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Fatigue and Its Effect on Cabin Crew Member Performance

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Since 1993, the National Transportation Safety Board (NTSB) has stated *fatigue* was a contributing factor in eight airline catastrophes in the US resulting in 250 fatalities. Many proposals to mitigate fatigue as a safety issue in aviation have been suggested. Those on the NTSB List of Most Wanted Transportation Safety Improvements involve "hours of on-duty work" rules, which provide an essential set of limits on the work day for all transportation workers. However, most fatigue studies have focused on cockpit crew and not on the cabin crew. This report investigates cabin crew members, their scheduled work, rest and sleep times and the implications for aviation safety. A single case study is presented here, as well as a review of data suggesting why changes are necessary.

Keywords: fatigue, circadian, cabin crew

Background

Fatigue in aviation. Fatigue has been defined by John Caldwell, Ph.D., and Lynn Caldwell, Ph.D., who are both leaders in aviation fatigue research, as "the state of tiredness that is associated with long hours of work, prolonged periods without sleep, or the requirement to work at times that are 'out of sync' with the body's biological or circadian rhythms" (Caldwell, J. A. & Caldwell, J. L., 2003, p.15). Other contributing factors that create cabin crew member fatigue include early report times and breaks that are too limited to allow for eating or napping (Caldwell, J. A. & Caldwell, J. L., 2007). Cabin noise, vibration, turbulence and diminutive cabin quarters all add to increased stress levels and fatigue among Flight Attendants. Deficient crew rest space in operational areas or on aircraft, insufficient water supply or crew meals, commuting, sleep apnea or poor sleep habits also contribute to Flight Attendant weariness. Cabin crew member fatigue is predominantly thought of as a function of scheduling, workload requirements and many of the contributing factors mentioned above. As a result, this study looked at the affects of length and timing of work, off duty sleep quality and flight duty performance.

In the aviation environment, symptoms of fatigue include impaired mood, forgetfulness, reduced vigilance, poor decision-making, slowed reaction time, poor communication, or becoming fixated, apathetic, or lethargic (Conners et al., 2007). These symptoms result in performance errors and an unsafe environment during flight. Specifically:

> A person with a mental effectiveness of 70% has the same reaction time and cognitive ability as when he or she has a blood alcohol content (BAC) of 0.08 (the level corresponding to "legally drunk" in many countries). Studies have also shown an increase in human factors related accidents when people are fatigued and operating with decreased mental effectiveness (Sleep Performance, Inc., 2007, p.8).

Workload increasing the problem. "Between 1986 and 1999, the load factor for U.S. carriers serving domestic and foreign locations increased by about 13% and 21% respectively." Moreover, "from 1986 to 1998, the average U.S. domestic trip length increased from 767 to 813 miles, and the average foreign trip length increased from 2,570 to 3,074 miles" (National Research Council: Board on Environmental Studies and Toxicology, 2002). Current Flight Attendant duties reveal that their workload involves multiple tasks, consisting of walking, bending, lifting and pushing and being available to cope with numerous situations in the cabin. Juggling tasks, physical activity and dealing with the public are all stressful and increase the rate at which flight attendants are fatigued on these flights of increasingly long duration.

Solving the Problem. The FAA is in the process of deciding how to resolve and reduce risk of fatigue specifically as it falls under the Safety Management Systems (SMS) guidelines. Currently, the FAA is meeting with fatigue researchers, unions, airline management and the NTSB on how to resolve this issue.

The International Civil Aviation Organization (ICAO) is now requiring regulatory authorities worldwide to implement SMS. ICAO defines this as “an organized approach to managing safety, including the necessary organizational structures, accountabilities, policies, and procedures” (New, 2008, p. 1). Compliance with ICAO guidelines will be a step forward in operational safety, providing operators with a structure for recognizing and reducing the effects of universal hazards while constantly improving their programs. The program is based on a four-tiered model referred to as the “four pillars”: (1) safety policy, (2) risk management, (3) safety assurance, and (4) safety promotion (New, 2008, p. 1).

