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Flight Attendant Fatigue

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This report was integrated by the Civil Aerospace Medical Institute from reports prepared by the NASA Ames Fatigue Countermeasures Group.

16. Abstract

The Departments of Transportation and Treasury and Independent Agencies Appropriations Bill (House Rpt. 108-671) included a directive to the Federal Aviation Administration to conduct a study of flight attendant fatigue. The NASA Ames Research Center Fatigue Countermeasures Group (FCG) was contracted by CAMI to conduct the study. To meet the goals of the study, this report contains a literature review on fatigue as potentially experienced by flight attendants, an evaluation of currently used (actual vs. scheduled) flight attendant duty schedules, and a comparison of these schedules to the current CFRs. The report additionally reviews fatigue-related incident/accident information from the Aviation Safety Reporting System (ASRS) and the NTSB database. One report section describes the application of three different performance and fatigue models to assess how flight attendant duty schedules contribute to increased levels of fatigue and predicted changes in performance. The report concludes with 6 recommendations concerning issues that require further evaluation, including: (1) Survey of Field Operations. *To assess the frequency with which fatigue is experienced, the situations in which it appears, and the consequences that follow*; (2) Focused Study of Incident Reports. *To better understand details of the incidents;* (3) Field Research on the Effects of Fatigue. *To explore physiological and neuropsychological effects of fatigue, sleepiness, circadian factors, and rest schedules on flight attendants;* (4) Validation of Models for Assessing FA Fatigue. *An important step to understanding whether and how models could be used in conjunction with field operations;* (5) International Carrier Policies and Practices Review. *To learn how other countries address these issues and with what results;* and (6) Training. *FAs could benefit from information on fatigue, its causes and consequences, its interaction with circadian disruption, and how and when to employ countermeasures (e.g., scheduled naps, physical activity, social interaction, caffeine).*

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EXECUTIVE SUMMARY

The Departments of Transportation and Treasury and Independent Agencies Appropriations Bill (House Rpt. 108-671) included a directive to the Federal Aviation Administration to report back on the subject of flight attendant fatigue. *The following is the language from page 18 of the report*:

> Flight attendant fatigue study: The Committee is concerned about evidence that FAA minimum crew rest regulations may not allow adequate rest time for flight attendants. Especially since the terrorist attacks of September 11, 2001, the nation's flight attendants have been asked to assume a greater role in protecting the safety of air travelers during flight. Current flight attendant duty and rest rules state that flight attendants should have a minimum of nine hours off duty that may be reduced to eight hours, if the following rest period is ten hours. Although these rules have been in place for several years, they do not reflect the increased security responsibilities since 2001, and only recently have carriers begun scheduling attendants for less than nine hours off. There is evidence that what was once occasional use of the 'reduced rest' flexibility is now becoming common practice at some carriers. Because FAA regulations allow the rest period to commence shortly after the aircraft parks at the gate, the eight hour 'rest' period also includes the time it takes a flight attendant to get out of the terminal, go through customs if necessary, obtain transportation to a hotel and check in. Due to this situation, it is likely that many flight attendants are performing their duties with no more than four to six hours of sleep. To better understand the impact of the minimum rest requirements of CFR §121.467 and CFR §135.273, the Committee recommended a study of flight attendant fatigue. This study is to consider professional input from FAA's Civil Aeromedical Institute. The study should be finalized and submitted to the House and Senate Committees on Appropriations no later than June 1, 2005, including the agency's recommendations on potential regulatory revisions.

In response to this directive, representatives of the FAA from the Civil Aerospace Medical Institute initiated an agreement with NASA Ames Research Center to perform an evaluation of the flight attendant fatigue issue. The NASA Ames Research Center Fatigue Countermeasures Group (FCG) is independent of regulatory or advocacy influence and has extensive experience in conducting aeronautical fatigue studies (http://human-factors.arc.nasa.gov/zteam/).

To meet the goals of the study, this report contains a literature review on fatigue as potentially experienced by flight attendants, an evaluation of currently used (actual vs. scheduled) flight attendant duty schedules, and a comparison of these schedules to the current CFRs. The report additionally reviews fatigue-related incident/accident information from the Aviation Safety Reporting System (ASRS) and the NTSB database. One section of the report also describes the application of three different performance and fatigue models currently available as examples to provide the reader with an idea of how flight attendant duty schedules contribute to increased levels of fatigue and predicted changes in performance. The report concludes with recommendations concerning issues that require further evaluation.

Literature Review

Research has identified key findings concerning fatigue in occupational settings where sleep deprivation and disruption of circadian rhythms are known to occur. Among the findings are that such environments 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. Sleep debt is incurred and continues to build when we obtain less than the recommended 7-8 hours of sleep each night. The results of these potentially cascading effects show themselves in performance decrements. Research for this report found that the main contributing factors to flight attendant fatigue consist of:

Sleep loss has been shown in numerous studies to produce 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 polysomnographic evidence of increased sleep pressure.

Circadian rhythm disruption is affected by scheduling and sleep disruption. The effects of jet lag and shift work are often characterized by symptoms such as disrupted sleep, changes in mood state, loss of appetite, gastrointestinal disturbance, and disorientation. Sleep loss and circadian rhythms interact dynamically to regulate changes in alertness and performance. Cumulative sleep loss results in sleep debt, with chronic sleep deprivation, night after night, leading to cumulative and progressive performance decrements, even in healthy adults.

Length of duty. End-of-duty sleepiness and fatigue have been reported in flight attendants working both domestic and international flights. Fatigue during international flights is due mainly to flight duration and time zone differences, while fatigue on domestic flights is related to total working hours, landing frequency (number of legs), workload, and layover duration.

Workload. Flight attendants have reported increased perceived stress due to changes in duties and responsibilities since 9/11. The effects of sleep loss, circadian disruption, and scheduling in flight attendants are similar to those experienced by pilots although flight attendants duties are varied and include more physical activity, working in a noisy environment, with higher social involvement.

