The Systemic Effects of Fatigue on Military Operations

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Abstract

This paper uses recent accidents and incidents to identify the systemic causes of fatigue in military operations. At a strategic and tactical level, it is argued that inadequate risk assessments and a lack of 'joined up' planning often leave soldiers in situations where they are likely to make errors of commission and omission. At an operational level, fatigue has an insidious effect on the interaction between teams. Not only does it impair performance on shared tasks but it can also prevent soldiers from identifying the worst effects of fatigue in their colleagues. The significance of these insights cannot be underestimated. Night vision and remote sensing technologies increasingly support 24/7 operations. Unless greater attention is paid to the more complex, systemic aspects of fatigue then there seems little prospect that we will be able to reduce the growing numbers of accidents that have been experienced by many military organizations.

1. Introduction

A recent incident involving an US Army M985 Heavy Expanded Mobility Tactical Truck illustrates the impact of fatigue on operational effectiveness [1]. The driver had spent the day preparing for a night tactical road march involving a 73-vehicle convoy. He had few opportunities to rest before they left for the marshalling area around 21:30. With 6% moon illumination and 2-mile visibility, the crews used Night Vision Goggles (NVGs). They linked up with the rest of the vehicles in their section and at 24:00 the company commander conducted a convoy leaders briefing. At 02:30, several drivers fell asleep when the section came to a halt before refueling. Partly as a result, gaps began to appear in the convoy when it eventually started to move again. Shortly afterwards, the truck drove off the left side of a tank trail and partially turned over in a 4-foot deep stream. The driver drowned. The resulting investigation concluded that the incident was caused by inadequate risk assessment. Given the size of the convoy, the company commander delegated responsibility for ensuring adequate rest to squad leaders. They, in turn, did not review rest patterns on the day before the accident. Lack of sleep was compounded by the demands of driving using NVGs.

This case study shows how fatigue influences different levels within a military command structure. The driver was tired enough to crash the truck. However, fatigue also impaired the leaders' decision-making processes as they continued to drive through the night. It is, therefore, important not to view fatigue as a problem in isolation from other concerns. It is a 'systemic' factor that influences a host of adverse events ranging from poor operational risk assessment through communication failures to poor situation awareness [2].

2. Factors Influencing Fatigue

The 'systemic' nature of fatigue is illustrated by the ways in which different operational requirements interact and place sustained demands on key personnel. The dedication and motivation of military personnel also makes it difficult for them to refuse these different demands even when they endanger safe or successful operations. For example, a US Army helicopter crew recently prepared for a training exercise by sleeping until mid-morning. By 16:00, they had finished a preflight inspection but then received immediate instructions for them to return to their home base. They took off at 17:30 and arrived back by 22:30. They were told that their unit was preparing for immediate deployment. The pilot completed preparations by 00:30 and was told to get some sleep but to be back on the airfield by 05:00. He managed to sleep for less than an hour given the stresses involved in preparing for deployment. He also struggled to gain any sleep as a fixed wing aircraft transported them and their machines to their destination. On arrival, the unit took part in intelligence and threat briefing, detailed mission planning and map studies. By 24:00 on the second day, the unit was moved on transport aircraft to a forward staging base. By 02:30 they arrived at the forward base to unload and prepare their aircraft. By 06:00 the pilot and his colleagues were waiting for clearance to takeoff. He concluded "I collapsed in exhaustion. My first day of combat had added another 16 hours of wakefulness, bringing the total to 62 hours. I couldn't help wondering what I would have done if the mission extended any further before I could get some sleep" [3]. FAA requirements suggest that commercial pilots should have nine consecutive hours of rest in any 24 hour period prior to a flight (US Code Title 14, part 121.471).

Such examples illustrate the practical problems that undermine many of the principles expressed in the US Army's FM22-51 Leaders' Manual for Combat Stress [2]. This reiterates the need for military personnel to continuously monitor the possible impact of fatigue on their teams. However, as we have seen, competing demands of military operations force the rapid redeployment of scarce resources between training and operations. Such incidents illustrate that fatigue often arises from the interaction between different organizational demands rather than one which is the result of negligence or carelessness by a single individual.

