Fatigue: Investigation of a Human Factor for Regional Airline Pilots

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FATIGUE: INVESTIGATION OF A HUMAN FACTOR
FOR REGIONAL AIRLINE PILOTS

by

Douglas S. Mikkelsen

A Thesis Submitted to the
Aeronautical Science Department
in Partial Fulfillment of the Requirements for the Degree of
Master of Aeronautical Science

Embry-Riddle Aeronautical University
Daytona Beach, Florida
Summer 1998
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FOR REGIONAL AIRLINE PILOTS

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This thesis was prepared under the direction of the candidate's thesis committee chair, Dr. Thomas R. Weitzel, Department of Aeronautical Science, and has been approved by the members of his thesis committee. It was submitted to the Department of Aeronautical Science and was accepted in partial fulfillment of the requirements for the degree of Master of Aeronautical Science

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The project was a success because of the team effort displayed by everyone involved. It was an enjoyable and educational experience, which I am hopeful will help to improve regional airline safety.
ABSTRACT

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This study analyzed the causes of regional airline pilot fatigue and the impact on pilot performance. An instrument was developed and refined through a field study validation by a panel of experts. The final instrument was distributed to three groups of regional airline pilots. The data supported the literature review, which revealed many causes of pilot fatigue, including flight crew schedules that are not compatible with human limitations; Federal Aviation Regulations (FARs) that have not evolved with the advancement of aircraft performance and the public demand for 24 hour availability of flights; and poor personal habits. An analysis of the data and literature led to the following conclusions: (a) the existing flight crew schedules and FARs pertaining to flight time limitations and rest requirements are not compatible with human limitations, (b) fatigue has a negative impact on pilot performance, and (c) pilot fatigue has been a contributing factor in many aircraft accidents and incidents.
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18. How many of these errors resulted in a decreased level of safety?

19. How many of these errors led to a violation of the FARs?

20. What percentage of time have you felt fatigued during your last 500 hours of flight time?

21. How many fatigue related errors have you made during your last 500 hours of flight time?

22. How many of these errors resulted in a decreased level of safety?

23. How many of these errors led to a violation of the FARs?
ABBREVIATIONS AND ACRONYMS

The following is a list of abbreviations that appear in the text of FATIGUE:

INVESTIGATION OF A HUMAN FACTOR FOR REGIONAL AIRLINE PILOTS

AIA American International Airways
ASRS Aviation Safety Reporting System
CDO Continuous Duty Overnight
CEO Chief Executive Officer
CHIRP Confidential Human Factors Incident Reporting Programme
CVR Cockpit Voice Recorder
FAA Federal Aviation Administration
FAR Federal Aviation Regulation
fpm feet per minute
GPWS Ground Proximity Warning System
ICAO International Civil Aviation Organization
IFR Instrument Flight Rules
IMC Instrument Meteorological Conditions
K-S Kolmogorov-Smirnov Goodness of Fit Test
NASA National Aeronautics and Space Administration
NPRM Notice of Proposed Rule Making
POI Principal Operations Inspector
SPSS Statistical Package for the Social Sciences
TAR Time Available for Rest
TCAS Traffic Alert and Collision Avoidance System
CHAPTER I
INTRODUCTION

There has been a rapid evolution of the aviation/aerospace industry throughout the 20th century. The Wright brothers accomplished the first manned, controlled, powered flight on December 17, 1903. Non-stop flights across the Atlantic were made as early as 1919. The first jet aircraft were flown in the 1940s, and Chuck Yeager became the first man to fly an aircraft faster than the speed of sound in 1947. Neil Armstrong and Ed Aldrin landed the Lunar Module on the moon on July 20, 1969. Twelve years later the most complex flying machine ever built (the space shuttle Columbia), was launched from the Kennedy Space Center. On December 23, 1986 Jeana Yeager and Dick Rutan made the first nonstop-without-refueling flight around the world. The aircraft and missions flown have changed drastically over the last 95 years, however the pilots flying them are still human.

The aviation industry has evolved into a 24-hour operation. Unfortunately this creates a great challenge to human physiology. Irregular work schedules, rotating shifts, and night work are very common; and can all lead to pilot fatigue. The duties of an airline pilot have changed dramatically over the years. However, the physiological limitations of the pilots have remained the same, and the Federal Aviation Regulations (FARs) are essentially unchanged.
Fortunately, the aviation industry is served by some very exceptional human beings. Pilots tend to be achievement oriented, with a very strong desire to progress and succeed. The hub and spoke system has created a greater demand for flights to operate on-time, which in turn places a subtle pressure on the flight crews to stay on schedule. Maintenance and weather delays combined with passenger complaints may heighten this pressure. A flight crew may succumb to these pressures, and continue with their schedule, despite an unsafe level of fatigue. "There are no supermen where fatigue is concerned" (Enders, 1989, p. 1.4).

There is a lack of consensus as to the measurement and definition of fatigue. Therefore investigators typically supply their own definition of the term (Dodge, 1982). Researchers at the Federal Aviation Administration (FAA) Civil Aeromedical Institute have offered the following definition of fatigue:

The undesirable state produced by effort -- either the physical or mental effort of doing work or the effort of maintaining vigilance when there is no physical work to be done. Fatigue is an undesirable state because it causes people to commit errors; fatigue can adversely affect not only the accuracy but also the timeliness of performance (Higgins et al., 1982).

The preceding definition, although accurate is perhaps incomplete. A more recent and comprehensive definition provided by Hawkins (1993) considered the items included in the preceding definition as well as two additional ways that fatigue is produced; "[Fatigue] may reflect inadequate rest, [and] may refer to symptoms associated with disturbed or displaced biological rhythms which are often described by the sufferer simply as jet lag. [It is important to be specific when discussing the condition of fatigue], its origins, effects and remedial action" (p. 57).
Lyman and Orlady (1981) analyzed the data collected by the National Aeronautics and Space Administration (NASA) Aviation Safety Reporting System (ASRS) and reported that performance decrements associated with fatigue resulted in significant potentially unsafe conditions in the aviation system. Duty and sleep schedules were the major factors contained in the reports. In 1984, the British Confidential Human Factors Incident Reporting Programme (CHIRP) disclosed that the majority of the reports received by their safety reporting system during the first 18 months of operation, involved fatigue, sleep, and work patterns. A CHIRP administrator concluded that “the importance of disrupted sleep as a causative factor in accidents may have been underestimated” (Green, 1985, p. 638).

Humans perform many critical functions in the daily aviation operations. Therefore, human physiological limitations should be considered in order to reduce fatigue and increase regional airline safety. To reduce the number of human errors in the cockpit, crew schedules should provide ample time for adequate, consistent rest and proper nutrition.

The Importance of the Study

Thousands of people travel on regional airlines every day in the United States. These passengers deserve a well rested flight crew and the highest possible level of safety. Federico Pena addressed an international symposium on fatigue and stated that “the traveling public has just as much right to expect transportation operators to be unimpaired by fatigue as they have the right to expect operators to be unimpaired by alcohol or drugs” (NTSB, 1996, p. 8). The mission of every airline should be to safely transport the passengers to their desired destinations. Making a profit for the owners or shareholders (although
necessary for the airline’s continued existence) has to remain secondary to this primary mission.

In 1980, NASA sponsored a workshop on pilot fatigue and circadian desynchronosis, in response to a Congressional request to determine whether “the circadian rhythm phenomenon, also called jet lag, is of concern” (NASA, 1981, p. 1). A very diverse group of experts attended the workshop, including representatives of airline pilots and management, and scientists from academia, the military services and federal agencies. The statements made by the participants during the first day indicated that:

most did not perceive a major problem relating to pilot fatigue or to circadian desynchronosis as factors in air safety. As the participants received additional information from their colleagues, these views began to change. . . (p. 4)

After 3 days of discussions it was determined that pilot performance degradation as a result of fatigue is a problem that should concern the aeronautical community. Perhaps these workshops should be held on a regular basis.

The workshop participants agreed that pilot fatigue is increased (and therefore pilot performance is degraded) as a result of:

1. Sleep loss or deprivation and alterations of habitual sleep/wake cycles.
2. Circadian desynchronization associated with time-zone changes and irregularity of work/rest cycles.
3. Long duty hours.
4. Other human factors such as:
   a. Long periods of low activity and lowered sensory input.
   b. Letdown/relaxation/boredom.
   c. Less than optimal nutrition.
   d. Use of alcohol or other non-nutritive substances used to counteract fatigue and sleep difficulty. (NASA, 1981, p. 5)
These four items roughly coincide with the previously mentioned definition of fatigue offered by Hawkins.

Despite the enlightened awareness displayed by many of the workshop attendees, there appears to be a reluctance on the part of pilots, airline management, and the FAA to admit that fatigue in the cockpit is a problem which negatively impacts the safety of flight. Some of the participants felt that “it was neither fair nor correct to imply that pilot fatigue (or pilot performance degradation) was a cause of accidents, since the number of airline accidents is relatively small” (NASA, 1981, pp. 4-5).

There is a “common belief that fatigue is not an acceptable excuse for an error because flying when tired is so much a part of the pilot profession” (Graeber, 1988, p. 306). One purpose of this study is to help dispel that belief, and perhaps improve regional airline safety.

**Statement of the Problem**

This study proposes to analyze some causes of regional airline pilot fatigue and introduce some correlation between human fatigue and pilot performance.

**Research Questions**

The research questions to be addressed are: Within the U.S. regional airline industry, (a) What are the causes of pilot fatigue? and (b) What is the impact of fatigue on pilot performance?
Delimitations

The following restrictions existed with regard to the conduct of the proposed research:

1. The study was limited to pilots employed by regional airlines registered in the U.S.A., flying aircraft with 19 to 70 passenger seats.

2. Cognitive fatigue is the only type of human fatigue that was examined in this study.

3. The study analyzed the impact of fatigue on regional airline pilots, and did not consider other employee groups (flight attendants, ramp personnel, mechanics, dispatchers, etc.).
CHAPTER II
REVIEW OF THE LITERATURE

The lack of adequate time for rest between scheduled duty periods is a primary concern of regional airline pilots. One regional airline Captain submitted the following report to the NASA ASRS:

I completed a minimum crew rest, and the next day my duty was 13:45. Both the First Officer and myself are showing signs of fatigue. I am unable to concentrate, cannot repeat clearances back if they contain more than 2 bits of information, and I cannot even remember my flight number. I have fixation on simple tasks. I am going to take some time off without pay because these effects seem to be cumulative and intensifying each stressful day. Commonly, I have had to go 18 to 24 hours without eating. Attempts to ensure sleep needs and eating patterns is met with counseling and disciplinary action. (NASA ASRS Accession No. 123033)

The symptoms and characteristics of fatigue and sleep deprivation mentioned by this Captain are very typical of the reports submitted to the NASA ASRS.

Most people experience some level of fatigue almost every day of their lives. It may be a welcome feeling at the end of a long day and is typically not given serious thought. An individual under the influence of fatigue may recognize diminished performance or effectiveness, however safety is typically not a concern. “Unfortunately, this is not the case for those who fly airplanes” (Graeber, 1988, p. 305).