Schedules

CFRs §121.467 and §135.273 require that flight attendants receive a minimum rest period of nine consecutive hours following a scheduled duty period of 14 hours or less. This rest period may be reduced to eight hours if the subsequent rest period is at least 10 consecutive hours. Further, changes to the rest period can occur when additional flight attendants are scheduled for a particular flight. "Rest period" is not the same as sleep hours, since it includes the time required to travel to and from the airport, time for meals, personal hygiene, and time to relax and go to sleep. The report provides a comparison between *scheduled* on-duty and off-duty layover times and *actual* schedules. The small sample of schedules reviewed were limited and not scientifically based. Overall, our small sample found the duty and rest times were *scheduled* to be compliant with the CFRs, but a small number of the *actual* times extended beyond these limitations when unforeseen operational and weather-related events disrupted the original schedule.

Incident Reports

Seventeen flight attendant fatigue-related incident reports were identified in the ASRS database. ASRS reports cannot reveal the prevalence of the flight attendant fatigue problem; however, they do provide evidence that fatigue is an important issue. Some reports mentioned a lack of adequate rest or meals and listed general symptoms of fatigue. Flight attendants also reported that fatigue had affected completion of critical tasks and expressed a lack of confidence in their ability to handle unusual situations and/or perform adequate security duties.

Fatigue Models

Different biomathematical models of fatigue, sleepiness, and performance are available and could be applied to flight attendants schedules. All models are based on the combination of homeostatic and circadian influences but they differ in the number and nature of the factors that are included. Three models were selected to examine the manner in which they predict fatigue and performance. Although the three selected models differed in particulars, results indicated that they produced consistent results. This analysis was offered as a first step toward the further development and validation of models for predicting flight crew fatigue.

Conclusions

A review of the evaluation materials available for this report has suggested that some segments of this workforce are experiencing fatigue and tiredness and, as such, is a salient issue warranting further evaluation. The Committee on Appropriations (House Rpt. 108-671) suggested that the practice of airlines to schedule closer to the CFR minima on a more regular basis, and very short periods post-flight before the beginning of the rest period may be contributing to this effect. However, the limited nature of the study did not allow us to determine the extent to which scheduling practices either within a single carrier or across carriers were problematic. An additional factor is the difference between the *scheduled* work/rest periods and the *actual* work/rest periods as they play out in field operations**.** Aircraft-related and weather delays as well as other unforeseen operational events contribute to extending a duty period beyond what was originally scheduled.

CFRs provide end points or not-to-exceed levels of regulation. But CFRs do not, and perhaps cannot, capture the multiple variables that impact fatigue and the individual's ability to tolerate fatigue. Taken from the standpoint of just the pre-determined dimensions of the flight itself, the CFRs do not distinguish among the number of segments flown, daytime versus nighttime flights, flights that are uni-meridianal vs. those that are transmeridianal, and regional versus domestic flights.

To truly address the fatigue issue, regulations must be combined with sound and realistic operational practices and supplemented, as needed, by personal strategies. Air travel will always require flexibility in operations in order to adjust to unusual and/or non-routine circumstances. From the standpoint of flight attendant fitness and well-being, consideration needs to be given to the establishment of work/rest practices that take into account the occurrence of unusual circumstances.

This report was developed with data that became available in the short time before the study's deadlines. However, not all the information needed could be acquired to gain a complete understanding of the phenomenon/problem of flight attendant fatigue. Given the nature of the issue and the questions that remain unanswered, the following are a few suggestions offered for continued research to address the topic of flight attendant fatigue.

1. A scientifically-based, randomly-selected flight attendant *Survey of Field Operations*.
2. A fuller understanding of fatigue-related incidents can be achieved by a follow-up *Focused Study of Incident Reports*.
3. *Field Research on the Effects of Fatigue* would explore the impact of rest schedules, circadian factors, and sleep loss on flight attendants.
4. *Validation of Models for Assessing Flight Attendant Fatigue* would be an important step to understanding whether and how models could be used in conjunction with field operations.
5. A study of *International Policies and Practices* to see how other countries address these issues. This study would provide additional data to supplement other on going research.
6. *Training.* Flight crews could benefit from exposure to information on fatigue, its causes and consequences, its interaction with circadian disruption, and how and when to employ countermeasures.

Contents

FLIGHT ATTENDANT FATIGUE

SECTION 1: CURRENT STATUS

Chapter I. Background

The Departments of Transportation and Treasury and Independent Agencies Appropriations Bill (House Rpt. 108-671) included a directive to the Federal Aviation Administration to report back on the subject of flight attendant fatigue. *The following is the actual language from page 18 of the report*:

> Flight attendant fatigue study: The Committee is concerned about evidence that FAA minimum crew rest regulations may not allow adequate rest time for flight attendants. Especially since the terrorist attacks of September 11, 2001, the nation's flight attendants have been asked to assume a greater role in protecting the safety of air travelers during flight. Current flight attendant duty and rest rules state that flight attendants should have a minimum of nine hours off duty that may be reduced to eight hours, if the following rest period is ten hours. Although these rules have been in place for several years, they do not reflect the increased security responsibilities since 2001, and only recently have carriers begun scheduling attendants for less than nine hours off. There is evidence that what was once occasional use of the 'reduced rest' flexibility is now becoming common practice at some carriers. Because FAA regulations allow the rest period to commence shortly after the aircraft parks at the gate, the eight hour 'rest' period also includes the time it takes a flight attendant to get out of the terminal, go through customs if necessary, obtain transportation to a hotel and check in. Due to this situation, it is likely that many flight attendants are performing their duties with no more than four to six hours of sleep. To better understand the impact of the minimum rest requirements of CFR §121.467 and CFR §135.273, the Committee recommended a study of flight attendant fatigue. This study is to consider professional input from FAA's Civil Aeromedical Institute. The study should be finalized and submitted to the House and Senate Committees on Appropriations no later than June 1, 2005, including the agency's recommendations on potential regulatory revisions. (108th Congress 2d Session, HOUSE OF REPRESENTATIVES Report 108-671, DEPARTMENTS OF TRANSPORTATION AND TREASURY AND INDEPENDENT AGENCIES APPROPRIATIONS BILL, 2005, SEPTEMBER 8, 2004, p.18.)

In general, even relatively modest sleep restriction significantly increases sleepiness levels and degrades cognitive readiness and performance (Van Dongen, Maislin, Mullington, & Dinges, 2003). As found in flights, as well as other transportation venues, fatigued individuals suffer from variable and inefficient performance; impaired attention, information processing, and reaction time; reduced short-term memory capacity; and increased involuntary lapses into varying durations of actual sleep episodes (Balkin, Thome, Sing, Thomas, & Redmond, 2000; Dinges, 1995).

