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**Human factors in Aviation: A Survey**

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**Abstract**

The topic of human factors is continually gaining higher levels of visibility in all spheres of engineering, however, the elements that drive future human interactions with emerging technologies have room for further studies. A considerable amount of effort has been invested in improving the physical motor skill-centric design considerations. Emerging aerospace organizations face the challenges of proper interpreting and implementing these emerging human factor requisites. A lot of the emphasis in the average design organization is typically centred around (hardware and software components: the system performing to its stated requirements, meeting the reliability specification, and the system's impact safety of flight; but less is truly focused on all facets of the human in the loop.

**Keywords:** Emerging aerospace.

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**Introduction**

To err is human, that is how the saying goes. It is a fact of life. People are not precision machinery designed for accuracy. In fact, we humans are a different kind of device entirely. Creativity, adaptability, and flexibility are our strengths. Continual alertness and precision in action or memory are our weaknesses. We are amazingly error tolerant. We are extremely flexible, robust, and creative, superb at finding explanations and meanings from partial and noisy evidence. The same properties that lead to such robustness and creativity also produce errors. The natural tendency to interpret partial information although often our prime virtue can cause operators to misinterpret system behavior in such a plausible way that the misinterpretation can be difficult to discover.

Errors are an inevitable part of flying. No matter how good a pilot's training is, we can never hope to eliminate all errors. Nowhere in life can we ever muster enough brainpower and diligence to make mistakes impossible. Even at our very best, we see a shadow cast by our own brilliance.

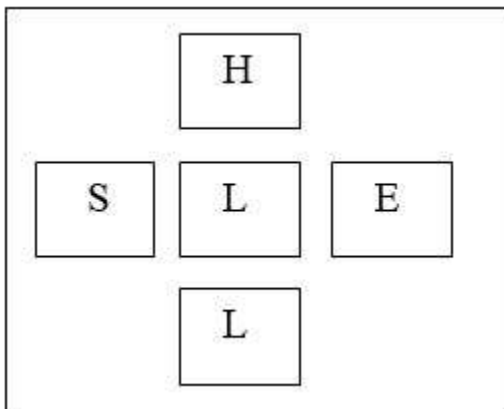
This paper will discuss human error in a general sense, human error specific to aviation, maintaining situational awareness in aviation and human error reduction techniques. The goal is to become educated in human error in order to determine how to reduce, if not eliminate, human error in aviation. Many of the causal factors that contribute to accidents can be viewed as different "types" of human error.

Human error can be defined as inappropriate human behavior that lowers levels of system effectiveness or safety, which may or may not result in an accident or injury. Technically, the term human error could include mistakes made by humans operating a system, humans who designed the equipment, humans who supervise the worker, and who trained or advised the worker. However, the term is usually used to describe operator error, the inappropriate behavior of the person directly working with the system. There are numerous ways to classify and categorize human error. We have a tendency to want to view error at the operator level. First, we tend to blame the individual; second we try to identify any other factors. A model of *contributing factors in accident causation* – CFAC is proposed. The factors are broad & encompass most factors found in other models. Their model includes and emphasizes management, social and psychological factors. Also, human factors variables are recognized in the categories: Physical environment, Equipment design, and Work itself. Operator errors can occur for many reasons, including inattentiveness, poor work habits, lack of training, poor decision-making, personality traits, social pressures and so forth. There have been several attempts to classify the types of errors that people make during task performance. These classifications are then used to try to improve human performance.

### The shell model

The “SHEL” model was first advocated by Professor Elwyn Edwards in 1972 and a modified diagram to illustrate the model was later developed by Captain Frank Hawkins in 1975 (Figure 1). The component blocks of the SHEL model (the name being derived from the initial letters of its components: Software, Hardware, Environment, Liveware) are depicted with a pictorial impression of the need for matching the components. The following interpretations are suggested: liveware (human), hardware (machine), software (procedures, symbology, etc.) and environment (the conditions in which the L-H-S system must function). This block diagram does not cover interfaces which are outside Human Factors (e.g. between hardware-hardware; hardware-environment; software-hardware) and is intended only as an aid for understanding Human Factors.

Liveware (or the human) is at the centre of the model. Human is generally considered the most critical as well as the most flexible component in the system. Yet people are subject to considerable variations in performance and suffer many limitations, most of which are now predictable in general terms. The edges of this block are jagged, and so the other components of the system must be carefully matched with them if stress in the system and eventual breakdown are to be avoided. In order to achieve this matching, an understanding of the characteristics of this central component is essential. Examples of those important characteristics are as follows:



*Figure.1 SHEL model*

Liveware is the hub of the SHEL model of Human Factors. The remaining components must be adapted to and matched with this central component. Liveware-Hardware: This interface is the most commonly considered when speaking of human-machine systems: the design of seats to fit the sitting

characteristics of the human body; of displays to match the sensory and information-processing characteristics of the user; of controls with proper movement, coding and location. The user may not be aware of an L-H deficiency, even when it finally leads to disaster, because the great virtue of human adaptability may mask the effects of such a deficiency. However, the deficiency continues to exist and may constitute a potential hazard. Ergonomics deals mostly, although not exclusively, with issues arising from this interface.

Liveware-Software: This encompasses the interface between humans and the non-physical aspects of the system such as procedures, manual and checklist layout, symbology and computer programmes. The problems may be less tangible than those involving the L-H interface and consequently more difficult to detect and resolve (e.g. misinterpretation of checklists or symbology).

