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Physio-Cognitive Risk Factors that Affect Human Performance in Aviation

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Paper I

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On August 14, 2013, about 0447 central daylight time (CDT), UPS flight 1354, an Airbus A300-600, N155UP, crashed short of runway 18 during a localizer non-precision approach to runway 18 at Birmingham-Shuttlesworth International Airport (BHM), Birmingham, Alabama. The captain and first officer were fatally injured, and the airplane was destroyed by impact forces and post-crash fire (NTSB, 2014). The National Transportation Safety Board determined that the probable cause of this accident was the flight crew's continuation of an unstabilized approach and their failure to monitor the aircraft's altitude during the approach, which led to an inadvertent descent below the minimum approach altitude and subsequently into terrain. Contributory to the accident were the captain's performance deficiencies likely due to factors including, but not limited to, fatigue, distraction, or confusion, consistent with performance deficiencies exhibited during training; and the first officer's fatigue due to acute sleep loss resulting from her ineffective off-duty time management and circadian factors.

Aim

This accident highlights some physio-cognitive human risk factors that can have detrimental effects on the optimal performance of flight crew and lead to fatal outcomes and the aim of this paper is to discuss concepts such as fatigue, sleep/ circadian rhythm, Stress, alcohol and flying within the operational environment relevant to Ghana Airforce operations. will be discussed, and remedial measures suggested to improve personnel coping strategies, performances and reduce errors associated with these risk factors.

Fatigue

Fatigue may be acute, occurring over a relatively short time period after significant physical or mental activity, or it may be chronic, developing because of insufficient sleep over a prolonged period (perhaps because of jet lag or shift work) or it may stem from continual physical or mental activity with insufficient rest periods. Chronic fatigue can also be an outcome of depression and stress or it can result from behavioral issues including excessive alcohol or caffeine use, working late into the night or simply being in unfamiliar or uncomfortable surroundings (Caldwell, 2003).

Chronic Fatigue

Chronic fatigue is the result of cumulative effects of fatigue over the longer term. Temperature, humidity, noise, workstation design and Hypoxia are all contributing factors to fatigue. Unfortunately, in our operational environment we sometimes underestimate the risk factors of fatigue by sub-consciously considering it as sign of weakness or lack of toughness as soldiers. Fatigue has no respect for rank, trade and experience-level and the detrimental effects on performances can be adverse.

Symptoms of Fatigue

The principal symptom of fatigue is tiredness (not necessarily sleepiness) but can also include headaches, general body aches and pains, and bleary eyes. More specifically, fatigue impairs concentration, complex cognitive tasks and manual dexterity. Harris (2011) observed that fatigued aircrew exhibited a great deal more reliance on automated systems than did their non-fatigued counterparts. Studies suggest that fatigued workers are more prone to be satisfied with lower performance and find it difficult to detect and correct errors. In fact, fatigued crews tend to be channelized in their attention and concentrate on one problem while allowing other problems to develop (Harris, 2011).

Sleep and fatigue

The human body systems are regulated on a 24-hour basis by what is known as the circadian rhythm. This cycle is maintained by several agents: day and night, meals, social activities, etc. When this cycle is disturbed, it can negatively affect safety and efficiency. Symptoms of circadian rhythm disturbance or circadian dysrhythmia include sleep disturbance, disruption of eating and elimination habits, lassitude, anxiety and irritability. That will lead to slowed reaction, longer decision-making times, inaccuracy of memory and errors in computation which will directly affect operational performance and safety.

The most common symptom of circadian dysrhythmia is sleep disturbance. Tolerance to sleep disturbance varies between individuals and is mainly related to body chemistry and emotional stress factors. In some cases, sleep disturbance can involve cases of over-all sleep deprivation. When that stage is reached it is called Situational Insomnia, i.e. it is the direct result of a situation. In all cases, reduced sleep will result in fatigue. Some people have difficulty sleeping even when living in normal conditions and in phase with the circadian rhythm. Their case is called *Clinical Insomnia*. They should consult a medical doctor and refrain from using drugs, tranquillizers or alcohol to induce sleep, as they all have side effects which will negatively affect their performance and therefore the safety of flights.

