12-1-2010

# Effects of Fatigue and Self-reported Countermeasures Used by Regional Airline Pilots Conducting Continuous Duty Overnight

Andrew LaVenture

# EFFECTS OF FATIGUE AND SELF-REPORTED COUNTERMEASURES USED BY REGIONAL AIRLINE PILOTS CONDUCTING CONTINUOUS DUTY OVERNIGHTS

by

Andrew M. LaVenture
Bachelor of Science, University of North Dakota, 2007

A Thesis
Submitted to the Graduate Faculty
of the
University of North Dakota
in partial fulfillment of the requirements

for the degree of
Master of Science

Grand Forks, North Dakota
December
2010

This thesis, submitted by Andrew M. LaVenture in partial fulfillment of the requirements for the Degree of Master of Science from the University of North Dakota, has been read by the Faculty Advisory Committee under whom the work has been done and is hereby approved.

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This thesis meets the standards for appearance, conforms to the style and format requirements of the Graduate School of the University of North Dakota, and is hereby approved.

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Department: Aviation

Degree: Master of Science

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TABLE OF CONTENTS

LIST OF FIGURES

Figure Page

LIST OF TABLES

ABSTRACT

Fatigue poses a significant risk to commercial aviation. When pilots become fatigued they are more likely to make errors and in some instances those errors have been causal factors in accidents. Research not only tells us how the human body is affected by fatigue but also what can be done to temporarily reduce its negative impact on performance. However, relatively little data is available pertaining to one specific type of flight operation, the Continuous Duty Overnight (CDO). They are frequently conducted by regional airlines within the United States and typically resemble schedules for workers on a $3^{rd}$ shift, otherwise known as the night shift.

This study utilized an online survey tool to gather data from pilots at one mid-sized regional airline. The pilots provided data on a variety of areas including fatigue, sleep habits, fatigue countermeasures, continuous duty overnights, and their perceptions of safety. Results tend to suggest that pilots at this airline are aware of how their body reacts to fatigue, what measures are necessary to obtain quality sleep, and that the airline itself is operating safely. Nevertheless, several unnerving trends were observed. Many of the pilots admitted to sleeping while on duty and in flight, a practice that is currently forbidden by the Federal Aviation Administration. Additionally, a substantial portion of participants indicated they did not notice the detrimental affects of fatigue until three or more hours of sleep loss had been accumulated. This is contrary to research by Caldwell (2009) that indicates as little as one to two hours of sleep loss can substantially affect pilot performance.

Regardless of regulatory changes, biomedical research, and flight crew education, fatigue will continue to impact flight operations at regional airlines. The simple fact is that fatigue will never be a non-issue. However, this study and others like it have shed light on important factors that allow pilots to use the most effective strategies possible to combat fatigue for short durations until quality sleep can be obtained. Airlines are strongly encouraged to incorporate fatigue education into their initial and recurrent ground training programs. But ultimately it is the responsibility of the individual pilot to ensure he or she is well rested and fit for duty.

# CHAPTER I

# INTRODUCTION

Aviation safety is of paramount concern for all persons who work within the industry as well as for those who utilize it for transportation. The effects of fatigue and the serious physical and cognitive detriments associated with it have been well documented (Caldwell, Mallis, Caldwell, Paul, Miller, & Neri, 2009). Even so, every year accidents across all industries, not just aviation, cite fatigue as a contributing factor. As airlines adapt to keep pace with the ever-increasing 24-hour society that exists in the United States, they find themselves operating more flights at night and in the early hours of the morning.

The effects of fatigue can be likened to the effects of alcohol; they impair the human body's ability to operate at peak efficiency (Air Line Pilots Association, 2008; Rosekind, Co, Neri, Oyung, & Mallis, 2002). They are also deceptive in that pilots may be unable to accurately judge their own level of fatigue impairment. Before arriving at work, it is paramount that pilots receive quality sleep. Methods to achieve this include: creating a dark and quiet space, relaxing prior to sleep, and avoiding stimulants such as nicotine and caffeine prior to bed (Caldwell et al., 2009). While the best solution to fatigue is sleep, there are many times when pilots must remain awake. Countermeasures may be used during periods of sleepiness to temporarily increase alertness. Examples include: caffeinated beverages, exposure to bright light, cooler temperatures, and many others (Co, Gregory, Johnson, & Rosekind, 1999; Rosekind et al., 2002).

Like food, the human body requires sleep. It is a physiological state used to rest and regenerate every day. The average adult requires approximately eight hours of sleep every 24 hours (Co et al., 1999). When this need is not met, sleep debt can accumulate. Sleep debt can be classified as either acute or chronic depending on how long a person has been deprived. As little as one to two hours of sleep loss can result in a serious determent to a pilot's performance (Rosekind, Gander, Gregory, Smith, Miller, Oyung, Webbon, & Johnson, 1997; Rosekind et al., 2002). Care must always be given when creating airline schedules to ensure pilots are receiving adequate sleep before, during, and after a trip.

A certain type of airline operation of considerable concern is: Continuous Duty Overnights (CDO). These flights typically operate at night and into the early hours of the morning; times that have been shown to be difficult for humans to perform at peak physical and cognitive efficiency (Co et al., 1999; Rosekind et al., 2002). The following provides a thorough explanation:

> *A crew working a CDO will generally operate the last flight out at night, have on duty time on the ground (anywhere from 0-8 hours) at the destination and then operate the first flight back in the morning. Since the break between flights is not sufficient to qualify as a free from duty rest period, the crewmembers remain continuously on duty. Crew members would normally require 9 hours of consecutive rest for a scheduled flight time of less than 8 hours. Since crews can legally be kept on duty up to 16 hours the airlines use this to "manage" and comply with the Federal Aviation Administration's (FAA) minimum crew rest requirements by keeping the crew on duty for the*

> *entire night. At the destination, the airline may or may not provide the crew with a hotel room for rest. This would generally be determined by the airline's collective bargaining agreement.* (Airline Glossary, 2009, p.1)

A typical CDO may resemble this: Crew reports to the airport at 2100 hours for a 2200 departure. The flight may be between one and two hours. Upon arriving at the out station, the crew heads to the hotel for about five hours. At 0430 hours the crew reports back to the airport for a 0500 departure. Following a return flight of about one to two hours, the crew is then released from duty around 0730. Generally this pattern will repeat three to five times before a scheduled day off is granted.

While some people do choose to fly these types of schedules, it is thought that most pilots do not; rather they are assigned because a pilot does not have enough seniority to acquire a different schedule. Should this be the case, it is of vital importance that pilots receive training on the topics of sleep, fatigue, fatigue prevention measures, and operational fatigue countermeasures. The understanding one may gain from learning about his or her own personal limitations through such an education could help to prevent some future aviation incidents and accidents.

## Purpose of the Study

A review of the literature will show that (1) fatigue is a serious safety concern for aviation, (2) there are numerous effective fatigue countermeasures for short-term fatigue mitigation, and (3) there has been only limited study of fatigue countermeasures used by regional pilots on continuous duty overnights. Therefore, the following are the goals of this study:

1. Determine what regional pilots are doing now to combat fatigue on CDO's.

2. Analyze if those reported choices are effective based on previous research.
3. Identify any immediate hazards or dangerous trends.
4. Determine if a recommendation for more flight-crew education is necessary.

A solid understanding of what pilots are currently utilizing to combat fatigue will indicate any current trends as well as differences between pilots performing CDO's and those with regular flight patterns. Analyzing the responses and comparing them to previous fatigue research will allow for evaluation of any similarities or anomalies. It is likely that many comparisons will be found as many pilots cope with fatigue in similar fashions. However, the possibility of unique fatigue countermeasures is not unfeasible. An important step is also to identify any hazards or dangers affecting the pilot group and airline operation. These may necessitate expedited reporting to ensure flight safety. Lastly, it will be essential to make a determination of whether or not an adequate knowledge base exists within the survey population. If not, recommendations for training should be made.

## Research Questions

The following research questions were carefully crafted to specifically look at (1) regional flight operations and (2) continuous duty overnights (CDO's). While this study is not able to examine all facets of fatigue as it pertains to regional airlines, it will attempt to scrutinize important categories discussed in this section. Those categories should yield vital data that can be reported back to the pilot group, pilot union, company management, and other regional airlines with similar operations. The ultimate goal is to improve aviation safety. The following are the four research questions selected for this study:

1. What symptoms of fatigue are most noticed by regional airline pilots?

2. What operational fatigue countermeasures are most used by regional airline pilots conducting continuous duty overnights?
3. What strategies are used most by regional airline pilots to achieve high-quality sleep between flights while conducting a continuous duty overnight?
4. What level of concern exists amongst regional airline pilots in regard to fatigue and how does this vary within the population?

# CHAPTER II

# LITERATURE REVIEW

## Sleep

Just as humans have a basic need for water, food, and shelter; they also have a need for sleep. In fact, Rosekind et al. (1997) goes so far as to declare: "sleep is a complex, active, physiological state that is vital to human survival" (p. 158). The amount of sleep needed varies from person to person depending on numerous factors including age. Generally speaking, adults need approximately eight hours of quality sleep per night to be fully rested (ALPA, 2008; Caldwell et al., 2009; Goode, 2003; Rosekind et al., 1997; Rosekind et al., 2002). The type and quality of sleep is also important. Sleep can be broken into two distinct categories: Non-rapid eye movement (NREM) and rapid eye movement (REM) sleep that alternate throughout any given sleep period (Rosekind et al., 2002).

During NREM sleep the body's mental and physiological functions slow to a minimum and includes but is not limited to: heart rate, breathing, and brain activity. NREM can be further broken down into four stages with the deepest sleep occurring during stages three and four. At the other end of the spectrum is REM sleep. During REM the brain becomes extremely active and is the time when people are mostly likely to experience dreams. Even though the REM sleep is associated with rapid bursts of eye movement, the body and its muscles are generally in a paralyzed state. Furthermore, it should be noted that the deepest sleep typically occurs in the first half of a sleep period (Rosekind et al., 2002).

The quality of sleep is often just as important, if not more, to the amount and type of sleep obtained. Disruptions from light, sound, vibration, alcohol, medication, gastrointestinal and/ or other physiological needs may interrupt the natural sleep cycle leading to a lower quality sleep. These, and other interruptions can fragment the sleep period resulting in a person feeling tired even after a full eight or more hours of sleep (Co, Rosekind, Johnson, Weldon, Smith, Gregory, Miller, Gander, & Lebacqz, 1994; Rosekind, et al., 2002).

## Circadian Rhythm

Rosekind et al. suggests that over time through evolution the daily cycles of our surrounding physical environment have influenced our body's biological clock located in the brain (2002). This biological clock is referred to as our circadian rhythm, *circa* meaning about and *dies* meaning day. The body's circadian clock regulates more than just sleep cycles. It also helps to coordinate body temperature, hormones, digestion, and performance. Each person develops a unique circadian rhythm that is generally very close to the 24 hours it takes for the earth to make one full rotation. On average, the typical circadian cycle is 24.2 hours for an adult. However research has shown that some people can develop cycles as long as 50 hours (Rosekind et al., 2002).

The human body is programmed to sleep at night and be awake during the day. Within the 24-hour cycle there are two documented times of increased sleepiness: between 3am-5am and 3pm-5pm. Studies have also indicated that performance and alertness have been significantly affected during a nocturnal window from 2am to 6am

(ALPA, 2008; Co et al., 1994; Rosekind et al., 2002). This is of particular concern for regional pilots who will be conducting the last leg of a CDO during these times.

Circadian cycles are not set to a fixed schedule; in fact most people synchronize their cycles daily without even knowing. Three factors including exposure to sunlight, work/ rest schedules, and social interaction can all play a part in adjusting the circadian clock. Conversely, circadian desynchronization can also occur. Typically this will happen when someone's clock cannot adapt to changes being made with their wake/ sleep schedule. Two prime examples of this are jet-lag or crossing multiple time zones and shift work or working on the *backside* of the clock. During shift work the human must fight against the natural urge to sleep from both the internal circadian clock as well as external environmental cues (ALPA, 2008; Co et al., 1994; Rosekind et al., 2002). Research suggests "Even people who have worked a night shift for years may never completely physiologically adapt to that schedule due to the conflict between the body clock and environmental cues" (Rosekind et al., 2002, p. 31).

The effects of shift work are further compounded when people switch back to daytime activity on their days off. This continual switching and circadian desynchronization can lead to problems with other body systems that are regulated by the circadian clock such as: digestion, body temperature, hormones, etc. Documented symptoms of shift work include: Disturbed sleep, increased sleepiness at work, decreased physical and mental performance, and generally a more negative mood (Co et al., 1994; Rosekind et al., 2002). Lastly, Rosekind (2002) states that "if you experience jet lag or a reversed work/rest schedule, keep in mind that circadian disruption can result in decreased alertness and performance, which in turn, can affect skills critical for flying" (p. 33).

