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Lori J. Brown

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COUNTERMEASURES TO MITIGATE EFFECTS OF FATIGUE AMONG FLIGHT ATTENDANTS: TO
IMPROVE TRANSPORTATION SAFETY AND PRODUCTIVITY

Lori J. Brown
Western Michigan University, College of Aviation
Kalamazoo, Michigan, United States
John Niehaus
Western Michigan University, College of Aviation
Kalamazoo, Michigan, United States

As airlines restructure and cut corners to make ends meet, flight attendants are experiencing a new
industry trend that must be put to rest. At many carriers, flight attendants are forced to work to the
point of exhaustion because of poorly scheduled duty time, lengthened duty days, or flagrant
company violations of schedules. Research efforts on human factors: including the effects of
fatigue, sleepiness, sleep disorders and circadian rhythms—on transportation safety has become a
top priority. Research has identified key findings concerning fatigue in the flight attendant
occupation, where sleep deprivation and disruption of circadian rhythms are known to occur
(Testimony of Patricia A. Friend, 2007). With models, new technology, and convenient logical
interface tools, we can anticipate worker fatigue and improve safety. Decreasing fatigue and its
associated errors, we would enable operational improvements to further meet business
requirements of today’s airlines, especially in these lean times.

As the deep concessions demanded of flight attendants during the recent and ongoing financial turmoil of the airline
industry have taken hold; it has become clear that airline management hopes to keep crews working longer duty
days, with greatly reduced time off between said duties. As stated by the AFA, “Some air carriers are routinely
taking advantage of a “reduced rest” provision in the Federal Aviation Administration’s Flight Attendant Duty Time
and Rest Regulations which allows the minimum rest of nine hours to be reduced to eight.” Flight Attendants have
reported that in some cases they have forgotten to perform critical safety functions, including the arming of doors
and even fallen asleep on the jump-seats.

The NTSB itself has recognized the danger posed by fatigue in the transportation industry, and has recommended
setting work hour limits for transportation operators based on fatigue research, in the areas of pilot fatigue, air traffic
control, and some research on maintenance fatigue. There is no doubt that pilot, air traffic control and maintenance
fatigue is of serious concern; however, the industry also needs to realize the flight attendant fatigue is also a serious
concern, particularly in the era of heightened security awareness (Testimony of Patricia A. Friend, 2007).

Research has shown that such work environments provided by the aviation industry, can result in an inability to get
to sleep (which may lead to further disruption of the circadian rhythm) and to the accumulation of sleep debt. The
results of these potentially cascading effects show themselves as a decrease in performance. Sleep loss has been
shown in several studies to create waking neurobehavioral deficits; which include vigilance degradations, increased
lapses of attention, cognitive slowing, short term memory failures, slowed physical and mental reaction time, rapid
and involuntary sleep onsets, decreased cognitive performance, increased subjective sleepiness, and polysomno
graphic evidence of increased sleep pressure (Nesthes, & Schroder, 2007).

A web-based survey conducted post 9/11, assessed the fatigue of flight attendants working for a major U.S. airline
(Sherry & Philbrick, 2004). This web-based survey revealed pervasive fatigue on a number of dimensions using
multiple measures. The authors concluded that the studied cohort was “clearly one of the most fatigued populations
we have studied.” The data from this study detailed that the average amount of sleep reported was 6.4 hours, an
amount known to cause fatigue problems, particularly if continued over a number of days.

According to the Association of Flight Attendants CWA (AFA-CWA), the Federal Aviation Administration (FAA)
finally delivered the flight attendant fatigue study to Congress, who requested it at AFA-CWA’s urging in 2007.
Originally due back to the Transportation and Infrastructure Committee in June 2005, the FAA had been ignoring
the requests of AFA-CWA and Congress to release the results for over a year.
Patricia Friend, AFA-CWA International President said "Fatigue has been overlooked for too long which is what makes this study even more vital." The results confirm that flight attendants are frequently "experiencing issues consistent with fatigue and tiredness" and that "fatigue appears to be a salient issue warranting further evaluation." According to recommendations cited in the report, "based on the incident reports, flight attendant comments, and the outcomes from the sampling of actual duty and rest time, it appears that the opportunities for adequate rest for flight attendants need to be further evaluated."