The current NTSB approach to mitigate fatigue is twofold. On one hand, it recommends scheduling changes determined by using scientific-based computer models which consider circadian rhythms and the need for significant rest periods. In addition, the NTSB advocates educational programs for crew members and updating company attendance policies that discourage employees from calling in fatigued.

To show compliance with the ICAO and NTSB recommendations, the FAA may soon be more proactive in addressing the subject of fatigue. For example, Fatigue Risk Management Systems (FRMS) programs may be required in the near future at commercial airlines.

> FRMS is often understood to be a scheduling or rostering tool. It is actually a wider risk-management concept, which incorporates all mitigation strategies, training and education, and performance measures integrated to managing crew or operator fatigue in a manner that promotes safe operations (Graeber, 2008, p. 3).

Experiment

Limitations and Assumptions. Time and funding issues limited this study to collecting questionnaire data and Sleep Bracelet© results from only one flight attendant. This work assumes that the flight attendant in this study is representative. Because there was only one respondent, it was not possible to determine if the results were representative of a range of people and situations (e.g. psychometrically reliable). Future work should target collecting data from a pool of Flight Attendants.

Data Collection. Two sources of data were provided: (1) a quantitative source, data collected by a Sleep Bracelet© wrist monitor provided by Sleep Performance, Inc., and (2) a qualitative source of data, a questionnaire developed by the author.

The subject wore the Sleep Bracelet© for three consecutive trips and answered the questionnaire relating to these duty periods. The approximate time frame for acquiring the data was three weeks. This data was analyzed with descriptive statistics which describes the data by tables and graphs (Table 1, Figure 1 and 2). Additionally, the raw data is presented in a graphical format using the Sleep Bracelet© software detailing the changes that occurred in performance (Figure 2).

A two part questionnaire was based on a literature review and personal experience in the area of aviation safety and service. The first section was demographic information; the second section was a subjective questionnaire covering the time the Sleep Bracelet© wrist monitor was worn. The subjective questionnaire addressed sign in, layover and pick up times as well as crew rest length and passenger loads. Additional inquiries about noise levels of hotel rooms, crew break rest areas, passenger disruption issues, staffing of crew members and nutrition were posed. A panel of independent experts reviewed the questionnaire for face validity and found it acceptable, and the content was evaluated by the author.

Independent Data. Independent data was also collected from the participant's trips. Official airline records displayed the differences between the "scheduled" flying times and "actual" flying times, as well as significant ground delays. The "scheduled" flying time shows the trip's original planned time. The "actual" flying time is the final time it took to complete the trip (Table 1).

Results

Data Acquisition Time. The data acquisition time is broken down into baseline preset (calibration hours) working prep/working (time allocated to prepare the aircraft before boarding and flying time), sleep, and personal (free time) (Figure 1). During the acquisition time, discrepancies were mostly noted in the area of sleep time. There were 129 hours of sleep time recorded. These hours calculated into 35% of time sleeping; which averaged to 8.6 hours per day.

From the total sleep time, the participant was at rest for 13 hours during which the Sleep Bracelet© had noted the participant was sleeping. These discrepancies were due to minor time differences of sleep and wake periods reported by the participant. The inconsistency in total hours gives a 3.5% error rate. This error rate validates the accuracy of the Sleep Performance, Inc. sleep analysis since it falls within the error rate of 10% or less published by the manufacturer.

Mental Fatigue Analysis. As seen in Figure 2*,* the shaded lines indicating High Risk, Reduced and Normal within the bar graph along with the dotted line showing the 70% range of where cognitive impairment begins was interpreted 100% accurately and did correctly highlight mental effectiveness.

Discussion

The results of the quantitative data from the Sleep Bracelet© confirms that mental alertness is affected by long duty periods without a break as compared to long duty periods with a break. These results also highlight the affects of circadian rhythm on performance depending on time of day. Crew member's sleep is minimized the night before pick up because of the time change and a break in the body's circadian rhythm. Therefore, sleep is interrupted and is not restful. The Sleep Bracelet© was effective and accurate in demonstrating how the circadian rhythm controls our sleep patterns even when we cross time zones. Based on this study, the Sleep Bracelets© would be a useful tool in assisting with designing fatigue reducing schedules for cabin crew members.