Circadian Rhythms: A number of factors influence the effects of fatigue on military operations. For example, circadian rhythms can influence performance, alertness, behavior and mood. The majority of people feel the greatest need for sleep between 03:00-05:00 and 15:00-17:00. Periods of greatest alertness seem to cluster between 09:00-11:00 and 21:00-23:00. Many different factors affect the synchronization of these episodes of alertness and sleepiness. It can take more than three weeks to adjust to a new time zone or to adapt to a new shift pattern. The period of adjustment is influenced by the degree of disruption and a range of external factors, including exposure to light.

Disruptions in circadian rhythms have contributed to a range of military incidents and accidents. For example, the Canadian Forces recently lost a Sea King helicopter during a deck-landing and C-6 gun training mission [4]. The aircraft suffered a loss of lift shortly after take off, hit the flight deck and rolled over on its right side. Although the cause of the accident was traced to a possible compressor stall in one of the engines, the subsequent investigation argued that 'circadian desynchronism' contributed to the incident. At the time of the accident, the aircrew was on board a vessel in an operational 'work up' in the Arabian Gulf. The evening before the flight, the ship advanced clocks from midnight to 01:00 and then immediately practiced an emergency fire drill. The entire ship's company was involved until approximately 02:00. The Helicopter Air Detachment Commander took these disruptions into account and rescheduled the flights to start at 10:45 rather than 08:00. However, the investigation argued that the early fire drill coupled with the time zone change may have prevented the crew for responding to warning signs before the accident. These included a delay in starting the engine and pooling of water spray in front of the in-takes; "in light of these events, it is possible that TMD (circadian disruption) may have affected the aircrew during their assessment of whether or not to perform engine-related maintenance or to even continue with the launch" [4]. This incident again illustrates the 'systemic' nature of fatigue in military operations where crew performance is adversely affected by activities, such as the fire drill, that are outside of their immediate control.

Environmental Factors: Environmental factors, including noise, vibration and time-stress, exacerbate the impact of fatigue. These factors often characterize military operations. For example, recent UK and US military engagements have placed personnel in relatively hot environments. Sleep patterns do not, in general, improve over time where heat disrupts restorative rest intervals [5]. These environmental factors are important systemic causes of fatigue because they interact with many other factors that complicate military operations. For instance, heat can exacerbate the boredom and fatigue that can be associated with repetitive tasks. Many recent accidents have occurred in convoys where drivers have been required to wear Kevlar helmets and body armor.

Other external factors, including noise, both induce fatigue and prevent sleep. For example, a Canadian reservist worked all day prior to helping her unit move to an exercise area. She also attended military training classes before reaching bed around midnight. She was then assigned Fire Picket duty from 03:00-04:30. Her immediate superior requested that she be taken off the duty but was overruled by his superior. She tried to sleep after her duty but was prevented by the noise coming from the Armory. She was then awoken shortly before 05:00. Within an hour of departure, she fell asleep at the wheel of a utility vehicle. It left the road and rolled several times. She suffered multiple injuries and was unable to work for several months [6]. This accident illustrates how the demands on particular soldiers are exacerbated by the difficulty of sleeping in many operational environments. It also again illustrates the role that leaders play in managing fatigue; her immediate superior was over-ruled in his attempt to provide additional rest.

3. Consequences of Fatigue

The US Army Centre for Combat Readiness [1] has identified a board range of problems that stem from fatigue in military operations: difficulty in thinking clearly; poor performance; greater tolerance for error; inattention to details; increased lapses of attention; increased irritability; decreased motivation, attempts to conserve effort; increased errors; slow and irregular reaction times; impairment in communicating and cooperating with other soldiers, headaches or stomachaches; poor morale.