Modeling to Minimize the Effects of Fatigue on Cognitive Performance

Different bio-mathematical models of fatigue are available for use by flight attendants. The following is a list of a few of the most accepted models and tools, including a very short description of each: (Neri D., & Nunnely S. 2004)

1. The Two-process Model (Achermann, 2004) is based on the assumption that there is a linear interaction between a sleep/wake dependent homeostatic and circadian process that generates the timing of sleep and waking.
2. The System for Aircrew Fatigue Evaluation (SAFE) (Belyavin and Spencer, 2004) is a program used to assess the fatigue implications of aircrew schedules and uses the QinetiQ alertness model.
3. The Sleep, Activity, Fatigue, and Task Effectiveness (SAFTE) Model (Hurst, Redmond, Johnson, Thorne, Belenky, Balkin, Strom, Miller, and Eddy, 2004) is based on the assumption that there are three components: a sleep reservoir, circadian rhythm, and sleep inertia that combine additively.
4. The Fatigue Avoidance Scheduling Tool (FAST) is a fatigue assessment tool based on the above mentioned, SAFTE. This model predicts the effectiveness of humans based on the amount of sleep and allows users to determine the best schedule to avoid fatigue. This allows airlines additional risk management, and can be used as a safety and accident tool, training tool, and to predict performance for various work schedules (Hurst, S.R., Redmond, D.P., Johnson, M.L., Thorne, D.R., Belenky, G., Balkin, T.J., et al., 2004).

Countermeasures

We can use results garnered from previous fatigue studies to suggest potential countermeasures to sleep and circadian issues that flight and cabin crews encounter. Each individual crew member will benefit from these countermeasures differently, and will need to later decide which garners the best results for them. This is why education about fatigue and countermeasures is a crucial element of training. In order to maximize the success for each individual crew member, researches suggest, trying different combinations for different periods of time to discover what is the most effective (Fatigue Countermeasures Group, 2005).

One of the most crucial countermeasures is the early recognition of fatigue in yourself or other crew members. Individuals must recognize fatigue in order to address it. Since it is difficult for people to estimate their own alertness and fatigue levels, more objective criteria may help in assessment. Some of the signs that may be caused by fatigue are: forgetfulness, poor decision making, slower reaction time, decreased vigilance, communication difficulties, fixation, lethargic, and moodiness. If any of these signs are apparent, the individual can employ an alertness strategy. Alertness strategies can be categorized as:

Preventive strategies: Those used before flying or between flights to reduce the effects of fatigue, sleep loss, and circadian disruption. These are strategies that are employed prior to checking in for a trip, or during layover time. These techniques can help ensure restorative sleep and minimize circadian rhythm interruptions. At home: get the best possible sleep before flying, try to get at least 8 hours of sleep and use strategic naps. These techniques can help to decrease the likelihood of the crewmember starting the trip with a sleep deficit.

Operational strategies: Used during flights to maintain alertness and performance. The only things that can reverse physiological sleepiness, is a sleep period or nap. Strategic caffeine consumption while on duty to acutely increase your alertness can be effective, though is not recommended within several hours before going to sleep. Stay hydrated and be sensible about nutrition. Move, stretch, exercise (walk about the cabin), this is an advantage that flight attendants have over a pilot, the feasibility to get exercise. Caffeine, activity, artificial indoor lighting, or other stimulation, can mask sleepiness, and help you maintain a level of alertness until you can get sleep. These strategies do not necessarily affect the underlying physiological mechanisms of fatigue, but focus on managing fatigue during operations. Primarily, these short-term strategies help to stave off, or mask underlying physiological sleepiness
It is important to note that, when an individual uses two or more of the countermeasures together, it can produce a "synergistic" approach, maximizing alertness and performance; thereby, increasing safety and productivity.