## Fatigue

The Merriam-Webster Dictionary (2010) defines fatigue as "weariness or exhaustion from labor, exertion, or stress." The signs and symptoms of fatigue can present themselves in numerous ways and generally vary from person to person. Some common examples include: forgetfulness, poor decision making, slowed reaction time, reduced vigilance, poor communication, fixation, apathy, lethargy, complacency, bad mood, and nodding off (ALAP, 2008; Caldwell et al., 2009; Co et al., 1994; Rosekind et al., 2002).

In aviation, and for pilots especially, there are many factors that contribute to fatigue. The following are examples cited by Rosekind (2002): Prolonged wakefulness, irregular sleep and wake schedules, night flying, pilot not flying/ monitoring role, workload, and the physical environment. Regional pilots are also exposed to multiple takeoffs and landings, restricted sleep schedules, extended flights, and Continuous Duty Overnights. Just as the body craves food after periods of starvation it also needs sleep following periods of prolonged wakefulness. According to the Airline Pilots Guide to Fighting Fatigue (2008), studies have shown that prolonged wakefulness of 17 hours equates to an approximate blood-alcohol level of 0.05%. Furthermore, prolonged wakefulness of 24 hours equates to an approximate blood-alcohol level of 0.10%. Both examples would be over the legal limit prescribed by the Federal Aviation Administration of 0.04% (FAR §91.17) and demonstrates how fatigue can impair a pilot.

Flight operations in modern airlines are driven in a large part by customer demand. As such, flights occur at all hours of the day and pilots' schedules vary tremendously from day-to-day, week-to-week, and month-to-month. Humans are creatures of habit and these random and sometimes unpredictable schedules make it difficult for pilots to fall into a rhythm. Instead, pilots' must constantly be adjusting their internal circadian clock to meet the demands of the 24-hour aviation industry, a process that can lead to increased fatigue (Co et al., 1994; Rosekind et al., 2002).

The type of work being performed also has an impact on fatigue. During periods of low workload, such as pilot not flying/ or monitoring duties, underlying fatigue can manifest due to boredom. This increases the likelihood of complacency and may result in unintended sleep. Further complicating the matter are today's modern aircraft with highly automated navigation and autopilot systems that reduce pilot workload. At the other end of the fatigue-causing spectrum is high workload. Increased mental and/or physical workload for short or sustained durations can tire the human body (Rosekind et al., 2002). An aviation specific example of this could be pilots attempting to deviate for severe weather while dealing with a medical emergency in the passenger cabin. The increased mental and physical demands of that situation may cause the pilots to exhibit signs and symptoms of fatigue faster than would otherwise occur.

Another significant component affecting fatigue is the physical environment itself. Aircraft in general, but specifically regional aircraft, can encompass a wide variety of cabin temperatures, pressure, noise, vibration, turbulence, and humidity (Rosekind et al., 2002). Temperature plays a significant factor in personal comfort but also can create extra stress for the body. In extreme heat, the body must exert more energy to keep itself cool and visa-versa for cold environments, possibly resulting in a faster onset of fatigue. Pressure changes typically don't bother most people but may become dangerous during illness when ears and sinuses are congested. While not typically associated with fatigue, prolonged exposure to noise, vibration, and turbulence can result in increased fatigue from excessive sensory stimuli. Lastly, low humidity within the aircraft can lead to dehydration and occasionally nosebleeds. Encountered individually, the above-mentioned factors can usually be compensated for; unfortunately, they are frequently all present during any given flight (ALPA, 2008; Rosekind et al., 2002).

## Common Misconceptions

Many people, including pilots, believe they are a good judge of their actual level of sleepiness and fatigue (Caldwell et al., 2009; Co et al., 1994; Rosekind et al., 1997; Rosekind et al., 2002). After the list presented earlier in this section on signs and symptoms of fatigue, fatigue would seem fairly easy to detect. However as Rosekind (1997) illustrates in one study, a crewmember reported the highest level of subjective alertness but was soundly asleep just six minutes later. ALPA (2008) states it best: "Warning! Fatigue is hazardous! …A fatigued crewmember may be unable to recognize his/her level of impairment" (p. iv). Individuals who have been awake for long periods of time must realize that they need to rest or sleep even if they do not feel overly tired.

Caldwell (2009) highlights two additional important misconceptions. First, fatigue cannot be overcome by motivation, training, or willpower. Second, fatigue susceptibility is different for every person. Fatigue is fundamentally a physiological problem that cannot be fixed with a *magic bullet* or other gimmick solutions. Each flight schedule, aircraft, season, and location presents different demands that must be handled on a case-by-case basis (Caldwell et al., 2009; Rosekind et al., 2002).

Lastly, studies have shown that pilots, on average, receive less sleep during a trip than they do before or after that trip. This trend was seen in long-haul, short-haul, and overnight cargo operations. While there is no specific data to illustrate the point, it can be inferred that pilots may assume they receive the same amounts of sleep pre/post trip as they do while on a trip; this is clearly contradicted by the findings (Rosekind et al., 2002). One possible reason for the decreased sleep is that the schedule required by the trip is in opposition to the pilot's own circadian rhythm. Should there be an early report time required in the morning it would seem logical to simply go to bed early. However, it is known that shortening of the circadian rhythm is substantially more difficult than lengthening it. The pilot in question may be unable to fall asleep earlier and thus remain awake until his/ her natural bedtime, resulting in a drastically shortened sleep period (Co et al., 1994; Rosekind et al., 2002).

## Sleep Debt

The effects of sleep loss can be categorized as either acute or chronic (Rosekind et al., 1997). Sleep loss is additive in nature and can result in cumulative sleep debt. Estimates by Rosekind (2002) indicate that most people in the United States get between 1.0 and 1.5 hours less sleep each night than they require. When computed out over a five day work week, a typical person may accumulate as much as 7.5 hours of sleep debt, or almost the equivalent of one whole night of sleep. Unfortunately in today's busy world, sleep is often put off to accommodate other things and shows people are not concerned about satisfying this important physiological need. It does however seem to indicate why many people in the United States sleep in on the weekends (Co et al., 1994; Rosekind et al., 1997; Rosekind et al., 2002).

To further illustrate the point on the effects of sleep loss on vigilance, Rosekind (2002) cites one study indicating "that after a short period of partial sleep loss, performance lapses increase and stabilize until sleep is completely recovered" (p. 21). In other words, after sleep debt is incurred, even after only one night, human performance is significantly affected. The question then becomes, how much sleep must be lost before significant impairment occurs? According to Rosekind (1997) "Laboratory data indicate that, for most people, 1 night with 2 hours less sleep than is usually required is sufficient to degrade subsequent waking performance and alertness significantly" (p. 158). Prolonged acute sleep debt may become chronic if steps are not taken to correct the problem. Symptoms of chronic sleep debt or chronic fatigue are similar to those of acute fatigue but are more persistent. Overcoming chronic sleep debt is not as simple as sleeping for extended periods of time. Instead, depending on the severity, it may take several days to several months to recover (Co et al., 1994; Rosekind et al., 1997; Rosekind et al., 2002).

## Fatigue Research

### *International (long-haul)*

Petrie & Dawson (1997) examined symptoms of fatigue and coping strategies in international pilots. Their study surveyed 188 pilots flying international routes in an effort to determine what symptoms of fatigue they noticed as well as what methods they used to cope with fatigue while on duty. Based on the results they were able to sort the symptoms fatigued pilots exhibited into five groups: sleepiness, cognitive dysfunction, emotional disturbance, boredom, and physical effects. Coping strategies were also categorized into five groups: planning energy use, active coping, mental withdrawal, communicating with other crew, and coffee drinking. A major limitation of this study was the self-reporting nature of the survey tool as it difficult for humans to accurately describe their level of fatigue. Nonetheless, this study provides valuable insight into the fatigue countermeasures used by pilots in New Zealand.

Another study involving New Zealand pilots by Petrie, Powell, and Broadbent (2004) looked at fatigue self-management strategies and reported fatigue in international pilots. This larger study included mainly international but also regional pilots. Findings indicate that fatigue is still a significant concern for the pilot group. As many as 30% of pilots surveyed said fatigue interferes with their normal social life. The study emphasizes the importance of developing personal coping strategies for mitigating the effects of fatigue. One key development discussed in detail was the introduction of legal flight deck napping. This practice was reportedly used by about half of the pilot group and those who did report taking naps indicated having lower levels of fatigue when compared to pilots who did not nap.

Petrilli, Roach, Dawson, and Lamond (2006) examined pilots at an Australian airline. Their goal was to "investigate commercial airline pilots' self-rated fatigue and sustained attention using a psychomotor vigilance task (PVT) before and after international flights" (p. 1349). Nineteen pilots were selected for the study and were closely monitored for 15 days during which time they kept sleep diaries and wore activity monitors. When at work they completed the PVT before and after each flight, based on their reaction times a score was assigned that could be correlated to their level of fatigue.

Results indicate that fatigue does have an impact on reaction time. Furthermore, the authors were concerned that flight and duty time regulations are primarily based on hours worked and rest periods as opposed to a pilot's actual sleep requirements.

Lamond, Petrilli, Dawson, and Roach (2006) investigated whether short international layovers allow sufficient opportunity for pilots to recover. The authors wanted to determine if pilots on international patterns were affected by the length of a layover prior to the inbound (return) flight. This information would be incredibly useful in understanding how flight patterns should be built to minimize the affects of fatigue and improve pilot performance. Pilots in this study followed similar procedures to other fatigue studies by keeping sleep/ duty diaries, wearing activity monitors, and completing psychomotor vigilance task (PVT) tests at predetermined times. Although the sample size was small (only 19 pilots participated) they were able to obtain valid data to indicate that those pilots on short layovers not only received less sleep but their response times suffered when compared to the longer layovers. According to the authors, the data suggests: "short slips (<40hrs) do not allow pilots the opportunity to obtain sufficient sleep to reverse the effects of fatigue accumulated during the outbound flight" (p. 1285).

Eriksen and Akerstedt (2006) wrote about aircrew fatigue in trans-Atlantic morning and evening flights. The authors set out to compare the sleepiness and sleep of pilots flying in the morning versus in the evening in an effort to discern if there were any significant differences. Seven crews participated in the morning group and seven crews participated in the evening group. All flights in this study traversed at least 6 time zones. Data was collected using watch-like personal activity monitors (actigraph), sleep/wake diaries, and the Karolinska sleepiness scale (KSS). The findings suggest several important trends.  First, there were no significant differences between morning and evening crews when comparing the actigraphy over the course of the study.  Second, there were no significant differences in the use or amount of in-flight napping by the crews.  Third, evening crews were awake for far longer durations than the morning crews presumably because they did not sleep all day prior to reporting to work.  Lastly, evening flights involved greater levels of sleepiness when compared to morning flights.  The authors believed that some of the findings could be attributed to natural circadian issues. Further study was recommended to determine what measures could be used to alleviate excess fatigue for night flights including the use of pre-departure napping, caffeine, etc.

German researchers Gundel, Drescher, Maaß, Samel, and Vejvoda (1995) discussed the sleepiness of civil airline pilots during two consecutive night flights of extended duration.  Using EEG measurements in addition to subjective ratings by the crews, researchers were able to closely monitor 22 pilot volunteers as they operated B767 aircraft at night.  The study demonstrated that pilots showed an increased level of sleepiness during the second night flight compared to the first.  Data from both the EEG and subjective sleepiness ratings supported this and also indicated that pilots received approximately two hours less sleep during the layover compared to pre/post trip sleep. The authors voiced concern over the fact that pilots in this type of operation must continuously shift their schedules between night work and days off never allowing for complete circadian synchronization.  Due to this fact, recommendations for methods to alleviate fatigue were suggested including strategic use of napping.

*Military*

In a study of Indian Air Force Pilots, Taneja (2007) reported on the awareness and attitudes of Indian Air Force Pilots with regard to fatigue. There were three objectives in the study: first, to determine the knowledge base for pilots on the topic of sleep; second, to document current sleep habits; and third, to ascertain what countermeasures pilots are using to combat fatigue. Survey results indicated that many pilots received slightly less than the average eight hours of sleep required by most adults during the week but then slept longer on the weekends in an apparent effort to recover the lost sleep. A large portion also believed that a nightly sleep loss of one to two hours had no effect on the subsequent day's performance. Countermeasures used by pilots ranged from naps to coffee and tea to smoking. A strong majority of the respondents desired more information on healthy sleep habits and wanted to better understand their body's physiology. The consensus for the best option of doing this was for the squadron Medical Officer to periodically brief the pilot group.

Fatigue and sleep debt in an operational Navy squadron by Hardaway & Gregory (2005) examined two different EP-3 squadrons as they flew from an air station in Washington State to a base in Southwest Asia. The first squadron (crew A) flew the route as was normally planned and scheduled. Crewmembers completed surveys before, during, and after the flights to document their subjective level of fatigue. The second squadron (crew B) received substantial additional training prior to departing on topics including: sleep hygiene, circadian physiology, and effective fatigue countermeasures. Additionally crew B changed the schedule to include an extra layover between days two and three to aid in their transition and recover from any accumulating sleep debt.