FAA/NASA approach to the present committee's concern:

In response to the Congressional direction, representatives of the FAA Civil Aerospace Medical Institute (CAMI) initiated an agreement with the NASA Ames Research Center, Fatigue Countermeasures Group (FCG) that has extensive experience in conducting aeronautical fatigue studies (http://human-factors.arc.nasa.gov/zteam/). The deadline established by Congress for the delivery of the report (June 2005) posed severe limitations on the study design. The team proposed to provide an interim report by May and an addendum report by the end of the fiscal year. Even the extended time frame associated with the delivery of the addendum report limited the extent of the study and as a result, attention was focused primarily on a review of the existing scientific literature on fatigue issues, flight attendants and flight crew, an assessment of existing incident and accident databases, and an analysis of schedules for flight attendants from a small sample of convenience. The limited sample of flight attendant duty schedules were compared with the current CFRs and assessed using three fatigue models to determine potential fatigue states among the schedule examples. The report also provides a description of gaps in current knowledge about flight attendant fatigue, with recommendations for additional issues that should be evaluated with regard to flight attendant fatigue. The NASA fatigue countermeasures group met the established timelines in the delivery of the respective reports and FAA management elected to consolidate both reports into a single document.

Chapter II. Introduction

1. Definition of fatigue

The term "fatigue" has been criticized as a vague multidimensional construct that can be interpreted in a variety of ways (Åkerstedt, Knutsson, Westerholm, Theorell, Alfredsson, & Kecklund, 2004; Dodge, 1982; Hawkins, 1993; Winget, DeRoshia, Markley, & Holley, 1984), the term is now widely used, and in general is understood to reflect the underlying sleepiness/tireness that results from extended wakefulness, insufficient sleep, and circadian desynchrony (Åkerstedt, 1995a). For the purposes of this report, we define fatigue in the aviation environment in terms of its symptoms, which consist of: impaired mood, forgetfulness, reduced vigilance, poor decision making, slowed reaction time, poor communication, nodding off, or becoming fixated, apathetic, or lethargic (Rosekind et al., 1996).

Performance, alertness, and well-being of personnel working in the aviation industry, including flight attendants, are significantly influenced by the presence of circadian rhythms in physiological and psychological processes, by the necessity for shift work duty schedules, extended wakefulness on night flight duty, and the effects of transmeridian flight upon sleep quality and duration and upon circadian rhythmicity in domestic and international routes. These influences reflect 1) the *body's circadian timing system* or the body's internal clock, and 2) the *homeostatic mechanism* or recent sleep history, which includes the amount of time since the last sleep period and the amount of prior sleep (Caldwell, 2005).

2. Bases of fatigue

Circadian rhythms. Circadian rhythms result from cyclic environmental influences (exogenous) or self-sustained (endogenous) oscillations. Circadian rhythms are characterized primarily by phase (time reference point in the cycle), period (time to complete one oscillation cycle), and amplitude (change from the cycle mean value to the peak or trough of the oscillation). Circadian rhythms are primarily synchronized by local light-dark cycles, but also by periodic social synchronizers, which include social contacts and activities (Klein & Wegmann, 1980; Winget et al., 1984). The circadian rhythm results in an increased sleep tendency and diminished capacity to function during early morning hours (circa 0200-0700), and, to a lesser degree, during a period in mid-afternoon (circa 1400-1700; Mitler, Carskadon, Czeisler, Dement, Dinges, & Graeber, 1988). These rhythms peak in the late afternoon (during the day) and trough in the predawn or early morning hours (at night). The body-temperature rhythm, which in shift workers often coincides with performance rhythms (Folkard & Monk, 1985) peaks at approximately 1700 and dips at around 0500. Conversely, melatonin levels, which are inversely-related to alertness (Arendt, Deacon, English, Hampton, & Morgan, 1995) tend to be lowest at 1600 and highest at 0400.

Homeostatic sleep process. The homeostatic mechanism can result in progressive deterioration in alertness and performance, which is superimposed on the circadian rhythmic modulation of these functions (Caldwell, 2005). The homeostatic regulation of sleep and wakefulness is primarily a function of two factors. The first is the amount (and quality) of sleep obtained prior to a given period of performance; and the second is the amount of continuous wakefulness prior to the period of performance (Caldwell, 2005). Sufficient daily sleep, a key component in the homeostatic regulation of alertness, is often one of the first casualties in aviation operations. In general terms, it appears that aircrews suffer from work-related sleep disturbances in the same manner as do industrial shift workers who primarily complain about their sleep patterns or their lack of sleep (Costa, 1997). Insufficient sleep is central to the homeostatically-based drowsiness and inattention that is known to be problematic in work that involves non-standard schedules. Importantly, it should be noted that duty time is not the same as wakefulness. Sleep loss is measured by time awake, not the time one is on duty (Caldwell, 2005).

Continuous wakefulness periods of 19-22 hours on long-haul flights (Nicholson, Pascoe, Spencer, Stone, & Green, 1986) can contribute substantially to aviation crew fatigue (Caldwell, 2005). Wakefulness prolonged by as little as three hours can produce decrements as serious as those found at the legal limits of alcohol consumption (Arnedt, Wilde, Munt, & MacLean, 2001). The consequences of losing even one - two hours of sleep in a single night may result in decrements in daytime function contributing to human error, accidents and catastrophic events (Mitler et al., 1988; Powell, Schechtman, Riley, Li, Troell, & Guilleminault, 2001). Another study showed the physiological alertness of a night shift worker between the hours of 0200-0800 was comparable to that of a day shift worker who had obtained only four hours of sleep for two consecutive nights (National Commission on Sleep Disorders Research, 1993).