**Herbal Countermeasures**

Valerian root is the strongest of the herbal relaxants. It is used by some people who cite its calming effects to treat insomnia, stress, nerve disorders, headaches, gastrointestinal and respiratory problems, and smooth muscle cramps. Valerian root should not be used in high doses or for prolonged periods of time, as it can cause symptoms such as headache, nausea, and restlessness.

Kava kava is used by some as a muscle relaxant and to treat depression, nervous anxiety, insomnia, restlessness, as well as a host of other conditions. Side effects with frequent usage in high doses include weakness, leg paralysis, lack of motivation, and inflammation of body and eyes which leads to scaly rashes that can turn into ulcers.

Melatonin is a naturally occurring hormone produced by the pineal gland in the brain. Since its secretion increases at nighttime, and is correlated with the sleep/wake cycle, melatonin is being studied as a treatment for insomnia. Many companies claim that melatonin fights stress, aging, jet-lag, high blood pressure, and immune system deficiencies. However, not much is known about long-term side effects; so any use of melatonin should be under a medical doctor’s supervision. Melatonin is sold as a dietary supplement and is not approved by the FDA, so it is not regulated for purity (Fatigue Countermeasures Group, 2005).

**High Lux Lights**

Originally aimed at the treatment of seasonal affective disorder (SAD) and winter blues, NatureBright® Photodynamic Therapy (PDT) products have recently been applied to people with mood and cognitive problems, shift work fatigue, jet-lag, disturbances of the sleep-wake cycle, and premenstrual syndrome (PMS). These and similar products have been involved in many studies relating to shift (night) workers whom amount to an estimated 270 million workers (Leger, Philip, Jarriault, Mélaine, Choudat, 2008), many of which are flight attendants, pilots, and air traffic controllers.

The February ninth 2006 edition of the Harvard Gazette mentioned the medical school’s own research on light therapy, stating that “the eyes are part of a light reception system that can keep you alert when sleep starts to fog your brain” (Cromie, 2009, p. 2). The Harvard study also suggested that “light may be a powerful countermeasure for the negative effects of fatigue for people who work or study at night” (Cromie, 2009, p. 2). This is essential for pilots and flight attendants of whom, the safety of hundreds of passengers depend every night.

Researchers have been able to demonstrate that bright light pulses of 10,000 lux, at about 30 minutes a day, were able to help adjust employees to new circadian rhythms (Leger, et. al., 2008). The light entering the retina is said to affect neurons in the suprachiasmatic nuclei (SCN) of the hypothalamus, which is the compound that affects circadian light/dark cycles in humans. These neurons secrete a chemical called vasopressin, which studies have shown is a neuropeptide involved in synchronizing these cycles. When a person is undergoing bright light therapy, the properly tuned, high lux wavelength of light enters the retina and is thought to re-energize inactive neurons in the SCN. These neurons once again begin secreting vasopressin, allowing the subject to redevelop a normal sleep cycle (Forbes, Morgan, Bangma, Peacock, Adamson, 2009).

Western Michigan University and Nature Bright have collaborated on a pilot study designed to research the feasibility of high lux lights to mitigate fatigue for pilots, flight attendants, and air traffic controllers. The ethoses of the study are focused on “Long Haul” schedules for flight attendants and pilots. Some of the light products tested are:

- **Sun Touch Plus® Light and Ion Therapy system**: The desk top device emits powerful 10000 Lux Sky Effect light and high density negative ions. Pilots, flight attendants, and air traffic control could consider using light therapy in their rooms before flight/shift to increase concentration, and reduce fatigue.

- **Dia® portable light therapy unit**: The portable device emits 5000 Lux Sky Effect light (LED source) and is rechargeable. If pilots and flight attendants need to use light therapy when they are away or during flight, this portable unit can be used to help reset circadian rhythms.
Sky Effect® lighting: The overhead fluorescent lamp emits bright blue-enriched white light. Replacing office lighting for the Sky Effect lighting can create a therapeutic environment for increasing alertness and calmness. The crew and airports can use the Sky Effect light for calming travel anxiety, and increase staff concentration throughout.