Sleep and Sleep Deprivation

Insufficient sleep is a potential source of pilot fatigue which may in turn have an impact on flight safety. A sleep deprived individual may not perform as
well as he normally would after a sufficient rest period, and may even doze off on the job (Stokes & Kite, 1994).

Members of the NASA Ames Research Center Fatigue Countermeasures Program conducted an analysis of crew fatigue factors. This study pointed out that in the past sleep was viewed as an inactive state in which the human body is essentially turned off. However, scientific findings have proven that “sleep is a complex, active physiological state that is vital to human survival” (NTSB, 1994, pp. 133-134).

Fatigue and sleepiness are terms used to describe the symptoms of sleep deprivation. These terms are very similar to other symptoms of deprivation such as thirst or hunger. As an individual falls asleep, the external environment is perceptually disengaged. In other words the individual no longer integrates outside information. A person who is suffering from sleep deprivation is susceptible to episodes of microsleep (sometimes referred to as “spacing out”). These spontaneous events typically last for just a few seconds, however during this time the individual will not respond to external information, and therefore suffer a significant performance degradation (NTSB, 1994). This would certainly be a very hazardous situation if the individual was driving a car or flying an airplane.

Researchers have failed to reach a consensus as to the optimal amount of sleep. In 1975, Webb and Agnew pointed out that people typically slept 9 hours per night in the early 20th century. Several studies have shown that people typically sleep 2 hours more than usual, when they are allowed to sleep as long as they would like (Aserinsky, 1969; Gagnon, DeKoninck, & Broughton, 1985; Verdone, 1968). There is a range of sleep requirements among individuals. Most adults require approximately 8 hours of sleep in order to
achieve a maximum level of performance and alertness while awake. However, some individuals are able to achieve these maximum levels after less than 6 hours of sleep, while other individuals may require greater than 10 hours of sleep (NTSB, 1994).

The symptoms of sleep deprivation are frequently dismissed as a minor annoyance. This is a potentially dangerous attitude because the typical symptoms of fatigue are slowed reaction time, difficulty prioritizing tasks or making decisions, impaired judgment, and having to continuously recheck information or activities because of memory degradation. Additional symptoms include decrements to vigilance and psychomotor coordination, headaches, burning eyes, fixation and increased negative emotions (worsened mood) (NTSB, 1994). An individual suffering from these performance decrements is “unlikely to be aware of the manner and extent of his deteriorating performance” (Hawkins, 1993, p. 78).

Sleep loss is cumulative in nature, and individuals will accumulate a sleep debt after repeatedly receiving less sleep than they require. For example, when an individual who requires 8 hours of sleep only receives 6 hours, a sleep deprivation of 2 hours has been incurred. If the individual continues to receive only 6 hours of sleep over five consecutive days, then the total sleep debt will accumulate to 10 hours. Recuperation from a sleep debt generally requires deeper sleep over a period of two to three days (NTSB, 1994).

Researchers at NASA Ames have differentiated sleepiness into two distinct components. The first is physiological sleepiness, which results from sleep loss. The second is subjective sleepiness, which is “an individual’s introspective self-report regarding the individual’s level of sleepiness” (NTSB, 1994, p. 135). Many factors such as caffeine, physical activity, or a stimulating
environment will affect this subjective self-report. Individuals will typically report less sleepiness and a higher level of alertness, when one or more of these factors are present. Thus the tendency is for an individual to allow subjective sleepiness to mask the true level of physiological sleepiness. “This individual, in an environment stripped of factors that conceal the underlying physiological sleepiness, would be susceptible to the occurrence of spontaneous, uncontrolled sleep and the performance decrements associated with sleep loss” (NTSB, 1994, p. 135).

Circadian Rhythms

Human beings (and many other living organisms) have a circadian (derived from the Latin words circa [about] and dies [day]) “clock” in the brain. This clock regulates the pattern or rhythm of many physiological and behavioral functions, including our sleep/wake pattern, body temperature, hormone secretion, digestion, performance, and mood (Graeber, 1988). These rhythms follow a period of approximately 24 hours, and are influenced by several different zeitgebers (time givers). The most powerful are bright light (either from the sun or an artificial source) and darkness, however meals and physical and social activity also influence the circadian rhythms (Hawkins, 1993).

Scientific studies have revealed that the period between 0300 and 0500, and the period between 1500 and 1700, are periods of maximal sleepiness for most individuals. These time periods are determined by our circadian rhythms, and regulated by the brain (NTSB, 1994). Individuals studied during these critical periods before dawn and in the middle of the afternoon have demonstrated a higher error rate leading to industrial incidents and accidents. “Knowing when industrial errors, incidents, and accidents are most likely to
occur across the day/night cycle can help to focus job design and redesign activities for safety-sensitive jobs” (Miller & Mitler, 1997, p.12).

Most people live in harmony with their circadian system by working during the day and sleeping at night. However, there are many people (including pilots) with jobs that conflict with their circadian rhythms. A 1994 study of short-haul air transport operations revealed significant variations in flight crew duty and rest schedules. The researchers found that the inconsistent duty and rest schedules resulted in the pilot subjects taking longer to fall asleep, sleeping less, waking up earlier, and reporting lighter, poorer sleep with more awakenings (Gander, Graeber, Foushee, Lauber, & Connell, 1994).

Circadian rhythms do not adjust immediately, and may never fully adjust to new sleep/wake schedules. The circadian rhythms of people who work at night and sleep during the day seem to be only distorted and not completely repositioned (Torsvall, Akerstedt, Gillander, & Knutsson, 1989). “Therefore, people probably have little voluntary control over the timing of performance deficits related to sleep disruption” (Miller & Mitler, 1997, p. 14).

A disturbed pattern of biological rhythms is known as circadian disruption or circadian desynchronization, and has an influence on performance and safety (Hawkins, 1993). A study was conducted in 1970 which measured the performance of experienced pilots flying an F-104 simulator. The pilot’s total performance as determined by three independent flight parameters showed significant rhythmic variations as a function of the time of day, and consistently worsened at night between the hours of 2100 and 0900 (Klein et al., 1970). It is important to recognize that night work significantly compromises an individual’s ability to receive adequate sleep (Miller & Mitler, 1997).
In addition to the aforementioned sleep and performance decrements, there are several other symptoms associated with circadian desynchronization. These include:

hunger at unusual times, digestive disturbances such as queasiness and constipation, and miscellaneous aches and pains. Chills can occur as body temperature now drops during waking hours instead of during sleep. Psychological symptoms include confusion, irritability, and other mood impairments, as well as a general loss of mental efficiency. Difficulties with time and distance estimation have also been noted, as well as psychomotor performance degradation, headaches, and anxiety. (Stokes & Kite, 1994, p. 271)

The time required to resynchronize the disturbed circadian rhythms varies from several days to several weeks (NTSB, 1994). There are several factors including age, physical fitness, and personality type that may affect the length of time required to adapt to a new sleep/wake schedule or new time zone (Hawkins, 1993). A study conducted by the NASA Ames Research Center revealed that:

age was significantly correlated with an increased number of awakenings, a higher percentage of light drowsy (i.e., restless) sleep, a lower percentage of deep (slow-wave) sleep, and lower sleep efficiency. This was particularly true for those crewmembers over 50 years of age. (The Royal Aeronautical Society, 1989, p.5.4)

Fatigue Related Incidents and Accidents

On November 1-2, 1995 a symposium on fatigue in transportation was co-sponsored by the NTSB and the NASA Ames Fatigue Countermeasure Research Group. The Chairman of the NTSB, Mr. Jim Hall opened the symposium by remarking that fatigue is one of the major hazards of transportation, and that during the 23 year period from 1972 to 1995, the NTSB issued nearly 80 fatigue-related safety recommendations. Hall continued:
while we all study the problem, accidents continue to happen. . . .
Commuter pilots often fly a dozen legs in one day, and after a shortened
rest period, do it again the next day. . . . The American taxpayers
invested millions of dollars in research into programs that examine
fatigue. . . . At some point we must decide that, while research should
never end, the time for study must yield to a time for action. (NTSB, 1996,
pp. 4-5)

Jim Danaher, Chief of the NTSB Operation Factors Division (retired
January, 1998) also addressed the symposium attendees. He stated that:

In its investigation of numerous accidents in all transportation modes, the
Safety Board has identified serious and continuing problems concerning
the far-reaching effects of fatigue, sleepiness, sleep disorders, and
circadian factors in transportation system safety. We have seen repeated
instances of poor scheduling of work and rest periods in all transportation
modes that have or might have affected adversely the performance of
operating personnel. (NTSB, 1996, p.11)

Accident investigators have rarely named fatigue as the probable cause
(or even a causal factor) of an accident. This does not mean that the crew was
necessarily well rested at the time of the accident. The problem is that fatigue is
very difficult to measure even in advanced laboratories, and nearly impossible
to precisely measure after an accident (Barlay, 1990).

A French accident investigator stated that:

our lack of knowledge about fatigue may well prove to be the chief
explanation of those accidents which are now put down to “pilot error” or
“the human factor” simply because we don’t quite understand what
makes well-qualified, conscientious specialists, like pilots, commit almost
unbelievably stupid mistakes. (Barlay, 1970, p. 322)

That statement was made approximately 30 years ago, and although our
knowledge of fatigue has grown substantially since then, accident investigators
continue to use the generic term “pilot error”, because it is difficult to prove that
fatigue was a causal factor. After an accident the investigators typically
consider the flight crew’s duty, flight, and rest schedule for the preceding
72 hours. However, even a detailed analysis of a crew’s schedule is not sufficient to determine the impact of fatigue on their performance.

**The First Solo Flight Across the Atlantic**

One of the earliest reports of pilot fatigue was made by Charles Lindbergh. He departed from New York on May 20, 1927, on his record setting, first solo flight across the Atlantic. He came close to not completing the flight after falling asleep at the controls. Fortunately he woke up and recovered from his descent toward the Atlantic Ocean (Graeber, 1988).

The night before his departure, the weather forecast changed, and he had to make arrangements late that night for a departure at dawn. He posted a friend as a guard outside his hotel room door, but was unable to get any sleep. He made his departure early the next morning, and found himself fighting exhaustion after only four hours of flight. Eight hours into the flight his lack of sleep became hazardous, as portrayed in his journal:

> My eyes feel dry and hard as stones. The lids pull down with pounds of weight against their muscles. Keeping them open is like holding arms outstretched without support. After a minute or two of effort, I have to let them close. Then, I press them tightly together, forcing my mind to think about what I'm doing so I won't forget to open them again; trying not to move stick or rudder, so the plane will still be flying level and on course when I lift them heavily. (Lindbergh, 1953, p. 233)

**Continental Express - Pine Bluff, Arkansas**

On April 29, 1993, a Continental Express Brasilia (30 passenger turboprop aircraft) entered a stall and lost approximately 12,000 feet of altitude before the flight crew was able to regain control. The aircraft experienced a descent rate in excess of 17,000 feet per minute (fpm), roll angles in excess of 90 degrees, and suffered extensive damage to the left engine. The crew
executed a forced landing at Pine Bluff, Arkansas; they were unable to stop the aircraft on the runway. Twelve passengers and one crewmember received minor injuries. The NTSB report (1994a) stated that “contributing to the accident was fatigue induced by the flight crew’s failure to properly manage provided rest periods” (p. 31).