Cognitive Performance: How et. al. [7] have shown that higher subjective assessments of 'sleepiness' are associated with poorer performance. However, it can be difficult to validate the insights that are obtained from self-reporting of fatigue. Itoi et al [8] asked sleep-deprived participants to predict whether they would fall asleep over the next 2-minute interval on a scale from 0% to 100% likelihood. On those occasions when a participant did fall asleep within the 2 minute interval, the average likelihood estimated by the participants was only 55%. In other words, they did not think they would fall asleep immediately before they did fall asleep. This has considerable practical implications; it can be difficult for military personnel to accurately assess their level of fatigue as they become increasingly tired. This can be illustrated by a recent incident involving a KC-135 air refueling tanker in Iraq. The pilot inadvertently transferred too much fuel from one side of the aircraft causing a potential imbalance after the crew had completed twelve 6-7 hour missions. As in many military incidents, it is only the realization that an accident was averted that eventually forced the crew to accept how tired they had become. The pilot reported; ''I don't think you really know the fatigue that sets into your body until you are finally able to rest. Even though I was getting enough rest at night ... my body and senses became very numb, because of the demand for the missions in Operation Iraqi Freedom, our crew had become so tired that we forgot the little things" [9].

These findings support the argument that fatigue should be viewed as a systemic problem in military operations. Lab studies and recent incident reports show that that there will continue to be a significant number of adverse events if we continue to rely upon individuals to determine when they most need to take a break. In contrast, we would argue that the hazard analysis recommended in the US military's new Composite Risk Management should explicitly consider the impact of fatigue on every operation.

Lapses and Situation Awareness: Increases in subjective levels of fatigue can have numerous adverse consequences. These include a rise in the frequency of lapses in attention. These can extend to 'microsleeps' that can last from 0.5 to 10 seconds. Lapses can also be compounded by other problems of attention, such as the encysting that occurs when soldiers become preoccupied with one particular task to the detriment of overall situation awareness. This can be illustrated by the loss of transport aircraft at the Guantanamo Naval Base. The crew had been off-duty up to 2 days prior to the accident but had then flown overnight cargo schedules for two nights before the accident. They were allocated the accident trip unexpectedly shortly after being released from duty. During the crash, the pilot was so focused on finding a strobe light that he failed to respond to other crew members' warnings that they were approaching a stall speed [10]. By focusing on the individual behavior of the pilot, there is a danger that we will look too closely at the lapse without considering the wider crew interactions and leadership decisions that led to this incident. It is, therefore, surprising that so few field studies have considered the impact of systemic or organizational factors on fatigue in military operations.

False Responding: Fatigue not only leads to errors of omission, such as lapses, but can also lead to errors of commission. These include the 'false responding' that occurs when individuals react inappropriately or in response to signals that did not occur. It is important to stress that these problems do not arise in isolation. The combination of lapses, false responding and memory impairment can be illustrated by a recent collision between two Canadian F-16s in the Gulf. One of the aircraft was taxiing when it struck the other and suffered a hydraulic failure. This removed control of the nose wheel steering but rather than setting the parking brake, the pilot continued down the taxiway. This bled off pressure from the brake/jet fuel starter accumulators, eventually damaging the brakes. The safety investigation board found "mental fatigue caused by sleep issues, dehydration, and hunger slowed response time, decreased performance and led to distraction" [11]. The initial collision was arguably caused by a lapse, which was then compounded by a form of false responding as the pilot continued down the taxiway.

Risk and Decision Making: An investigation of accidents and incidents involving the US Air Force's C-5 fleet reported that 55% were related to problems of attention, including lapses and false responding. A further 24% stemmed from decision making problems [12]. This interaction between fatigue and decision making has been explored by several military studies under 'laboratory conditions'. For instance, one investigation looked at the reactions of young, stressed, sleep deprived military personnel when ordered to fire with live ammunition at 'real people' rather than the targets that they had expected during an exercise. The majority fired their weapons. Only one student tried to warn his colleagues when he observed people in the target area [13]. Other studies have looked at the impact of fatigue on decision making by more experienced staff. For example, the Evaluation of Risks (EVAR) table has been used to assess the acceptance of risk in a maritime counter-terrorism exercise [14]. Compared with 'baseline' data, military pilots showed increased levels of impulsiveness when fatigued. This finding has significant consequences for decision making as the US Army promotes an integrated risk-based approach to operational, tactical and strategic planning.