At completion of the pilot study, a research project will be designed to look further at the mitigating effects of neurons secreting vasopressin, allowing the subject to redevelop a normal sleep, reduce fatigue, elevate mood, and increase business productivity.

New Technologies and Innovations
Boeing and Airbus now have the technology to integrate crew alertness systems into modern aircraft. These systems are designed to alert the crew if no crew activity is detected within a specified time limit; some even measure blink rate. After the silent “crew response” advisory is triggered, an aural warning is triggered. This continuous aural warning is sufficient to wake a pilot. Most of these systems work in conjunction with the Flight Management Computers. Although this integration may prove to be effective for pilots, where does this leave the flight attendants?

Crew-centered technologies such as integrated sensor/software systems are able to monitor the state of awareness of crew members and automatically assess fitness for duty in real time. These systems embody two innovations: utilizing true 3D sensor data and employing sophisticated machine-learning techniques to assess state of awareness, fatigue, and vigilance. This crew monitoring system utilizes a new high-speed, high-resolution sensor based on Structured Light Illumination (SLI) capable of capturing 3D scenes within the cockpit and cabin in real time; along with an advanced pattern recognition system that can monitor facial expressions and body language. These crew monitoring systems will constantly gauge the state of awareness of each individual crew member. The monitoring can also be customized to individual crew members; potentially providing very sensitive and accurate detection of crew mental and emotional states. This system may be combined with remote sensors for monitoring vital functions to enhance effectiveness.

Figure 1: Monitoring crew members for fatigue

The Facial Action Coding System (FACS), a scheme for determining human emotional states, was developed over a span of years. There has also been work that defines a continuum of these measurable states on two axes: state of awareness (mapped between arousal and sleep) and state of well-being (mapped between pleasure and displeasure). The FACS approach has had successes in various arenas, particularly psychology (Michigan Aerospace Corporation, 2007).


Figure 2: Six of the seven basic emotions (Pantic, M., Context-sensitive Facial Expression Analysis, Man-Machine Interaction Group Electrical Engineering, Math and CS Delft Univ. of Tech).
Crew Alertness Monitoring System (CAMS) – a sophisticated monitoring system for real-time assessment of the functional state of all crew members. This system will integrate the best available approaches and develop additional technologies as needed to attain performance levels deemed adequate for assessment. The platform will be flexible for easy addition of inputs to enhance performance. Figure 4 illustrates the process for integrating all bio-inputs in order to assess the functional state of an individual.

In summary
Recommendations for further study include: (House Rpt.108-671)
1) A scientifically based, survey of flight attendants to assess the frequency with which fatigue is experienced, the situations in which it appears, and the consequences.
2) A focused study of aviation incident reports in order to determine what role fatigue played in already reported safety incidents.
3) The need for research on the effects of fatigue. This research would explore the impact that rest schedules, circadian factors and sleep loss have on flight attendants’ ability to perform their duties.
4) The determination and validation of fatigue models for assessing how fatigued a flight attendant will become.
5) Development of training material to reduce the level of fatigue that may be experienced by crews and to avoid factors that may increase fatigue levels.

With a convenient logical interface tool, we can anticipate worker fatigue, optimize schedules, reduce risk of error, and improve safety. We can also isolate fatigue related events through the use of mitigations and countermeasures, staffing analysis and workforce planning (Nesthes, D.J., Schroder, 2007).

It is abundantly clear that flight attendant fatigue is real; it is a problem, and one that is growing. Some may argue that an error caused by flight attendant fatigue is not as serious one caused by a pilot. However, an error caused due to flight attendant fatigue can lead to a tragic loss of life in the event of an in-flight emergency or during an evacuation. The recent ditching of US Air Flight 1549 is a perfect example of the link between safety and the flight attendant. To effectively address fatigue, we must combine regulations with operational practices, countermeasures, and education.

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