Remedial Measures

To overcome problems of sleep disturbance personnel should adapt a diet close to their meal times, learn relaxation techniques, optimize the sleeping environment, recognize the adverse effects of drugs and alcohol and be familiar with the disturbing effects to circadian dysrhythmia to regulate their sleep accordingly. It should be noted that physical fitness will have favorable effects on emotions, reduces tension and anxiety and increases resistance to fatigue. Factors known to positively influence fitness are exercise, healthy diet and good sleep/rest management. Finally, it is each individual responsibility to arrive at the workplace “fit to fly”.

Stress

Stress can be found in many jobs, and the aviation environment is particularly rich in potential stressors. Stress can result both from occupational sources and non-occupational sources (and an interaction between the two). If it is accepted that stress is deleterious to both performance and health, then it is in the best interests of the Ghana Airforce to assist personnel in coping with the problem. The UK National Work Stress Network (2006) puts it quite neatly: ‘Work-stresses go home with the worker: home-stresses come to work with the worker’. The UK Health and Safety Executive (2008) define stress as ‘the adverse reaction people have to excessive pressure or other types of demand placed on them ‘.

Symptoms of Stress

Some of these stressors have accompanied the aviation environment since the early days of flying, such as weather phenomena and in-flight emergencies. The effects of repetitive sectors, operating across many time zones, working unsociable hours and being separated from family and friends are only a few aspects of operational missions that influences the human. Military aviation is safety critical in nature and the demands of having to constantly achieve high levels of performance are themselves wearing. This must be remembered when appraising the role of flight crew. Stressed personnel may experience increased irritability, a deterioration of relationships with family and friends, sleep disturbances, depression or anxiety, headaches and indigestion. This can lead to an increase in stress-related work absences, increased smoking, drinking and/or drugs use and reductions in performance (e.g. stemming from an inability to concentrate) and an increased unwillingness to work as part of a team or accept advice.

Consequences of Stress

Ultimately, stress can result in far more serious chronic health consequences, for example cardiovascular disease; impaired immune function; ulcers; an increased pre-disposition to cancer; musculoskeletal disorders; and psychological disorders such as longer-term anxiety and depression. The International Labor Organization Encyclopedia of Occupational Safety and Health (2007) further suggests that in addition to these consequences there is evidence to suggest that stressful working conditions interfere with safe work practices and increase the likelihood of errors and injuries at work. It also noted that some studies related stress to an increased risk of suicide.

Stress can also be associated with life events which are independent from the aviation system but tightly related to the human element. Such events could be sad ones like a family separation, or happy ones like weddings or childbirth. In all situations, individual responses to stress may differ from a person to another, and any resulting damage should be attributed to the response rather than the stressor itself.

In the aviation environment, individuals are encouraged to anticipate, recognize and cope with their own stress and perceive and accommodate stress in others, thus managing stress to a safe end. It is highly recommended that peers, supervisors and commanding officers understand the hazard posed to operations by stress and not to 'write it off' as a non-factor in operational mission planning and execution. The Ghana Airforce Flight Surgeons Office must be utilized by all and periodically brought in to facilitate capacity and awareness sessions for personnel. Failure to do so will only aggravate the stressful situation and might compromise operational safety.

Alcohol

In the US, An American Airlines pilot flunked two sobriety tests before a 7 a.m. flight out of Detroit. An Alaska Airlines pilot flew a commercial plane from California to Oregon and back again, all while allegedly drunk (Fox, 2016). Between 2010 and 2015, FAA records show 64 pilots were cited for violating the alcohol and drug provisions, and in 2015, some 1,546 personnel who must ensure airline safety, including 38 pilots, tested positive for one or more of five illegal drugs (FAA, 2017). It has been reported that up to 12 per cent of professional pilots drink alcohol as a means of coping with stress and fatigue (Harris, 2011). These stressors may either be of a personal nature, a product of work-related pressures or an interaction between the two (such as the effects of long stopovers).