Findings indicate that crew B received more sleep and reported feeling less fatigued than crew A. The crewmembers in the second squadron also indicated that the training they received was very helpful in achieving quality sleep on the extended layover mid-trip. The authors therefore recommended that crews transitioning over multiple time zones receive training prior to departing on the subjects listed above as well as be given the opportunity to recover mid-trip with an extended layover.

LeDuc, Caldwell, and Ruyak (2000) investigated the effects of exercise as a countermeasure for fatigue in sleep-deprived aviators. For the study, 12 US Army Aviators resided at the Army Aeromedical Research Laboratory for one week during which time they were bombarded with a variety of tests and assessments. During one segment of testing, participants were sleep deprived for 40 hours while periodically engaging in 10-minute bouts of exercise. Most participants showed increased alertness following the exercise but fell asleep faster when compared to baseline tests. The authors found "that short bouts of exercise may ameliorate some of the increases in sleepiness and fatigue associated with sleep loss for a short period of time but are not likely to prevent performance decrements" (p. 249). Exercise as a fatigue countermeasure does temporarily improve alertness but people must be warned that exercise may ultimately lead to higher levels of fatigue than if no exercise had been undertaken.

Caldwell, Caldwell, Brown, and Smith (2004) examined the effects of 37 hours of continuous wakefulness on US Air Force F-117A pilots. This study used a controlled environment to test 10 US Air Force pilots using a variety of methods to measure the impact of sustained wakefulness. Some of the research tools included: the multi-attribute task battery (MATB), the profile of mood states (POMS), an eyes open/ closed EEG, and a flight simulator evaluation. One purpose of the study was to establish a baseline set of data to which later tests of fatigue countermeasures could be compared. The authors of this study found that, as predicted, there were significant fatigue-related degradations due to prolonged wakefulness. Areas impacted included: cognition, mood, as well as objectively measured flight simulator flight performance. According to the article, future studies would examine the effects of both pharmacological and non-pharmacological fatigue countermeasures.

### *Regional Airline Operations*

Regional airlines in the United States continue to play an ever-increasing role in commercial aviation. Since the introduction of the hub and spoke system regionals have provided a vital link between smaller communities and large commercial airline hubs. Typically this is accomplished through business agreements between a regional and larger commercial carrier often called code-sharing. As code-share partners, reservations and ticketing are handled by the main-line carrier and passengers are sometimes unaware that their flight will be operated by a contracted airline.

Depending on several factors, regional airlines are governed by either Part 121 or 135 of the Federal Aviation Regulations (FAR). In simplistic terms, the number of passenger seats on the aircraft determines what part of the FARs the regional carrier will operate under, but not always. Part 135 regulates passenger aircraft with 30 or fewer seats while part 121 regulates those with more than 30 seats. Other important distinctions include flight time limitations and required support staff. Pilots at a 121 carrier are limited to 30 flight hours per week, 100 per month, and 1,000 per year; on the other hand pilots at a 135 carrier may fly up to 34 hours per week, 120 per month, and 1,200 per year

(FAR §121.471; FAR §135.265). Additionally, unlike part 121 carriers, part 135 carriers are not required to have licensed dispatchers or cabin crews. This shifts the responsibility of passenger safety and flight planning to the pilots who must ensure correct routing, weight & balance, aircraft performance, as well as verify present and forecasted weather conditions. In contrast, dispatchers at a 121 carrier are also a valuable resource while in flight, providing timely updates to pilots concerning information vital to the flight (Co et al., 1999).

Regional airline scheduling practices also pose a unique challenge for pilots. Oftentimes regional pilots will fly multiple flights per day, sometimes as many as six or more flight segments. When compared to pilots at major airlines, this is nearly double the number of daily flights, if not more. In an effort to maximize pilot and aircraft utilization, regional pilots may be on duty for up to 16 hours, the maximum allowed by the FARs. However, it must be noted that those 16 hours do not include personal time required by the pilot to prepare for the day or get ready for bed. It is not unrealistic for regional pilots to be awake for upwards of 20-plus hours, especially if required to commute to work (Co et al., 1999; Rosekind et al., 1994).

Commuting is a common occurrence for many pilots at all airlines, including major carriers. With the ever-changing nature of the industry, many pilot bases are opened and closed each year. Instead of packing up and moving every time the airline changes their operation, many pilots settle down in cities that fit their needs opting to commute to work rather than living in base. To make commuting more manageable, many pilots have *crash pads* at their base. A crash pad is typically a house or apartment near the airport that is shared by multiple pilots so they have a place to sleep and store personal items. Commuting is further complicated by airline scheduling practices that may stipulate a minimum number of days off as low as nine or ten per month. This may mean that most of a pilot's days off will either be spent at a crash-pad away from home or attempting to commute to or from work (Co et al., 1999; Rosekind et al., 1994).

Another practice common at many regional airlines is scheduled reduced rest. While originally intended as a provision to ensure crew rest should flight schedules be become irregular, many regionals now create flight patterns that allow only the minimum required rest of eight hours at an overnight station. The rest period generally begins shortly after arriving at the destination and ends at the report time the following morning. Time for transportation to and from the hotel, eating, personal needs, and sleep are all included within the eight hours, thus reducing the number of hours available for sleep to as few as 6 or less (Co et al., 1999; Rosekind et al., 1994).

Environmental factors are also of concern to many regional pilots. Depending on the type of aircraft, some provide better heating and air conditioning than others. It is not uncommon for turbo-prop aircraft without an auxiliary power unit (APU) to be very hot in the summer and bitterly cold in the winter. These extremes place added demands on the bodies of the pilots that can, in some cases, lead to dehydration or hypothermia depending on the circumstances. Moreover regional aircraft, especially turboprops, operate at lower altitudes where there is a higher prevalence of thunderstorms. This can complicate operations in summer months when pilots must be extra vigilant to avoid thunderstorms and associated turbulence (Co et al., 1999; Rosekind et al., 1994).

A survey by NASA (Co et al., 1999) revealed interesting information about regional flying. Most pilots surveyed believed fatigue to be a "moderate" or "serious" concern (89%). A substantial number, 88%, also believed fatigue to be a common occurrence in regional flying. When fatigue does occur, 92% indicated it to be a "moderate" or "serious" safety issue. More than three-fourths (80%) of the pilots admitted to having nodded off (slept) during a flight at some point in their career. Additionally, 56% reported that they had been on a flight where "arrangements had been made for one pilot to sleep during the segment" (p. 12). While the number of pilots conducting CDO's was not reported, several important metrics were discussed. Ground time (stand-up portion) of CDO's was between 4.8 and 7.7 hours with an average of 6.4. Time available for sleep ranged from 3.2 to 6.2hours and averaged 4.8. However, time actually slept spanned 2.6 to 5.9hours with a reported average of 4.6 hours. Most pilots made some attempt to sleep during the overnight portion of the CDO yet over half acknowledged not having slept at some point in their career before flying the inbound leg (Co et al., 1999).

In a National Transportation Safety Board (NTSB) study of commuter airlines cited by Co (1999), short turn times were listed as a concern by pilots who felt they did not always have enough time to prepare for the next flight. On average, turn times were reported to be about 27 minutes with the shortest being just under 7 minutes. While this does increase airline efficiency, it also leaves little time for crews to tend to physiological needs such as eating and using the restroom. The NTSB has recommended that all scheduled passenger service utilizing aircraft with 20 seats or more be conducted under Part 121, the same as major carriers. Two reasons why include: "[1] regional/ commuter airlines become increasing like major airlines in the passengers they serve and in the size and sophistication of aircraft, and [2] to the public, what used to be a clear distinction between commuter airlines and majors has become unclear, if not transparent" (p. 4). Recommendations from the NASA study also indicate that increased and continued education on the topic of fatigue is necessary for all industry personnel, especially in the areas of human physiology, scheduling practices, and effective countermeasures (Co et al., 1999).

## Fatigue Education

There are many great fatigue educational resources available to pilots from a variety of sources that include but are not limited to: the Air Line Pilots Association (ALPA, 2008), NASA (Co, 1994; Rosekind et al., 1997 & 2002), and research by Caldwell (2009). Strategies to mitigate fatigue can be broken down into two distinctive categories: Preventative strategies and operational countermeasures. Preventative strategies can be defined as measures aimed at the physiological causes of fatigue and are designed to keep the sleep loss and circadian disruption caused by work demands to a minimum (Rosekind et al., 1997). Operational countermeasures provide temporary relief from the symptoms of fatigue and are used to minimize the impact of sleep loss and circadian disruption on alertness as well as on-the-job performance. In short, preventative strategies are used prior to arriving at work and operational countermeasures are used at work to help pilots complete the mission safely.

### *Preventative Strategies*

The phrase: *sleep hygiene* is used to describe methods and practices that all persons should use to obtain quality sleep. This can be accomplished through the use of a bedtime routine and utilizing techniques that each person finds effective for himself or herself. Caldwell (2009) provides a detailed list of strategies for optimizing sleep opportunities (p. 42):

- When possible, wake up and go to bed at the same time every day to avoid circadian disruptions.
- Use the sleeping quarters only for sleep and not for work.
- If possible, establish a consistent and comforting bedtime routine (for example: reading, taking a hot shower, and then going to bed).
- Perform aerobic exercise every day, but not within 2 hours of going to bed.
- Make sure the sleeping quarters are quiet, totally dark, and comfortable.
- Keep the sleep environment cool.
- Move the alarm clock out of sight so you can't be a clock watcher.
- Avoid caffeine in drinks and other forms during the afternoons/ evenings.
- Don't use alcohol as a sleep aid (it may make you sleepy, but you won't sleep well).
- Avoid cigarettes or other sources of nicotine right before bedtime.
- Don't lie in bed awake if you don't fall asleep within 30 minutes; instead, leave the bedroom and do something relaxing and quiet until you are sleepy.

Additionally, for people who must do shift work such as CDO's there are some extra strategies to employ. Napping before reporting to duty has been shown to help maintain alertness (Caldwell et al., 2009). The naps should utilize some, if not all, of the strategies discussed above but consideration should be given to the use of eye masks, earplugs, and black out shades to aid in achieving quality sleep. Lastly, the importance of good nutrition and regular exercise cannot be overlooked (Co et al., 1994; Rosekind et al., 1997; Rosekind et al., 2002).

*Operational Countermeasures*

There are a variety of countermeasures that have been shown to be effective in operational settings, but it is the responsibility of each person to learn which ones work best for themselves. Common to most work settings, including aviation, are caffeinated beverages. Ranging from coffee and tea to soft-drinks, the stimulant effects of caffeine do help to temporarily improve alertness (Rosekind et al., 1997; Rosekind et al., 2002). How the caffeine is consumed is just as important as the decision to utilize it as a countermeasure. For the most beneficial results, caffeine should be avoided when already in an alert state. Instead, caffeine should be used to combat specific periods of sleepiness by slowly consuming a beverage. Pilots must be aware that the effects of caffeine may not be immediately apparent and could take upwards of 15 to 30 minutes but will generally last three to four hours (Rosekind et al., 1997; Rosekind et at., 2002).

A controversial countermeasure is the use of cockpit napping. While not currently approved by the FAA for use in the United States, other countries and airlines have implemented procedures for its use. According to Caldwell (2009) the following foreign carriers have authorized cockpit-napping procedures: Air Canada, Air New Zealand, British Airways, Emirates, Finnair, Lufthansa, Swissair, and Qantas. Furthermore, survey results indicate that many US pilots (56%) are already utilizing in-flight napping even though it is not authorized (Caldwell et al., 2009; Co et al., 1999). After all, the most effective fatigue countermeasure is sleep and NASA studies have indicated that naps do improve subsequent alertness and performance (Rosekine et al., 2002).

Other countermeasures involve simple activities such as: stretching, adjusting cockpit lighting, engaging in conversation, taking a break, and regulating the flight deck temperature. By stretching in a seat or taking a break and leaving the flight deck pilots can move their muscles, increasing blood flow and promoting wakefulness. At night, increasing the flight deck lighting can be used to keep pilots alert. However, caution must be used to prevent degradation of night vision, which could have severe consequences during the approach and landing phase of flight. Adjusting the flight deck temperature is also a possible countermeasure. Each person reacts differently to temperature but generally a comfortable to cool temperature works best to promote alertness. Lastly, by engaging in social interaction with other crewmembers, pilots can stimulate their brains through conversation and combat fatigue. This technique is also beneficial as it allow crewmembers to monitor each other’s subjective level of fatigue (Caldwell et al., 2009; Co et al., 1994; Rosekind et al., 1997; Rosekind et al., 2002).