3. Scope of the report

Aircrew fatigue is often thought of primarily as a function of scheduling and workload (Samel, Wegmann, & Vejvoda, 1995), and the present report will focus on these issues within the framework of the existing CFRs. Therefore, the primary issues addressed here are on the effect of the duration of work (and to some extent the intensity of workload), the timing of work hours, time zone shifts, and the subsequent impact on off-duty sleep quality and flight duty performance. However, although other factors such as age, gender, various individual factors, type of aircraft, cabin class, cabin air quality, physical and medical problems, aircraft factors, and personal or domestic situations (e.g., marital status and commuting from domicile location) also may contribute to flight attendant fatigue, these will be noted only briefly since a detailed analysis and discussion of these variables would be beyond the scope of this report because they logically vary regionally and individually. (For a detailed discussion of these issues see: Enck, Muller-Sacks, Holtman, & Wegmann, 1995; Ewing, 1999; Haugli, Skogstad, & Hellesoy, 1994; Hunt & Space, 1994; Nagda & Koontz, 2003; Rayman, 1997; Smolensky, Lee, Mott, & Colligan, 1982; Tashkin, Coulson, Simmons, & Spivey, 1983).

Chapter III. Code of Federal Regulations (CFRs)

Regulations set forth by the FAA for Aeronautics and Space are contained in Title 14 of the Code of Federal Regulations (CFR). CFR §121.467 and §135.273 of Title 14, were established in August, 1994, to provide flight attendant duty period limitations and rest requirements. For the purpose of this report, only the regulations pertaining to fatigue will be discussed. Specifically, on August 15, 1994, the FAA issued a regulation that, for the first time, set the *length of duty and rest requirements for airline flight attendants.* Delays due to litigation resulted in postponement in implementing the CFRs until February 1996.

Overall, the FAA regulatory authority applies when an aircraft is in operation, which is defined as the time when the aircraft is first boarded by a crew member, preparatory to a flight, to when the last crew member leaves the aircraft after completion of the flight, including stops on the ground during which at least one crew member remains on the aircraft (National Research Council Board on Environmental Studies and Toxicology, 2002).

The current regulations (§121.467 and §135.273) require that flight attendants receive a minimum rest period of nine consecutive hours following a scheduled duty period of 14 hours or less. This rest period may be reduced to eight hours if the subsequent rest period is at least 10 consecutive hours. Following a scheduled duty period of greater than 14 hours, but no more than 20 hours, a minimum rest period of 12 hours must be provided. This may be reduced to 10 hours if the subsequent rest period is at least 14 consecutive hours. If the rest period is reduced to 10 hours, the flight attendant may not be scheduled for a duty period of greater than 14 hours during the 24-hour period commencing after the beginning of the reduced rest period. Flight attendants may not be scheduled for duty if they have not had at least the minimum rest requirement. Furthermore, flight attendants must be relieved from duty for at least 24 hours during any seven consecutive calendar days.

A 14-hour duty period may be extended up to 20 hours if the carrier schedules additional flight attendant(s) to the minimum complement required. One additional flight attendant is required above the minimum complement to extend the scheduled duty hours to 16 hours. If two additional flight attendants are scheduled, the duty hours may be extended to 18 hours; and if three additional flight attendants are scheduled, the duty hours may be extended to no more than 20 hours. For example, if the minimum flight attendant complement required for a B757-200 is four, and five flight attendants are scheduled for duty, the scheduled duty period may be extended to a maximum of 16 hours. Table 1 below summarizes the CFRs requirements as related to flight attendant schedules.

The CFRs do not regulate the total number of hours a month a flight attendant is authorized to work, although this is usually defined in collective bargaining agreements. The CFRs also do not focus on the actual hours of sleep obtained between flights, or the timing of the duty periods (in relation to the body's internal clock) despite the fact that these factors are generally considered to be more important than absolute "time on task."

Table 1: *Summarized Flight Attendant (FA) Rest Periods According to the CFRs*

Scheduled Duty Period	Normal Minimum Rest Period	Reduced Rest Period	Subsequent Rest Period	Number of FAs Required
14 hours or less	9 hours	8 hours	10 hours	Minimum
14-16 hours	12 hours	10 hours	14 hours	Minimum +1
16-18 hours	12 hours	10 hours	14 hours	Minimum +2
*18-20 hours	12 hours	10 hours	14 hours	Minimum +3

*Applies only to duty periods with one or more flights that land or take off outside the 48 contiguous States and the District of Columbia.

Note: Generally, off-duty time begins no less than 15 minutes after the aircraft pulls into the gate and continues until one hour prior to a flight attendant's next departure.

SECTION 2: U.S. FLIGHT ATTENDANTS

Chapter IV. Flight Attendant Responsibilities

1. General

A study and extensive task analysis of flight attendant duties was conducted by Damos Aviation under contract with the Association of Professional Flight Attendants (personal communication, Patt Gibbs, March 4, 2005) however, this information was not available and could not be included in this report. A discussion based on a literature review is provided below.

As cited in the National Research Council Board on Environmental Studies and Toxicology (2002), the number of flights and the fraction of seats occupied (load factor) has risen, and seats are more densely packed, particularly in economy class. "Between 1986 and 1999, the load factor for U.S. carriers serving domestic and foreign locations increased by about 13% and 21%, respectively. And from 1986 to 1998, the average U.S. domestic trip length increased from 767 miles to 813 miles, and the average foreign trip length increased from 2,570 miles to 3, 074 miles (AIA, 2000)." Flight stages have steadily increased since 1950, particularly on international flights with nonstop flights of 12-14 hours now being commonplace (Hunt & Space, 1994). In terms of flight workload, CFR §121.391 specifies that at least one flight attendant is required in an aircraft with a seating capacity of 9-50 passengers, two flight attendants for 51-100 passengers, and one additional flight attendant is required for each unit of 50 extra seats.

Flight attendants' responsibilities, including workload duties and their respective changes (especially increases due to 9/11), can be traced for several decades. For example, on international flights before World War II, workload duties lasted from 16-24 hours, depending upon weather. The flight attendants were required to check passports, prepare formulas for infants, care for children, pass out reading and writing material, make up berths for 16 passengers, serve up to three complete meals, and wash dishes if additional meals were necessitated by weather delays. Therefore, it was not uncommon for a flight attendant to work up to 25 hours without sleep (Alter & Mohler, 1980). Examination of current flight attendants' duties reveals that their workload incorporates multiple tasks, consisting of considerable walking, bending over, heavy lifting and pushing, and dealing with a variety of stressful situations in the cabin. Further, flight attendants' duties encompass pre-flight, flight, and post-flight tasks (For a full description of flight attendant duties, see Appendix 1). On average, a flight attendant arrives one to two hours before flight and then, among other activities, is responsible for:

–**During pre-flight:** checking company e-mail, attending a pre-flight briefing, checking all emergency and other equipment, monitoring passenger access and seating, assisting with the stowing of luggage, arming doors, and filling out and providing the flight crew with relevant paperwork.

