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Evaluating Human Factors in the Commercial Pilot-Airplane Airman Certification Standards

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By:

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Abstract

This research aimed to identify risk management elements in the Commercial Pilot-Airplane Airman Certification Standards (ACS), and to evaluate tasks relating to or involving human factors. The investigation examined the risk management elements under each task in the Commercial Pilot-Airplane ACS and classified them under the preconditions for unsafe acts of the Human Factors Analysis Classification System (HFACS). The method of investigation was a qualitative research approach to determine the human factors element prevalent in the Commercial Pilot-Airplane ACS. Three research questions were stated: (1) Which factor under the preconditions for unsafe of HFACS has the highest number of tasks relating to or involving human factors? (2) Which risk management element is prevalent in the commercial airplane pilot ACS**?** (3) In order of priority, which risk elements need to be emphasized in the training programs? An analysis of the data and information synthesis was done to arrive at results, conclusions, and recommendations to improve the training program. The recommendations are: (1) Conduct adequate training in the use of aircraft systems and automation to enhance human performance and to reduce workload, stress and fatigue, and human errors; (2) Include scenario based training (SBT) in the training syllabus that will challenge pilots to improve decision-making that can mitigate loss of situational awareness and lack of effective crew resources management; and (3) Incorporate team building techniques into the training syllabus to enhance crew performance.

Introduction

The problem addressed in this study is that human factors contribute to aircraft incidents and accidents more than other factors (Munene, 2016). This problem has led to the Federal Aviation Administration (FAA) replacing the Practical Test Standards (PTS) for commercial pilots with the ACS (FAA, 2018b). Human error is found to be the most significant issue in flight operations and is implicated in almost all aviation accidents (Munene, 2016). As aircraft become more reliable, humans have played a progressively more important causal role in aviation accidents due to human limitations (Wiegmann & Shappell, 2003). Statistics reveal that approximately 80 percent of aviation accidents are attributable to human factors, which has made it an important topic to address in the industry (Munene, 2016). Wiegmann, Rich & Shappell (2000) further stated that "a growing number of aviation establishments are tasking their safety personnel with developing safety programs to address the highly complex and often nebulous issues of human error" (p. 1).

The FAA took a practical step to address this issue in the training environment by replacing the PTS for commercial pilots with ACS to communicate the aeronautical knowledge, risk management, and flight proficiency standards for pilots and to reduce human errors associated with flight operations. "The ACS is a portion of the safety management system (SMS) framework that the FAA uses to mitigate risks associated with airman certification training and testing" (FAA, 2018b, p. iii). It offers an all-inclusive and combined presentation of the standards that an applicant needs to successfully pass both the knowledge and practical tests for a certificate or rating (FAA, 2018b). However, the ACS has become a more useful tool than simply passing both knowledge and practical tests for a rating or certificate; it provides a framework to mitigate human errors that aviation organizations can adopt in the initial and recurrent training programs for company pilots.

Intent

This qualitative research aimed to evaluate the Commercial Pilot-Airplane ACS, focusing on the Risk Management elements and identifying tasks that relate to or involve human factors. Risk management is vital to successful and safe flight operations due to human errors identified in many aviation accidents (Munene, 2016). The risk management elements in each task in the ACS were evaluated and classified using the preconditions for unsafe acts in Human Factors Analysis Classification System (HFACS) model. The Human Factors Analysis and Classification System (HFACS) is a safety tool that aids in identifying and analyzing organizational factors that contribute to aircraft accidents (Small, 2020). This research aimed to identify risk management elements that seem to be more prevalent under the precondition for unsafe acts of HFACS and provide a priority listing of what may need to be emphasized in the training programs.

Research Questions

- Which factor under the preconditions for unsafe of HFACS has the highest number of tasks relating to or involving human factors?
- Which risk management element is prevalent in the Commercial Pilot-Airplane ACS**?**
- In order of priority, which risk elements need to be emphasized in the training programs?