The crew had been assigned a 3 day sequence with a report time on day 1 of 1328. They were on duty until 2246 and then began a reduced rest period of approximately 8 hours. The Captain received approximately 6 hours of sleep and the First Officer received approximately 4 1/2 hours of sleep, during this first rest period. They were not provided with a sufficient amount of time to receive adequate rest (NTSB, 1994a, pp. 9-11).

The second day was relatively short with a duty period from 0650 to 1130, followed by an 18 hour rest period. The Captain and the First Officer received approximately 4 1/2 hours of sleep, during this second rest period. They were provided with a sufficient amount of time to receive adequate rest, “however they did not take advantage of this opportunity” (NTSB, 1994a, p. 27). It is unclear whether the crew chose to sleep such a short period of time, or were unable to sleep due to internal factors (e.g. circadian disruption) or external factors (e.g. noisy hotel).

The crew reported for duty at 0530 on the 3rd day and had been on duty for approximately 10 hours at the time of this accident. The Captain stated that “the workload was slightly heavier on the last day due to having seven legs to fly in [Instrument Meteorological Conditions] IMC” (NTSB, 1994a, p.27). The accident occurred on the crew’s seventh leg, in the late afternoon, during one of the periods typically associated with low levels of performance and alertness. The NTSB stated that “the combined effects of cumulatively limited sleep, a
demanding day of flying, and a time of day associated with fatigue had an effect on crew performance” (p. 27).

American International Airways - Guantanamo Bay, Cuba

On August 18, 1993, at 1654 Eastern Daylight Time, a DC-8 operated by American International Airways (AIA) crashed 1/4 mile short of the runway, after the Captain lost control of the airplane while on approach to the U.S. Naval Air Station at Guantanamo Bay, Cuba. The airplane was destroyed by the impact and subsequent fire, however the crew miraculously survived to tell their story. A photograph of the wreckage is provided in Appendix A. This was the first aircraft accident in which the NTSB cited crew fatigue as the probable cause in their report. Therefore, the researcher has reviewed this accident in detail (NTSB, 1994b).

Several airports are included in the discussion of this accident. A decoding of their respective three-letter airport codes is as follows:

<table>
<thead>
<tr>
<th>Code</th>
<th>City, State</th>
</tr>
</thead>
<tbody>
<tr>
<td>ATL</td>
<td>Atlanta, GA</td>
</tr>
<tr>
<td>CLT</td>
<td>Charlotte, NC</td>
</tr>
<tr>
<td>DFW</td>
<td>Dallas/Ft. Worth, TX</td>
</tr>
<tr>
<td>NGU</td>
<td>Norfolk, VA</td>
</tr>
<tr>
<td>UGM</td>
<td>Guantanamo Bay, Cuba</td>
</tr>
<tr>
<td>YIP</td>
<td>Ypsilanti, MI</td>
</tr>
</tbody>
</table>

The crew had been assigned a four day sequence beginning at ATL on August 16. They were on duty for 13 hours the first night (from 2300 to 1200 noon the following day). This duty period included four flights (ATL-CLT-YIP-STL-DFW), and a total of 5.6 hours of flight time. They were released from duty at 1200, and were provided hotel rooms near the DFW Airport. Their next duty period was scheduled to begin 11 hours later, at 2300 (NTSB, 1994b).

The Captain went to bed immediately upon arrival at his hotel room at 1300, and slept until 1800. He then arose, jogged, showered, had dinner, and reported for duty. The First Officer and Flight Engineer had breakfast prior to
going to sleep, some time after 1300, and received 8 hours and 6 hours of sleep respectively, prior to reporting for duty that night at 2300 (NTSB, 1994b).

They departed DFW at midnight and arrived at YIP at 0325. They had coffee and doughnuts while waiting for their next departure. They departed YIP at 0620 and arrived in ATL at 0752. They were scheduled to be on a rest period in ATL until 2300, however due to mechanical problems on another one of the carrier’s DC-8s, the crew was reassigned to continue on from ATL-NGU-UGM-ATL (NTSB, 1994b).

The crewmembers discussed their reassignment, and although they knew it would be a long day, and might be “pushing the edge” (approximately 24 hours on duty and 12 hours of flight time), they realized it was a legal assignment according to the FARs. The First Officer stated in his post-accident interview that his knowledge of previous company actions regarding crewmembers refusing trips, deterred him from refusing this trip. Several former AIA pilots expressed their concerns about AIA crew scheduling practices, in testimony given to the NTSB after this accident. One pilot had witnessed a crew being subjected to intimidation by AIA management, after the crew had refused to fly a trip at the end of a long duty day (NTSB, 1994b).

The AIA Chief Executive Officer was interviewed by the NTSB after the accident. He said that the company must often assign long duty times and “work everything right to the edge” of what is allowed by the FARs, in order to remain competitive. He indicated that this practice is “common” in the industry. He went on to say that “good” pilots are recognized for “pulling for the company” through support of company requirements, and that these good pilots are upgraded to the position of Captain, out of seniority (NTSB, 1994b, pp. 63-64).
The crew elected to accept the reassignment and departed ATL at 1010 and arrived at NGU at 1140 (NTSB, 1994b). The flight from ATL to NGU was operated under FAR 121.505. This regulation limits flight and duty time to 8 and 16 hours respectively, in any 24 consecutive hours.

The crew departed NGU approximately 2 1/2 hours later, at 1413 and arrived in the Guantanamo Bay airspace at approximately 1630 (after being on duty for more than 16 hours). The flight from NGU to UGM was operated under FAR 121.521 (because UGM is an international destination). Flight crewmembers flying under this regulation may be placed on duty for 144 continuous hours, without a rest period. According to the AIA chief crew scheduler, the carrier does have an unwritten, in-house policy of not assigning a crew to more than 24 consecutive hours of duty. The Captain and AIA’s Principal Operations Inspector (POI) both testified that 24 hour duty periods are not uncommon at AIA (NTSB, 1994b). Flight time is limited by FAR 121.521 to a maximum of 12 hours in any 24 consecutive hours; 20 hours in any 48 consecutive hours; and 24 hours in any 72 consecutive hours.

The Captain was the flying pilot for the flight from NGU to UGM. The crew initially requested runway 28, however the Captain made a decision to try the approach to runway 10 (this approach requires a close-in right base, and a short final approach because of the close proximity of the prohibited Cuban airspace) (NTSB, 1994b). The Cockpit Voice Recorder (CVR) transcript of the conversation between the crewmembers is provided in Appendix B.

The Captain simply got too slow with a steep bank, and stalled the aircraft. A 20,000 hour pilot, with a very experienced crew, was so fatigued that he stalled and crashed a “perfectly good airplane.” The NTSB stated that “the substandard performance by an experienced pilot may have reflected the
debilitating influences from fatigue” (NTSB, 1994b, pp.59-60). The Captain demonstrated a level of performance well below that which is usually expected from a Captain with his level of experience. However, there is nothing in the Captain’s aviation records that would suggest he is a substandard pilot. In fact there were several sources which confirmed the Captain’s superior airmanship skills.

At the NTSB post-accident hearing, the Captain was asked how he felt just prior to the accident. His response was:

All I can say is that I was -- I felt very lethargic or indifferent. I remember making the turn from the base to the final, but I don’t remember trying to look for the airport or adding power or decreasing power. . . . I don’t recall the engineer talking about the airspeeds at all. So it’s very frustrating and disconcerting at night to try to lay there and think of how. . . you could be so lethargic when so many things were going on, but that’s just the way it was. (NTSB, 1994b, p.60)

The crew would have flown another leg from Guantanamo Bay back to Atlanta, if not for the accident. The flight from UGM to ATL would have been operated under FAR 91, which currently has no limitation on flight or duty time. This final leg is referred to as a “tail end ferry” because it occurs at the end of an FAR 121 revenue flight (or sequence of flights). Tail end ferry flights are typically a means of repositioning the airplane back to the home base, or placing it in position for the next revenue flight. The manager of the FAA Air Carrier Branch testified at the NTSB hearing after the AIA accident. He stated:

. . . the most immediate concern of the FAA is the other commercial flying loophole that exists in the supplemental rules that permits these post Part 121 ferry flights to be conducted under Part 91. We need to close that loophole. . . We are also concerned about the clarity and the possible ambiguity of certain requirements in the supplemental rules. (NTSB, 1994b, p. 45)
The probable causes of this accident as determined by the NTSB were:

the impaired judgment, decision-making, and flying abilities of the
captain and flight crew due to the effects of fatigue. . . . Additional factors
contributing to the cause were the inadequacy of the flight and duty time
regulations applied to 14 CFR, Part 121, Supplemental Air Carrier,
international operations, and the circumstances that resulted in the
extended flight/duty hours and fatigue of the flight crewmembers. . . .
(NTSB, 1994b, p. 78)

The limitations of human physiology regarding sleep, circadian rhythms,
and fatigue were all key factors in the AIA accident. The crewmembers were
highly motivated, experienced professionals. Their performance was limited by
physiological capabilities, and was not a reflection of their training, experience,
or motivation.

Northwest Airlines - Guantanamo Bay, Cuba

There was another fatigue related incident at Guantanamo Bay, less than
two months after the AIA accident. On October 18, 1993, the right main landing
gear of a Northwest Airlines DC-10 struck a runway edge light, while landing on
runway 10. Crew scheduling had called the Captain at 2330, on October 17,
and assigned him this trip with a report time of 0210 on October 18. The
Captain said that he “only managed to receive about one hour of rest before
leaving for the airport after being awake all day” (NTSB, 1994b, p. 41).

Impact of Fatigue on Pilot Performance

The greatest fear that pilots may have regarding fatigue is that of falling
asleep at the controls. However, most pilots recognize that there are many less
extreme effects of fatigue that may have an equally serious impact on flight
safety (Graeber, 1988).
The International Civil Aviation Organization (ICAO) recognizes that the initial demonstration of proficiency and the continuation of recurrent training and checkrides helps to ensure that flight crewmembers maintain a high level of competence. However they also recognize that:

the effectiveness with which this competence is available for use depends upon each crewmember being sufficiently will rested to utilize his capabilities efficiently. Otherwise he may not respond to the degree that his proficiency should ensure, but may make errors of judgment or action such as are associated with much lower degrees of proficiency than he has attained. This effect can be aggravated by various combinations of unfavourable operational circumstances, but the continuation of any task long enough under even the most favourable circumstances will ultimately produce fatigue and consequent loss of efficiency. (ICAO, 1984, p. 1)

Individuals that have been subjected to sleep deprivation in controlled laboratory studies “demonstrate poorer performance despite increased effort, and may report indifference regarding the outcome of their performance” (NTSB, 1994, p.47). Therefore the AIA Captain’s report of feeling “very lethargic or indifferent” is typical for an individual who has experienced sleep deprivation or circadian disruption.

The degree of impact of fatigue on pilot performance is determined by at least three core physiological factors. Accident investigators typically examine these factors for evidence related to fatigue:

1. Cumulative sleep loss: It has been established in scientific literature that people typically require 6 to 10 hours of sleep each day to be fully alert. There is evidence which suggests that a loss of just 2 hours of sleep can lead to a significant degradation of alertness and performance.