Alcohol is a primary and continuous depressant of the central nervous system. In persons intolerant of alcohol, impairment of judgment and of recently learned, complex, and finely tuned skills begins to occur at blood alcohol concentrations as low as 5.4 mmol per liter (0.025 percent), followed by the loss of more primitive skills and functions, such as gross motor control and orientation, at concentrations in excess of 11 mmol per liter (0.05 percent) (Hill, 1986) .This writer does not know the level of alcohol related issues and accidents among operational personnel in the Ghana Airforce and have not been able to determine if there are records in any database for research in the Ghana Airforce, but it will be beneficial to highlight the effects of alcoholism among personnel. Harris (2002) suggested five basic reasons for alcohol consumption and flying among pilots:

a. **Promulgation of information** – Very few pilots were aware of the appropriate regulations. Rules that pilots are unaware of are ineffective.
b. **Stressors** – One of the fundamental reasons for drinking and flying was an inability of some individuals to control their use of alcohol. Job-related stresses were frequently cited as a common cause of heavy drinking in professional pilots.
c. **Socialization** – Long-haul flight crew members commonly report drinking socially with other crew members after flights and as a means of helping them to relax, especially after crossing several time zones. Other authors have suggested that military pilots, are from what may be characterized as a 'drinking culture', where great store is placed upon factors such as camaraderie and 'team spirit'. It is unlikely that a drink-flying event would immediately follow such a social gathering, however, it is more likely that after a heavy drinking session a pilot may fly the following day with an unacceptably high blood alcohol level (BAC) in addition to a hangover.
d. **Lack of knowledge** – A fundamental lack of knowledge about the rate at which BAC declines as a function of time and the amount of alcohol consumed. The problem of accidentally transgressing the drinking and flying regulations is quite common. Does the Ghana Airforce have a policy and procedure to check blood alcohol levels and are operational crew conversant with the regulations on BAC? In a study in the UK, 24 per cent of UK pilot's license holders could not determine when their BAC was likely to fall below 20mg/dl after drinking and may therefore be in danger of inadvertently infringing the regulation (Harris, 2011).
e. **Attitudes, beliefs and opinions** – Attitudes, beliefs and opinions towards the use of alcohol all effect the likelihood of drinking and flying and in many ways. Research found that self-reported drinking behavior was much more conservative when consuming whisky compared to wine or beer. It has been observed that 'hard' liqueur was perceived to be more dangerous to consume prior to flying than either wine or beer. Two potential groups of drinking and flying pilots have been identified: 'inadvertent drink-flyers', who did so because of a lack of knowledge and 'non-believers' in the regulation. The latter felt that they were safe to fly before their BAC had dropped below the 20mg/dl limit. Members of the 'non-believers' group of pilots tended to be older and more likely to be highly experienced pilots.

Recommendations for counter-measures to alcoholism is based on a deterrence model by Vingilis and Salutin (1980) which suggests remedial actions at three levels:

1. The Ghana Airforce must improve the primary level interventions through effective education about the effects of alcohol on performance.

2. There should be enforcement of the existing regulations in the Ghana Airforce Flying Orders (i.e. increasing the likelihood, or perceived likelihood of apprehension of offenders) on alcohol and operational task.
3. Tertiary level interventions should aim at reducing the chances of repetitive acts through either punitive sanction (aimed at suppressing offending behavior) or through counselling and rehabilitation (targeted at eliminating the root cause of offending behavior).

The Ghana Airforce can also adopt the FAA policy that requires at least 10 per cent of all airline employees, including pilots, to be randomly selected for drug and alcohol testing and they may require up to 50 per cent of employees in safety-critical roles to be tested in any calendar year. In the case of a pilot producing a positive breath test with an indicated BAC of between 20mg/dl and 39mg/dl, that person is prohibited from flying until a repeat test indicates that their BAC is below 20mg/dl or at least eight hours have elapsed from taking the initial test.

The provision of Personnel Assistance Programmed (PAP) that offers confidential counselling and rehabilitation may be the most effective approach to reducing the likelihood of drinking and flying rather than reliance on the punitive components. The Office of the Ghana Airforce Flight Surgeon must be encouraged and publicized to provide these assistances.