The data from the scheduled trips reveals that frequently the actual flying time is longer than the scheduled flying time because of headwinds, routing due to weather, ground delays or air traffic. This is significant since it shows how actual total hours flown are often longer than scheduled flying hours. These actual scenarios demonstrate why layover times can be shortened or the drive home from a trip may be later than a cabin crew member anticipated.

Conclusion

The objective results of this study from the Sleep Bracelet© determine that it is consistent with the questionnaire and flight schedule data from the airline. The usefulness of the Sleep Bracelet© in identifying and predicting the fatigue risk of flight schedules with the aid of a computerized Fatigue Avoidance Scheduling Tool (FAST™) and a Sleep Activity Fatigue and Task Effectiveness Model (SAFTE™) model developed by the Institutes for Behavior Resources (IBR) is evident by the results shown in this study. "The FAST™ model is software which makes predictions about the levels of performance effectiveness that can be expected with specific work/rest schedules" (Caldwell, Jr. & Caldwell, 2003, p. 119). For example, based on this study, a commercial airline could implement earlier departures out of an East Coast Airport and later departures out of Europe to be more consistent with the East Coast time circadian rhythms of cabin crew members. Scheduling earlier take offs out of East Coast Airports to Europe would keep crew members on landing times that do not fall into the body's low circadian rhythm cycle.

The later departure times out of Europe would allow the body to adjust and be more rested for take off. A computerized program would be extremely beneficial in achieving this most important fatigue mitigating strategy. The benefits of creating timetables that are less fatiguing include improved attention and mental cognition and improved disposition and crew coordination (Caldwell, Jr. & Caldwell, 2003).

The technological advancement of computerized systems such as the FAST™ model would help aviation carriers identify which "city pairs" or trip combinations may cause fatigue. Schedule design principles of a computerized system would assist the FAA in reevaluating the scheduling and layover time regulations of 14 CFR 121.467 and 135.273 as they are currently written.

Table 1. *Actual versus scheduled flying time.*

TRIP	On Duty Layover (ODL)	Actual ODL	HOURS Scheduled Flying	Actual Flying	Difference Flying	Unscheduled Additional (%) Flight time	Unscheduled Additional (%) Duty time
1	25h 10m	24h 39m	15h 45m	16h 53m	1h 08m	7.2	14.2
2	25h 10m	24h 48m	15h 45m	16h 30m	1h 15m	4.8	n/a
3	24h 55m	25h 01m	17h 30m	17h 44m	0h 14m	1.3	n/a
Total	75h 15m	74h 28m	49h 00m	51h 07m	2h 37m	13.3	14.2

Note: There were 2 hours (h) and 37 minutes (m) of additional flying time calculated after all three round trips were completed. This averaged approximately 52 minutes per round trip of extra flying time based on head winds and airspeed. There was a 3 hour and 30 minutes ground delay with passengers on board the aircraft while a mechanical issue was being repaired on July 30 (Trip 1). This time was not included as additional flying time but was credited as "holding time" due to the extended period with passengers on board the aircraft while still parked at the gate. Here is another example of how a duty day can be longer than planned because of mechanical problems with an aircraft.
Trip 1: July 28 through July 30 (JFK BRU JFK)
Trip 2: August 4 through August 6 (JFK BRU JFK)
Trip 3: August 8 through August 10 (JFK MXP JFK)

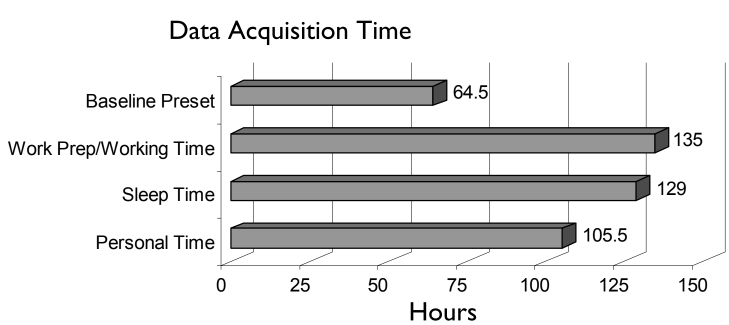

Figure 1. Data Acquisition Time.