Liveware-Environment: The human-environment interface was one of the earliest recognized in aviation. Initially, measures taken were aimed at adapting the human to the environment (e.g. by using helmets, flying suits, oxygen masks and G suits). Later, attempts were made to alter the environment to match human requirements (e.g. by applying pressurization, air-conditioning and soundproofing). Today, new challenges have risen, notably ozone concentrations and radiation hazards at high flight levels, and the problems associated with disturbed biological rhythms and sleep because of high-speed transmeridian travel. Since illusions and disorientation are involved in many aviation occurrences, the L-E interface must also consider perceptual errors induced by environmental conditions (e.g. illusions occurring during approach and landing). The aviation system operates within the context of broad managerial, political and economic constraints. These aspects of the environment will interact with the human via this interface. Although the modifications to these factors are generally beyond the function of Human Factors practitioners, they should be considered and addressed by those in management with the ability to do so.

Liveware-Liveware: This is the interface between people. Flight crew training and proficiency testing have traditionally been conducted on an individual basis. If each individual crew member was proficient, then it was assumed that the team comprising those individuals would also be proficient and effective. This is not always the case, however, and for many years attention has been increasingly turned to the breakdown of teamwork. Flight crews function as groups and group interactions play a role

in determining behavior and performance. In this interface, one is concerned with leadership, crew cooperation, and teamwork and personality interactions. Staff/management relationships are also within the scope of this interface, as corporate climate and company operating pressures can significantly affect human performance.

### Human error

The number of pilots is far smaller than the number of drivers, and aircraft crashes are much less frequent than auto accidents. Statistically the chances of death while riding in a motor vehicle are 30-50 times greater than while riding in a commercial aircraft. However, the number of people who fly as passengers in aircrafts is large enough, and the cost of a single air crash is sufficiently greater than that of a single car crash that the human factors issues of airline safety are as important as those involved with ground transportation. The competing tasks that pilots must perform involve maintaining situation awareness for hazards in the surrounding airspace, navigating to three-dimensional points in the sky, following procedures related to aircraft and airspace operations, and communicating with air traffic control and other personnel on the flight deck. Much of the competition for resources is visual, but a great deal more involves more general competition for perceptual, cognitive and response-related resources. Depending on many factors, from the aircraft type to weather conditions, the pilot's workload can range from under load to extreme overload.

### Human error reduction

In order to reduce human error, one of the first things needed is a change in attitude. The behavior we call human error is just as predictable as system noise, perhaps more so: therefore, instead of blaming the human who happens to be involved, it would be better to try to identify the system characteristics that led to the incident and then to modify the design, either to eliminate the situation or at least to minimize the impact for future events. One major step would be to remove the term "human error" from our vocabulary and to re-evaluate the need to blame individuals. A second major step would be to develop design specifications that consider the functionality of the human with the same degree of care that has been given to the rest of the system.

Human error and their negative consequences are decreased in one of the three ways viz., system design, training and personnel selection. For system design, errors can be reduced by: making it impossible for a person to commit an error, making it

difficult to commit an error, or making the system error tolerant so that when errors occur, the negative consequences are avoided. Error tolerance can be achieved by methods such as feedback to the operator about current consequences, feedback about future consequences, and monitoring actions for possible errors. Design features can be included so that erroneous actions can be reversed, if they are noticed, before they have serious consequences on system performance. Human Factors principles should be applied to design. The goal is to reduce, if not eliminate, risk through design. An important thing to remember is that reliability goes down as complexity goes up.

When system design or information support cannot be used, then selection and training methods should be designed to minimize operator error. Training and Personnel Selection are important factors; however because mistakes are unavoidable in human performance even the most experienced, and best trained pilots will make errors. The notion of "error management" has developed in the past two decades in order to help solve this problem. While we must accept the inevitability of error, we must nevertheless maintain performance standards. Error management demands that we distinguish between an individual being reckless or showing a disregard for the rules, and mistakes that are simply the product of human limitations. "Error management" represents a fundamental shift in aviation philosophy from "excellent airmen commit no errors" to "excellent airmen commit, recognize and resolve errors."

The first and most basic premise of error management is that human error is universal and inevitable. Error management views human performance as a two-sided coin --human performance and human error. The coin's two sides are inextricably linked. We cannot have one without the other. Error is universal. Error is inevitable. One cannot engage in human performance of any form without human error. A second, and equally critical, premise of error management is that error does not, has not, and will not cause an incident, an accident, or a fatality. Consequences cause incidents, accidents, and fatalities. While error is universal and inevitable, consequences are not universal or inevitable. The logic of this premise is beyond dispute. Errors happen all the time. Incidents, accidents, and fatalities do not. Error management targets the gap between the errors and their consequences. Error management holds the view that any attempt to address flight safety, which does not acknowledge universal and inevitable human error will fall short of the mark. The acknowledgement

removes the stigma associated with error. It depersonalizes error. Error is no longer a reflection upon the crewmember. Just as the sun will rise in the east and set in the west, errors will occur. Error management also assumes technical proficiency.

### Conclusion

Human factors awareness can lead to improved quality, an environment that ensures continuing worker and aircraft safety, and a more involved and responsible work force. More specifically, the reduction of even minor errors can provide measurable benefits including cost reductions, fewer missed deadlines, reduction in work related injuries, reduction of warranty claims, and reduction in more significant events that can be traced back to maintenance error.

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