In conclusion, the paper discussed concepts such as fatigue, sleep/ circadian rhythm, Stress, alcohol and flying relevant to the operational environment in the Ghana Airforce. Remedial measures such as the learning of relaxation techniques, optimizing the sleeping environment, recognizing the adverse effects of drugs and physical fitness will have favorable effects on emotions, reduces tension and anxiety and increases resistance to fatigue. The Ghana Airforce flight surgeon's office must facilitate capacity and awareness sessions for personnel through effective education about the effects of alcohol on performance and coping strategies against these factors which can decrease human performance and increase operational errors and safety occurrences.

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Paper II

Practical Human-factors Training and Implementation Program in Ghana Airforce Operations

On June 5, 2000, a Ghana Airforce Fokker 27 was involved in an approach-landing accident at the Kotoka International Airport in Accra and resulted in 7 fatalities (Aviation safety Network, 2018). On June 2, 2012, an Allied Air Boeing 727-200 cargo airliner overrun runway 21 in Accra, breached the airport security wall and crossed over the Giffard Road, near Elwak Stadium (Aviation Safety Network, 2018). The accident resulted in 12 fatalities because of impact with a passenger vehicle on the Giffard Road near the El-Wak Stadium in Accra. Human factors were cited as contributory factor to these accidents in aviation operations. That has highlighted the ever-present and ongoing risk of aircraft accidents involving multiple fatalities to aviation operations in Ghana. There is the need to strive for more efficient aircraft operations in an increasingly complex aviation system.

Aim

The aim of this paper is to provide an overview of some human factors concepts within the aviation operational environment which can lead to the development of appropriate policies, strategies and practical tools to mitigate the adverse impact of human performance failures and errors on aviation operations in the Ghana Airforce. Principles such as Humans and Error, Crew Resource Management, Communication, Threat Error Management and Lone-Oriented Safety Audits (LOSA) will be briefly discussed. Relevance to Ghana Airforce operations will be cited and recommendations made to enhance safety in flight operations.

What is Human Factors

Human factors remain one of the key areas in which human errors and risk of operational hazards encountered by personnel and organization can be managed. The multidisciplinary field of human factors is devoted to optimizing human performance and reducing human error and incorporates the methods and principles of the behavioral and social sciences, engineering, and physiology (Harris, 2011). Human factors delve into the science of people working together in concert with machines and aims at achieving safety and efficiency by optimizing the role of people whose activities relate to complex hazardous systems such as aviation (ergonomics). Ergonomics focus on human- centered design which attempt to minimize the opportunities for error to occur or if an error does perchance happen, its consequences minimized. Ergonomics ensures that the system is made 'error tolerant'.

It is recognized that inadequate system design or inadequate operator training can contribute to individual human error that leads to system performance degradation. Further, it is recognized that inadequate design and management of crew tasks can contribute to group errors that lead to system performance degradation and hence the relevance of human factors in operational planning (Harris, 2011).

Humans and Error

The human element is the most flexible, adaptable and valuable part of the aviation system. But it is also the most vulnerable to influence, which can adversely affect its performance. Lapses in human performance are cited as causal factors in most of incidents/accidents, which are commonly attributed to "Human Error". Human Factors have been progressively developed to enhance the safety of complex systems, such as aviation, by promoting the understanding of the predictable human limitations and its applications to properly manage the 'human error'. It is only when seeing such an error from a complex system viewpoint that we can identify the causes that lead to it and address those causes. One of the important aspects of human factors is the applied component known as Crew Resource Management (CRM).

Crew Resource Management (CRM)

Crew Resource Management aims at teaching crew members how to use their interpersonal and leadership styles in ways that foster crew effectiveness by focusing on the functioning of crew members as a team, not only as a collection of technically competent individuals, i.e. it aims at making aircrew work in "Synergy" (a combined effect that exceeds the sum of individual effects). Human Factors training aims at modifying attitudes and behavior patterns through knowledge, persuasion and illustration of examples revealing the impact of attitudes and behavior on flight safety. Effective CRM builds the capacity of flight crew to utilize all available resources to effectively make safe and rapid decisions in both normal and non-normal situations.