The increased impulsiveness revealed from the EVAR study is illustrated by the following case studies where fatigue contributed to poor judgment. These accidents also illustrate the dangers that can arise when tired personnel eventually try to sleep. A Canadian soldier had been involved in several days of 'high intensity' training. He, therefore, took the opportunity to sleep in a military truck and started the engine to keep the heater on. Some time later he was told to move into position but collapsed when he got out of the cab. Medical personnel diagnosed carbon monoxide poisoning and dehydration [15]. In another incident, a section had been riding all day in an Armored Assault Vehicle Command (AAVC) [16]. By 21:00 the unit was ordered to rest. However, the location for their AAVC was constrained by the need to maintain good radio communications with the alpha section and regimental Tactical Operations Centers. A Staff Sergeant set up a security plan and took the first watch. The radioman retrieved his gear and bedded down five meters behind the AAVC. At 22:00, the staff sergeant looked for the radioman to take a watch but could not find him and posted another soldier. Three hours later, a fuel truck arrived and two soldiers searched the position with their flashlights. They then gave the AAVC driver permission to move 100 meters down the hill for refueling. This was completed by 02:00 and the AAVC moved back to its original position driving over the radioman on the way. Such incidents illustrate the importance a more integrated approach to fatigue management. Incidents not only stem from lapses and inappropriate responses. They also occur when tired teams of soldiers seek to grab any rest that they can during sustained military operations.

4. Countermeasures for Fatigue and Sleep Loss

Military personnel can employ a range of different measures to counter the effects of fatigue. These range from altering shifts to the use of drugs as stimulants or to promote sleep. These approaches have numerous drawbacks because they tend to focus on the symptoms of the problem rather than the systems level causes that have been identified in previous sections of this paper.

Restorative Sleep: US Army FM22-51 advocates the maintenance of 'sleep discipline' in order to ensure that all soldiers maximize limited opportunities for rest under unpredictable circumstances [2]. 6 to 8 hours of sleep should be obtained whenever possible, with a minimum of 4 hours uninterrupted or 5 hours interrupted sleep in every 24. The Field Manual also acknowledges the need for flexibility in shift patterns where, for instance, the usual wartime shift of 12 hours may be too long to maintain optimum performance in demanding tasks. Shorter shift patterns have to be balanced against the time that can be wasted as personnel move to rest quarters and dining facilities More frequent shift changes can also create problems in ensuring that hand-over information is passed on with every change of personnel.

Many operations provide limited opportunities for the continuous sleep that is typically required to combat fatigue. In consequence, several military organizations have promoted the 'NASA nap'. This was developed to help astronauts maintain high levels of performance during long-duration space flights, where normal sleep patterns might become divorced from the usual circadian rhythms. The NASA nap lasts for 40 minutes but should not occur within four hours of a more sustained sleep cycle. This caveat is important because it can be difficult for personnel to 'switch off' when they do get the opportunity to rest, especially if they have recently used stimulants to reduce the impact of fatigue. Conversely, carbohydrates and sugary foods can be used to help induce sleep. Small meals that are rich in protein provide stop-gap measures to fight off fatigue. Exercise and hydration are also important in managing boredom and fatigue over sustained periods of time. Restorative sleeps can, therefore, be seen as one component of wider management techniques that also consider task prioritization, workload, nutrition, exercise etc.

Restorative rests cannot be relied upon under operational pressures when, as noted previously, it can be difficult for teams to diagnose that they are suffering from fatigue. This can be illustrated by a 'near miss' involving Canadian personnel flying out of Kabul. The crew was familiar with the area. However, this may have instilled a level of confidence that led them to omit necessary navigational planning. As a result they flew at low altitude into a box canyon. The crew performed a slow, tight turn that led the aircraft to stall. They managed to restart the engines at 250 feet above ground level. The investigation argued that the crews' performance was adversely affected by 'acute fatigue ('jet-lag') and chronic fatigue ('sleep-debt')'. In particular, the crew did not 'exercise their option of calling a ''time-out'' – they perceived a definite pressure to get the job done. The operational imperative emphasized at the time may have created a mindset in the crew to push personal limits, thus unwittingly promoting skewed decision making processes. The crew did not advise their Chain of Command of their fatigued state in an effort to seek other risk mitigation strategies' [17]. A key observation in this paper is that the Chain of Command often has a better perspective on the potential dangers of fatigue than the personnel who must strive to meet multiple operational demands on military organizations.

