based errors has remained unchanged.

What if only examine the human error mishaps are considered? Then the picture changes dramatically. In fact, the percentage of skill-based errors associated with human error mishaps has risen steadily since FY 1991. To the extent that mishap data accurately reflects the worst of Naval Aviation, it would appear that indeed proficiency has begun to erode. Regardless of one's opinion of accident data however, the findings presented here provide reason for pause.

Assume for the moment that the percentage of skill-based errors prevalent in human error related mishaps is more relevant than the rate data. Given this, several explanations have been suggested for the apparent increase including the reduction in flight hours, changes in aircrew training, and/or pilot retention. Regardless of the cause however, the U.S. Navy/Marine Corps has embarked on a concerted effort to improve basic flight skills and proficiency in the Fleet. For instance, they have instituted a "back-to-the-basics" approach that focuses on such issues as: 1) re-emphasizing the need for an efficient instrument scan, 2) prioritizing attention, and 4) refining basic flight skills. In addition, there are efforts underway to develop low-cost simulators that focus on basic flight skills and issues of proficiency. While PC-based aviation training devices are gaining popularity in the civilian sector, their use in military aviation is only now being explored in the U.S. Navy/Marine Corps.

Again, this is where HFACS can provide useful data to those tasked with tracking the success or failure of putative intervention and mitigation strategies. For the first time, the U.S. Navy/Marine Corps can objectively and directly track the effects these strategies have on specific types of human error rather than rely on an overall mishap rate that is effected by a variety of issues and might not present a clear picture. Ultimately, by employing HFACS, safety professionals can gain a better understanding of human error associated with military aviation mishaps based upon quantitative data rather than anecdote and conjecture.

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