SECTION I: Executive Summary

Humans by their very nature make mistakes; therefore it is unreasonable to expect error-free human performance. It is no surprise then, that human error has been implicated in a variety of occupational accidents, including 70% to 80% of those in civil and military aviation (O'Hare, Wiggins, Batt, & Morrison, 1994; Yacavone, 1993). In fact, while the number of aviation accidents attributable solely to mechanical failure have decreased markedly over the past 40 years, those attributable at least in part to human error have declined at a much slower rate (Shappell & Wiegmann, 1996). It appears that interventions aimed at reducing the occurrence or consequences of human error have not been as effective as those directed at mechanical failures. Clearly, if accidents are to be reduced further, more emphasis has to be placed on the genesis of human error as it relates to accident causation.

The predominant means of investigating the causal role of human error in aviation accidents remains the analysis of accident and incident data (Shappell & Wiegmann, 1997). Unfortunately, most accident reporting systems are not designed around any theoretical framework of human error. Indeed, most accident reporting systems are designed and employed by engineers and front-line operators with limited backgrounds in human factors. As a result, these systems have been effective at identifying engineering and mechanical failures, whereas the human factors component of these systems are generally narrow in scope. Furthermore, even when human factors are specifically addressed, the terms and variables used are generally ill defined and the data structures poorly organized. Postaccident databases are therefore not conducive to a traditional human error analysis, making the identification of intervention strategies onerous (Wiegmann & Shappell, 1997).

What is required, therefore, is a general human error framework around which new investigative methods can be designed and existing postaccident databases restructured. However, previous attempts to apply error frameworks to accident analysis have met with encouraging, yet limited, success (O'Hare et. al., 1994; Wiegmann & Shappell, 1997). This is due primarily to the fact that performance failures are influenced by a variety of human factors that usually are not addressed by traditional frameworks. With few exceptions (e.g., Rasmussen, 1982), human error taxonomies do not consider the potential adverse mental and physiological condition of the individual (e.g., fatigue, illness, attitudes, etc.) when describing errors in the cockpit. Furthermore, latent errors committed by officials within the management hierarchy, such as line managers and supervisors are often not addressed, even though it is known that these factors directly influence the condition and decisions of pilots (Reason, 1990). Therefore, if a comprehensive analysis of human error is to be conducted, a taxonomy that takes into account these multiple causes of human failure must be offered.

Human Factors Analysis and Classification System (HFACS)

The Human Factors Analysis and Classification System (HFACS) has recently been developed to meet these needs (see Figure 1). This system, which is based upon Reason's (1990) model of latent and active failures addresses human error at each of four levels of failure: 1) unsafe acts of operators (e.g., aircrew), 2) preconditions for unsafe acts, 3) unsafe supervision, and 4) organizational influences. The HFACS framework was originally developed for the U.S. Navy and Marine Corps as an accident investigation and data analysis tool. Since its original development, however, HFACS has been employed by other military organizations (e.g., U.S. Army, Air Force, and Canadian Defense Force) as an adjunct to preexisting accident investigation and analysis systems. To date, the HFACS framework has been applied to over 1,000 military aviation accidents yielding objective, data-driven intervention strategies while enhancing both the quantity and quality of human factors information gathered during accident investigations (Shappell & Wiegmann, 2001).

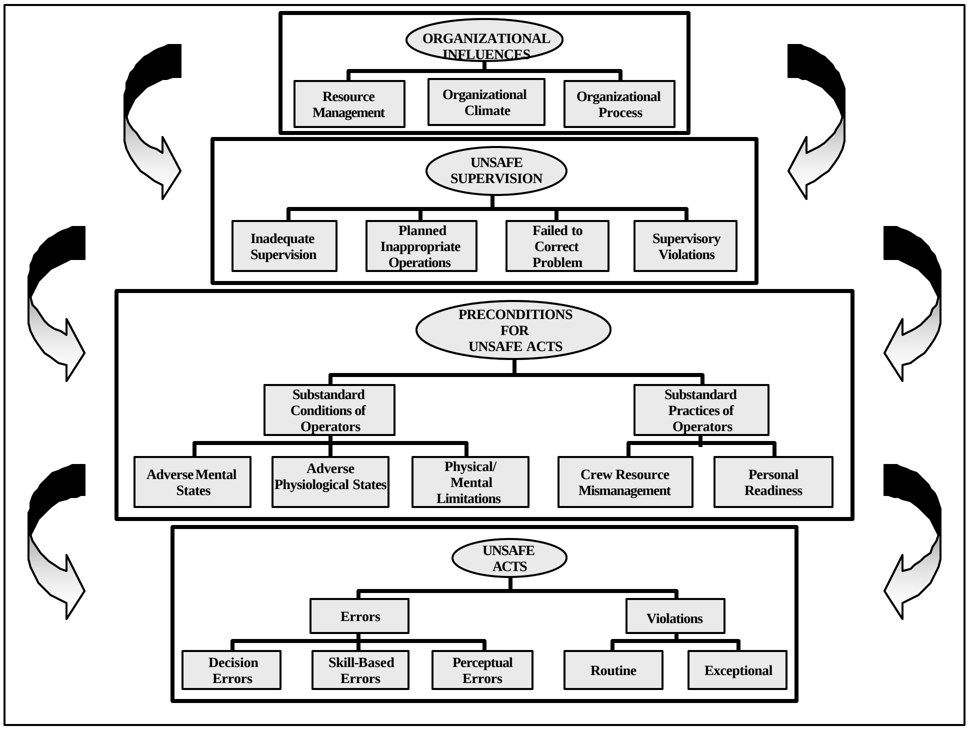

Figure 1. Categories of accident causal-factors within HFACS.