Motivation and Task Rotation: The manner in which highly motivated personnel strive to overcome the effects of fatigue and boredom can be illustrated by an involving a US Army helicopter pilot. He was providing air support to a training exercise but the start was delayed and so was forced to maintain a hover; '…as we waited, boredom set in. I scanned with the target acquisition designation sight (TADS)—trying to find anything of interest—until my thumb was sore. The end of the mission was approaching quickly and the infantry we were supporting was finally situated (they) requested assistance from our company for an undetermined amount of time past the scheduled completion time….I was tired, but I didn't know the extent of my fatigue until I caught myself doing the jello-neck head bob in the cockpit. I told the back-seater about falling asleep, and he said he knew because he had been watching my head tracker bob up and down as I fell in and out of consciousness…I tried to keep myself awake while the PC kept us at a hover, but I fell into a full sleep right before our company broke station to return to the assembly area' [18]. This incident illustrates the danger of relying on high levels of motivation to provide resilience against the impact of fatigue. It also illustrates the systemic interactions that complicate the management of fatigue in military operations. Inadequate planning and risk assessment led to a situation where the pilot felt motivated to extend the mission beyond his scheduled completion time. The pilot and his superiors underestimated the demands of repetitive and fatigue-inducing tasks; sustaining a hover while waiting for the infantry.

Cognitive Strategies and Monitoring: Many accidents and incidents are averted when colleagues notice the symptoms of fatigue including physiological changes, such as drooping eyelids or yawning, as well as psycho-social and cognitive effects, such as irritability and forgetfulness. However, it can be dangerous to rely on such countermeasures. For example, a US Marine was one of three people who left a base around 00:45 and exited onto an interstate. About 01:10, the driver fell asleep at the wheel and swerved left, hitting a guardrail and forcing the car into a roll. The marine was thrown out of the car. The investigation asked 'Why did this mishap occur? Fatigue. With both passengers asleep in the rear seat, no one noticed the driver was getting drowsy. Despite the late hour, no buddy system was in place. Someone besides the driver always needs to stay awake and watch for the telltale signs of fatigue' [19]. In this incident, the passengers could have helped to keep the driver awake. However, in many other tactical contexts it can be irritating and inconvenient to have a team member continually check that you are awake. Persistent interruptions can, themselves, lead to errors in complex, safety-related tasks.

Fatigue not only degrades performance in primary tasks but also impairs many of the cognitive functions that support the detection of performance problems in others. Initially, an individual may be relatively effective in identifying potential 'errors'. This can lead to a sense of complacency as their level of fatigue increases. As a result less attention may be allocated to checking as performance deteriorates within a team. Monitoring can also increase perceived levels of stress and may even increase perceived fatigue. Read-back techniques and checklists can be used to support these activities and US Army doctrine advocates 'over-learning' so that tasks become automatic. Key activities should be rehearsed until 'you can do it in your sleep' [2]. However, none of these techniques provide a panacea for the problems of fatigue. In consequence, many military organizations have sought technological and pharmaceutical counter measures for fatigue.

Drugs: Ideally, drugs that promote sleep should have an immediate effect without any 'hangover' if the rest is interrupted for operational reasons. 20mg, or twice the recommended dose, of zolpidem is required under simulated troop transport conditions to improve restorative sleep. However, twice the recommended dosage (0.5mg) of triazolam was shown not to improve the daytime sleeping of troops being deployed on a flight from the US to Europe during Operation Bright Star. Mental tasks were impaired for up to eight hours after the drugs had been administered. Another study focused on the use of triazolam by Ranger rifle platoons [21]. Doses of 0.5mg and 0.25mg improved sleep in the cold. Only the higher of the two doses was shown to impair performance 4 hours after it was taken. After 24 hours, the group given 0.25mg did better in complex mental tests that those without any medication. However, some soldiers fell asleep before they finished getting into their sleeping bags. This raises obvious concerns for the safe use of such drugs in harsh environments.