2. Continuous hours of wakefulness: A safety study was conducted by the NTSB on flight crew-involved, major accidents of U.S. Air Carriers for the period from 1978 through 1990. This study determined that pilots made more
procedural and tactical decision errors after elevated periods of wakefulness (NTSB, 1994b).

3. Circadian disruption (Time of day): As previously mentioned, the body is primed to sleep during the period from 0300 to 0500 and again from 1500 to 1700. An individual who remains awake during these periods may experience a decreased level of alertness and performance. Circadian disruption may be defined as a failure to sleep during these periods, or an effort to sleep outside of these periods.

Therefore the greatest impact of fatigue on pilot performance “would be expected when an individual carrying a substantial sleep debt is required to operate for an extended period of continuous wakefulness, and the time of the operation passes through a period of increased sleepiness” (NTSB, 1994b, p. 48).

The AIA crew’s performance was degraded by fatigue, as indicated by the following:

1. Impaired decision-making skills: The crew had established a plan to use runway 28. It has a straightforward approach procedure, that is more appropriate for large, fast aircraft. However the Captain unilaterally decided to use runway 10.

2. Fixation: The Captain made at least seven comments about the strobe light. His fixation on the strobe led to his exclusion of several sources of critical information.

3. Poor judgment: The Captain elected to use 50 degrees of flaps, despite the fact that AIA’s flight manual prohibited the use of 50 degrees of flaps (except for emergency purposes). He also elected to continue the approach
after several comments from the First Officer and Flight Engineer about their airspeed and ability to make the landing.

4. Slow reaction time: The crew should have reacted immediately to the stall warning. Their slow response to the warning was the final link in the chain leading to this accident.

5. Decreased memory and mental functioning: The crewmembers had some difficulty remembering and interpreting crossing radials, waypoints, and radio frequencies.

The Captain of the AIA DC-8 had received 7 hours of sleep in the 57 hours prior to the accident, and had been continuously awake for 23.5 hours. The First Officer had received 10 hours of sleep in the 57 hours prior to the accident, and had been continuously awake for 19 hours. The Flight Engineer had received 12 hours of sleep in the 57 hours prior to the accident, and had been continuously awake for 21 hours. Finally, the accident occurred during one of the periods of maximal sleepiness -- 1500 to 1700 (NTSB, 1994b).

The worldwide airline fleet is expected to increase nearly 60% by the year 2010. With the current accident rate, there will be a major accident every week, by the year 2010. A Boeing safety engineer has found that human error has been the primary cause of more than 80% of the accidents (Weener, 1990). Adequate pilot rest is one of the primary issues that needs to be addressed, in order to lower the accident rate and change these projections (Pasztor, 1996).

Federal Aviation Regulations

Flight time limitations and rest requirements were first established in the 1930s. These FARs placed a limit on the number of hours an airline pilot could
fly each day, week, month, and year, and also specified a minimum number of
hours of rest preceding different amounts of flight time. Sixty years later these
regulations are essentially unchanged.

FAR 135.265

This FAR applies to pilots flying aircraft with 30 seats or less, on domestic
routes. The maximum total commercial flight time for these pilots is:
1. Within any calendar year, 1200 hours.
2. Within any calendar month, 120 hours.
3. Within any seven consecutive days, 34 hours.
4. Between required rest periods, 8 hours.

The minimum required rest period (defined by the FAA as block in to block out)
prior to flight for these pilots is:
1. For less than 8 hours of scheduled flight time, 9 hours of rest (may be
   reduced to 8 hours of rest).
2. During any 7 consecutive days, a 24-hour rest period.

The maximum duty period (implied) is 16 hours.

FAR 121.471

This FAR applies to pilots flying aircraft with more than 30 seats, on
domestic routes. The maximum total commercial flight time for these pilots is:
1. Within any calendar year, 1000 hours.
2. Within any calendar month, 100 hours.
3. Within any seven consecutive days, 30 hours.
4. Between required rest periods, 8 hours.
The minimum required rest period prior to flight for these pilots is:

1. For less than 8 hours of scheduled flight time, 9 hours of rest (may be reduced to 8 hours of rest).

2. During any 7 consecutive days, a 24-hour rest period.

The maximum duty period (implied) is 16 hours.

**Development and Revision of FARs**

Testimony before the NTSB at a public hearing after the AIA accident, revealed that “the United States and France are the only countries in the world that base their aviation hours of service regulations on flight time while most other countries base it on duty time” (NTSB, 1994b, p. 66). The ICAO establishes international standards and recommended practices for the safe operation of the international aviation system, and then monitors the member States for compliance. The ICAO has noted that there is significant variation in the manner in which member States develop and issue their flight and duty time limitations and rest requirements. Some States develop and issue the regulations at the government level, while other States permit the airlines to develop the rules, and then submit them to the State for approval (ICAO, 1984).

Several attempts have been made to update and revise these regulations, however these attempts have failed because of the inappropriate strategy used by the FAA. The FAA’s strategy for developing regulatory change is based upon input from an outside advisory committee. These committees are typically unable to obtain a consensus from industry management and labor groups, and therefore the proposed changes are usually shelved. The NTSB has expressed concern that “efforts to change existing regulations by means of the committee negotiating process are ineffective” (NTSB, 1994b, p. 66).
The NTSB is also concerned with:

... the length of time without revision of the current flight/duty time regulations and the continuing slowness and difficulty of the current regulatory review process. New evidence has become available in the past 20 years on fatigue, and it increasingly substantiates that fatigue is a more pervasive and debilitating factor in transportation safety than was previously realized. The Safety Board believes that the FAA should revise the regulations pertaining to permitted flight and duty time. (NTSB, 1994b, p. 68)

The FAA issued a Notice of Proposed Rule Making (NPRM) in 1995 (NPRM 95-18). The highlights of this NPRM are provided in Appendix C. This proposal includes several revisions to the flight and duty limitations and rest requirements. The following revisions would be beneficial for the reduction of fatigue:

1. Decrease duty time limit for two pilot crew from 16 hours (implied) to 14 hours.
2. Increase normal scheduled rest period from 9 hours to 10 hours.
3. Increase weekly rest period from 24 hours to 36 hours.
4. Set maximum duty period for reserve pilots based upon time from notification to report time.
5. Include Part 91 flight time (training and ferry flights) in Part 121 limits.

Additionally, the NPRM 95-18 Appendix B lists the following revisions that would be detrimental for the reduction of fatigue:

1. Increase flight time limit for two pilot crew from 8 hours to 10 hours
2. Increase weekly flight time limit from 30 hours to 32 hours.
3. Increase annual flight time limit from 1000 hours to 1200 hours (ALPA, 1996).

As with previous NPRMs, the FAA has been unable to receive a consensus from industry management and labor groups. The latest information
available from the FAA indicates that the majority of this NPRM will not be enacted (it is possible that the provision requiring FAR Part 91 flight time to be included in FAR Part 121 limitations, will become a regulation).

The NTSB recognizes that the current flight and duty time regulations rely on the judgment and integrity of each individual pilot. The burden of refusing a trip because of fatigue is placed on the pilots, because the FARs allow the airlines to schedule their pilots well beyond many human limitations. A fatigue expert called upon to help with the investigation of the AIA accident stated that “individuals are normally poor at recognizing their own fatigue state and tend to strongly underestimate it” (NTSB, 1994b, p.64).

As previously mentioned, the CEO of AIA stated that “good” pilots were recognized for “pulling for the company” through support of company requirements, and that these “good” pilots were upgraded to the position of Captain, out of seniority (NTSB, 1994b). This type of upgrade policy places a large amount of pressure on the pilots to complete their assigned schedule, regardless of an unsafe level of fatigue.

The NTSB addressed this issue after the AIA accident as follows:

Given the pressures of the actual commercial environment, it does not seem realistic to rely on the crew’s self assessment and willingness to confront company pressures as a safety mechanism to prevent the assignment of tired crews. The FARs set the baseline of what is permitted legally in hours of service, and competitive pressures make it likely that air carriers will operate at or near the baseline to maximize crew utilization and company profits. The Safety Board is concerned that companies are unlikely to voluntarily change their policies, or that individual crewmembers will take an aggressive position in the determination of fatigue limits; rather, it will require regulation to enact change to prevent the recurrence of this type of accident. (NTSB, 1994b, pp. 64-65)
Flight Crew Work and Rest Scheduling

A pairing or sequence is a pilot’s schedule as published by the airline’s crew scheduling department, however the Time Available for Rest (TAR) has been derived by the author as depicted in Table 1. The author’s TAR is similar to that utilized by Weitzel (1997).

Table 1
Time Available for Rest (TAR)

<table>
<thead>
<tr>
<th>Activity</th>
<th>Layover City</th>
<th>Home Base</th>
</tr>
</thead>
<tbody>
<tr>
<td>Postflight duties</td>
<td>:15</td>
<td>:15</td>
</tr>
<tr>
<td>Transfer time (Airport to Hotel/Home)</td>
<td>:30</td>
<td>1:00</td>
</tr>
<tr>
<td>Personal hygiene and a meal (before sleep)</td>
<td>:45</td>
<td>:45</td>
</tr>
<tr>
<td>Personal hygiene and a meal (after sleep)</td>
<td>:45</td>
<td>:45</td>
</tr>
<tr>
<td>Transfer time (Hotel/Home to Airport)</td>
<td>:30</td>
<td>1:00</td>
</tr>
<tr>
<td>Preflight duties</td>
<td>1:00</td>
<td>1:00</td>
</tr>
<tr>
<td>Subtract from total layover to derive TAR</td>
<td>3:45</td>
<td>4:45</td>
</tr>
</tbody>
</table>

This study will examine two examples of regional airline pairings. The following details are provided to help facilitate the interpretation of the pairings:

1. Departure and Arrival times are provided in local time.
2. Block is the time scheduled from gate to gate.
3. Duty is the time from one hour before the first departure to 15 minutes after the last arrival (of that particular duty period).
4. Individual duty periods are separated by a solid line.
5. TAR is the time available for rest (derived by subtracting 3:45 from the total time at the layover city or 4:45 from the total time at the pilot’s home base)
6. TARs within brackets are not part of a legal rest period, however they are shown as time for potential napping.
7. A decoding of the respective three-letter airport codes is as follows:

<table>
<thead>
<tr>
<th>Code</th>
<th>City, State</th>
</tr>
</thead>
<tbody>
<tr>
<td>ABE</td>
<td>Allentown, PA</td>
</tr>
<tr>
<td>ACY</td>
<td>Atlantic City, NJ</td>
</tr>
<tr>
<td>CLE</td>
<td>Cleveland, OH</td>
</tr>
<tr>
<td>DCA</td>
<td>Washington, DC</td>
</tr>
<tr>
<td>JFK</td>
<td>New York, NY</td>
</tr>
<tr>
<td>LNS</td>
<td>Lancaster, PA</td>
</tr>
<tr>
<td>PHL</td>
<td>Philadelphia, PA</td>
</tr>
<tr>
<td>RDG</td>
<td>Reading, PA</td>
</tr>
</tbody>
</table>

Continuous Duty Overnight (CDO)

Continuous duty overnights are a very common scheduling technique. Some major airlines schedule a small percentage of their crews for CDOs, however CDOs are much more prevalent at the regional airlines. CDOs are legal within the current FARs, however many pilots report high levels of fatigue and a decreased level of safety while flying these trips. Table 2 is an example of a flight crew pairing utilizing CDOs.