Literature Themes

The early causes of errors and accidents were thought to be aircraft technical failure (Gong, Zhang, Tang, & Ly, 2014). However, statistics show that about 80 percent of all major accidents, both military and civilian, usually involve human factors (Munene, 2016). Since aviation safety depends on mitigating human errors in all facets of the system, much attention is being directed to human factors by aviation governing agencies to identify ways to mitigate human errors (Latorella & Prabhu, 2000). Human factors in various domains is seen as the study of the relationships between people and their activities through the systemic application of the human sciences, cohesive within system engineering to ensure machines and equipment are safe to use for humans (National Business Aviation Association (NBAA)). The concept of human factors deals with the integration of human capabilities, limitations, and behaviors with systems designed to enhance human performance and the general well-being of the operators (Koonce, 1999).

Human factors awareness in the aviation industry can enhance productivity and lead to an environment that ensures continuing worker and aircraft safety (FAA, 2018a). A human factors framework involves gathering information about human abilities, limitations, and other characteristics and applying it to tools, machines, systems, tasks, jobs, and environments to produce safe, comfortable, and effective human use (Zhang, 2008). Erjavac, Lammartino, & Fossaceca, (2018) stated that "the HFACS is a tool applied to define a framework intended to recognize focal areas for the safety community to alleviate similar future system failures" (p.1). HFACS has been used in many domains to analyze human errors in the hierarchy they occur.

A Canadian scientist, Gordon Dupont, in 1993 identified lack of communication, complacency, lack of knowledge, distraction, lack of teamwork, fatigue, lack of resources, pressure, lack of assertiveness, stress, lack of awareness, and norms as factors that degrade human's ability to perform efficiently and safely. Gordon described these factors as dirty dozen. They were initially used in maintenance but are now adopted in all areas of the aviation industry to address issues leading to human errors (Skybrary, 2020). Gordon Dupont's dirty dozen framework can also be seen as preconditions for unsafe acts and part of the causal factors of loss of situational awareness (SA). In research conduct by the National Aeronautics and Space Administration (NASA), situation awareness is identified as one of the seven major areas targeted for human error reduction in its Aviation Safety Program (ASP) (Endsley, Garland, & Georgia, 2000).

The HFACS framework was primarily designed as an investigation and data analysis tool for the U.S. Navy and Marine Corps. Since then, it has been explored by other organizations such as the FAA to analyze the underlying causes of aircraft accidents (Wiegmann & Shappel, 2001). HFACS framework identifies situational factors, personnel factors, and condition of the operators as the preconditions for unsafe acts. The preconditions for unsafe acts is used in analyzing causes and trends of human errors contributing to aircraft accidents. Generally, errors are consequences of actions or inactions, which reduce safety margins and lead to deviations from operational rules. Most errors are easily trapped when the crew maintains situational awareness (Marquardt, 2019).

Situational awareness is a fundamental aspect of risk management and has become an increasingly salient factor contributing to flight safety and operational performance (Salas & Dietz, 2011). It is a vital component of safe and effective operations in the flight deck, maintenance tasks, and the air traffic management spectrum. Problems with situational awareness were found to be the leading causal factor in a review of military aviation mishaps (Endsley, Garland, & Georgia, 2000). Statistics of aviation accidents reveal that approximately 85 percent of accident reports include a mention of the loss of situational awareness (Skybrary, 2016). Stanton, Chambers, & Piggott (2001) stated the importance of situational awareness in maintaining safe control of an aircraft and the need for people to maintain an adequate awareness of system status to track the development of events as they gradually unfold.

Data Collection and Analysis Plan

To address the problem stated, risk elements under each task in the ACS were evaluated and classified into three functional categories of precondition for unsafe acts (situational factors, personnel factors, and condition of the operators) in the HFACS model according to their predominant risk management elements. There are 60 tasks in the ACS, of which ten are unrelated to airplane single-engine and multi-engine land, leaving 50 tasks that could be classified under the preconditions for unsafe acts. Tasks grouped under Situational Factors were chosen based on risk elements associated with the physical environment, tools, and technology. Tasks grouped under Personnel Factors were chosen based on risk elements associated with communication, coordination, and planning, and fitness for duty. Tasks grouped under the condition of the operators were based on mental state, physiological state, physical and mental limitations.