Rather than promoting sleep, stimulants provide short-term relief from the symptoms of fatigue. They are expedients when restorative sleep is not possible [22]. Present advice suggests that caffeine is best used for periods of up to 40 hours. Around 200mg is required, depending on the individual's background tolerance. Caffeine can be found in coffee (100 to 175 mg per cup), soft drinks (31 mg), tea (about 40 mg) and 'over the counter' stimulants (65 mg per tablet). Caffeine is the only stimulant that can be used by flight crews without prior approval. However, the US Air Force continues to authorize dextroamphetamine for some prolonged aviation operations. The US Army also allows the use of this drug to combat severe aviator fatigue. Like many stimulants, it improves perceived energy levels, vigor, and alertness. It also interferes with recovery sleep and should be avoided within four hours of a sleep cycle [20]. There are further concerns over the use of stimulants in military operations. The US Army and Air Force Exchange Service (AAFES) has banned products containing ephedra after one soldier died from an apparent heart attack and another suffered heat-related injury during physical training [22]. The US Agency of Healthcare Research and Quality has not, however, identified any causal link between such events and the use of ephedra [23].

Technological Countermeasures: Ground Proximity Warning Systems (GPWS) and Automated Ground Collision Avoidance Systems have been successfully deployed to combat fatigue by reducing the number of Controlled Flights into Terrain (CFIT). However, these systems are less effective for 'nap of the earth' operations. In the last two years, the US Army has lost five AH-64s in CFIT accidents in Afghanistan and Iraq. Although fatigue was not a cause in every accident, they all occurred in spite of the technological warnings provided by GPWS. On land, lane control systems have also been developed to sense when drivers inadvertently drift out of position. However, this technology has obvious limitations for military applications in areas with poor highways and few lane markings. Alternate 'smart cruise control' systems using short-range radar can provide collision warnings. Although this technology has been deployed in a range of military vehicles, it suffers further limitations. It can be expensive both to install and maintain. There are also calibration issues when units operate in convoys. The radar obstacle detection warnings may be continually going off even though drivers are alert to potential problems. This creates pressures to disable the warning system. False alarms can also fuel complacency so that drivers will ignore warnings even when they are necessary to avert a collision.

Night vision equipment can also help to reduce some of the fatigue associated with night operations. As with the technologies cited above, however, it can also contribute to adverse events especially when soldiers come to rely on these systems. For instance, the US Combat Readiness Center describes an incident in which an M1A1 had completed an attack and was moving to the assembly area. The driver and commander were both using NVGs to navigate but neither was using an approved scanning technique. They failed to see an unmarked fighting position and the tank slid into the hole. In another similar incident, a group of Bradley fighting vehicles was conducting reconnaissance in a desert environment with low contrast during a particularly dark night. They were expecting enemy fire and so were driving without any illumination using NVGs and GPS. As they approached their objective they came across what appeared to be two small ditches. They crossed the first then all three Bradleys went over a 15 foot cliff. Two soldiers were killed, and eight others were injured [20]. Both incidents stemmed from the interaction between fatigue and the particular operating characteristics of NVG technology. They also illustrate the clear need to consider the impact of fatigue on the risk assessments that increasingly guide every level in the chain of command within the US Army.

5. Conclusions

This paper has used recent accidents and incidents to identify the systemic causes of fatigue in military operations. It has been argued that the true nature of this problem can only be understood if the results from lab based studies are seen in the context of the operational demands that are placed on personnel. In particular, we have shown at a strategic and tactical level that inadequate risk assessments and a lack of 'joined up' planning often leave soldiers in situations where they are likely to make the errors of commission and omission that are associated with extreme fatigue. At an operational level, we have argued that fatigue has an insidious effect on the interaction between teams. Not only does it impair performance on shared tasks but it can also prevent teams from identifying the worst effects of fatigue on their colleagues. Unless greater attention is paid to these more complex, systemic aspects of fatigue there is little hope that we will reduce the growing numbers of accidents experienced by many military organizations.