Table 2
Continuous Duty Overnight (Flight Crew Pairing)

<table>
<thead>
<tr>
<th>Day</th>
<th>From</th>
<th>To</th>
<th>Depart</th>
<th>Arrive</th>
<th>Block</th>
<th>Duty</th>
<th>TAR</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>JFK</td>
<td>CLE</td>
<td>2200</td>
<td>2355</td>
<td>1:55</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>CLE</td>
<td>JFK</td>
<td>0620</td>
<td>0810</td>
<td>1:50</td>
<td></td>
<td>[2:40]</td>
</tr>
<tr>
<td>2</td>
<td>JFK</td>
<td>DCA</td>
<td>0900</td>
<td>1005</td>
<td>1:05</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>DCA</td>
<td>JFK</td>
<td>1030</td>
<td>1135</td>
<td>1:05</td>
<td>14:50</td>
<td>5:40</td>
</tr>
<tr>
<td>2</td>
<td>JFK</td>
<td>CLE</td>
<td>2200</td>
<td>2355</td>
<td>1:55</td>
<td></td>
<td>[2:40]</td>
</tr>
<tr>
<td>3</td>
<td>CLE</td>
<td>JFK</td>
<td>0620</td>
<td>0810</td>
<td>1:50</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>JFK</td>
<td>DCA</td>
<td>0900</td>
<td>1005</td>
<td>1:05</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>DCA</td>
<td>JFK</td>
<td>1030</td>
<td>1135</td>
<td>1:05</td>
<td>14:50</td>
<td>5:40</td>
</tr>
<tr>
<td>3</td>
<td>JFK</td>
<td>CLE</td>
<td>2200</td>
<td>2355</td>
<td>1:55</td>
<td></td>
<td>[2:40]</td>
</tr>
<tr>
<td>4</td>
<td>CLE</td>
<td>JFK</td>
<td>0620</td>
<td>0810</td>
<td>1:50</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>JFK</td>
<td>DCA</td>
<td>0900</td>
<td>1005</td>
<td>1:05</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>DCA</td>
<td>JFK</td>
<td>1030</td>
<td>1135</td>
<td>1:05</td>
<td>14:50</td>
<td>?</td>
</tr>
</tbody>
</table>
The crew assigned to this sequence is scheduled to report to the airport on Day 1 at 2100 in order to complete the preflight duties associated with a 2200 departure. One leg is flown the first night, and after 15 minutes of postflight duties, and 30 minutes of transfer time (airport to hotel), the crew is generally to the hotel by 40 minutes past midnight. Allowing 45 minutes for personal hygiene and a snack, the crewmembers can usually be in bed by 0125; the result is 2:40 available for rest (TAR). The crew will have to arise at approximately 0405, to be in the hotel lobby by 0450, for transfer to the airport. The airport report time is 0520 for a 0620 departure. Scheduled flying consists of three legs, with a return to domicile at 1135. The crew is then released from duty until 2100 that day, at which point the previous sequence is repeated. Many regional pilots are domiciled at large cities, with major airline hub airports. The time required for the crew to transfer to the employee parking lot and drive home is typically 1-2 hours. Another 1-2 hours is required to reverse the process that night, leaving a maximum TAR of 5:40.

The rest period provided at night (at CLE in this pairing) is not long enough to be considered the FAR required rest period (the minimum FAR time is 8 hours). Most regional airlines do provide a hotel room for their pilots to nap during this short rest period. However, at least one regional airline has threatened to stop providing hotel rooms for crews on CDOs. Anecdotally, these pilots have been told that because the duty period is continuous (from 2100 until 1150 in this pairing), the airline has no obligation to provide a hotel room. The FAR required rest period is provided at the crew’s domicile (from 1150 until 2100 in this pairing), however as previously described, the maximum TAR is 5:40. The crew may not be able to take full advantage of this already
short time allotted for rest, either in terms of the quantity or quality of sleep, because the rest period has been provided during the day (Holley, 1974).

Some regional airline pilot groups have been able to negotiate a labor contract restriction that limits the number of CDOs to three in a row (as shown in this sample pairing). Similarly, other regional pilots are scheduled for up to five CDOs back-to-back (a sixth consecutive CDO would exceed the limitation in FAR 121.471 or FAR 135.265, which requires a 24 hour rest period during any 7 consecutive calendar days).

The regional airlines schedule continuous duty overnights for a number of reasons. One of these is an attempt to save money on hotel costs. If the same crew that flies the last flight to CLE, also flies the first flight out in the morning, then only one crew incurs layover costs in that city. Most regional airline flight crews consist of two pilots and a flight attendant; three hotel rooms are required (utilizing one crew on layover requires half the costs of two crews on layover). However, the increased payroll costs associated with CDOs may more than offset the hotel savings associated with the single crew utilization. Appendix D has been included as a descriptor of cost efficiency associated with CDOs.

The logistical issue is another reason for the existence of continuous duty overnights. The frequency of flights to a particular city and the type of aircraft used are factors. The last flight in and the first flight out may require a larger or smaller aircraft (gauge, in airline marketing terminology) than other daily flights in a city pair. Table 3 represents a typical city pair daily schedule served by different gauge aircraft.
Table 3
Service between JFK-CLE

<table>
<thead>
<tr>
<th>Flight #</th>
<th>Aircraft</th>
<th>From</th>
<th>To</th>
<th>Depart</th>
<th>Arrive</th>
<th>Block</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>EMB</td>
<td>CLE</td>
<td>JFK</td>
<td>0620</td>
<td>0810</td>
<td>1:50</td>
</tr>
<tr>
<td>2</td>
<td>BE2</td>
<td>JFK</td>
<td>CLE</td>
<td>0900</td>
<td>1055</td>
<td>1:55</td>
</tr>
<tr>
<td>3</td>
<td>BE2</td>
<td>CLE</td>
<td>JFK</td>
<td>1130</td>
<td>1320</td>
<td>1:50</td>
</tr>
<tr>
<td>4</td>
<td>BE2</td>
<td>JFK</td>
<td>CLE</td>
<td>1600</td>
<td>1755</td>
<td>1:55</td>
</tr>
<tr>
<td>5</td>
<td>BE2</td>
<td>CLE</td>
<td>JFK</td>
<td>1830</td>
<td>2020</td>
<td>1:50</td>
</tr>
<tr>
<td>6</td>
<td>EMB</td>
<td>JFK</td>
<td>CLE</td>
<td>2200</td>
<td>2355</td>
<td>1:55</td>
</tr>
</tbody>
</table>

The crew scheduling department has several options to get the crew assigned to Flight # 6 back to JFK:

1. Have them work Flight # 1 the following morning (CDO).

2. Have them deadhead on Flight # 3 or # 5 the following day (they could not work either of these flights because they are not qualified on a BE2, however this option does provide them with a legal rest period per the FARs).

3. Have them work Flight # 1 two days later (this would result in a 30:25 layover).

The option usually chosen is to assign the crew to a CDO, and have them work the first flight out the following morning. The second option is undesirable, because it requires the airline to pay the crew to ride as passengers in seats that could otherwise be sold to paying passengers. The third option is also undesirable, because the crew must remain at CLE for two nights, when they could otherwise be flying an airplane (this would double the airline’s hotel bill and increase staffing requirements).

Overnight cargo pilots routinely fly schedules very similar to the CDOs flown by regional airline pilots. A recent study of overnight cargo flight operations revealed that:
During daytime layovers, the average sleep episode was 3 hours (41%) shorter than nighttime sleeps and was rated as lighter, less restorative, and poorer overall. Sleep was frequently split into several episodes and totaled 1.2 hours less per 24 hours than on pretrip days. . . On duty days, reports of headaches increased by 400%, of congested nose by 200%, and of burning eyes by 900%. (Gander et al., 1996, p. 1)

This study demonstrated that overnight cargo operations, as with other night work such as CDOs, involve physiological disruption not experienced by pilots flying a daytime schedule.

**Multi-Day Trip**

The 4-Day trip provided in Table 4 illustrates the irregular work schedule faced by many regional airline pilots on a daily basis. As with the CDO, this pairing is legal within the current FARs, but certainly may exceed an individual’s tolerance to fatigue. The crew assigned to this trip is scheduled to report to the airport at 0530 on Day 1. The duty period is scheduled to be almost 16 hours. The crew will complete 13 flights with a total block time of 7:45. There is one break in the day (0800-1010) with sufficient time for the crew to eat a meal. The rest of the breaks are either 20 or 30 minutes, during which the crew is required to complete preflight duties.

The first duty period ends at 2120 (15 minutes after their last arrival), and the second duty period begins at 0535 (one hour prior to the first departure). This leaves a TAR of 5:45, and an FAA defined rest period of 8:15, which is known as a “reduced rest period.” The normal rest period required by FAR 121.471(b)(1) is “9 consecutive hours of rest for less than 8 hours of scheduled flight time” (FAR, 1998, p. 327). Therefore, the crew is required to receive compensatory rest as provided in paragraph (c)(1) of the same regulation which states:
a rest required under paragraph (b)(1) of this section may be scheduled for or reduced to a minimum of 8 hours if the flight crewmember is given a rest period of at least 10 hours that must begin no later than 24 hours after the commencement of the reduced rest period. (FAR, 1997, p. 327)

Table 4
4-Day Flight Crew Pairing

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The second day includes another duty period of almost 16 hours. The crew will complete 12 flights with a total block time of 7:55. There is one break in the day (0910-1120) with sufficient time for the crew to eat a meal. The second duty period ends at 2115 and the third duty period begins at 0715. This leaves a TAR of 7:30, and an FAA defined rest period of 10:00.

The third day is split into two separate duty periods. The first duty period is 3:50, including three flights with a total block time of 1:45. This duty period ends at 1050 and the final duty period begins later that evening at 1915, leaving a TAR of 4:40, and an FAA defined rest period of 8:10.

This rest period is provided during the day, which is a significant shift to the crew’s sleep schedule, and will cause circadian disruption. Also the crew just completed a rest period less than 4 hours prior to the commencement of this rest period. These factors will combine to create a very difficult environment for the crew to receive any sleep, prior to their final duty period, which is a continuous duty overnight.

The final duty period is 15:50, including eight flights with a total block time of 6:30. There is one break in the duty period (0025-0545) with sufficient time for the crew to nap. The TAR is only 1:35, however the opportunity to take a shower and eat a meal will be helpful for completing this duty period, which ends at 1105 on Day 4. Their next trip pairing can not begin until at least 2105 that night, because of the requirement for a 10 hour compensatory rest period, following the previous reduced rest period.

Flight crew schedules are typically computer generated and presently lack the flexibility to sufficiently consider natural circadian variations and personal tolerance. Hawkins asserted that flight crew schedules:
usually assume that the human is some kind of machine which can automatically obtain restorative benefit from a given number of hours off duty, regardless of when these hours are given. . . . They ignore scientific knowledge and inevitably lead to lowered performance during aircraft operation (1993, p. 79).

