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HUMAN FACTORS IN AIRCRAFT ACCIDENTS: A HOLISTIC APPROACH TO INTERVENTION STRATEGIES

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Human error has been implicated in almost 70-80% of civil and military aviation accidents. It appears that attempts to understand human factors in aircraft accidents and apply remedial strategies have been made in isolation in addressing a particular link in the whole process of aircraft accident prevention. The suggested holistic approach to minimize aircraft accidents, aims to provide a composite and macroscopic view of the activities within the aviation environment that can be targeted to produce the desired results. It also provides a microscopic look at possible domains within each link. Targeting one particular aspect or link in the entire process may or may not influence the other components in the loop. Such an approach would address the experience and certainty of safety investigators with regards to contribution of human factors in aircraft accidents and the understanding of temporal relation between various human factors at one end to issues of intervention strategies based on sound human factors principles and a follow up evaluation of the impact of these intervention strategies on the other end. The influence of safety culture in integrating the diverse components of the accident prevention program is highlighted.

INTRODUCTION

Aviation is an inherently dangerous and unforgiving environment. The weakest link in the man machine environment interface in aviation still remains the human being. Human error has been implicated in a variety of occupational accidents including 70-80% of those in civil and military aviation (O'Hare, Wiggins, Batt, & Morrison, 1994; Wiegmann & Shappell, 2001a; Yacavone, 1993) There is widespread concern in the aviation industry that the expected growth in air traffic during the next decade could lead to an average of one major commercial accident per week unless the current, already low accident rate of human error accidents is reduced even further (Sarter & Alexander, 2000).

It is not that attempts have not been made to understand human factors in aircraft accidents and apply remedial strategies. Lack of aircrew coordination or crew resource management (CRM)- effective communication of information and coordination of actions by aircrew was identified in the early 90's as the most common aircrew causal factor across military (Yacavone, 1993) and commercial aviation (Kayton, 1993). CRM training was designed to minimize such errors. Initial follow up research results were encouraging (Alkov & Gaynor, 1991; Kayton, 1993). However, it soon became obvious that while such training did have immediate and detectable effects on aircrew behavior, the effects may be very short lived (Helmreich, Merritt, & Wilhelm, 1999). Recent studies have shown that CRM programs have had modest impact on reducing accidents and that CRM continues to play a role in almost 30% of all aviation accidents (Wiegmann & Shappell, 2001a). Macroscopically, it therefore appears, that intervention strategies aimed at reducing the occurrence or consequences of human error have not been as effective as were expected.

What then could be the possible causes for failures of such intervention strategies? For this we will have to step back and look at the existing philosophies of dealing with the problem of human error in aviation accidents. The prevailing methodology of investigating and preventing human error in aviation accidents today remains the analysis of aircraft accidents and analyzing accident and incident databases (Wiegmann & Shappell, 2001a). Research has however shown that the post accident databases as they exist today are typically not conducive to a traditional human error analysis (Wiegmann & Shappell, 1997). The fact that, as stated earlier, human error continues to be responsible for 70-80% of all aviation accidents, makes one conclude that intervention strategies derived from such databases have therefore not been totally successful in impacting human error.

Thesis

It somehow, appears that, attempts till now have been made in isolation in addressing a particular link in the whole process of aircraft accident prevention, which can be depicted as in Figure 1. Sarter and Alexander (2000) observe that research on human error has focused primarily on the development of error classification schemes, the design of error-tolerant systems, and error prevention through training and design. These efforts have targeted the problem piece meal with a specific perspective and objective, and it is likely that certain vital areas may have been underplayed/missed. For example, no research has quantified the minimum training and expertise a safety investigator should have to competently identify human factors in aircraft accidents. Similarly, there appear to be as many error taxonomies/frameworks as the number of human factor researchers (Senders & Moray, 1991). Sadly, though, there has been yet, no published attempt to integrate all the possible intervention strategies in the entire process against which an industry/organization could evaluate its existing safety program and decide the interventions best suited to that particular organization's needs. This paper makes an attempt to provide a holistic and complete overview of the possible approaches to human factors investigation and mitigation in aviation accidents.