–**During routine flights:** attending to passenger safety and comfort. Flight attendants provide safety instructions; enforce safety rules; prepare and serve food and drinks; distribute pillows, blankets and magazines; work audio and video equipment; collect trays, glasses, newspapers and the like; answer passenger questions; and communicate as needed with the flight crew.

–**During non-routine flights:** depending on the emergency, flight attendants must notify the cockpit of malfunctioning equipment or emergency situations, deal with ill or disruptive passengers, operate first-aid or other medical equipment, distribute medication, operate emergency equipment, instruct passengers on emergency landings, direct the evacuation of passengers, and the like.

–**During post-flight:** disarming doors, deplaning passengers, checking and tidying the cabin, reporting cabin discrepancies to the flight deck crewmembers, and reporting to operations for company e-mail and other instructions.

As indicated above, flight attendants are required to perform a number of physically demanding tasks. Many flight attendants report that they spend most of their flight time on their feet. But they are also challenged emotionally, e.g., by requirements to perform multiple tasks on a tight schedule, and by being the POC that all passengers look to for information, help, and support. In short, one of the stressors of flight attendants is that they are always "on".

But surely the greatest challenges are related to ensuring safety and especially responding to a non-routine situation. It is here that the abilities, skills, and training of the flight attendants are most challenged and where one would expect the effects of other stressors such as fatigue and circadian dysfunction to have the greatest impact.

Historically, the number of flight attendants in service has greatly increased and the diversity of the flight attendant population has significantly broadened. But this has changed recently with contractual reductions of flight attendant/passenger ratios to the CFR floor in the 1990s. Therefore, the effects of workload and fatigue upon flight attendants in the current workforce should take into account age and sex differences, and personal issues, such as family responsibilities, as well as other factors such as the impact of cabin qualities (noise and air quality) physical responses (dehydration and sinus congestion), and flight and duty times.

2. Flight attendant responsibilities, fatigue and the issue of post 9/11

Although scientific studies documenting flight attendant workload post 9/11 are not available, there are anecdotal reports indicating that the workload for flight attendants has increased. For example, prior to 9/11 passenger disruption was reported to be the number one complaint submitted by flight attendants to the Aviation Safety Reporting System [ASRS], (Connell, Mellone, & Morrison, 2000). According to that study, one-fourth of passenger disruptions resulted in a cockpit crewmember leaving the cockpit to help resolve the situation. Since recent security regulations require cockpit crews to secure and remain in the cockpit, the flight attendants have to deal with problem passengers without help from the cockpit crew.

It can also be presumed that at a minimum security duties would include closer inspection of passengers as they board, greater vigilance and monitoring of passenger behavior during flight, and a sweep of the aircraft cabin before and after each flight leg. It has also been suggested that the behavior of flight attendants vis-à-vis passengers has changed since 9/11. Flight attendants are showing more concern for and attention to meeting passenger needs. Passengers are arriving at the aircraft more harried and annoyed than previously, and the flight attendants appear to be trying to compensate. Although helpful to the passengers, this added attention places additional workload on the flight attendants.

While these examples make it apparent that an increase in flight attendant workload has probably occurred, these particular issues were not specifically addressed in this study.

Chapter V. Background Literature on Flight Attendant Fatigue

1. Literature Review

The literature review concerning flight attendant fatigue and associated relevant factors incorporates information from scientific publications, including experimental studies and survey reports. It additionally includes information from other articles, websites, and sources. In reporting this literature we have made an effort to evaluate the validity and reliability of the information presented, and to include only those that appear to be the most objective, unbiased, and relevant.

It should be remembered that, from a scientific perspective, the fatigue literature has certain limits. These limits are not unique to the fatigue area but are general across domains. Experimental studies tend to be limited by small numbers of participants and often include non-representative subjects (i.e., some studies were not conducted with flight attendants). Also, questionnaires and surveys may be limited by self-selected respondents or by low response rates. Media or website reports tend to be anecdotal, and reports from many sources lack peer review. However, taken together, these studies provide a considerable base of information that cannot be obtained any other way. By selective screening, these data can broaden our understanding of, and approach to, managing flight attendant fatigue.

Sleep loss effects

In a study of progressive sleep loss effects over an extended period, adult participants receiving less than eight hours time in bed each evening, demonstrated neurobehavioral performance deficits, i.e., lapses in attention on a simple reaction time test (Van Dongen et al., 2003). The performance deficits seen from chronic sleep restriction of six hours per night over an extended period was equivalent to performance deficits seen after two nights of complete sleep deprivation. This study also showed that chronic sleep restriction resulted in a significant increase in subjective sleepiness. In a survey of 3412 flight attendants (Smolensky et al., 1982) fatigue was found to be five to 7 times higher in flight attendants who slept poorly, felt emotional pressures, and worked multiple day trips. Accumulated sleep loss becomes a sleep debt towards the end of a workweek, leading to increased sleepiness (Roehrs, Carskadon, Dement, & Roth, 2000).

Fatigue can be measured objectively by assessing physiological levels of sleepiness (e.g., electroencephalogram (EEG); simple reaction time tasks) or subjectively with questionnaires. Subjective levels of sleepiness may be masked by factors such as environmental stimulation, physical activity, or caffeine, thus making it difficult to estimate one's sleepiness or alertness level. Although physiological levels of sleepiness tend to co-vary with subjective levels of sleepiness (Van Dongen & Dinges, 2000), research has demonstrated that individuals cannot be relied upon to self-detect neurobehavioral impairment due to fatigue (Leproult, Colecchia, Berardi, Stickhold, Kosslyn, & Van Cauter, 2003). Some physiological and cognitive changes that may occur as a result of fatigue include microsleeps (brief intrusions of EEG indicators of sleep greater than 5 sec), lapses in attention (reaction times greater than 500 milliseconds), slowed reaction time, increase in errors, short-term memory impairment, lack of situational awareness, and impaired decision making (Caldwell, 2005).