24-Hour Reserve Duty

Both major and regional airlines typically assign 10-20% of their pilots to reserve duty in order to maintain schedule reliability. Sick calls, pilot training, and mechanical, weather or ATC delays are reasons that a pilot on reserve may be called in to cover a trip. Some airlines have been required by their FAA POI to limit the reserve pilots “on-call” period to 15 hours per day. Other airlines are allowed to schedule their reserve pilots for 24 hour duty periods, typically for 6 consecutive days. It is unclear why the FAA has taken this position of selective enforcement (which provides a competitive advantage to those airlines permitted to schedule pilots to 24 hour duty periods, by allowing reduced staffing levels).

Several years ago, a regional airline manager questioned the FAA as to whether a pilot assigned to reserve status is on duty. The Assistant Chief Counsel at the Regulations Division of the FAA issued a legal interpretation on December 13, 1993 which states:

FAA interpretations have consistently defined “duty” as “actual work for the air carrier or the present responsibility for such should the occasion arise.” In addition, FAA interpretations have stated that a “rest period” is determined prospectively, is a continuous period of time, and is a time period during which the flight crewmember is free from all restraint by the air carrier. Accordingly, any conduct by the crewmember that constitutes “duty” may not also be considered “rest.”

Under section 121.471(b), when a crewmember reports for a flight, you must look to the preceding 24 hours to determine if the pilot had received the required 9, 10, or 11 hour rest period. Because a reserve pilot has a present responsibility to work if called, that pilot is not free from restraint
and, consequently, is not receiving the rest specified in the regulation. (FAA, 1993, p. 1)

Several of the largest regional and major airlines still have 24 hour reserve, despite this legal interpretation. These large airlines may have more power and influence with their individual POIs, than the smaller airlines that have been required to limit their reserve duty periods to 15 hours. The pilots assigned to 24 hour reserve are unable to plan their rest periods, because they have no idea when crew scheduling will call to assign them a trip. A pilot may go to sleep at 2300, and then be awakened at midnight by a telephone call from crew scheduling, for a trip with a report time of 0200, and a 16 hour duty period.

The pilots employed by airlines that limit reserve duty to 15 hour “windows” are able to plan their rest periods, because they know in advance when their rest period is scheduled. This provides the reserve pilot with an FAR required 9 hour rest period, prior to each 15 hour reserve window.

**NASA Aviation Safety Reporting System**

In 1975 the FAA and NASA executed a Memorandum of Agreement, which allows NASA to function as a third party for the receipt, processing, and analysis of Aviation Safety Reports. “This cooperative safety reporting program invites pilots, controllers, flight attendants, maintenance personnel, and other users of the National Airspace System (NAS), or any other person, to report to NASA actual or potential discrepancies and deficiencies involving the safety of aviation operations” (U.S. Department of Transportation, 1997, p. 1).

The information gathered from this program is to be used by the FAA to determine unsafe conditions, and take any necessary corrective actions. In order to enhance the uninhibited flow of information from the pilots, controllers,
etc., the FAA has agreed that unless there is a criminal offense or accident, the information gathered will not be used for enforcement purposes. The FAA has further agreed that when an FAR has been violated, and the FAA learns of the violation from a source other than a NASA ASRS report, a finding of violation may be made, however neither a civil penalty nor certificate suspension will be imposed, provided a NASA ASRS report has been submitted (along with a few other miscellaneous conditions) (U.S. Department of Transportation, 1997).

The program has proven to be very successful, as more than 70,000 reports have been submitted to NASA during the period between January 1, 1988 and March 23, 1998 (K. L. Etem, personal communication, March 23, 1998). Several excerpts from deidentified NASA ASRS reports have been provided:

We were a cabin and cockpit crew, overworked and fatigued to the point of unsafe conditions. . . . On arrival in Dallas, our Captain requested the crew (cockpit and cabin) be replaced due to fatigue, mental and physical. I called our scheduling department. Scheduler quoted from our contract that we had to stay on the plane for 1 hour, then work another 1 hour flight to Houston. I was shocked because we were at a crew base where they could replace us. We had been on duty at this point in excess of 14 intense hours, and they told us to work 2 more hours! I called scheduling back and told them that due to our exhaustion [and] fatigue we could not function in an emergency and we must be replaced. Scheduling replaced us but my cabin crew has been unduly suspended for 7 working days, approximately 2 weeks of work, for making a decision for the safety of the passengers and our own. (NASA ASRS Accession No. 110833)

Everyone is fatigued and 'burned out'. I know the FAA says it's legal to work these schedules but they are not the ones flying them. I think the duty regulations under Federal Aviation Regulations Part 135 should be changed. (NASA ASRS Accession No. 182481)

I was about to embark on the seventh leg of a trip and had been on duty for more than 12 hours. My captain called in fatigued, but I did not. I was pressured to continue because the company president had informed my Chief Pilot that because I am still on (my new hire) probation that I should be careful not to call in fatigued or sick. Although the flight from San
Francisco to San Luis Obispo was uneventful, when I arrived I felt as though I had been in a microsleep during the flight because I did not remember segments of it. I feel that the company should use probation as a means of weeding out employees who have poor performance and not as a means to pressure pilots to fly unrealistic schedules. As I am writing this I am on a trip that is two days long. The first day is normal, but my layover is 8:14 followed by a seven leg day that has a duty time of 13:22. This second day is unrealistic and I am scared that if I call in fatigued I could lose my fob. Yet I am also scared that I will be flying physically and mentally tired. (NASA ASRS Accession No. 188094)

Following a reduced rest (8 hours) after more than a 14 hour duty day, [in a twin turboprop commuter]. . . . We were both extremely fatigued and easily distracted. . . . As long as Part 135 carriers are allowed to schedule pilots to fly fatigued they will do so. Line pilots fear using the word fatigue to schedulers because they fear disciplinary action. My company’s viewpoint is that if it is legal you should be able to do it. . . . The only way any scheduling changes will occur is if the FAA changes its rest requirement policy. Right now the rest requirements are really an accident waiting to happen. (NASA ASRS Accession No. 206269)

Under certain emotional strain and stress a pilot should be able to disqualify himself from a flight without reprisal from the company or management (as would be the case in our airline). (NASA ASRS Accession No. 214452)

We were hungry, weak and had no opportunity to acquire a nutritional meal. Our judgment may have been impaired with a lack of nutritional sustenance. There are many trips where we fly a total of 8 hours or more and are on duty for 14 to 16 hours without access to a morsel of food. This, in my view, poses a serious decrement to safety. (NASA ASRS Accession No. 215225)

We desperately need more restrictive rest requirements. Our company routinely uses ‘reduced rest’ requirements to schedule pilots. There is an intimidation factor which keeps the pilots flying at low performance standards because the company is operating within FARs (barely). It is frustrating to know that with proper rest these ‘sloppy’ procedures would not occur. (NASA ASRS Accession No. 239725)

When I land, I have not eaten in 27 hours. I catch the bus to the parking lot feeling sick and fatigued (I had flown 9 hrs, 16 mins that day). . . . I complained to our Chief Pilot that we needed crew meals delivered to us. He said we should try to negotiate that in our next contract. Negotiate eating? Is this really a safe way to run an airline? The life of regional
airline pilots has us walking around like zombies most of the time. Why do we have to negotiate for basic needs such as food and sleep instead of having FARs to protect us instead of protecting company profits. (NASA ASRS Accession No. 244891)

I work for a large regional / national carrier and currently am a reserve captain. Our current working agreement has very little in the way of work rules regarding scheduling and hours of service, and thus, we are scheduled and flown to the maximum allowed by the FARs, which we all know leaves much to be desired with the reality of our circadian rhythms. Many people think that circadian rhythms only apply to long haul international pilots. However, after a number of years as both a military and commercial carrier pilot I’ve found that everyone’s body needs a routine, and radical changes can adversely affect one’s performance and ability to get adequate sleep during the supposed rest period. . . . I was far from peak performance and had there been a serious emergency the outcome may have been questionable. The FAA is mandating many items to enhance safety such as TCASII and GPWS, however, they seem to forget the most critical and complex piece of equipment on the aircraft: the pilot! (NASA ASRS Accession No. 254345)

I'm writing to describe a situation pertaining to chronic fatigue and the constant use of reduced rest by our company. . . . I was unable to perform my duties at 100 percent due to fatigue. . . . I realize continuous duty trips are a fact of life in this business. But, scheduling continuous duty trips back-to-back is dangerous and should be addressed immediately. The first day I was on duty 23 hrs 42 mins. (NASA ASRS Accession No. 254490)

We were on [the] last leg of [a] trip following a reduced rest overnight, preceded by a long day. We were tired! I believe our schedules are often too demanding and do not provide enough rest. The only reason there are not more fatigue related accidents is because of the professional and heroic job being done by pilots in this country. How can we be expected to be safe after long days and short nights? (NASA ASRS Accession No. 278642)

This was the 13th of 14 legs. . . . The longest break was 20 minutes. . . . The flights were (and are) scheduled well under actual block so we are almost always late. . . . leaving no time to even go to the bathroom. . . . I sincerely believe quick, strong and complete overhaul of the commuter pilot duty and day regulations must be implemented before more lives are lost to this absurd scheduling (all commuter airlines are guilty of it). (NASA ASRS Accession No. 287510)
I can be called on at any time during my reserve or standby status and must respond for flight duty in a timely manner, usually within 2 hours. No rest period exists. . . . The FAA has defined duty as: ‘either actual work for an air carrier or present responsibility for work should the occasion arise.’ Under this interpretation, no time during which a pilot is on reserve or standby duty could be considered ‘rest.’ Additionally, an associate FAA administrator and legal counsel are aware of those violations existing, but have elected not to take action, only to survey and evaluate the situation. Flight managers working for my carrier are aware of the rules and present interpretations regarding rest periods. They are also aware that the FAA is taking no action. These managers are promoting the violations of the FARs. Usually, a reserve or standby status is an assigned period of from 2-6 consecutive days. Normal fatigue and stress induced fatigue due to this type of assignment is unsafe. The threat of job security and loss of pay is management’s motivator. My job is in jeopardy if I elect not to fly when fatigued as a reserve or standby pilot. The public’s safety is being ignored by my carrier’s managers and the FAA. The burden to preserve safety rests totally on me alone. Our pilots continually fly fatigued with no alternative other than loss of job. (NASA ASRS Accession No. 288846)

Following reduced rest overnight (approximately 5 hours of sleep), we were cleared to taxi to Runway 25, but instead we had mistakenly thought we were cleared to taxi to Runway 7 and crossed runways 15L & 15R in the process. . . . My airline insists on continuing to schedule trips with less than 9 hours off duty for the overnight. . . . My airline’s policy is to subtract pay for fatigue calls. This makes it difficult for $20,000 a year commuter pilots to take themselves off line for being too tired. (NASA ASRS Accession No. 289721)