Table 1

Classification of Commercial Pilot Airplane ACS Tasks under the Precondition for Unsafe Acts of HFACS

Situational Factors		
• Airworthiness Requirements • Weather Information • Cross-country Flight Planning • National Airspace • Performance and Limitations • Operation of Systems • Preflight Assessment • Flight Deck Management • Engine Starting	• Go-around / Rejected Landings • Steep Turns • Steep Spiral • Chandelles • Lazy Eights • Eight on Pylons • Pilotage and Dead Reckoning • Navigation Systems and Radar Services	• Emergency Descent • Emergency App & Landing • System & Equipment Malfunctions • Engine Failure During Takeoff Before V_{MC} • Engine Failure after Liftoff • Approach & Landing with an Inoperative Engine

• Traffic Patterns • Normal Takeoff & Climb • Normal App & Landing • Soft-filed Takeoff and Climb • Soft-field App & Landing • Short-field Takeoff and Maximum Performance • Short-field App & Landing	• Maneuvering During Slow Flight • Power-off Stalls • Power-on Stalls • Accelerated Stalls • Spin Awareness	• Maneuvering with One Engine Inoperative • V_{MC} Demonstration • One Engine Inoperative (Simulated Instrument) • Instrument Approach with an Inoperative Engine
Personnel Factors		
• Pilot Qualification • Taxiing • Before Takeoff Check • Diversion	• Communications, Light Signals, Runway Lighting • Lost Procedure • After Landing, Parking & Securing	
Condition of the Operators		
• Human Factors • Supplemental Oxygen	• Pressurization • Emergency Equipment & Survival Gear	

Results

From the evaluation and classification of risk management elements of each task in the Commercial Pilot ACS, 39 tasks were classified under Situational Factors, seven tasks under Personnel Factors, and four tasks under the Condition of the Operators. Situational factors are directly related to the physical environment, tools, and technology. Tasks involving maneuvers that can lead to loss of control, failure to maintain coordinated flight, collision hazards, distractions, loss of situational awareness, failure to manage automation appropriately, and improper task management were classified under situational factors. Tasks that can lead to confirmation or expectation bias, division of attention while conducting pre-flight checks, poor communication, failure to utilize all available resources, and failure to records times over waypoints were classified under personnel factor. Tasks related to or involving hazardous altitudes, aeromedical and physiological issues, high altitude flight, and supplemental oxygen management were classified under the condition of the operators.

According to the classification, situational factors are the prevailing risk management elements in the Commercial Pilot-Airplane ACS and have the highest number of tasks relating to or involving human factors under the precondition for unsafe acts of HFACS. In the order of priority, factors associating with situational awareness are the main risk management elements that need to be emphasized in the training programs, followed by factors involving crew resource management and then conditions of the operators. A summary of these classifications can be found in Table 2.

Table 2

Summary of the classification of Commercial Pilot Airplane ACS Tasks under the Precondition for unsafe acts of HFACS

Situational Factors	Personnel Factors	Condition of the Operators
39	7	4
78%	14%	8%

Conclusions

Based on the classification of risk management elements using the preconditions for unsafe acts of HFACS, more risks are associated with tasks involving the physical environment, tools, or technology, which shows situational factors are the predominant risk management elements in the ACS that need to be embedded in the training program to reduce human errors. In support of this conclusion, Endsley, Garland, & Georgia (2000) stated that “having a high level of situational awareness is perhaps the most critical factor for achieving successful performance in aviation" (p. 1).

The goal of automation is to enhance human performance and improve safety. Automation increases productivity and reduces operator's workload, thereby reducing errors (Kanki, Anca, & Chidester, 2019). However, a lack of system understanding and training have contributed immensely to automation mismanagement and error, which has led to many aircraft accidents (Ackerman, Talleur, Carbonari, Xargay, Seefeldt, Kirlik, Hoyakimyan, & Trujillo, 2017). Automation is identified in the ACS as a prominent risk element that needs to be addressed in the training environment to improve safety.

Personnel Factors such as communication, coordination and planning, and fitness for duty are the second prevailing risk management elements in the ACS that may be incorporated into the training program to mitigate human factors issues. Effective communication is vital to flight safety by aiding crew coordination and attention to manage all available resources in the flight deck. Personnel factors and situational factors can pose serious safety concerns and affect situational awareness.