DISCUSSION

Figure 1 illustrates the typical components of a well-balanced accident investigation and prevention program, in an organization geared to understand and prevent human error in aircraft accidents. It explains the links wherein safety personnel could possibly intervene to prevent recurrences of aviation accidents.

Any aircraft accident would involve at least two components: the aircraft and the aircrew. While mechanical causes would deal with deficiencies in the machine, the aircrew would also be a subject of investigation in terms of his/her physical and physiological fitness to fly on one hand to the training and competency to fly that particular flight on the other.

Aircraft accidents could broadly be classified as being caused by mechanical causes or human error. Investigation of mechanical causes of aircraft accident have become much more precise given the wide range of sophisticated investigative techniques available today. These causes being precise and quantifiable, lead to intervention strategies that are specific and address a tangible cause. The results of such intervention strategies are obviously easy to evaluate.

Human factors in aircraft accidents, on the other hand, are less tangible and quantifiable than the mechanical causes. Variability in the thoroughness and precision of human factors investigation then result in accident databases that may not be amenable to easy interpretation. Aircraft accident investigation can suggest intervention strategies in various time lines-those that are immediate can be made even before the investigation is complete, but are significant to the aviation industry as a whole (NTSB, 2002b). Accident and incident data can be periodically analyzed to search human factors concerns. As and when problem areas are identified, specific strategies can be designed for those particular types of errors (e.g., CRM) and may constitute intervention strategies in the medium and long- term time frame. Once the intervention strategies have been adopted, there is obviously a need to provide feedback to the safety personnel on the effectiveness of those strategies. A decreasing number of similar accidents subsequent to changes introduced are obviously a positive feedback reflecting upon the success of the intervention strategies. The safety personnel should, however, be alert to the possibility of other human factors areas needing redress.

This loop as outlined in the figure, is a reiterative continuous one, given the fact that humans, by their very nature, make mistakes (Wiegmann & Shappell, 1997) and thus, it may be reasonable to accept that aircraft accidents will continue to occur in the foreseeable future.

We feel that this entire process is embedded and influenced by an environment that can be broadly termed as the organizational safety culture. This safety culture would influence each and every link and can be considered to be at the very core of a successful accident prevention program. The role of safety culture is discussed in detail later.

This sequence sort of provides the framework or template on which an organization can map its own existing system and decide whether efforts need to be addressed to a weak link, if any. What options would an organization have, if it were looking to address human factor issues in aircraft accidents? Would just going to the market to chose an off the shelf remedy or program which addresses the most current issue in aviation solve the problem for that organization. Or is there something like “one size fits all” product? Probably no. What is primarily required, is for the organization’s safety professionals to assess each of these links, as they exist in the organization against the reasonable recommendations for each domain as they exist in the aviation industry, and identify areas that need intervention. Unfortunately, at present, such reasonable recommendations do not exist which can be compiled, published, and circulated to each organization. Therefore, we now make an attempt to discuss what we consider are reasonable and valid industry standards and recommendations for each link.

In our suggested holistic approach to intervention strategies, the first link is the constituent of an aircraft accident itself. Over the years, benefits have resulted from improvement in the flying qualities of the aircraft. Examples of such innovations in aeronautical engineering include the reduced numbers of fatal accidents resulting from spins in general aviation and the benefits of precise navigation and flight controls in commercial airlines (Doughtery, 1975). An aviation accident, however, provides one more opportunity to evaluate the aircraft in general, and the human factors in the man machine interface in the cockpit, in particular.

The second component involved in an aircraft accident is the aircrew. There could be avenues of applying intervention strategies to the aircrew component in two broad areas: selection and training. Armed forces, worldwide have for long employed different selection strategies including personality tests in an effort to select candidates who would withstand the rigors of military aviation (Guilford, 1947). Military methods of crew selection have been adopted by various airlines and are used by civil aviation (Doughtery, 1975). Data supports a beneficial effect of improved crew selection in general aviation pilots, too (Doughtery, 1975). Though equivocal, there is evidence and research to suggest that certain personality traits and life stresses may be linked to error or accident proneness (Alkov, Gaynor, & Borowsky, 1985).