With a rapidly expanding technological and operational base in aviation aimed at major improvements in safety and efficiency the human factor continues to be an issue in sub-optimal outcomes in aviation. The various evolution of CRM and the challenges with implementation and acceptance since its inception in 1978 has resulted in positive dividends in terms of safety and efficiency. Any CRM program must have some essential components attached to it. The concept must be understood, certain skills must be taught, and inter-active group exercises must be accomplished. The evaluation of the non-technical skills (NOTECH) and attributes of the human operator is very important in current CRM modules. The main components of these NOTECH are:

a. **Co-operation** – Team building and maintaining, considering others, supporting others and conflict solving.
b. **Leadership and managerial skills** – Use of authority/assertiveness, providing and maintaining standards, planning and coordination, and workload management.
c. **Situation Awareness** – System awareness, environmental awareness and anticipation.
d. **Decision making** – Problem definition/diagnosis, option generation, risk assessment/option choice and outcome review.

To understand and utilize these components, personnel must be aware of synergy, the effects of individual behavior on the team work, the effect of complacency on team efforts, the identification and use of all available resources, the statutory and regulatory position of the pilot-in-command as team leader and commander, the impact of company culture and policies on the individual and the interpersonal relationships and their effect on team work. It is vital that CRM be fully inculcated in operational activities and fully assessed in flight operations.

Communication

Effective communication skills are the basis of successful teamwork. Effective communication provides information; establishes interpersonal relationships; establishes predictable behavior patterns; maintains attention to task and monitoring; and is a management tool. Generally, it has been found that crew performance improves with an increase in task-related communication (Kanki and Palmer, 1993). Studies in flight simulators have observed that high performing crews discussed in-flight problems in greater depth than did crews that performed less well. These crews also used the low workload flight phases to plan ahead and talk about options (Orasanu and Fisher, 1992). Furthermore, they talked more about strategy and planning but issued fewer commands during an emergency.

Aircraft commanders and team leaders in the Ghana Airforce have a responsibility to establish effective teams and that is enhanced by using communication tools to provide extensive crew briefings and debriefings before and after each flight. During these briefings they must establish their credibility as a leader, spelling out the required goals for performance and leading by example, yet at the same time encouraged all crew to be active participants in the management of the flight. In a cultural and organizational system that implicitly promotes a High Power Distant Construct (Hofstede, 1984), confrontation is generally circumvented and questioning or contradiction of superiors is avoided at all costs by sub-ordinates in flight operations.

It behooves on aircraft commanders to use the social aspect of effective communication to enhance the operational component through mutual respect for the input of subordinates. Subordinates must ensure respect for the captain's command authority but at the same time be assertive to voice their opinions. It has been suggested that there is an optimum authority gradient to promote effective communication and coordination between crew members. If the gradient is too 'flat' (e.g. two Captains or a junior Captain and a very senior co-pilot) then the dividing line of who is in charge can be unclear. If the gradient is too 'steep' with a domineering senior Captain and an unassertive junior co-pilot, this can inhibit communication, coordination and the cross checking of errors.

One of the roles of the 'other' pilot on the flight deck (whatever their designation or role is, be it co-pilot of Pilot-Not-Flying) is as an error checker and early warning system. This can only happen if open communication is established. It should be reinforced through training and continuous discussions during briefs/debriefs in the various operational squadrons. There is also a need for checklists and standard operating procedures to be performed on a 'challenge and response' basis. The system of 'monitor and cross-monitor' and 'challenge and response' is predicated upon the belief that crew members will alert each other to irregularities and errors.

Threat Error Management (TEM)

It is now understood that pilot errors cannot be entirely eliminated. It is important, therefore, that pilots develop appropriate error management skills and procedures. It is certainly desirable to prevent as many errors as possible, but since they cannot all be prevented, detection and recovery from errors should be addressed in training and briefings. Evaluation of pilots should also consider error management (error prevention, detection, and recovery).