The commuter airlines schedule with many successive continuous duty overnights. We were on our second one following two nights of 5 hour rest. We were. . . cleared to cross runway 18R and hold short of runway 18L. I crossed runway 18R and then continued across runway 18L. . . . Fatigue was the cause and as a note I will do my third consecutive duty overnight tonight, and by the morning, I will be more fatigued than I was this morning. (NASA ASRS Accession No. 294882)

This event occurred on the second day of a 3 day trip with more than 21 legs, and three 12 hour duty days. I’m also a reserve pilot and have no opportunity to establish a diurnal cycle. I was very tired and probably should not have been in an airplane, but this is considered normal in the commuter airlines. . . . We failed to turn on course. . . . and failed to level off at 8000 feet. . . . I feel reduced rest and no diurnal cycle contributed to this event. (NASA ASRS Accession No. 296219).
We had been on a continuous duty overnight and had slept maybe 4 hours. We were not as alert as we would have been had we slept all night. I feel reduced rest and continuous duty overnights should be eliminated. . . . (NASA ASRS Accession No. 296275)

We were towards the end of a long 2 day trip that we ended up blocking with over 18 hours of flight time. . . . the crew was fatigued from an excessively high amount of flying coupled with a reduced rest overnight. (NASA ASRS Accession No. 299039)

We currently fly continuous duty overnights. . . . then in the same month. . . report and fly day trips. Your body has no time to adjust, and you end up flying half asleep, or getting disciplinary action if you call in fatigued. There should be a law against a mix of all night trips and then all day trips in the same month. It is not safe because the body has no time to adjust its sleep cycle. Rest regulations that would take into consideration human factors such as circadian rhythms, and sleep cycles would be a lot safer. . . (NASA ASRS Accession No. 303127)

First day is 14 hours of duty, nine legs. . . . After 9 hours of what the regs call ‘rest’ . . . I was tired. It is difficult for a crewmember to determine fatigue. No doubt had I taken a check ride late in the first day, my performance would not have been all I was normally capable of. However, considering the repercussions of declaring myself fatigued, I am not likely to do so. . . . A pilot who calls fatigue often does receive ‘special attention’ from management. The current duty regs are a farce. Duty time of 15 hours increasable to 16 is outrageous. Reduced rests which can be scheduled ahead of time are ludicrous. . . . One needs 9 hours in the hotel room or at home. Basically, one needs to limit duty to 12 hours a day. I can usually do trips like described at the beginning of this report, but only because I am quite experienced in the aircraft and am senior enough to bid enough days off to recuperate between trips. (NASA ASRS Accession No. 306039)

We had extreme fatigue. The Captain had received a very late night phone call which caused him to get only 3 hours of sleep the previous night. The First Officer had received 4 hours of sleep the night before due to people in the adjacent room making noise all night. (NASA ASRS Accession No. 326033)

I was awakened by the workers cutting the lawn outside my building. . . . I got 4 hours of sleep that day, none of it continuous. I have never missed a day of work for any reason. Now I believe that it may be better to miss work than to be so tired as to not know what’s going on around me. (NASA ASRS Accession No. 339548)
I was so tired and it was so calm I just fell asleep. I estimate I slept for about 150 miles. The main factors that contributed to my sleepiness were flying when I would normally be asleep and having to stand around for hours while my plane was being worked on. . . (NASA ASRS Accession No. 346351)

This was our third continuous duty overnight in a row. We got about 4 1/2 hours of sleep the night before and that was interrupted in the middle of the night by a call from maintenance concerning a maintenance problem with the aircraft. . . (NASA ASRS Accession No. 351500)

I departed from a parallel taxiway instead of the runway. I never thought I could ever do such a stupid, unsafe maneuver -- I'm a professional! Leading factor: fatigue. . . We had already been up past 24 hours even though technically we were legal as far as duty time goes. (NASA ASRS Accession No. 356913)

My purpose for this report [is] a look at the human performance considerations. Consider the following: I have no autopilot on the BA3200. All flying is manual. No yaw damper, in moderate turbulence. . . aircraft yaws so much that you are exhausted once reaching destination. No flight attendant. Presence of a flight attendant assures me that at least the passengers are being taken care of and are seated with seat belts on. Many of the BA3200s have poorly maintained pressurization systems and must operate manually. . . adding to workload. . . . Schedules are sometimes very unsafe. Example: 15.2 hours of duty, 9.2 hours block (legal due to weather delay), 5.9 hours of which were hard IFR in icing. I realize that all of this is legal but it just doesn't make it safe. As a professional pilot I always desire and strive for standardization and good judgment. Fatigue insidiously destroys both. I readily admit that I did not call in fatigued when I should have. But since there is little policy to protect flight crews from losing our jobs from just one call-in, I feel almost no choice but to complete the trip. (NASA ASRS Accession No. 360184)

I am filling out this form not because of something that happened, but rather because of a potential disaster. I am very concerned of pilot fatigue, not only for myself, but of my fellow pilots and my passengers. As a commuter airline pilot, we are expected to fly, and the schedules are written to the point of maximum physical capabilities. . . . We are constantly putting in 8 or more hours of flight time and working 16 hour shifts a day. Somehow, this is legal. Working 16 hours a day is twice that of the normal 9-5 job. How can the FAA feel this is safe? We are responsible for many lives, yet we are allowed to work longer hours than truck drivers! At the end of a 16 hour shift, and 8 hours of flying, my mind
is mentally fatigued and my motor skills and reflex abilities, as well as
decision making abilities, all suffer. My last leg the other night of a 15
hour shift resulted in setting off the terrain alert on the GPWS and stall
warning horn on landing. I thought to myself, 'I should not be flying.' The
FAA needs to change these regulations to lower the maximum time on
duty. Certain airlines, such as the one I fly for, stretch these regulations
to maximum when creating the schedule, rather than creating safe
schedules. (NASA ASRS Accession No. 371453)

The preceding excerpts were extracted from safety reports that were
voluntarily submitted to NASA. Therefore it cannot be assumed that these
statements represent an unbiased perspective of the considered issues.
Nevertheless, the high frequency of reports that mention CDOs, reduced rest,
and inadequate FARs as causes of fatigue, indicate that these are recurrent
trouble spots. "In spite of limitations in the system for some kinds of research,
incident reports are extremely informative with respect to locating problem
areas in specific parts of the aviation system" (Kanki & Palmer, 1993, p. 104).
CHAPTER III
METHODS AND PROCEDURES

This descriptive study was conducted during a 7 month period beginning with the Winter of 1998 and ending during the Summer of the same year. A field study was conducted in January of 1998, primarily to gain feedback for the purpose of developing and improving the instrument. A 55% return rate was somewhat disappointing, however the subjects chosen for the field study were all graduate students with little or no experience in the regional airline industry, and therefore may not have had much interest in the topic of pilot fatigue in the regional airline industry. A higher return rate was anticipated from the subjects chosen for the actual study, who were all active regional airline pilots. (The field study cover letter and questionnaire in its entirety, is Appendix E of this text.)

Methods

The results of the January 1998 field study were reported and a decision was made to continue with the study by having a panel of experts review the instrument. The panel was chosen based upon their expertise concerning safety and human factors within the aviation industry. Three experts (Don Hunt of Embry-Riddle Aeronautical University, John Young of Purdue University, and John Piercy of a large U.S. regional airline) agreed to review the instrument for content validity and were also invited to make recommendations on the format, style, clarity, and conciseness. The expert interpretations of the survey items were important because “if experts read something into an item [that the
researcher did not plan to include, subjects completing a final scale might do likewise" (DeVellis, 1991, p.75).

The Instrument

Clarity and conciseness have an impact on reliability “because an ambiguous or otherwise unclear item, to a greater degree than a clear item can reflect factors extraneous to the latent variable” (DeVellis, 1991, p.75). The expert reviewers pointed out several items with problematic wording, and also pointed out “ways of tapping the phenomenon that [the researcher had] failed to include” (p.76). Based upon the input from the panel of experts, several modifications were made to the instrument. Four of the Likert scale items were modified for clarity, and another item was added concerning reserve duty. The demographic items, numbers 12-16, were left unchanged; and two of the remaining questions were modified for clarity. The four page format was left unchanged.

The research questions addressed in this study asked: Within the U.S. regional airline industry: (a)What are the causes of pilot fatigue? and (b) What is the impact of fatigue on pilot performance? The instrument contained several potential causes of pilot fatigue and provided the subject with the opportunity (using a five point Likert scale; “strongly disagree=1”, “disagree=2”, “undecided=3”, “agree=4”, and “strongly agree=5”) to address these potential causes. The subjects were able to address the impact of fatigue on pilot performance in several of the Likert scale items. The subjects also had the opportunity to estimate the number and severity of fatigue-related errors which they had made in their previous 80 hours and 500 hours of flight time. The cover letter and instrument in its entirety, is Appendix F of this text.
Subjects

The determination of the causes of pilot fatigue and the impact of fatigue on pilot performance within the regional airline industry was partially accomplished by a self-administered survey of three groups of U.S. regional air carrier line pilots. There are approximately 30 regional air carriers in the U.S. which fly aircraft having between 19-70 passenger seats. These regional air carriers employ more than 13,000 pilots, with approximately half of these being Captains and half being First Officers. Three regional airlines (groups) were chosen as a representative sample of the regional air carriers. The total number of subjects chosen to represent the three groups of U.S. regional air carrier pilots was 150: (a) 50 line pilots from Airline #1, (b) 50 line pilots from Airline #2, and (c) 50 line pilots from Airline #3.

Members of NASA’s Fatigue Countermeasures Program are currently conducting a research study to identify and quantify the factors that may contribute to fatigue, sleep, and circadian disruption in regional air carrier operations. Their subjects include regional airline pilots, as well as management personnel, and crew schedulers. The ultimate goal of NASA’s study is similar to this study, which is to use the results to make recommendations that may help to minimize the fatigue, sleep loss, and circadian disruption experienced by regional airline pilots. (NASA Fatigue Countermeasures Program, 1998)

Procedures

The three regional air carriers were somewhat randomly chosen from three different regions of the U.S. For bias control, the researcher’s previous regional air carrier employers were not chosen for this study. One pilot was
selected from each of the three chosen regional air carriers to distribute the survey packets.

The survey packets were completed during the third week of March 1998. Each packet consisted of a cover letter, one instrument, and a self-addressed, stamped envelope for the return of the completed instrument. The 150 packets were divided evenly into three boxes and express-mailed from Florida to the home address of each selected pilot at the three chosen regional air carriers. During the first week of April 1998 the researcher confirmed that the three selected pilots had distributed their respective 50 survey packets (25 to Captains and 25 to First Officers). The cover letters enclosed with each packet included a request for the subjects to return the completed survey by April 30, 1998.

The majority of the instruments were received by the researcher during the last two weeks of April 1998. However, perhaps due to the Easter holiday and the IRS imposed tax return deadline, completed instruments continued to be received until the second week of May 1998. The researcher was able to distinguish the returned instruments according to group by observing the postmark on the return envelope (the groups were in three distinct regions of the U.S.). The final return rates were as follows: (a) The pilots at the first airline returned 26 of 50 = 52%; (b) the pilots at the second airline returned 24 of 50 = 48%; and (c) the pilots at the third airline returned 29 of 50 = 58%. The total return rate was 79 of 150 = 52.7%.