Once selected, pilot training can play a very crucial role in the pilot’s ability to become a successful aviator. Training content, frequency and standardization all have varying impacts on pilot proficiency and possibly on aviation accidents. Improved standardization of flight techniques was associated with sharp reductions in the fatal traffic pattern and solo instruction accident rates (Doughtery, 1969) in U.S. general aviation flying. There is also strong evidence that continued participation in flight training is associated with a substantially lower risk of fatal accidents (Doughtery, 1969). These could themselves be important and critical areas of intervention in the overall effort to reduce human error accidents.

The next step after the occurrence of an aircraft accident is the process of accident investigation. There are two obvious areas that need attention. Who investigates and how they investigate? Each organization would use different classification schemes to classify an accident as minor or major, or in categories such as Cat A, B, C in the U. S. Navy (Naval Safety Center, 1995). Proportional to the category and nature of accident, safety investigators would be assigned. The human factors specialist is generally tasked with the study of human error, including fatigue, medications, alcohol, drugs, medical history, workload, equipment design and work – environment (NTSB, 2002b). While in principle very organization endeavors to evaluate the role of human factors in aircraft accidents, yet, the quality of human factors data collected may leave a lot to desire. The issue of investigator training and expertise in this specialist field has not been addressed. The reason for this inadequacy probably being that no benchmark exists on the type of training and expertise required for human factors investigations. There is a need for the industry to decide on a certain minimum exposure to human factors aspects in aircraft accidents so that a standardized level of investigation can be achieved.

The next issue in accident investigation is what tools the investigator uses while conducting the investigation. These can be divided into the accident investigation report and the autopsies conducted on pilots involved in fatal aircraft accidents. Each organization uses a different format of accident investigation report. The National Safety Transportation Board (NTSB) uses a very elaborate coding system wherein sequence of events must be substantiated by information that is documented in the factual report. The sequence of events would contain primary non-person (aircraft/ environment) and person -related (operations/ performance) findings along with direct and indirect underlying findings (NTSB, 2002c). Other organizations may prefer to use the detailed "free-form" text description of the accidents under categories of what happened, how it happened and why it happened. Unfortunately, these so called human factors investigative tools or accident-reporting systems have not been able to provide answers to the problem of human error in aviation.

A recent publication has attempted to provide the aviation safety practitioner an overview of human error perspectives in aviation (Wiegmann & Shappell, 2001b). Within the context of aviation, primarily 5 different perspectives have been identified: (a) cognitive, (b) ergonomics and systems design, (c) aeromedical, (d) psychosocial, and (e) organizational. Whatever error perspective and resulting framework or taxonomy is adopted by a particular organization, it is essential to ensure that the framework is valid, reliable, comprehensive, and captures the gamut of manifestations of human error (Wiegmann & Shappell, 2001b). Human Factor Analysis and Classification System (HFACS) has been reported to fulfill a large part of the above criteria (Wiegmann & Shappell, 2001a).

The second source of information obtained from fatal aviation accidents aims to minimize morbidity and mortality from aircraft accident. While the information in the autopsy report may not prevent future accidents, it plays a significant role in issues of crashworthiness and making aircraft accidents more survivable. Recent studies have reflected upon the need for more comprehensive and standardized autopsy reports that could realistically reflect upon the nature of crash forces and provide inputs into possible mechanism of injuries (Taneja & Wiegmann, 2001).