References

[1] US Army Safety Center, Fatigue, Countermeasure, (23)3:4-5, March 2002.

[2] Department of the Army, Leaders' Manual for Combat Stress Control, FM22-51, Washington DC, USA, Sept. 1994.

[3] US Army Safety Center, Sustaining Performance in Combat, Flightfax, (31)5:9-11, May 2003.

[4] Canadian Defense Force, Flight Safety Investigation Report 1010-12401 (Dfs 2-4-2), Cat. A Accident CH124A Sea King, 27 Sep 2004.

[5] US Army Safety Center,, 'Protect Your Squash', Countermeasure, (26)5:3-5, March 2005.

[6] Director General Safety, Pushing the Limits Too Far, Canadian Defense Force, Ottawa, Safety Digest 2, 1997.

[7] J.M. How, S.C. Foo, E. Low, T.M. Wong, A. Vijayan, M.G. Siew, R. Kanapathy. Effects of Sleep Deprivation on Performance of Naval Seamen. Ann Acad Med Singapore. 23(5):669-75.

[8] A. Itoi, R. Cliveti, M. Voth, B. Danth, P. Hyde, A. Gupta, and W.C. Dement, Relationship between Awareness of Sleepiness and Ability to Predict Sleep Onset, American Automobile Association. Foundation for Traffic Safety, Washington DC, February, 1993.

[9] K. Fleming-Michael, Researcher Studies Sleep Deprivation's Effect on Decisions, U.S. Army Medical Research and Materiel Command, August 2006.

[10] National Transportation Safety Board. Uncontrolled Collision with Terrain, Douglas DC-8-61, N814CK, U.S. Naval Air Station, Guantanamo Bay, Cuba, August 18, 1993. Washington, DC: 1994; NTSB/AAR-94/04.

[11] Canadian Directorate of Flight Safety, Fatigue. Flight Comment, Chief of the Air Staff, Ottawa, Canada, 3-6, Spring 2005.

[12] Overview of Scientific Literature Concerning Fatigue, Sleep, and Circadian Cycle. Report for Office of Chief Scientific Advisor for Human Factors, Federal Aviation Administration, Battelle Memorial Institute, Jan. 1998.

[13] R.P.Larsen, Decision Making by Military Students Under Severe Stress, Military Psychology, (13)2:89-98, 2001.

[14] B. Sicard, Risk Propensity Assessment in Military Special Operations, Military Medicine, Oct 2001

[15] Canadian Director General Safety, Asleep at the CO Switch, Canadian Defense Force, Ottawa, Canada, Safety Digest 2, 1997.

[16] US Army Combat Readiness Center, Where Should I Sleep? Lessons Learned Ground Report, February, 2007.

[17] Canadian Defense Force, Hercules CC130327, Kabul, Afghanistan, 29 July 2003. Flight Comment – Air Safety Publication of the Royal Canadian Air Force (1)26, 2006.

[18] US Army Safety Center, Cockpit is No Place to Sleep, Flightfax, (34)4:6-7, April 2006.

[19] Ken Testorff , A Rude Awakening. Ground Warrior, US Navy Safety Center, Winter 2001.

[20] US Army Safety Center, Tank Night Vision Goggle Use, Lessons Learned, Ground Systems and Investigation , 2007.

[21] N.J. Wesensten, T.J. Balkin, and G. Belenky, Role of Sleep in Sustaining Individual and Organizational Effectiveness, US Army Physical Fitness Research Institute, Carlisle Barracks, Penn., USA, August 2007.

[22] AAFES Halts Sale of Ephedra, US Army Safety Center, Countermeasure, (23)10:16 October 2002.

[23] Ephedra and Ephedrine for Weight Loss and Athletic Performance Enhancement, Evidence Report 76. Number 03-E021, Agency for Healthcare Research and Quality, Rockville, MD, USA, 2003.