Purpose of the Present Project

The purpose of the present project was to explore whether HFACS could be used to complement preexisting systems within civil aviation in an attempt to capitalize on gains realized by the military. Research personnel at both the University of Illinois and the Civil Aerospace Medical Institute (CAMI) contributed to this project. These efforts have been highly successful and have shown that HFACS can be reliably used to analyze the underlying human factors causes of both commercial and general aviation accidents (Shappell & Wiegmann, 2001; Wiegmann & Shappell, 2002). Furthermore, these analyses have helped identify general trends in the types of human factors issues and aircrew errors that have contributed to civil aviation accidents. Indeed, AFS-800, the Aeronautical Decision Making (ADM) JSAT and the General Aviation Data Improvement Team (GADIT) have acknowledged the added value and insights gleaned from this project.

General Methodology

A comprehensive review of all accidents involving Code of Federal Regulations (CFR) Part 121, 135 and 91 aircraft between January 1990 and December 1998 was conducted using database records maintained by the NTSB and the FAA. Of particular interest to this project were those accidents attributable, at least in part, to the aircrew. Consequently, accidents due solely to catastrophic failure, maintenance error and unavoidable weather conditions such as turbulence and wind shear were not included. Furthermore, only those accidents in which the investigation was completed, and the cause of the accident determined, were included in the analysis. This yielded over 15,000 accident reports. Commercial aviation accidents were examined first, since they represented a smaller, more manageable number for the initial proof of concept. General aviation accidents were then analyzed during the second phase of analyses. Aviation psychologists, commercially rated pilots, and GA pilots subsequently coded the human causal factor associated with these accidents independently using the HFACS framework. Only those causal factors identified by the NTSB were analyzed. That is, no new causal factors were created during the error-coding process. The utility of HFACS was evaluated and the resultant trends in the human error data were analyzed.

Global Findings and Conclusions

The following is a summary of the general findings of this research project:

1. HFACS can be used reliably by multiple investigators to analyze the human factors problems associated with civil aviation accidents.

2. HFACS is comprehensive and captures all of the human error data contained in FAA and NTSB databases.

3. The application of HFACS has revealed previously unknown trends in human errors associated with civil aviation accidents. These included:

    a. Skill-based errors are the largest problem in both commercial and general aviation environments, followed by decision errors, violations, and perceptual errors.
    b. There has been no appreciable decline in the percentage of accidents associated with various unsafe acts over the decade of the 1990's.

4. Interventions have not been effective at reducing the types of unsafe acts that cause accidents.

5. Future interventions need to target specific types of errors identified by the HFACS analyses to be effective.

6. Follow-up analyses using HFACS need to be performed to evaluate the effectiveness of future interventions so that they can be either revamped or reinforced to improve safety.

Future Directions

To date, initial analyses using HFACS have generally been performed at a global level and several questions remain concerning the underlying nature and prevalence of different error types. In fact, AFS-800, the ADM JSAT, and the GADIT committees have directly requested that additional analyses be done to answer specific questions about the exact nature of the human errors identified, particularly within the context of general aviation. Some of these questions are:

1. What are the exact types of errors committed within each error category? In other words, how often do skill-based errors involve stick-and-rudder errors, versus attention failures (slips) or memory failures (lapses)?

2. How important is each error type, or how often is each error type the "primary" cause of an accident? For example, 80% of accidents might be associated with skill-based errors, but how often are skill-based errors the "initiating" error or simply the "consequence" of another type of error, such as decision errors?

3. How do the different error types relate to one another, or with other HFACS variables? Are there connections between the categories that, if known, could improve intervention development?

4. Do accidents that occur in different geographical regions or training facilities within the U.S. have different error patterns or trends?

5. What can be done to intervene given the information that is now available, and what more might be done with the additional refined data?

Answers to these questions are not available in the database as it currently exists. Therefore, additional fine-grained analyses of the specific human error categories within HFACS are needed to answer these and other questions that may arise, and to target problem areas within general aviation for future interventions.

Overview of the Remaining Document

The remaining sections in this report contain the numerous articles and presentations generated from this project. These materials provide a detailed description of the methods, results, conclusions, and recommendations associated with these efforts. The sections are organized in the following order:

1. Journal Articles and Book Chapters
2. Technical Reports
3. Proceedings Articles
4. Published Abstracts
5. List of Conference Presentations That Did Not Contain Any Publication
6. List of Invited Addresses