From safety viewpoint, once the aircraft accident investigation process is over, outcomes are possible that may be simultaneous and concurrent. The investigation may lead to immediate remedial solutions or safety recommendations based on observations during the investigation. Such safety recommendations are the most important part of the mandate of investigative agencies such as the NTSB (NTSB, 2002b). These recommendations are based on findings of the investigation and may address deficiencies that do not pertain directly to what is ultimately determined to be the cause of the accident (NTSB, 2002a, 2002b). With or without immediate safety recommendations, the accident investigation report is archived in the organization's accident database. How useful will this investigation report be in providing feedback on human factors is the concern, which needs to be addressed. Is the database human factors centered? Will the database eventually lend itself to scientific analysis? How frequently and systematically this data is analyzed to look for possible problem areas or trends? Who provides this expertise to conduct such analysis? Will it be safety personnel with human factors background or will it be non- human factor centered search and analysis. The answers to these questions will be determined by each individual organization.

It is felt that, all the above links and their outcomes could be influenced by one major factor broadly termed as Organizational Safety Culture. Turner, Pidgeon, Blockey, and Toft (1989) have defined organizational culture, in specific relation to safety, as " the set of beliefs, norms, attitudes, roles, and social and technical practices that are concerned with minimizing the exposure of employees, managers, customers and members of the pubic to conditions considered dangerous or injurious". Safety culture would influence the entire process of accident prevention? How does an organization consider or treat an accident? Is it treated as just one more occurrence, one unavoidable occurrence due to the inherent risks involved in the activity? Such an accident may then be investigated at a superficial level aiming to identify the unsafe acts of frontline operators. Once these unsafe acts have been identified, safety circulars /bulletins may be circulated across the organization citing the accident in question and suggesting enhanced safety consciousness or adherence to the existing procedures. Does such an attitude of the organization enhances flight safety or prevents future occurrences or unearths latent failures in the organization? Possibly, no.

On the other hand, a safety conscious organization would treat an accident as being the manifestation of similar underlying latent failures. The aircraft accident investigation in such an organization would focus on improving safety and preventing future accidents and incidents and not to apportion blame or liability. Such an investigation would systematically search for factors and failures in the organization that may have predisposed the unsafe acts of the operator. This organization would appear, at least theoretically, to successfully identify and plug the “holes” in the Swiss cheese model before they create a window of opportunity for catastrophe to strike again (Reason, 1990).

The two organizations, as described earlier, would also differ in their philosophy of monitoring human factor concerns via anonymous reporting systems and safety audits. Incident reports are a rich source of information regarding successful, albeit delayed error detection (Sarter & Alexander, 2000). In most cases, they involve errors that have already penetrated one or some of the defensive layers of a system (Maurino, Reason, Johnson, & Lee, 1995; Reason, 1990). The organization’s safety culture will also influence the adoption, maintenance and retrieval of human factors frameworks and databases for the accidents. Such safety consciousness in major airline organizations in the recent decades has been a welcome step towards enhancing flight safety. Effort and money need to be spent to analyze the organization’s own database to unearth safety hazards specific to the organization that would require distinctive intervention strategies for the organization. A constant vigilance and holistic approach towards flight safety is required even in times of fiscal austerity in the organization.

A pertinent question would be how does an organization identify organizational failures and factors contributing to aircraft accidents? Two approaches can possible identify the latent organizational factors that can jeopardize flight or airline safety integrity. Information may be available from a reactive analysis of accident /incidents involving organizational factors followed by a proactive approach (Reason, 1990) to seek safety critical information rather than waiting for adverse events to analyze.

The holistic approach to minimize aircraft accidents, thus aims to provide a composite and macroscopic view of the activities within the aviation environment that can be targeted to produce the desired results. It also provides a microscopic look at possible domains within each link. Targeting one particular aspect or link in the entire process will generally produce the expected results of those particular intervention strategies and may or may not influence the other components in the loop. It is our earnest belief, that if human factors problems associated with aircraft accidents have to be addressed in totality, a holistic approach needs to be adopted. Such an approach would address the experience and certainty of safety investigators with regards to contribution of human factors in aircraft accidents and the understanding of temporal relation between various human factors at one end to issues of intervention strategies based on sound human factors principles and a follow up evaluation of the impact of these intervention strategies on the other end. But these fixes may not be eventually successful unless an organization dedicated to improving aviation safety develops and nurtures a “safety culture” that persists in integrating the diverse components of the accident prevention program as outlined in this paper.

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