# CHAPTER III
# METHODOLOGY

Pilots at regional airlines face continuously changing flight schedules and are now operating more flights over greater distances than ever before. While the job requirements may be evolving, one type of flight operation is still utilized: Continuous Duty Overnights (CDO). Typically flown at night, CDO's raise a myriad of issues pertaining to fatigue and human factors. Relatively few studies have been conducted to investigate regional airline pilots on CDO's. Because the effects and impact of fatigue can never be fully alleviated, it is of vital importance to understand what strategies work best to identify fatigue and find countermeasures that are effective in fighting it for short periods of time. This chapter discusses the study population, sample, design, and proposed analysis in detail.

## Population

The population group examined in this study is regional airline pilots with special emphasis on those pilots flying CDO's. Airlines are defined as major, national or regional by the United States Department of Transportation (US DOT) based on revenue. Regional airlines are classified by the US DOT as having an annual operating revenue of less than $100 million (2010). Aircraft are assumed to be of the Transport Category as defined by the Federal Aviation Regulations (FAR). Pilot certification will be at the Commercial Pilot or Airline Transport Pilot (ATP) level. The population group is not limited by years of service and/ or experience in the form of flight time. Furthermore, the population group is not limited by age (except by FAR licensing requirements), gender, or rank (captain or first officer). The study will have the greatest applicability to pilots at regional airlines, operating under FAR part 121, with flight schedules that include CDO's. The pilots working at those types of operations typically undergo annual recurrent training that should include basic training on flight time/ duty time regulations. Lastly, the study assumes participants to have a high level of expertise and experience in understanding their own body's physiological states.

## Sample

The study surveyed pilots employed at a regional airline in the United States (not identified in this study). None of the participants were compensated for their time and all voluntarily submitted their responses. There were no time constraints to complete the survey and access to the survey was available anywhere with a computer and Internet connection. Each participating pilot was either a Captain or First Officer on active flight status with the company. All subjects had intimate knowledge of regional airline operations due to their daily job responsibilities. One hundred and thirty-eight (n=138) subjects completed the survey representing approximately 15% of the total pilot population at the regional airline. Adequate responses were collected from all three pilot domiciles as well as all three aircraft types providing valuable data for analysis.

## Study Design

Subjects were recruited for this study through a flyer placed in pilot mailboxes as well as through a message included in a *blast* email from the union representing the pilots. Both methods contained a general description of the study and Internet hyperlink directing them to a website where the survey could be taken. Appendix A of this document shows the invitation message. An online survey tool was chosen because it would allow flexibility for participants to take the survey anonymously at a time and place of their choosing. It also helps to ensure privacy, confidentiality, accuracy, and expedited analysis. A subscription to www.surveymonkey.com was purchased to administer the survey and is password protected. Once operational, the survey tool was available for six weeks to allow ample time for participants' with variable schedules to respond.

The study utilized a thirty-three question survey that collected both quantitative and qualitative data. Questions were created to collect information about: how the participants perceive fatigue, how they are affected by fatigue, what participants do to combat fatigue, as well as how they view safety at the airline. In order to allow for comparisons to previous fatigue studies, questions were formulated with significant influence from works cited in this papers literature review. A full listing of survey questions is available in Appendix C.

## Methods and Data Collection

Participant responses were saved at the completion of their session to the www.surveymonkey.com server. Upon completion of the surveying period, the results were downloaded onto a secure (password protected) laptop. Data was converted into Microsoft Excel format for further analysis. For certain functions and statistical analysis, SPSS (PASW Statistics Version 18) was utilized.

## Data Analysis

Research questions one through three will be reported in the results section of chapter three, then analyzed in the discussion section. Research question number four will require some additional investigation to determine significance; this will be accomplished with the help of SPSS statistical software. The threshold for significant associations will be set at the 0.01 and 0.05 alpha levels (2-tailed). Table 1 is a proposed sub-set for within groups statistical analysis. Each group will look for statistical significance amongst its variables in survey questions 11, 12, 13, and 33. Qualitative data was also accepted on select questions throughout the study. Every effort will be made to accurately judge the participants intent while determining the responses impact on the study's findings.

Table 1. Proposed Analysis

| Groups | Questions |
|---|---|
| Domicile<br>MSP<br>DTW<br>MEM | Is pilot fatigue a common occurrence? (q.11) |
| Position<br>Captain<br>First Officer | To what extent is pilot fatigue a concern? (q.12) |
| Aircraft Type<br>CRJ 900<br>CRJ 200<br>SAAB 340 | How significant a safety issue is fatigue? (q.13) |
| Continuous Duty Overnights<br>Actively Flying CDO's<br>Not Actively Flying CDO's | How safe is XXXXXXX Airlines? (q.33) |

## Validity and Limitations

The literature review shows many similar and effective survey techniques that are reflected well in this studies survey tool. Those previous questions have been reproduced in several studies creating data for analysis from different populations within aviation. Additionally, commercial aviators are generally well educated, technically savvy, and capable of thoroughly understanding questions presented to them. Until further analysis is completed, it is unknown if generalizations may be made to the larger aviation community or if the results apply only to this sample population.

Several limitations are present within this study. Due to the requirement that participants remain anonymous, there is no mechanism available to the researcher to follow up with participants during or after the survey period. Also, lack of participant identification raises the risk that pilots may take the survey more than one time. The IP Address logging feature on www.surveymonkey.com was disabled to allow for anonymity as well as permit multiple responses from the same computer, such as those located in airport crew rooms. Without a personal invitation letter or compensation for their time, the possibility does exist that some potential participants will elect not to respond. Even so, expectations are high for a strong response rate and honest participation from the desired population.

### Protection of Human Subjects

Every effort will be made to protect participants from harm. The survey received approval from both the University of North Dakota Intuitional Review Board and the Pilots Union prior to being distributed. Subjects were informed that participation is voluntary, they may answer only questions they are comfortable with, and participants may discontinue the survey at anytime. No method of linking responses to a participant is provided with the survey tool and no effort will be made by the researcher to identify participants. Some responses within the survey may indicate actions considered illegal under current Federal Aviation Regulations and are provided voluntarily by the participants. Lastly, in the unlikely case of a severe emotional reaction to the survey, instructions will be provided to participants on how to obtain necessary assistance.

# CHAPTER IV

# RESULTS

## Demographics

One hundred and thirty-eight (n= 138) pilots completed the study. This represents approximately 15% of the pilots on active flight status at the regional airline. Of the responding pilots, n=62 were Captains (44.9%) and n=76 were First Officers (55.1%). A majority (92.7%) were male with (7.3%) being female. The youngest participant was 24 and the oldest was 55. Average age for the group was 34.8 years old.

More than half of the pilots held an Airline Transport Pilot (ATP) certificate at n=84 (60.9%), while the remainder held Commercial Pilot Certificates (39.1%). A substantial number (n=110 or 79.7%) held a Flight Instructor Certification (CFI, CFII, or MEI) while only 20.3% did not. Table 2, shown below, describes the reported flight times of the participants. Pilots were asked to list (1) their overall total flight time, (2) the amount of time flown under FAR Part 121 at an air carrier, and (3) their total time when hired by the regional airline.

Table 2. Reported Flight Time

| Category | Minimum Value | Maximum Value | Mean |
|---|---|---|---|
| Total Time | 900 | 22,000 | 5,764 |
| Part 121 (Air Carrier) | 200 | 18,000 | 4,417 |
| Total Time at Hire Date | 238 | 8,500 | 1,701 |

Of the survey respondents, 59.4% (n=82) were based in the Minneapolis (MSP) domicile, 24.6% (n=34) Detroit (DTW), and 15.9% (n=22) Memphis (MEM). Table 3 further describes how many pilots are assigned to each domicile and what percentage of the company that represents. The bottom row of that table indicates the percentage of participation in this study within each domicile group.

Table 3. Survey Response Rate by Domicile

| Category | MSP | DTW | MEM |
| --- | --- | --- | --- |
| Pilots per Domicile | 477 (52.3%) | 267 (29.3%) | 167 (18.3%) |
| Percentage of domicile population that participated in study | 17.2% | 12.7% | 13.2% |

Of the pilots participating in the survey, n=42 (30.7%) operated the SAAB 340, n=25 (18.2%) the CRJ 200, and n=70 (51.1%) the CRJ 900. Table 4 indicates the number of pilots assigned to each aircraft and the percentage of the company that represents. Additionally, the bottom row indicates the percentage of survey participation within each aircraft type.

Table 4. Survey Response Rate by Aircraft Type

| Category | SAAB 340 | CRJ 200 | CRJ 900 |
| --- | --- | --- | --- |
| Pilots per Aircraft | 243 (26.7%) | 186 (20.4%) | 482 (52.9%) |
| Percentage of pilots per aircraft that participated in study | 17.3% | 13.4% | 14.5% |

In an effort to determine a pilot's relative seniority, each participant was asked to estimate their bidding seniority within their assigned domicile and aircraft type. This is important because with higher (top) seniority, a pilot has greater control over their monthly work schedule and vise versa. Pilots were asked to choose from the following choices: Top 25%, 26 to 50%, 51 to 75%, and Bottom 25%. All but one person selected a response to the question. Table 5 illustrates the percentage of response within each seniority bracket.

Table 5. Response Rate by Seniority

| Seniority | Percentage |
|---|---|
| Top 25% | 32.8% |
| 26% to 50% | 24.8% |
| 51% to 75% | 16.8% |
| Bottom 25% | 25.5% |

Data indicates that subjects participating in this study live in twenty different US States, as shown by Figure 1. One hundred thirty-five of the pilots reported the location of their primary residence while only three elected not to answer. Although the survey tool did not ask participants if they commuted to their assigned domicile, some inferences as to commuter status may be possible from this data set.

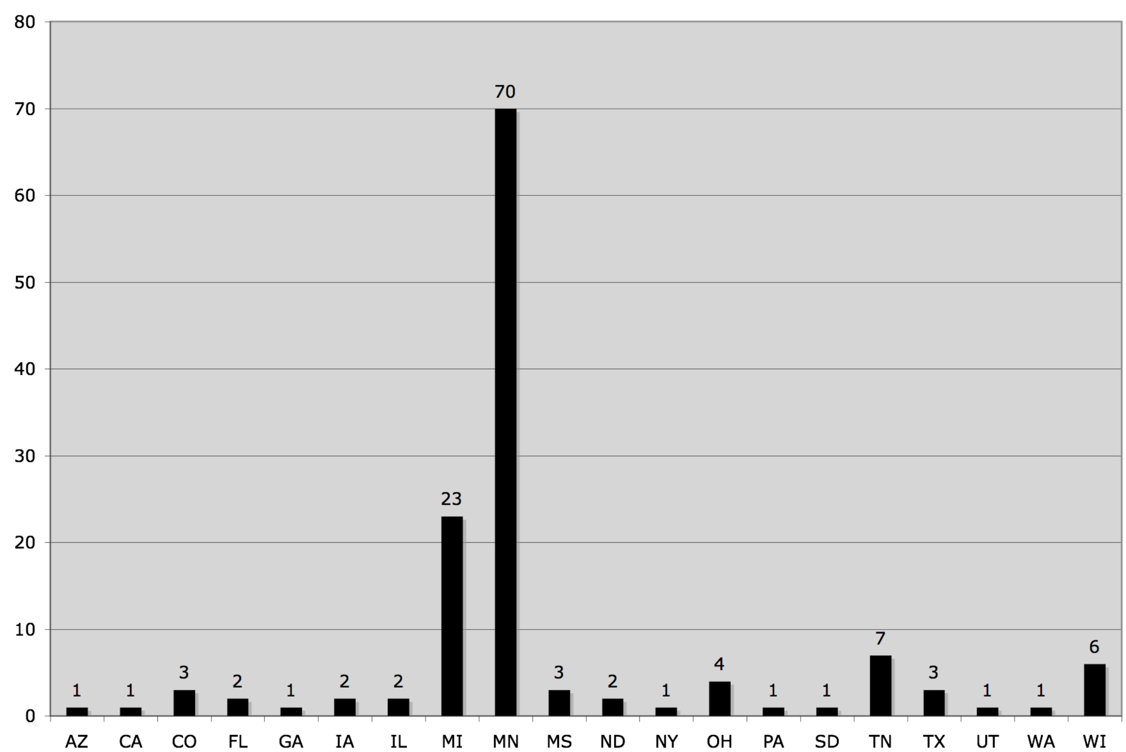


Figure 1. Location of Primary Residence by State.

## Continuous Duty Overnights

Nearly all pilots participating in this survey (98.5%) reported that they had at some point in their career flown a CDO. Almost half (49.3%) had flown one within the previous six months and 16.1% indicated they were currently flying CDO's. When asked why they are (were) flying CDO's, 67.2% (n=90) stated that it was due to their seniority or lack thereof. 32.8% (n=44) reported it was their personal choice to fly CDO's. Three questions were asked in regards to CDO scheduling: (1) on average, how long is the scheduled ground time at an out-station (2) on average, how much time is available for sleep at the out-station (3) and on average, how much sleep do you get while between flights? The responses are described in Table 6.