Several studies have documented the degree that sleep loss is associated with performance decrements equivalent to the consumption of the legal limit of alcohol (0.05% -0.1% blood alcohol levels; Dawson & Reid, 1997; Lamond & Dawson, 1999; Williamson, 2000). Wakefulness prolonged by as little as three hours can produce performance decrements (Arnedt et al., 2001), while the consequences of even one to two hours of nightly sleep loss over a week may result in decrements in daytime function leading to human error, accidents, and catastrophic events (Mitler et al., 1988; Powell et al., 2001). Monk (1980) showed that layover sleep for aircrew on international flight schedules was disrupted and truncated to durations below their sleep times at home.

Workload

In terms of flight workload, 14 CFR §121.391 specifies at least one flight attendant is required in aircraft with seating capacity of 9-50 passengers, two flight attendants for 51-100 passengers, with an additional flight attendant required for each unit of 50 extra seats. The only other set of specifications obtained for flight attendant complement was from the Australian flight regulations, which pertain to flight attendant complement on charter and public transport aircraft. These regulations provide that a flight attendant is required for 15-36 passengers; aircraft carrying 36-216 passengers shall carry a flight attendant for each unit of 36 passengers; aircraft with more than 216 passengers shall have not fewer than one flight attendant for each floor level exit in any cabin with two aisles (for more information on the Australian Civil Air Regulations, please refer to www.aph.gov.au/senate/committee/rrat_ctte/completed_inquiries/2002-04/civilaviation_nz/submissions/sub2.doc).

In recent years, there have been many changes in commercial aviation that have affected duty cycles and workload. Meanwhile, the scientific understanding of the impact of work hours, sleep, and circadian factors has advanced considerably as well. One of the present concerns is that the associated regulations designed to manage flight crew fatigue have not kept pace with these changes (Caldwell, 2005).

In a number of studies the amount of walking that occurs during duty hours has been shown to be related to workload intensity and duration. Fatigue was attributed to workload by 58% of flight attendants in a study conducted by Smolensky et al. (1982). In a recent study by Morley-Kirk and Griffiths (2003), generally, high workload demands were reported by 83% of flight attendants. On-duty walking distance was reported to be greater than their off-duty walking distance and was significantly correlated with length of the duty day, the end-of-duty stress level, and reported fatigue. In another workload-related study with 118 female flight attendants (Hagihara, Tarumi, & Nobutomo, 2001), the number of walking steps was measured with pedometers during international flights. The total average number of steps taken per flight attendant during flights of an approximate duration of 10.6 hours was 10,742.8, or 14.0 steps/min. Another study found length of duty day had significant effects on end-of-duty sleepiness and upon fatigue levels in both international and domestic flight attendants, and also on end-of-duty stress for domestic flight attendants (Galipault, 1980).

Several researchers also report that for international flight attendants, end-of-duty fatigue is proportional to the percentage of cabin occupancy (Galipault, 1980). Each cabin-type served, had an impact on cabin crew well-being and fatigue. For example, task loads are especially high in the economy class and was associated with lower well-being than business cabin (Morley-Kirk & Griffiths, 2003). Vejvoda et al. (2000) evaluated physiological and workload stress in 44 flight attendants during transmeridian flights working in first, business, and economy cabin classes. They found that the flight attendants working in economy class had higher blood pressure levels, and incidences of heart rates greater than 120 beats/min, compared with the flight attendants working the other two classes. Flight attendants working in business class also showed heart rate increases greater than those working first class. Those working in economy class had significantly shorter sleep periods during the transmeridian flights, suggesting that their work periods limited the opportunity to nap. Also, the relatively higher physiological and subjective work stress measures reported by the flight attendants working economy class were attributed to higher workload demands (Vejvoda et al., 2000).

Flight duration and type

Several studies have examined the question of the amount of time a flight attendant has to be on duty before fatigue sets in. In one study (Simonson, 1984) the majority of flight attendants set the fatigue range as between six and 10 hours. However, 21% were not fatigued until completing 11-15 hours of duty. In a second study (Galipault, 1980) the duty length that flight attendants thought induced tiredness ranged from four hours (10%), to five - six hours (51.1%) up to seven - nine hours (27.6%). This study also found that short duration flights with beverage or snack service produce large increases in end-of-duty fatigue.

International vs. Domestic. Flight attendants on international routes are more likely to be older and have higher tenure than flight attendants on domestic routes. MacDonald, Deddens, Grajewski, Whelan, and Hurrell (2003) found that international flight attendants reported lower ratings of fatigue effects than domestic flight attendants. The domestics experienced very high correlations of fatigue with age, start and end-of-duty stress, sleepiness and pulse rate. Job strain and fatigue was significantly higher among domestic flight attendants, who had higher job demands. It is interesting to note that in this study, the international flight attendants reported less stress and sleepiness than domestic flight attendants despite reporting nearly twice as many average hours of commute times. International flight attendants are provided with a rest opportunity during the cruise portion of the flight. Even though any sleep achieved may be less than optimal (turbulence, noise, crowded conditions), it is nonetheless more restorative than no sleep at all. Older flight attendants on domestic flights were found to have greater fatigue effects resulting from multiple flight legs than younger flight attendants (MacDonald et al., 2003).

A survey of 211 female flight attendants assigned to nonstop international flights (Ono, Watanabe, Kaneko, Matsumoto, & Miyao, 1991) revealed that fatigue complaints increased after the second meal service (seven- ten hours after takeoff). Among the different flights, differences in fatigue levels were attributed to length of the flight, the time zone differences, and the possibility for adequate rest during the layover. In domestic operations, increased fatigue was associated primarily with elapsed working hours, landing frequency, and the number of consecutive duty days.