There were 434 hours of data recorded by the Sleep Bracelet©. Of this recorded time, the only discrepancy was noted in the actual amount of sleep time. A total of 3.5 hours out of 129 hours were noted by the participant, which is a 3.5% error rate. This is below the 10% error rate published by the manufacture.

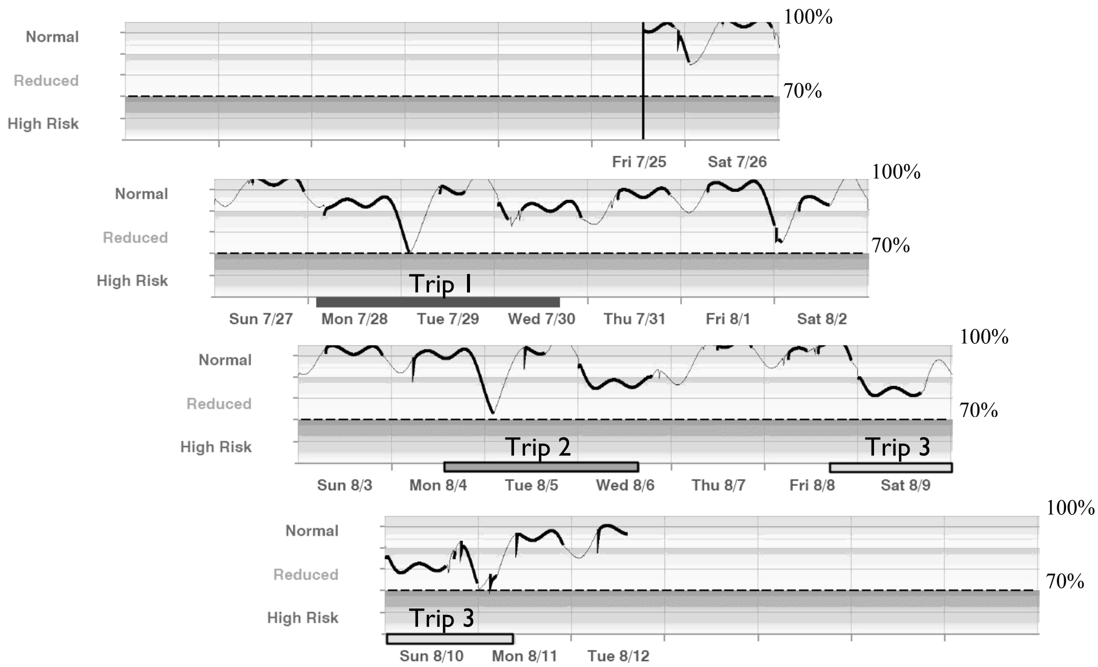

Figure 2. Mental Fatigue Analysis.

The areas indicating High Risk, Reduced and Normal within the bar graph along with the dotted line showing the 70% range of where cognitive impairment begins was interpreted 100% accurately and did correctly highlight mental effectiveness.

Scheduled breaks clearly reduced the possibility of mental effectiveness from falling into the high-risk zone during this study. Where the dark lines (period of work or time awake) have no break for long phases and dip to a lower level near high risk are times where no significant rest period could occur during long periods of wakefulness. When the dark lines stayed within the normal to slightly reduced range of mental effectiveness, breaks averaged at least one to two hours during extended periods of wakefulness. The circadian influence of arriving in the late night and pre-dawn hours along with the homeostatic factor of having been awake for a continuous period seems to coincide at these landing times and shows the most dramatic impact on the Sleep Performance, Inc. graph.

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