Table 6. Reported CDO Schedules and Sleep

| Category | Minimum Value | Maximum Value | Mean |
|---|---|---|---|
| Average Scheduled Ground Time | 3 hours | 8 hours | 6.4 hours |
| Average Time Available for Sleep | 1.5 hours | 7 hours | 4.7 hours |
| Average Time Actually Spent Sleeping | 0.0 hours | 7 hours | 4.1 hours |

In a separate question, subjects reported how often they did sleep at the out station using the following choices: "never," "rarely," "occasionally," and "frequently." The vast majority (78.2%) stated they frequently slept while 15.8% occasionally obtained sleep. Only 3.8% reported they never slept on a CDO while the remainder (2.3%) rarely slept. Lastly, 42.6% (n=58) of pilots reported that at some point they had flown the final (inbound) leg of a CDO without getting any sleep at the out-station. Slightly more then half (57.4%) indicated they had not flown the final leg without some sleep.

Symptoms of Fatigue

Survey respondents were asked to identify signs and symptoms of fatigue they recognized in themselves (Figure 2). A list of 10 common fatigue related symptoms was presented to the pilots. They were instructed to select all that were applicable. Only one subject did not submit any responses. Other subjects selected as few as one or as many as all ten. The average number of symptoms selected was 4.92. An option to write-in additional symptoms was available and Table 7 displays the responses.

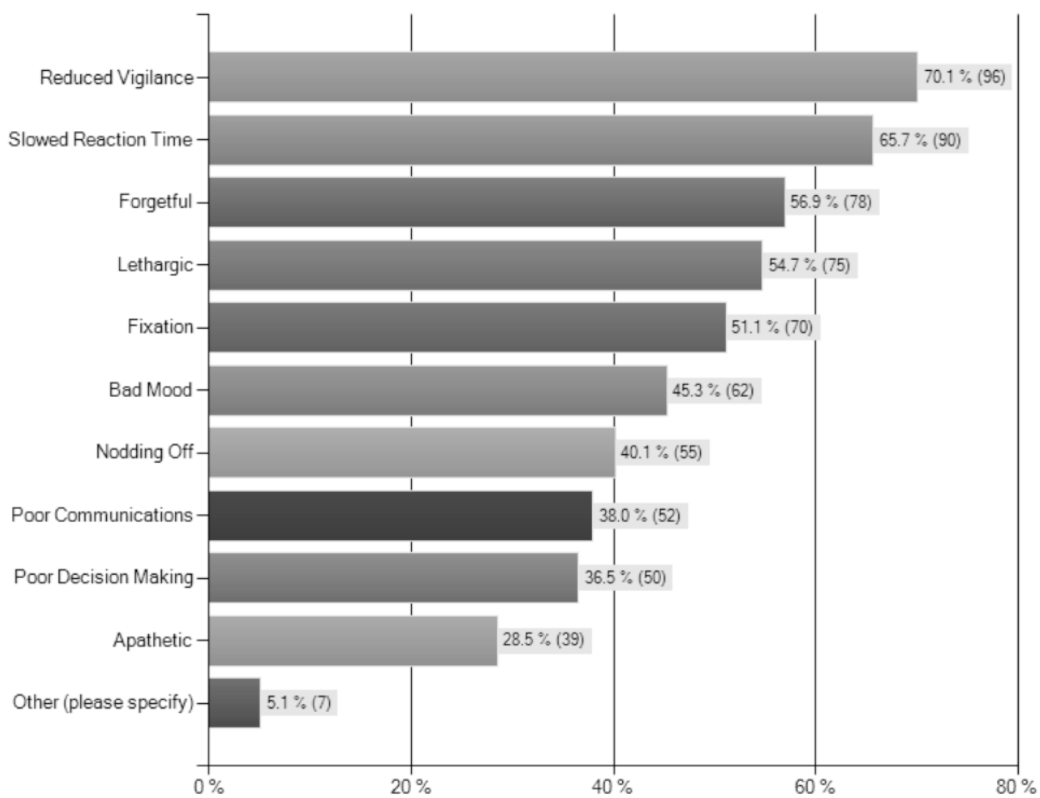


Figure 2. Signs and Symptoms of Fatigue Noticed by Regional Pilots.

Table 7. Write-In Responses: Fatigue Signs and Symptoms

| | |
|---|---|
| 1 | Mistakes with MSP |
| 2 | Concentration becomes difficult. Missed radio calls. |
| 3 | complacency |
| 4 | I become quiet, don't talk |
| 5 | easily irritated |
| 6 | difficult to concentrate |
| 7 | task oriented less people oriented |

Operational Fatigue Countermeasures

Pilots in the study were asked to report what strategies they use while in flight to combat the effects of fatigue. Twelve commonly cited operational countermeasures were listed as well as an option to write-in additional comments. Subjects were instructed to select all that applied to them. Only one responded did not answer the question. Of the respondents who did select responses, the average number of countermeasures selected was 4.1. Some pilots selected only one while others selected as many as nine. Results are displayed below in Figure 3. Table 8 contains the custom write-in responses pertaining to this topic.

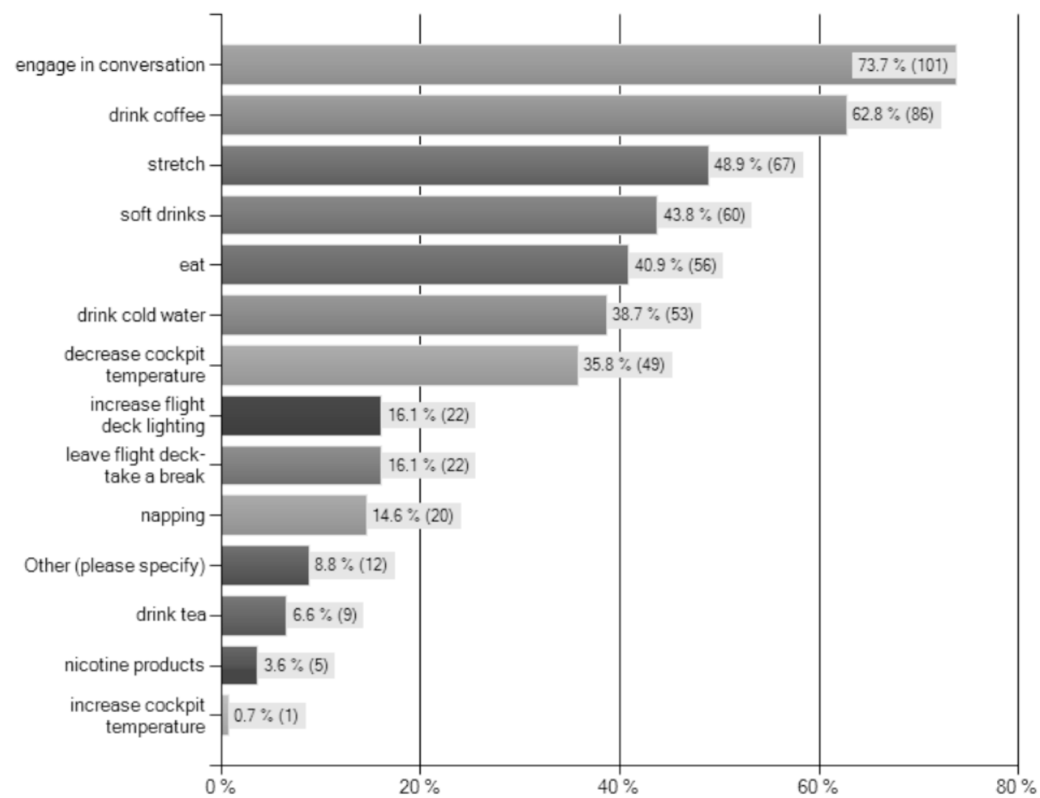


Figure 3. Operational Fatigue Countermeasures Used by Regional Pilots.

Table 8. Write-In Responses: Operational Countermeasures

| | |
|---|---|
| 1 | chew gum |
| 2 | pinch myself |
| 3 | Caffeine |
| 4 | i take alot of naps in between flights which allows me to operate with only 6 hours of continuous night sleep |
| 5 | Doing puzzles in newspaper |
| 6 | reading |
| 7 | do usa today puzzles |
| 8 | 5 hour energy drink |
| 9 | Listen to ADF |
| 10 | stretch out in back row during turnaround |
| 11 | Music |
| 12 | exercise |

## Strategies for High Quality Sleep

Subjects who had experience with Continuous Duty Overnights (CDO) were asked to disclose what tactics they use(d) to obtain quality sleep during their short stay at the overnight location. Twenty-two participants did not answer the question, although one hundred-sixteen did. A list of twelve possible strategies was presented to the pilots and included several that have been proven to interfere with good sleep hygiene habits. Subjects were free to select all responses that applied to them and an option to write-in additional responses was available to all study participants. Of the pilots that responded to the question, the most responses selected was six and the fewest was one with an average response of 2.2. Figure 4 displays the strategies for high quality sleep as submitted by the pilots in rank order. Table 9 contains the write-in responses to the survey question.

## Sleep

Pilots were asked to rate their ability to achieve a good nights sleep from the following choices: “very poor,” “poor,” “good,” and “very good.” The greatest response was in the “good” group at n=102 (75.6%). This was followed by “very good” at 12.6%,

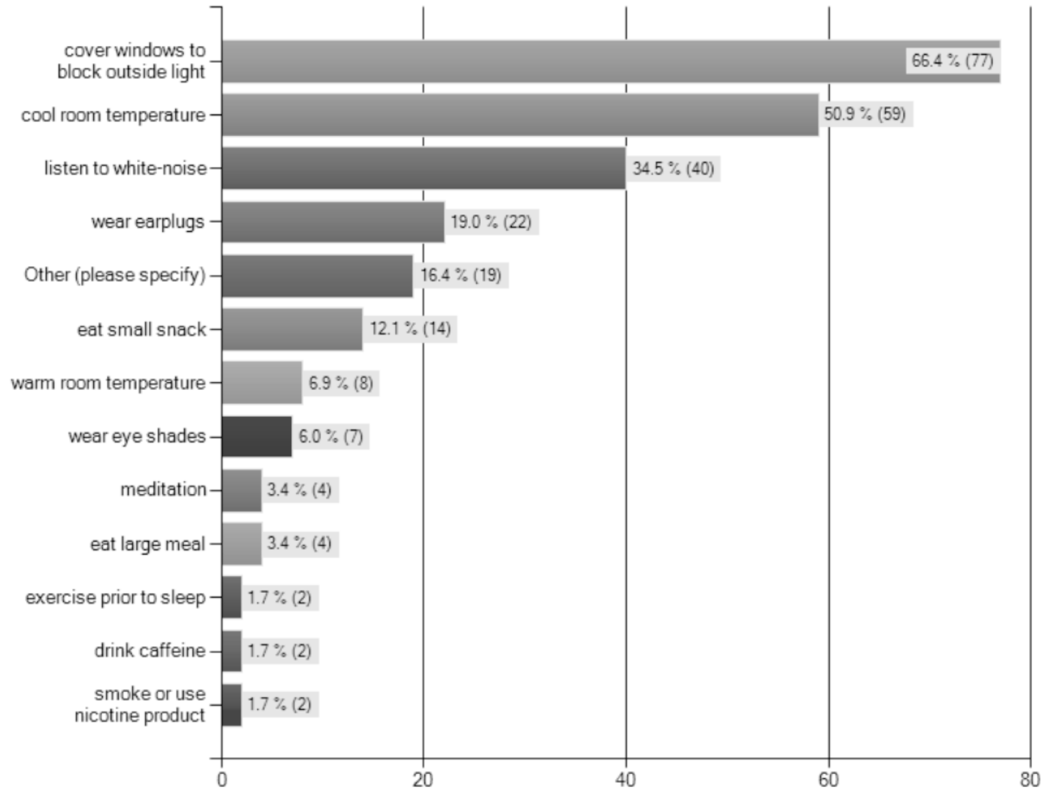


Figure 4. Strategies Used for High Quality Sleep.

Table 9. Write-In Responses: Strategies for High Quality Sleep

| | |
|---|---|
| 1 | lay in bed 30-45 min till finally wind down and fall asleep |
| 2 | Wash feet. |
| 3 | listen to MP3 music |
| 4 | lots of water |
| 5 | none |
| 6 | read or watch tv |
| 7 | Nothing...it's usually a pretty normal nights sleep for me |
| 8 | meletonine |
| 9 | Not watch TV or turn on computer, and read |
| 10 | None |
| 11 | listen to music |
| 12 | melatonin |
| 13 | don't turn tv on even though it sometimes helps to unwind, it can be a distraction |
| 14 | watch tv |
| 15 | drink some water |
| 16 | i sleep 5 to 6 hours during the day during my rest period |
| 17 | If I'm doing CDO's I don't need any help falling asleep |
| 18 | pick the best pillow and try to fall asleep |
| 19 | calming music |

"poor" at 10.4%, and "very poor" at 1.5%. Three participants did not answer the question. Next, participants were asked to divulge how much sleep they needed each night to be fully rested. The average for the sample population was 7.7 hours of sleep each night. On the low end one pilot reported needing only 5.5 hours and at the opposite end one pilot indicated needing ten or more hours per night. Lastly, pilots were asked to report how much sleep loss they must accumulate before it had a significant impact on their ability to function. The results can be seen in Figure 5.