Long Haul vs. Short Haul. A survey of 190 flight attendants (Nagda & Koontz, 2003) showed that tiredness and lack of energy were higher in response to long haul (52.8%, 22.8%, respectively) than short haul (31.7%, 12.7%) and ground control (35.0%, 9.0%). The most common physiological symptom associated with long-haul flying is sleep disturbances, including difficulty falling asleep, spontaneous night awakenings, and early morning awakenings (Samel & Wegmann, 1989). A number of studies of flight attendants have found that fatigue symptoms associated with factors such as disruption of circadian rhythm are exacerbated by longer flight durations. Nagda and Koontz (2003) found that the frequency of symptoms related to circadian rhythms increased with longer flights, rapid changes in time zones, and early morning or late night flights. Haugli et al (1994) reported that the largest percentage differences between long (LH) and short hauls (SH) occurred in the sleep and mood problems, with sleep problems in 27.7% (SH) versus 61.6% (LH), fatigue in 52.9% (SH) versus 74.1% (LH), easily tired in 29.5% (SH) versus 42.3% (LH), and irritability in 23.6% (SH) versus 43.1% (LH).

Boeing and Airbus have established new ultra long-range aircraft capable of flying extended non-stop flights such as 18 hours and 30 minute flights from Los Angeles to Singapore. These ultra long flights will clearly increase the potential for decreased alertness and performance efficiency in the flight attendants assigned to duty on these routes (Mallis, Colletti, Brandt, Oyung, & DeRoshia, 2005).

Shift work. An examination of flight attendant schedules reveals that in many ways, flight attendants face fatigue factors similar to those encountered by industrial shift workers. Shift work is defined as any non-standard work schedule (e.g., evening or night shifts, rotating shifts, split shifts, and extended duty hours) in which most of the hours worked are outside the period between 0800 and 1600. In shift workers, night work is often performed at or near the trough or minimum of the circadian rhythms in performance and alertness, and the sleep-wake cycle is often desynchronized from the external day-night cycle and from the prevailing social interaction cycle (Holley, Sundaram, & Wood, 2003). Shift work results in a state of almost permanently conflicting synchronizers, and therefore re-adaptation during shift work may be slower and less complete than after time zone flights (Samel & Wegmann, 1989). A major ramification of shift work is sleepiness and unintentional sleep (Åkerstedt, 1995a, 1995b).

Mental performance changes from 10 to 30% over a 24-hour period and follows the circadian cycle (Klein & Wegmann, 1980). However, some field studies have shown considerably larger shifts associated with fatigue related to continuous duty, with oscillations from mean performance up to 100% (Klein & Wegmann, 1980). In examining subjects who had consumed the legal limit of alcohol (0.1% blood alcohol), Dawson and Reid (1997) found 11.6% shifts in mental performance, while Lamond and Dawson (1999) found a range of 14% to 49% in the same measure. It is apparent that performance decrements equivalent to consuming the legal limit of alcohol occur with circadian disruption in field operations - ***even without the loss of sleep.***

In general, operating near the trough of the circadian cycle has been associated with a significantly high incidence of accidents. For example, single vehicle auto accidents present a major peak from midnight to 0700, especially between 0100-0400, with a small secondary peak between 1300-1600. The peak time for single vehicle truck accidents is between 0100- 0700. Another study found similar results with a major peak in errors occurring between 0200-0400 and a minor peak between 1400-1600 (Mitler et al., 1988). Additionally, shift work schedules have been found to disrupt physiological circadian rhythms, disturb sleep-wake cycles, contribute to physical and psychological problems, as well as social and domestic problems (Barton, 1994).

Flight attendants, like other shift workers, suffer from desynchronized circadian rhythms along with associated sleep disruptions and performance decrements. Unlike the usual shift worker, flight attendants are often in new environments, attempting to sleep in unfamiliar beds, and generally away from their at-home routines.

Transmeridian flights

In the aviation operational environment, sleep cannot be taken at the time of the usual or optimal circadian phase due to the mismatch between the internal circadian clock and external synchronizers, and due to night flights and irregular duty hours. This mismatch results in increased fatigue, sleepiness, acute and accumulative sleep loss, and performance decrements (Graeber, Dement, Nicholson, Sasaki, & Wegmann, 1986; Klein & Wegmann, 1980; Samel & Wegmann, 1989; Winget et al., 1984). Sleep problems are exacerbated when aircrews have to operate multiple transmeridian flights in close succession (Sasaki, Kurosaki, Spinweber, Graeber, & Takahashi, 1993).

Rapid time-zone transitions result in a phase shift between the circadian rhythms of an individual as he/she embarks on a trip and the external environmental synchronizers of the destination environment. A phase shift means that a reference point (rhythm phase or timing of an environmental synchronizer) has been advanced or delayed in time, while the rhythm period length remains constant. The resulting disruption of circadian rhythmicity has been described as "jet-lag", rhythm desynchronization, dysrhythmia, or desynchronosis (Winget et al., 1984). A study of long distance travelers (Criglington, 1998) using a major U.S. carrier and major international airline, found that 94% suffered jet-lag symptoms and 45% considered their symptoms severely bothersome. The jet-lag symptoms included tiredness over the first five days after arrival (90%), interrupted sleep after arrival (93%), and lack of motivation and energy (94%). In a different study (Vejvoda et al., 2000), jet-lag symptoms were reported by 80% of flight attendants with 22% reporting severe symptoms. The most difficult flights were continuous short-haul flights. Coping mechanisms were often inappropriate and included use of alcohol or anxiolytic drugs to induce sleep (Sharma & Shrivastava, 2004). An earlier survey including 3412 flight attendants, linked a combination of excessive fatigue and mental exhaustion to sleep problems in 63.1% of this sample. Over 71% felt fatigued during flights at least three - four times during a 30-day span and only 9.1% felt no fatigue. Time zone travel also resulted in moderate to severe sleep problems in 78.1% of respondents (Smolensky et al., 1982).

It should be remembered that performance deterioration can result from circadian rhythm disturbances and not solely from sleep loss. Moreover, the circadian minimum in alertness and performance sometimes occurs in flight, at which point the chances of performance error are high (Holley et al., 2003).

Number of zone changes. The degree of deterioration in sleep duration and quality and in performance efficiency is dependent upon the number of time zones crossed. Fatigue levels increase to critical levels during 9-time zone flights after eight hours of flight time (Samel et al., 1995.) However, performance deterioration may occur in response to only a one-hour time change (Monk, 1980). Sleep quality and recovery is also dependent upon the number of time zones crossed. The response to crossing 10 times zones was found to be significantly worse in terms of sleep quality, adaptation, and days needed for recovery than crossing seven time zones (Suvanto & Ilmarinen, 1987c). Sleep quality, perceived adjustment and perceived recovery times were all longer after 10 time zone changes and eastward flights than after seven time zone changes heading westward (Suvanto, Partinen, Harma, & Illmarinen, 1990).