The introduction of a Threat, Error Management (TEM) module and scenario-based training for GAF pilots as part of primary and recurrent training will be beneficial. TEM recognizes that since not all errors

can be prevented, it is important that errors be managed properly. These may be either latent threats (threats that are not always easily identifiable, but which predispose the commission of errors) or overt threats (factors that can more easily be identified as having the potential to increase the likelihood of an error).

Line -Oriented Safety Audits

Line -Oriented Safety Audits (LOSA) is highly recommended in Ghana Airforce flight operations. As part of the proactive safety management system, flight operations data are collected on a non-jeopardy basis by trained observers during regular task-orders (They will jump-seat as passive observers). These data form the basis of an audit process to check the everyday safety health of the various operational squadrons at an organizational level. LOSA allows the Ghana Airforce to check the effectiveness of the following:

a. Identify threats in the Ghana Airforce external operating environment (e.g. adverse weather, traffic congestion or airport conditions). Frequently occurring threats or those that are often mismanaged by crews can be prioritized for further investigation or training. LOSA can also identify positive behaviors which are beneficial to safety which can be used to benefit operations through developing procedures or advisories.

b. Identify threats from within the Ghana Airforce operations (e.g. operational time pressures, dispatch errors or problems with ramp personnel). Operational threats regularly arising from certain departments suggest that these areas should be targeted for improvement.

c. Assess the degree of transference of training to the line. Allows Air Operations Directorate (DAO) and Validation and Standards Directorate (DVSI) to review the effectiveness of training and if it transfers to line operations though the data provided by TEM and Safety Reporting, Standard Operation Procedures Reviews etc.

d. Check the quality and usability of procedures.

e. Provide insight concerning problems with SOPs. If several different crews make the same error when applying an SOP, it can be an indication that the procedure is ill-timed, over-long, confusing and/or competes with other concurrent flight deck activities.

f. Identify design problems in the flight deck interface. A LOSA can capture aircraft handling and automation management errors which may be indicative of systemic flaws in design and which can also help in developing SOPs to help circumvent these design defects.

g. Understand pilots' shortcuts and workarounds. These are rarely observed during line checks as pilots normally operate 'by the book' in such circumstances. LOSA can provide data concerning such non-standard practices, some of which may be superior ways of working to airline SOPs. The adoption of unsafe shortcuts and workarounds can also be identified and remedied.

h. Assess safety margins. A LOSA can provide information about the prevalence of threats and errors that are mismanaged. These can be regarded as precursors to incidents and accidents. In this way it can be established how close to the edge of the safety envelope an airline is operating.

i. Provide a baseline for organizational change. LOSA data can be used to provide baseline data against which organizational interventions can be assessed to establish if they have been effective in reducing the instance of threats, errors or undesired aircraft states.

j. Provide a rationale for allocation of resources. LOSA data provide an insight into both the safety strengths and weaknesses in the Ghana Airforce and hence provide a data-driven rationale for the allocation and prioritization of organizational resources.

k. LOSA provides a tacit understanding of latent threats include such things as organizational (safety) culture, scheduling or vague policies. Overt threats to safety encompass issues such as the operating environment, individual pilot factors (e.g. attitude, training or fatigue) and crew factors (teamwork, leadership, etc.).

In conclusion, the paper highlighted some human factors concepts relevant to the aviation operational environment of the Ghana Airforce. Understanding these concepts can assist in the development of appropriate policies, strategies and practical tools to mitigate the adverse impact of human performance failures and errors on aviation operations in the Ghana Airforce. Concepts such as Humans and Error, Crew Resource Management, Communication, Threat Error Management and Line-Oriented Safety Audits (LOSA) were discussed.

The paper recommends a proactive effort to inculcate CRM, TEM and LOSA training in the primary and recurrent training programs for all flight operations personnel. The scenario-based training components of CRM and TEM as part of primary and recurrent training will be beneficial for operational personnel. These training can be assessed as part of category upgrades and promotion examinations for operations personnel. The strength and effectiveness of these program can be assessed through LOSA, where the observed practices will be compared to promulgated procedures and policies which must become an inseparable part of the Ghana Airforce safety culture.

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