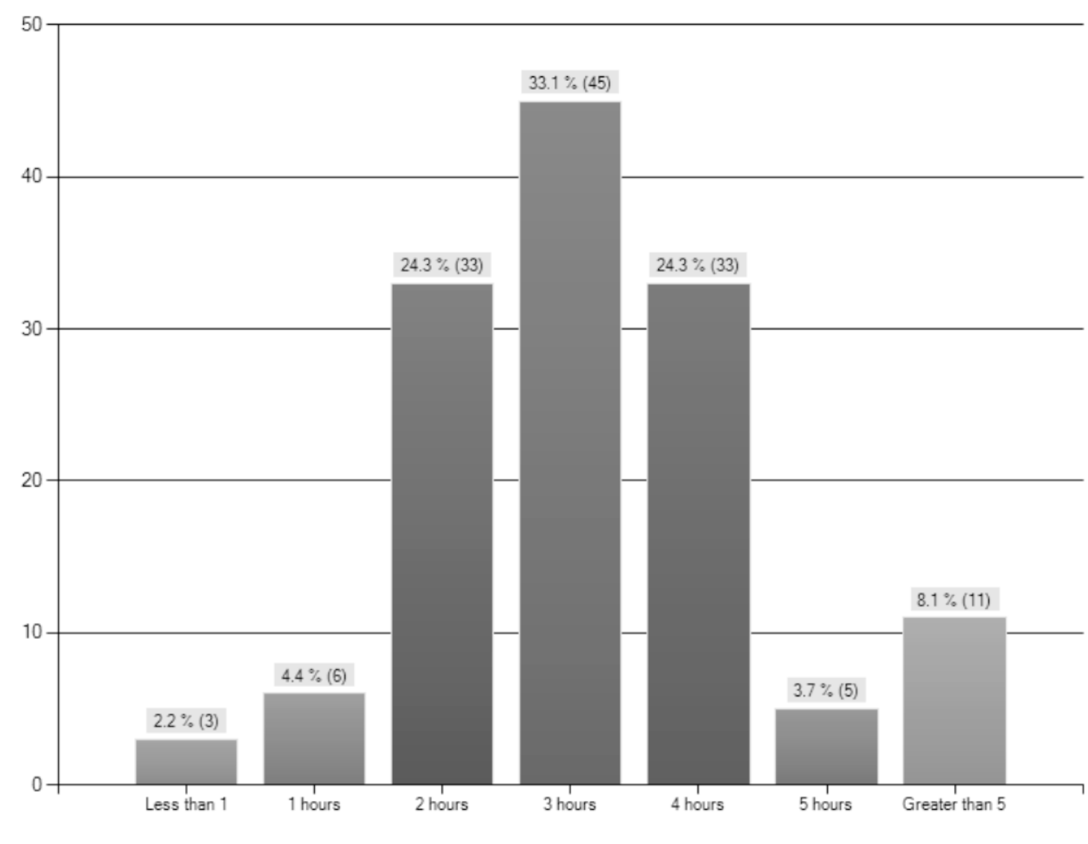


Figure 5. Reported Sleep Loss Required to Impact Ability to Function.

## Fatigue

When asked if fatigue was a common occurrence at their airline, 63% (n=87) of pilots in this study reported it was (yes). The remaining 37% (n=51) reported that is was not (no) and all participants submitted a response to the question. To determine the level of concern regarding fatigue at the airline subjects were asked to select from four responses: (1) not at all, (2) minor, (3) moderate, and (4) serious. The greatest response at 50.7% (n=70) indicated that fatigue was considered a "moderate" concern. This was followed by "minor" at 40.6% (n=56), "serious" at 8% (n=11), and finally "not at all" at 0.7% (n=1).

Pilots were asked to identify what phase of flight was most affected when they were in a fatigued state. Six phases of flight were presented and subjects could only select one answer. All but one study participant answered the question and the results are presented in Figure 6. Just over half (59.1%) of the pilots admitted to either sleeping or "nodding off" while in flight at some point in their career. 40.9% (n=56) denied having ever slept while in flight and one subject did not answer the question. Additionally, 88.4% (n=122) disclosed that at some point in their career they had been on a flight where the other pilot either slept or "nodded off." Only 11.6% (n=16) of the pilots reported no to that same question indicating that they have not been on a flight where another flight crewmember has slept.

## Safety

To determine the perceived risk to safety when pilots become fatigued, participants were asked to rate fatigue's impact on safety as: "serious," "moderate," "minor," or "not at all." A substantial number of participants (51.1%) indicated that it was a moderate safety issue. Slightly fewer (37.2%) stated it was a serious problem. 10.9% described it as minor and only 0.7% said fatigue was not a problem in terms of safety. Overall safety at the regional airline was judged separately and all subjects supplied a response. 57.2% described their regional airline as being "safe" while 36.2% indicated it was "very safe." The remaining 6.5% stated it was "unsafe" and no pilots reported it to be "very unsafe."

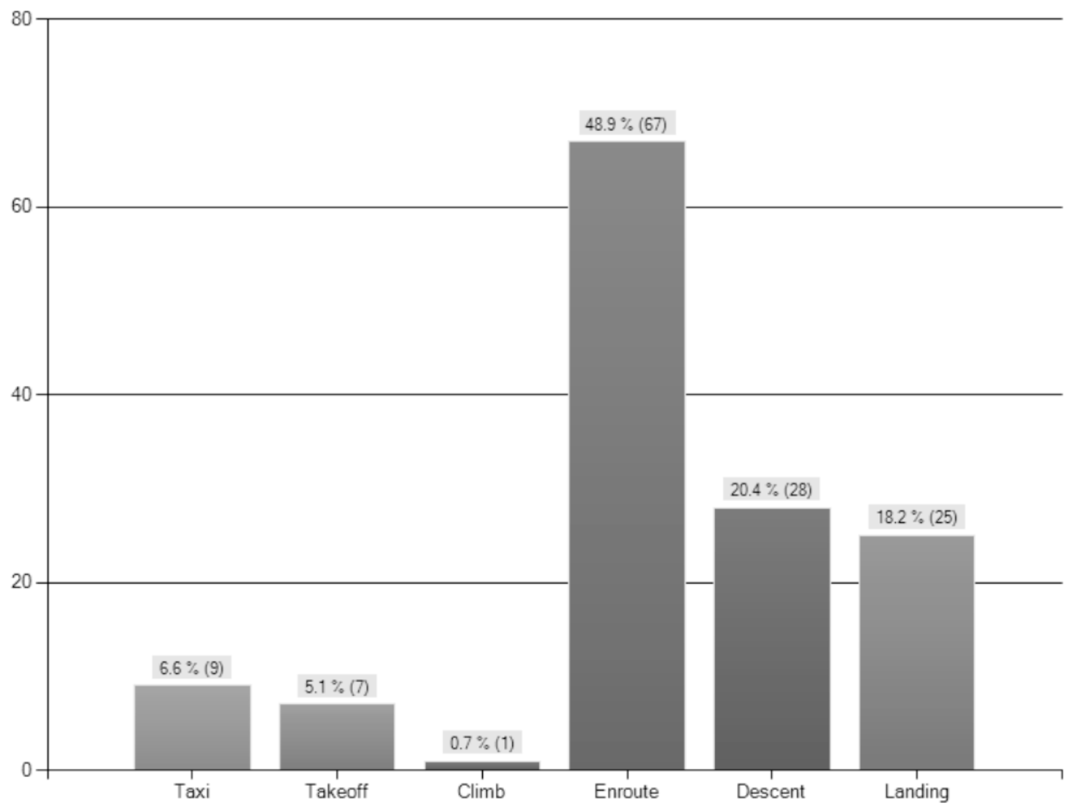


Figure 6. Phase of Flight Most Affected by Fatigue.

## Education

More than half of the pilots at the regional airline (63.5%) indicated they had received a formal education or training on the subjects of fatigue and/ or sleep at some point. Methods for receiving that education included: College or university classes, workshops or seminars, airline ground schools, and/ or self-study courses. The remaining 36.5% indicated they have never received any formal education on the topic. Furthermore, 61.6% (n=85) believe that more training is needed on the subjects of sleep and fatigue specific to regional airline operations. The remainder of the sample population (38.4%) did not believe more education was necessary.

## Analysis of Concern Towards Fatigue and Safety

Tables 10, 11, 12, 13, and 14 display results from tests conducted to determine if any significant differences exist regarding perceptions towards fatigue and safety. Survey questions (11, 12, 13, and 33) can be viewed in Appendix C and results will be discussed in Chapter V. The groups evaluated were: position (Captain and First Officers), domicile (Minneapolis, Detroit, and Memphis), aircraft (CRJ 900, CRJ 200, and SF340), as well as those currently flying CDO's and those not currently flying CDO's. T-Tests were utilized for comparisons with two means (position and pilots flying CDO's). One-Way ANOVA was used for groups with more than two means (domicile and aircraft).

Table 10. T-Test Results for Captains and First Officers

| Question | Groups | Mean | *t* | df |
|---|---|---|---|---|
| Is Fatigue Common (q.11) | Captain | 1.3065 | -1.378 | 136 |
| | First Officer | 1.4211 | | |
| Is Fatigue a Concern (q.12) | Captain | 2.6290 | -.508 | 136 |
| | First Officer | 2.6842 | | |
| Is Fatigue a Safety Issue (q.13) | Captain | 3.2295 | -.290 | 135 |
| | First Officer | 3.2632 | | |
| Overall Safety (q.33) | Captain | 3.3065 | .169 | 136 |
| | First Officer | 3.2895 | | |

Note. $^*p < .05$ (no significance found)

Table 11. ANOVA Results for Domicile

| Question | Groups | Mean | SS | df | Mean Sq | F |
|---|---|---|---|---|---|---|
| Is Fatigue Common | MSP | 1.3780 | B .273 | 2 | .136 | .578 |
| (q.11) | DTW | 1.4118 | W 31.879 | 135 | .236 | |
| | MEM | 1.2727 | | | | |
| Is Fatigue a Concern | MSP | 2.6463 | B .121 | 2 | .060 | .148 |
| (q.12) | DTW | 2.6471 | W 54.872 | 135 | .406 | |
| | MEM | 2.7273 | | | | |
| Is Fatigue a Safety Issue | MSP | 3.2469 | B 1.516 | 2 | .758 | 1.692 |
| (q.13) | DTW | 3.1176 | W 60.046 | 134 | .448 | |
| | MEM | 3.4545 | | | | |
| Overall Safety | MSP | 3.2561 | B .951 | 2 | .475 | 1.399 |
| (q.33) | DTW | 3.4412 | W 45.868 | 135 | .340 | |
| | MEM | 3.2273 | | | | |

Note. *p < .05 (no significance found)

Table 12. ANOVA Results for Aircraft Type

| Question | Groups | Mean | SS | df | Mean Sq | F |
|---|---|---|---|---|---|---|
| Is Fatigue Common | CRJ 900 | 1.3429 | B .124 | 2 | .062 | .261 |
| (q.11) | CRJ 200 | 1.4000 | W 31.890 | 134 | .238 | |
| | SF 340 | 1.4048 | | | | |
| Is Fatigue a Concern | CRJ 900 | 2.6571 | B .011 | 2 | .006 | .014 |
| (q.12) | CRJ 200 | 2.6400 | W 54.865 | 134 | .409 | |
| | SF 340 | 2.6667 | | | | |
| Is Fatigue a Safety Issue | CRJ 900 | 3.2899 | B .424 | 3 | .212 | .461 |
| (q.13) | CRJ 200 | 3.2800 | W 61.076 | 133 | .459 | |
| | SF 340 | 3.1667 | | | | |
| Overall Safety | CRJ 900 | 3.3286 | B .456 | 2 | .228 | .660 |
| (q.33) | CRJ 200 | 3.3600 | W 46.274 | 134 | .345 | |
| | SF 340 | 3.2143 | | | | |

Note. *p < .05 (no significance found)

Table 13. T-Test Results for Pilots **Currently Flying CDO's**

| Question | Groups | Mean | *t* | df |
|---|---|---|---|---|
| Is Fatigue Common (q.11) | Flying CDO's | 1.1818 | -2.032* | 135 |
| | Not Flying CDO's | 1.4087 | | |
| Is Fatigue a Concern (q.12) | Flying CDO's | 2.6818 | .200 | 135 |
| | Not Flying CDO's | 2.6522 | | |
| Is Fatigue a Safety Issue (q.13) | Flying CDO's | 2.9091 | -2.644* | 134 |
| | Not Flying CDO's | 3.3158 | | |
| Overall Safety (q.33) | Flying CDO's | 3.2273 | -.627 | 135 |
| | Not Flying CDO's | 3.3130 | | |

Note. *p < .05

Table 14. T-Test Results for Pilots Flying CDO's **Within the Past 6 Months**

| Question | Groups | Mean | *t* | df |
|---|---|---|---|---|
| Is Fatigue Common (q.11) | Flying CDO's | 1.3529 | -.396 | 136 |
| | Not Flying CDO's | 1.3857 | | |
| Is Fatigue a Concern (q.12) | Flying CDO's | 2.7500 | 1.666 | 136 |
| | Not Flying CDO's | 2.5714 | | |
| Is Fatigue a Safety Issue (q.13) | Flying CDO's | 3.2059 | -.729 | 135 |
| | Not Flying CDO's | 3.2899 | | |
| Overall Safety (q.33) | Flying CDO's | 3.2353 | -1.226 | 136 |
| | Not Flying CDO's | 3.3571 | | |

Note. *p < .05 (no significance found)

# CHAPTER V

# DISCUSSION

## Symptoms of Fatigue

The data indicates that pilots are affected in numerous ways by fatigue. Each pilot may experience only a few symptoms while others may experience several. It is well known that detecting fatigue in oneself is difficult as fatigue degrades cognitive functions. While this is important to note, the data submitted is considered important and accurate because no one knows the participants better than themselves. The subjective nature of the particular survey question parallels other studies investigating self-reported effects of fatigue. Results indicated in Figure 2 illustrate symptoms of fatigue most noticed by participating subjects. It is important to note the table ranks symptoms in order of most reported and should not be confused with symptoms that have the greatest impact on a subject even though there may be some correlation.