Transmeridian flights across nine time zones with short (50 hour) layovers resulted in reduced sleep efficiency during the layover, which was characterized as too short and disturbed by awakenings. Recovery sleep during four post-flight days was characterized by difficulties waking up and feelings of not being refreshed from sleep (Lowden & Åkerstedt, 1998). In a study of aircrew (including 35 flight attendants) sleep on an eight time-zone trip flight from Stockholm to Tokyo with a short (51 hour) layover, it was found that the outbound flight day was characterized by 21 hours of wakefulness, during which sleepiness was elevated. Sleep lengths did not vary significantly but sleep efficiency was significantly reduced on both nights abroad and during the first recovery sleep. Night sleep abroad was reduced in sleep quality, contained more awakenings, and was characterized as less calm and refreshing. On the first free day in Japan, the subjects showed severely reduced alertness during a quarter of the day. Periods with severe sleepiness were more common on the homeward flight (Lowden & Åkerstedt, 1999).

Eastbound vs. westbound flights. Fatigue effects have been found to be dependent on flight direction. Eastbound flights result in significantly more fatigue than westbound flights. Resynchronization is 50% faster following westbound flights, with a rate of 88 min/day for westbound, and 56 min/day for eastbound flights. For example, the psychomotor performance rhythm requires three days to achieve 95% adaptation after westward flight, but requires eight days after return from eastward flights (Klein & Wegmann, 1980). Eastward transport was characterized by significantly worse sleep quality, adaptation, and recovery time than westbound flights, (Suvanto & Ilmarinen, 1987b). An increase in subjective fatigue during the second part of eastbound flight has been found to coincide with the observed circadian trough and period of increasing sleep deprivation (Samel & Wegmann, 1989). Lowden and Åkerstedt (1999) have found westward flights to be associated with extended wake spans during layover, increased sleepiness, and slow recovery on return home. Eastward flight was associated with longer sleep latencies, worse sleep quality, more difficulty arising, and more severe sleepiness during time awake.

The east vs. west effects of 4-day, round-trip transmeridan flights across 10 time zones (Helsinki to Los Angeles, return flight Seattle to Helsinki) on the salivary melatonin and cortisol levels in 35 female flight attendants has shown that the resynchronization rate of these hormones after westward, outgoing flights was faster than the resynchronization rate after eastward return flights (Harma, Laitinen, Partinen, & Suvanto, 1993). Klein and Wegmann (1980) found that resynchronization times to vary from 1.7-6.0 days (westward) to 2.9-11.3 days (eastward).

The impact of the direction of flight is compounded by day/night relationships. Samel et al. (1995) report that westbound flights are typically scheduled as day flights, while eastbound flights are more typically night flights. Nighttime flights have been associated with greater sleep loss and sleep disturbance than day flights (Gander, Gregory, Miller, Graeber, Connell, & Rosekind, 1998; Samel, Wegmann, & Vejvoda, 1997). In a study in which 24 flight attendants kept sleep logs, sleep loss was related to the number of night flights, but not to time zone changes (Preston, Ruffell-Smith, & Sutton-Mattocks, 1973).

Recovery duration. The rates of resynchronization of different circadian rhythms lead to transient internal dissociation, in which the normal phase relationships between rhythms are disrupted, resulting in sleep disturbances (Winget et al., 1984). It often takes at least 1 - 2 adaptation nights before sleep onset and efficiency is similar to sleep in a familiar environment (Caldwell, 1997). The rate of rhythm phase shift is most rapid during the first 24 hours and decreases exponentially thereafter (Winget, Bond, Rosenblatt, Hetherington, Higgins, & DeRoshia, 1975). Recovery from 4-day flights has been found to average four days (Harma, Suvanto, & Partinen, 1994).

Seasonal effects. Seasonal effects on circadian rhythm adaptability to transmeridian flight were evaluated in 21 flight attendants during Helsinki-Los Angeles - Seattle-Helsinki flights in both summer and winter. Salivary melatonin and cortisol levels were measured at two-hour intervals for five days before, during, and after the 4-day trip. Circadian rhythm phase shifts in the summer group were significantly greater than the winter group. After the eastward flight, the phase shifts in the summer group were significantly smaller than the winter group. In summer, when there is more environmental light during mornings and evenings, circadian rhythm adaptation was faster after both eastward and westward flights. Late sleeping times increased the exposure to the phase-delaying evening light after the westward flight. After eastward flights, most subjects were still asleep in the morning, and therefore not exposed to the phase-advancing effect of morning light (Harma, Laitinen, Partinen, & Suvanto, 1993).

Individual variability. Characteristics predictive of adaptation rates include circadian factors such as stability and amplitude; personal factors, such as age, motivation and personality; and environmental factors, such as Zeitgeber strength (Winget et al., 1984). Discovery that sleep onset and duration depend upon circadian body temperature phase provides a physiological basis for the performance deterioration observed in response to circadian rhythm desynchronization (Czeisler, Weitzman, Moore-Ede, & Knauer, 1980).

Additional factors

This review has concentrated on those factors affecting fatigue that are most closely associated with the CFRs, i.e., duration and intensity of work, timing of work and rest, and time zone shifts. However, it is important to remember that these are not the only factors impacting off-duty sleep quality and flight-duty performance. One must also consider the impact of aircraft factors such as the aircraft model and configuration, deck arrangements, humidity and air quality; airline factors such as work practices and general culture, as well as individual factors such as age, gender, general health, experience, and the highly variable personal/domestic situation including commuting requirements.

One area that is commonly reported as interacting with, and exacerbating issues of fatigue relates to meals and nutrition. End-of-duty fatigue has been associated with failure to eat dinner and not eating high protein food. There is some evidence that domestic flight attendants have less opportunity to eat during flight legs than international flight attendants, and that flight attendants on regional flights often cannot leave the aircraft between segments, resulting in their missing meals. Reports of occasions when flight attendants arrive at the hotel too