The condition of the operators is the third risk element that needs to be emphasized in the training programs. It is an important human factors problem in aviation that must be addressed to improve aviation safety. Research showed that conditions adversely affecting pilots' mental state can have detrimental effects on pilots' aeronautical decision-making and flight safety (Kanki, Anca, & Chidester 2019). The imbalance psychological state of a pilot can affect the Storage and retrieval of information in the brain and sets the stage for errors (Kanki, Anca, & Chidester 2019).

Recommendations

Enhancing human performance in flight operations begins with training to elucidate human capabilities, limitations, behaviors, and relationships with systems. Adequate training in aircraft systems and automation is extremely important to enhance human performance and reduce workload, stress and fatigue, and human errors. Tasks or flight lessons that can illustrate the loss of control, failure to maintain coordinated flight, collision hazards, and loss of situational awareness can be introduced in advanced aviation training device (AATD) or basic aviation training device (BATD) to ensure that pilots gain mastery over them before they are introduced in flight training device (FTD) or the aircraft. AATD/BATD is cost-efficient and affords pilots enough time to practice and become proficient in those Tasks. Automation training and maneuvers can be done separately in AATD/BATD if further training will take place in FTD. However, in the absence of further training in FTD, automation training and maneuvers should be taught together in the AATD/BATD to enhance multitasking skills.

Series of distractions can be introduced, especially during automation training to assist pilots in developing skills to effectively manage automation in a high workload environment, prioritize flight activities, and reestablish situational awareness. Research showed that automation directly impacts situational awareness by changing vigilance associated with aircraft flight path monitoring and pilots assuming passive roles instead of an active role in controlling the system (Endsley 1996). These impacts can be minimized through effective training and provide the crew with the ability to maintain situational awareness. Examples of distractions that can be introduced include dealing with unexpected situations, unexpected traffic alerts, head-down work, communication interruptions, changes in planned approaches, and many other distractions that can enable pilots to gain the skill to managing several tasks concurrently.

Scenario-based training (SBT) is an effective way to challenge pilots with various flight scenarios of risk management elements to improve decision-making and skills that can mitigate human errors such as loss of situational awareness and a lack of crew resources management (Summers, 2007). SBT should be incorporated into the training syllabus to provide a uniform training experience for company pilots and to illustrate human factors problems in flight training. SBT engages pilots by stimulating their brain activity, encourages them to think critically, and helps them develop mental toughness to solve problems requiring aeronautical decision-making, such as situational awareness and crew resources management.

A structured script of real-world experiences is required to be created to meet each training objective in the ACS. The training manager can develop realistic scenarios that other instructors can use for the flying they do. Situations that can lead to loss of control, failure to maintain coordinated flight, collision hazards, distractions, loss of situational awareness, failure to manage automation appropriately, improper task management; confirmation or expectation bias, division of attention while conducting pre-flight checks, poor communication, failure to utilize all available resources, and failure to records times over waypoints can be framed as scenarios in the training syllabus to help develop risk management skills.

Incorporating team-building techniques into the training syllabus will have a long-lasting impact on mitigating human errors in a complex environment by enhancing effective workload management, active monitoring of the aircraft flight path, effective communication, effective crew coordination, and flight deck automation management. The main goal of team-building training is for the crew to develop the ability to work together and achieve desired goals. Team-building training involves having two pilots in the simulator or having the instructor play the role of a crewmember. Each crew member’s role is to be defined according to standard operating procedures (SOP), and each one is expected to speak up when things are not executed as planned. Different scenarios should be introduced during the training for each pilot to act as pilot flying (PF) and pilot monitoring (PM). If the instructor is acting as a crew member, intentional errors should be committed to helping the pilot in training develop the skill of managing threats and errors as a team.

Emphasis should be placed on sharing mutual respect by trusting the expertise of one another and become interdependent. Each crew member should be encouraged to remain committed to their duties and be willing to help when their partner needs assistance. Active monitoring of other people’s duties is an essential component of team building, and it can be done by having each crew member monitor their partner and give constructive feedback. Team-building training should encourage open discussion to help flight crew cultivate the ability to share views and communicate effectively.

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