All of the response options listed for this particular question have potentially devastating consequences in regards to aviation safety. From “slowed reaction time” to “bad mood” to “nodding off,” each brings serious detriments to crew performance. It does seem odd however, that one of the least reported symptoms was “poor decision making.” Within the current sample there is no way to know for certain, but one explanation is that the pilots believe they were still capable of making good decisions while in a fatigued state. Whether or not this is the case, other symptoms that would typically interfere with the decision making process are highly reported (reduced vigilance, forgetful, and fixation).

It is also interesting to see the impact fatigue plays on crewmembers interpersonal relationships. Many pilots reported that fatigue put them in a bad mood and affected their ability to communicate. Several write-in responses support this with comments like: "I become quiet, don't talk," "easily irritated," and "task oriented less people oriented." The greatest concern with this is the potential for disagreements, bickering, and/ or fighting between crewmembers in the flight deck. Awareness of how fatigue impacts a person's ability to work in a crew environment is critical. A positive aspect is that many of the subjects have already identified this as a fatigue related problem, which in turn allows them to take steps to mitigate any negative impacts.

Overall, the responses in this study mirror data gathered in several other projects involving aviators in different operational settings. This suggests some degree of validation in that the results have been duplicated across the industry and around the world. "Slowed Reaction Time" is one prime example as expressed by the following studies: Taneja (2007) and pilots of the Indian Air Force; Rosekind et al. (1997), Co et al. (1999), and ALPA (2008) with United States based pilots; and lastly Petrie et al. (1997) involving long-haul international pilots. Additional similarities can be found with nearly every other reported symptom.

It would not be illogical to say that similarities in reported fatigue symptoms would also transcend industries. After all, the biological properties of humans are fundamentally the same in all people. While some individuals experience unique symptoms of fatigue or the same symptoms but at differing onsets, the overall indication is that all people experience similar symptoms when fatigued. This hypothesis along with the data solidifies the impression that there are no significant differences between pilot groups in regards to what symptoms of fatigue are noticed.

## Operational Countermeasures

It is widely accepted that the most effective method for alleviating fatigue is sleep. However, due to the operational needs of an airline and current Federal Regulations in the United States, sleep is sometimes not an immediately viable solution for regional airline pilots. The data indicates that pilots at this regional airline do utilize various methods to increase alertness while on duty. Figure 3 and Table 8 display the reported operational countermeasures used. As with the previous section, the results are ranked by most reported and not necessarily most effective.

A fascinating finding of this study is that the most simplistic operational countermeasure that requires no external devices or medium is the most commonly reported. Simply “engaging in conversation” is a method that nearly 74% of the subjects utilize. It can be assumed that process of engaging in conversation not only provides stimulation to the pilot but also allows them to simultaneously judge the mental state of the other crewmember. The most promising aspect of this countermeasure is that it is easy to use with no formal training and comes naturally to most all persons. However, a problematic aspect also exists in regards to U.S. Federal Regulations that state no unnecessary conversations shall occur below 10,000 feet. While this regulation is meant to reduce distractions, it may also be simultaneously contributing to fatigue in some instances during the critical decent and landing phases.

Three of the write-in responses from Table 8 indicate another simple method to remain alert: reading and puzzles. The responses under review are: “do [USA] [T]oday puzzles,” “reading,” and “doing puzzles in [the] newspaper.” It should be noted that the regional airline studied does have a policy forbidding reading material that is not company issued from being present in the cockpit. Nevertheless, Rosekind et al. (1997) validates the point that stimulation from reading and writing does have the ability to increase subsequent alertness. As always, there must be a balance between using the reading material to remain alert and the distraction it may cause to a pilots ability to monitor the aircraft.

One countermeasure not surprising was the reported use of caffeine in the form of coffee and soft drinks. While the study did not seek to identify if participants used caffeine strategically and/or effectively, it will be assumed that they are utilizing the countermeasure correctly. Previous research and publications by ALPA (2008), Co et al. (1999), Rosekind et al. (1997), Rosekind et al. (2002), and Taneja (2007) all cite strategic caffeine use as a highly viable and widely used throughout the world. The data from this study would tend to indicate that there are no substantial differences between participants at this regional airline and their global counterparts with regard to caffeine usage.

One of the most controversial fatigue countermeasures is cockpit napping. Under current guidelines published by the FAA regional airline pilots may not sleep while at their duty station within the flight deck. However, analysis of the data shows that approximately 15% of the study participants indicated it was one of the strategies they utilized while in flight. This is further supported by the almost 60% of pilots who stated they had slept on a flight at some point in their career and the nearly 90% who acknowledged they had been on a flight where the other crewmember had slept. Clearly this suggests that on numerous occasions at the regional airline studied, some pilots were so fatigued they required immediate sleep even though it was not permitted while in flight.

The danger associated with unapproved cockpit napping is that it reduces the flight deck crew to a single pilot system, which reduces their capability to trap errors. In addition, pilots have no guidance or procedures on how to successfully accomplish a planned cockpit nap. These are factors that have been addressed however by several airlines including: Air Canada, Air New Zealand, British Airways, Emirates, Finnair, Lufthansa, Swissair, and Qantas (Caldwell et al., 2009). Benefits of in-flight napping are well documented. ALPA (2008) states that a 20-minute nap can increase alertness by as much as 50%. A 40-minute nap can increase alertness by as much as 100%. Rosekind et al. (1995) indicates that naps have the ability to improve performance, alertness, and mood. Furthermore, Caldwell (2009) indicates that numerous U.S. commercial pilots are already utilizing cockpit napping strategies. This would suggest that results from this survey concerning napping are similar and consistent with previous studies of other pilot populations.

Around 16% of participants indicated that they take breaks by leaving the flight deck while almost half exploit some form of stretching to combat fatigue. Both of these strategies have been cited as effective by Caldwell et al. (2009). The process of moving the body, changing posture, and stretching muscles increases blood flow resulting in elevated alertness. Unfortunately, it is not known if the subjects in this study utilize this strategy because they were taught to do so or because it is a more basic physiological response to their fatigued state. Regardless of that fact, crewmembers are often restricted from being able to take a break because of strict security regulations and requirements for them to be at their assigned station excluding specific exceptions.

A fatigue countermeasure not well utilized by study participants was the use of flight deck lights at night. Only 16% of pilots reported they increased cockpit lighting to combat fatigue. Studies by Rosekind et al. (1997) and Caldwell et al. (2009) both emphasize the positive effects light for increasing short-term alertness. Bright light exposure can also, in some cases, work to lengthen circadian cycles and delay sleep onset. One possible explanation for the low utilization of this technique by pilots could be the emphasis placed on night vision during their training. It is very possible that pilots are concerned about the light hindering their night-adapted vision. A solution and suggestion would be to use this countermeasure during cruise flight but no later than 30 minutes prior to landing.

## Strategies for Quality Sleep

Data from the survey is very encouraging and indicates most of the pilots are using effective sleep hygiene techniques. Figure 4 and Table 9 detail the responses. The strategy with the highest reported usage (66%) was: covering windows to block outside light. Rosekind et al. (2002) and Caldwell et al. (2009) both cite this practice as vital to improving quality sleep. The impact light has on the body is well documented and is most associated with daytime activities and/ or increasing alertness. For crewmembers to seal the sleeping quarters from extraneous light removes that distracting stimuli whether it is from the sun, streetlights, or passing vehicles. This practice is especially important when pilots must go to bed prior to sunset or wish to sleep-in beyond sunrise.

The second highest reported sleep strategy (51%) was a cool room temperature. Studies have show that room temperatures between 65ºF and 70ºF are most ideal for quality sleep, ALPA (2008), Caldwell et al. (2009), and Rosekind (2002). Caution must be exercised however, as varying models of heaters/ air conditioners may actually hinder the sleep process. Some units have loud recirculation fans that are enough to wake up room occupants or keep persons from falling asleep. Additionally, thermostats may lack the necessary sensitivity and instead make room temperatures uncomfortably hot or cold resulting in disrupted sleep. Nonetheless this strategy has been proven to positively impact people's ability to achieve quality rest.

Other effective strategies survey participants reported using were: wearing earplugs, listening to white noise, as well as eating small snacks before bed. Reducing auditory stimulation or controlling what is heard can help people relax prior to sleep and help people remain asleep. Every individual should experiment with either some form of white noise and/ or earplugs to determine which method they prefer. Large meals should be avoided immediately prior to bed but small snacks often are appropriate. The type of snack must be carefully considered. For example, snacks high in sugars should be avoided as they have a stimulating effect on the body.

Included in the survey question regarding sleep habits were several choices that have been shown to decrease the body's ability to achieve quality sleep. This was done to ascertain if some people within the sample utilize inappropriate sleep hygiene techniques. However, it is important to note that all factors impact each person uniquely and may not be as detrimental as described by other authors. That being said, very few participants reported smoking or using nicotine products, drinking caffeinated beverages, exercising, or eating large meals just prior to bed. All of those have been shown to significantly decrease quality sleep ALPA (2008), Caldwell et al. (2009), and Rosekind et al. (2002).

Research has shown that on average, adults require approximately eight hours of sleep each night (Rosekind et al., 1997). Participants in this study reported needing an average of 7.7 hours of sleep each night, drawing close parallels to previous scientific findings. Due to the subjective nature of documenting required sleep it is difficult to determine the degree of accuracy surrounding this information. As Co et al. (1994) stated "while people tend to underestimate the amount of sleep they get, they tend to overestimate their alertness" (p. 191). Of particular concern is the participants' response to the question asking how much sleep must be lost before it has a significant impact on their ability to function. Research by Caldwell et al. (2009) indicates that as little as one to two hours of sleep loss can significantly degrade performance. However, nearly 70% of pilots in this study stated they didn't notice any degradation until three, four, five, or more hours of sleep loss had been incurred. This may be a sign of dangerous underestimation by the pilots. Fatigue's subtle onset combined with its capacity to degrade cognitive functions makes determining ones own mental state extremely difficult and may result in an incorrect diagnosis.

## Concern Towards Fatigue and Safety

In an effort to determine what level of concern exists amongst the airline pilots surveyed with regard to fatigue, several statistical tests were conducted. Participant groups were formed using demographic information provided in the survey. Four groups were chosen and included: Position (Captain & First Officers), Domicile (Minneapolis, Detroit, and Memphis), Aircraft (CRJ900, CRJ200, and SF340), as well as differentiating between pilots currently conducting CDO's and those with regular schedules. For comparison, survey questions 11, 12, 13, and 33 (reference Appendix C) were chosen because of their specific relevance to the topic. Responses within those four questions were given numerical values for expedited analysis and the values are listed adjacent to the responses shown in Appendix C.

No significance was found during examination of the position, domicile, and aircraft groups (Tables 10, 11, and 12). This tends to indicate a strong consensus across the pilot group in their attitudes towards fatigue and safety. Occasionally, in any workforce, differences may appear between groups located in different geographic regions or that operate dissimilar types of equipment. The data from these comparisons does not support that notion. Instead it suggests that despite any apparent differences in base location, complexity of aircraft operation, or pilot experience, there is a company-wide consensus in regards to the topics under review.

Of particular importance was the comparison of pilots currently flying CDO's with those not presently flying CDO's, as shown in Table 13. Two areas indicated significance: responses to question 11 concerning the occurrence of fatigue and question 13 pertaining to fatigue's impact on safety. Significantly more pilots' currently flying CDO's indicated [Yes] fatigue is a common occurrence at the airline in this study. While it is not known if the pilots in this group are themselves fatigued when on duty, research does confirm that flying a CDO requires working in opposition to natural circadian cues. It is likely that this group's flight patterns are a contributing factor in explaining why this difference exists.

Additionally, pilots currently flying CDO's reported significantly less concern towards fatigue's impact on safety than the remainder of the pilot group (question 13). It may seem counterintuitive that the group with the highest probability of experiencing fatigue at work would place reduced emphasis on its impact on safety. However, a simple explanation may be that because CDO's are 'normal' for these pilots' and they have become accustom to the type of operation, they no longer perceive the impact to safety to be as substantial. This has sometimes been referred to as either standardization of deviation or as normalization of deviation. In this instance the CDO would be the deviation from normal flight activities. Either way, pilots not currently flying CDO's consider fatigue to have a more sizeable impact on safety.

For the last comparison (Table 14) the same tests were conducted but the groups were now comprised of pilots who had flown CDO's within the past six (6) months [to include those pilots currently flying CDO's] and those who had not. No results indicated any statistical significance. This in and of itself is important. Removing oneself from the regiments of the CDO routine by just a few months may be enough to alter the pilot's perception of fatigue and its impact on safety. Specifically, the perception of the occurrence of fatigue is reduced while the opinion regarding fatigues impact on safety increases.

## Implications

The implications of this research are far reaching and could include: flight-crew training, scheduling practice, changes to policy and procedures, as well as training and research at academic intuitions. Furthermore, the findings also have relevance outside of the aviation industry with anyone or any company that operates around the clock. The data suggests that pilots currently working Continuous Duty Overnights are more likely to be fatigued but are less concerned about fatigue's impact on safety. This has the potential to be a very dangerous combination. There may be a sense of safety, albeit false, that is generated through repetition. Each time a CDO is successfully completed, it reinforces to the pilot he or she can fly in fatiguing conditions associated with the specific type of operation. Solutions for this predicament may need to include flight crew education and/or modifications to work rules that limit the number of CDO's that can be flown.

Of particular concern are the reports from the pilots acknowledging they have slept or nodded off while in flight. As previously stated, approximately 59% of subjects in this study responded they had. This is similar to findings by Rosekind et al. (2002) that found 80% of regional pilots had 'nodded off' in the cockpit. At the present time, the Federal Aviation Administration does not allow for pilots to sleep while on duty and at their assigned station. It is presumed that the pilots are aware of this regulation yet are more concerned with obtaining rest than abiding by the letter of the law. Research has also indicated that even short naps can substantially increase subsequent alertness (ALPA, 2008). Other countries and some airlines have already implemented procedures for in-flight napping but public perception in the United States may hinder legal adoption of practice.

The insidious nature of fatigue makes it difficult for humans to determine their level of impairment. Nonetheless, data indicates that participants in this study are aware of what signs and symptoms they exhibit when fatigued and that data is consistent with other similar subjective studies. A positive finding can be established in that subjects overwhelmingly reported using effective fatigue countermeasures to temporarily increase alertness while in flight. This suggests pilots have either been taught what strategies work best or have learned them independently during their career. It should be noted that nearly 64% of respondents indicated they had received some form of education on the topics of fatigue and/ or sleep. Even so, almost as many (62%) specify they would like to receive more training on the topic as it pertains to regional airline operations. Air carriers should take note of this finding and incorporate at least a basic awareness program into their initial and recurrent ground training programs.

While not unexpected, what is alarming is the reported data in relation to the amount of sleep loss that must accumulate before there is a negative impact on a person's ability to function [survey question 22, Figure 5]. Findings by Caldwell et al. (2009) and Rosekind et al. (2002) both imply as little as one to two hours of sleep loss can dramatically affect alertness. However, nearly 70% of pilots in this study indicated they were not impacted by fatigue until three or more hours of sleep loss had been incurred. This misconception may be due to inaccurate beliefs or lack of education on the subject and further compounded by previous encounters with fatigue that have set a precedence of uneventful outcomes.

## Limitations

One drawback of this study was the subjective nature of some questions that relied on participants to assess themselves. It is also possible that some participants answered questions based on how they ideally would respond to a situation rather than reporting their actual habits. Every effort was made in designing the survey tool to ask questions as clearly as possible and solicit responses based on what participants are actually doing instead of how they would like to do something. Lastly, the anonymous and self-reporting nature of the survey tool utilized means that the validity of the responses cannot be verified.

## Future Studies

The aviation industry continues to evolve yet fatigue will always have some impact on operations, even as we are on the verge of new science based regulations. While humans remain unchanged, the equipment and procedures have advanced rapidly in the last 20 years. Automation on newer aircraft is replacing pilots' typical in-flight duties involving active participation and manipulation of the aircraft with a new role involving primarily systems monitoring. It would be advantageous to study the effects of fatigue on pilots operating these dissimilar fleet types. For example, do the pilots utilize different fatigue countermeasures or find a particular flight regime more challenging and/or fatiguing?

Other research avenues include investigating different fatigue policies in place at regional and mainline air-carriers. Exploring how these differing policies affect employees' perception of fatigue and their decision making process. Do carriers that allow pilots to 'call in fatigued' without any repercussions vary in any significant way from carriers who do not? This endeavor would most certainly also involve evaluating corporate culture and assistance from researchers with a psychology background may be needed.

One of the most widely used fatigue countermeasures is caffeine. It is readily available in various forms throughout the world, including on commercial aircraft. Determining if crewmembers are using it effectively as a countermeasure would be very important in determining if more education is necessary. Just as caffeine can help in the fight against fatigue, it can also interfere when sleep is needed. Restless nights in a hotel may be preventable if improper caffeine usage can be identified and eliminated.

Lastly, the field of fatigue research cannot be limited just to aviation. Many other professions work during the same time period as pilots on continuous duty overnights. Police officers, doctors, truck drivers, convenience store clerks, and nuclear power plant technicians just to name a few. They may be able to share additional information on effective fatigue countermeasures as well as best practices for good sleep hygiene. The jobs may be different, but humans are still the common denominator. Learning from one another will ultimately improve everyone's safety.

APPENDICES

## Appendix A
## Recruitment Notice

The following recruitment notice was distributed via “blast” email from the pilots union as well as mailbox “stuffers.”

-----------------------------------------------------------------------------------------------

Help Needed!

Dear Fellow Pilot,

I am conducting research for a graduate school project concerning regional airline operations. Your participation in this 5-minute survey would be greatly appreciated!

This survey will help the researchers identify current trends in regional airline flight operations. Participation is voluntary, you may answer all questions or only those you feel comfortable answering. You will not be asked to identify yourself and your identity will not be linked to your responses in any way; this is a completely anonymous survey.

To take the survey, please go to the following website:
www.surveymonkey.com/s/XXXXXXX

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## Appendix B

## Survey Introduction

The following is the message all participants saw prior to starting the survey.

---------------------------------------------------------------------------------------------

Welcome XXXXXXX Pilots!

This survey will help the researchers identify current trends in regional airline flight operations. Participation is voluntary, you may answer all questions or only those you feel comfortable answering. You will not be asked to identify yourself and your identity will not be linked to your responses in any way; this is a completely anonymous survey. We recommend taking this survey in the privacy of your own home; however, you are not prohibited from completing the survey on crew-room or hotel computers.

Thank you for your participation!

To begin the survey, please select the “Next” Button.

---------------------------------------------------------------------------------------------

## Appendix C

## Survey Questions

1. Please enter your age in years
2. Please select your gender
    a. Male
    b. Female
3. Please select your current position
    a. Captain [1]
    b. First Officer [2]
4. Please select your current domicile
    a. Minneapolis (MSP) [1]
    b. Detroit (DTW) [2]
    c. Memphis (MEM) [3]
5. Please select your current aircraft
    a. CRJ 900 [1]
    b. CRJ 200 [2]
    c. SAAB 340 [3]
6. Please estimate your bidding seniority in your current position
    a. Top 25%
    b. 26 to 50%
    c. 51 to 75%
    d. Bottom 25%
7. Where do you live? (State of primary residence)
8. Please estimate your flight time to the nearest hour
    a. Total Flight Time
    b. FAR Part 121 Flight Time
    c. Total time when hired by XXXXXXX Airlines
9. Please indicate your current airman certificate
    a. Airline Transport Pilot (ATP)
    b. Commercial Pilot (CP)

10. Are you a flight instructor?

   a. Yes

   b. No

11. In your opinion, is pilot fatigue a common occurrence at XXXXXXX Airlines?

   a. Yes [1]

   b. No [2]

12. In your opinion, to what extent is pilot fatigue a concern at XXXXXXX Airlines?

   a. not at all [1]

   b. minor [2]

   c. moderate [3]

   d. serious [4]

13. If or when pilot fatigue occurs, how significant a safety issue is it?

   a. not at all [1]

   b. minor [2]

   c. moderate [3]

   d. serious [4]

14. When YOU are affected by fatigue, which phase of flight performance is MOST affected?

   a. taxi

   b. takeoff

   c. climb

   d. enroute

   e. descent

   f. landing

15. Have you ever slept or "nodded off" during a flight?

   a. Yes

   b. No

16. Have you ever been on a flight where the other pilot slept or "nodded off?"

   a. Yes

   b. No

17. Have you ever received a formal education or training on the subject of Fatigue an/ or Sleep? (select all that apply)
    a. No
    b. Yes- College or University Class
    c. Yes- Workshop or Seminar
    d. Yes- Airline Ground School
    e. Yes- Self-Study Course or Research
    f. Yes- Other (please specify)
18. Do you believe more training (specific to regional airline operations) is necessary on the topic of fatigue and sleep?
    a. Yes
    b. No
19. In general, what kind of sleeper are you?
    a. very poor
    b. poor
    c. good
    d. very good
20. How much sleep do YOU require each night to be fully rested? (in hours)
21. When you become fatigued, what signs and symptoms do you recognize in yourself? (select all that apply)
    a. Forgetful
    b. Poor decision making
    c. Slowed reaction time
    d. Reduced vigilance
    e. Poor communications
    f. Fixation
    g. Apathetic
    h. Lethargic
    i. Bad mood
    j. Nodding off
    k. Other (please specify)

22. How many hours of sleep loss must accumulate before YOU notice a significant impact on YOUR ability to funcion?
    a. less than 1
    b. 1 hours
    c. 2 hours
    d. 3 hours
    e. 4 hours
    f. 5 hours
    g. greater than 5
23. What strategies do you utilize to combat fatigue while IN flight? (select all that apply)
    a. drink coffee
    b. drink tea
    c. drink cold water
    d. drink soft drinks
    e. napping
    f. stretch
    g. engage in conversation
    h. increase flight deck lighting
    i. eat
    j. decrease cockpit temperature
    k. increase cockpit temperature
    l. leave flight deck- take a break
    m. nicotine products
    n. other (please specify)
24. Tell us about your experience with Continuous Duty Overnights (CDO). (Also known as: "high-speeds," "stand-ups," "naps," & "illegals")
    a. Have you ever flown a CDO? Yes or No
    b. Have you flown a CDO in the past 6 months? Yes or No
    c. Are you currently flying CDO's (this month or last) Yes or No

25. When (or if) you fly CDO's: is it because you choose to, or because your bidding seniority prevents other lines?
    a. CDO- By Personal Choice
    b. CDO- Due to bidding Seniority
26. During a continuous duty overnight (CDO), on average, how long is the scheduled ground time at the out-station? ("stand-up" portion of the CDO) (in hours)
27. During a continuous duty overnight (CDO), on average, how much time is available for sleep? ("stand-up" portion of the CDO) (in hours)
28. During a continuous duty overnight (CDO), on average, how much sleep do YOU get during the "stand-up" portion? (in hours)
29. How often do you sleep during the "stand-up" portion of a CDO?
    a. never
    b. rarely
    c. occasionally
    d. frequently
30. What strategies do you utilize to sleep, if any, while between flights when conducting a CDO? (at the hotel or outstation)
    a. cover windows to block outside light
    b. wear earplugs
    c. wear eye shades
    d. listen to white-noise
    e. cool room temperature
    f. meditation
    g. eat a small snack
    h. exercise prior to sleep
    i. eat a large mean
    j. warm room temperature
    k. drink caffeine
    l. smoke or use nicotine product
    m. other (please specify)

31. Please rate the hotel accommodations for the “stand-up” portion of a CDO.
    a. very poor
    b. poor
    c. average
    d. good
    e. very good
32. Have you ever flown the final segment of a CDO without getting any sleep at the outstation?
    a. Yes
    b. No
33. In your own opinion, how safe is XXXXXXX Airlines?
    a. Very Unsafe [1]
    b. Unsafe [2]
    c. Safe [3]
    d. Very Safe [4]

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