The following chapter of this text, the Analysis of Data, addresses both the quantitative and qualitative results of the research. The researcher's initial consideration of the appropriate treatment of the quantitative data included the use of factor analysis. However, it was determined that the number of variables
to be considered was too small for the use of factor analysis (Kachigan, 1991; Tabachnick & Fidell, 1996).

The quantitative data (with the exception of the demographic items) was determined to be ordinal data; therefore, the data was treated with nonparametric statistics. Specifically, the powerful Kolmogorov-Smirnov goodness of fit test and the Spearman’s rank order correlation test were utilized, in order to avoid being wasteful of information (Siegel, 1956).

In addition to the quantitative data gathered by the instrument in support of the causes of pilot fatigue and the impact on pilot performance within the regional airline industry, “a set of qualitative remarks (data) have been collected from the comments sections of the instruments” (Weitzel, 1997, p. 69). These qualitative remarks are included in Chapter IV.
CHAPTER IV
ANALYSIS OF DATA

The final quantitative data set totaled 79 cases from the three groups (26 from Airline #1, 24 from Airline #2, and 29 from Airline #3) with 31 variables (including three variables derived by the researcher, as discussed later in this chapter). The data was analyzed with the Statistical Package for the Social Sciences (SPSS) in a personal computer.

The cover letter included with the instrument instructed the subjects to feel free to skip any question that they would rather not answer. This statement was included because of the sensitive nature of several of the items which dealt with errors committed by the subjects and violation of the FARs. This resulted in 68 of 2449 = 2.8%, missing values within the data set. The cases which had variables with missing values have been omitted (listwise deletion) during specific data analyses.

The instrument (see appendix F) included three types of questions to be answered by the subject, followed by a full page for qualitative comments. The first was a set of 11 items that sought the opinions of the subjects on a five-point Likert scale. These 11 scale questions addressed some causes of pilot fatigue and the impact of fatigue on pilot performance. The second was a set of five demographic questions. Personal questions of a subjective nature regarding human fatigue, regional airline safety, and FAR violations comprised the third and last set of twelve items.
Demographics

A summary of the demographic variables is an appropriate starting point for the analysis of the data. The dichotomous gender variable was determined to be insignificant to this study. A Vice-President of Women in Aviation has stated that females comprise 4-5% of the U.S. commercial air carrier pilot population (S. Anderson, personal communication, July 27, 1998). Females comprised only 2.5% of the total participants in this study; thus the gender variable has received very little consideration. A group means comparison of the four remaining demographic variables is depicted in Table 5 (the standard deviations have been parenthesized).

Table 5
Means Comparison of Four Demographic Variables

<table>
<thead>
<tr>
<th>Regional Airline</th>
<th>Chronological Age in Years</th>
<th>Total Flight Time Hours</th>
<th>Regional Flight Time Hours</th>
<th>Flight Deck Position</th>
</tr>
</thead>
<tbody>
<tr>
<td>Airline #1</td>
<td>29.77 (5.09)</td>
<td>3184.62 (1808.41)</td>
<td>1870.19 (1566.56)</td>
<td>16 Captains</td>
</tr>
<tr>
<td>(n=26)</td>
<td></td>
<td></td>
<td></td>
<td>10 F/Os</td>
</tr>
<tr>
<td>Airline #2</td>
<td>33.04 (6.98)</td>
<td>5791.67 (4808.14)</td>
<td>4000.00 (4133.85)</td>
<td>7 Captains</td>
</tr>
<tr>
<td>(n=24)</td>
<td></td>
<td></td>
<td></td>
<td>17 F/Os</td>
</tr>
<tr>
<td>Airline #3</td>
<td>30.97 (4.20)</td>
<td>4703.45 (1641.75)</td>
<td>2898.14 (1630.88)</td>
<td>17 Captains</td>
</tr>
<tr>
<td>(n=29)</td>
<td></td>
<td></td>
<td></td>
<td>12 F/Os</td>
</tr>
</tbody>
</table>
Group Demographic Differences

Aircraft fleet types and pilot salaries are two factors that may have contributed to several of the group differences. Airline #1 utilizes a fleet of all turboprop aircraft, in contrast to the fleets of Airlines #2 and #3, which are comprised of both turboprop and jet aircraft. Accordingly, the pilot salaries are higher at Airlines #2 and #3. Inspection and SPSS analysis of Table 5 revealed the following group demographic differences.

Chronological Age. The pilots at Airline #1 were younger than the pilots at both Airline #2 and Airline #3. This might be expected because of the larger, more complex aircraft being flown at Airline #2 and #3 (as compared to the fleet at Airline #1). The airlines which fly larger aircraft typically demand more experience, which comes with age. The range for all of the participants was “22” to “50” years of age.

Total Flight Time. A common measure of a pilot’s experience is total flight hours. The pilots at Airline #2 and Airline #3 have significantly more total flight time than the pilots at Airline #1. The range for all of the participants was “900” to “17,800” hours of flight time.

Regional Flight Time. Regional airline pilots may fly up to 1200 hours per year according to the FARs. They typically fly somewhat less, with 1000 hours per year being common. The pilots at Airline #2 and Airline #3 have significantly more regional airline flight hours than the pilots at Airline #1. The range for all of the participants was “125” to “13,800” hours of regional flight time.
Flight Deck Position. The total participants included a nearly equal sample of 40 Captains and 39 First Officers. However, there is a significant difference within the group from Airline #2, with 7 Captains and 17 First Officers.

Likert Scale Items

The subjects were provided with the opportunity (using a five point Likert scale, from “strongly disagree = 1” to “strongly agree = 5”) to address potential causes of fatigue. The subjects were also requested to address the impact of fatigue on pilot performance in several of the Likert scale items.

Item 1

The researcher began this study with the belief that fatigue negatively impacts pilot performance. The participants agreed with this belief as reflected by the high mean responses from all three airlines, presented in Figure 1.

![Figure 1](image)

**Figure 1.** Fatigue has a negative impact on pilot performance.
Item 2

Human errors made by pilots on the flight deck are one manifestation of fatigue induced performance degradation. Therefore, this item was closely related to the first item, and the participant's responses were once again very high, as revealed in Figure 2. The item did not specify the severity of human errors on the flight deck, which can range anywhere from a missed radio call to stalling the airplane (as was the case in the AIA and Continental Express accidents).

Figure 2. Fatigue is a contributing factor to human errors on the flight deck.
Item 3

This item allowed the participants to expand on their view of human errors on the flight deck by relating pilot errors to regional airline safety. The mean response from each group was consistently somewhere between "agree" and "strongly agree," as displayed in Figure 3.

Figure 3. Fatigue-related human errors result in a decreased level of regional airline safety.
Item 4

This item provided the opportunity for the participants to express their opinion about the relationship between fatigue-related human errors and FAR violations. Some typical FAR violations include non-compliance with a clearance from Air Traffic Control (altitude, heading, or speed assignment), descent below decision height or minimum descent altitude during an instrument approach, and flight into restricted or prohibited airspace. The mean response was between "agree" and "strongly agree," and was consistent from all three groups, as shown in Figure 4.

Figure 4. Fatigue-related human errors have led to violations of FARs.
Item 5

Most regional airlines utilize the FARs pertaining to flight time limitations and rest requirements as limitations for their pilot schedules. Some regional airline pilot groups have been able to negotiate more restrictive limitations. The participants were asked if the existing FARs were adequate for the prevention of fatigue. The average response for group #1 was "disagree," while group #2 and group #3 scored between "disagree" and "strongly disagree," as presented in Figure 5.

Figure 5. The existing FARs pertaining to flight time limitations and rest requirements, provide adequate rest for the prevention of fatigue.
The researcher began this study with the belief that Continuous Duty Overnights create a great challenge to human limitations. When asked if Continuous Duty Overnights cause a high level of fatigue and a decreased level of safety, the participants agreed with the researcher’s belief. The average response from all three groups was between “agree” and “strongly agree,” as displayed in Figure 6.

Figure 6. Continuous Duty Overnights (Stand-ups, High-speeds) cause a high level of fatigue, and a decreased level of safety.
Item 7

Many regional airlines schedule their pilots for trips with "reduced rest" layovers. These rest periods are less than the normal length of time specified by the FARs. The participants were asked if reduced rest layovers cause a high level of fatigue and a decreased level of safety. Reduced rest is a "hot" issue with many regional airline pilots, and this is apparent from the average response from group #1 and group #2 between "agree" and "strongly agree," and from group #3, "agree," as shown in Figure 7.

Figure 7. Trips scheduled with "reduced rest" cause a high level of fatigue, and a decreased level of safety.
Item 8

Some regional airlines schedule their pilots for more than twelve departures and arrivals per day. The pilot's workload is higher in a terminal environment than it is at cruise, and this higher workload requires greater focus and concentration by the pilots. The participants consistently agreed with the statement "departures and arrivals demand intense concentration, and contribute to an increased level of fatigue," as presented in Figure 8.

**Figure 8.** Departures and arrivals demand intense concentration, and contribute to an increased level of fatigue.
Item 9

This item was modeled after the duty limitations and rest requirements observed by some countries other than the U.S. An increased rest period may help to overcome the fatigue associated with a duty day that includes a large number of departures and arrivals. The average response to the proposal for an increased rest period before and after a duty day with six or more departures and arrivals, was consistently between “undecided” and “agree,” as shown in Figure 9.

![Figure 9](image)

**Figure 9.** Duty days that include six or more departures and arrivals, should be preceded, and followed by a rest period two hours longer than normal.
Item 10

The FAR interpretation provided by the Assistant Chief Counsel at the Regulations Division of the FAA is in agreement with the statement that reserve duty is not rest. A rest period must be determined prospectively, and is a time period during which the flight crewmember is free from all restraint by the air carrier. The participants also agreed with this statement, as presented in Figure 10.

Figure 10. Reserve “duty” is not “rest”, and therefore a pilot on 24-hour reserve status has not received a rest period as required by FAR 121.471.
Item 11

Some airlines have been required by their FAA POI to limit the reserve pilots “on-call” period to 15 hours per day, while other airlines are allowed to schedule their reserve pilots for 24 hour duty periods. The pilots assigned to 24-hour reserve are unable to plan their rest periods, because they have no idea when crew scheduling will call to assign them a trip. The airlines chosen for this study either have reserve “windows” or no reserve duty at all. Therefore, the participants were unable to answer this item from current experience. The average response was consistently between “undecided” and “agree,” as shown in Figure 11.

![Figure 11](image)

Figure 11. 24-hour reserve causes a high level of fatigue, and a decreased level of safety.
Kolmogorov-Smirnov Test of Goodness of Fit

The Kolmogorov-Smirnov (K-S) test was utilized as a nonparametric test of significance. This test is similar to the chi square test in that it makes a comparison between the actual and expected (if the groups were equal) proportions observed in a study. Siegel and Castellan (1988) asserted that the "Kolmogorov-Smirnov test is more powerful in all cases than the chi-square test" (p. 151). In 1975, Ostle and Mensing also provided support for this test by stating that "since the Kolmogorov-Smirnov test is more powerful than the chi-square test, its use is to be encouraged" (p. 489).

The researcher derived three demographic variables to assist in the goodness of fit test. A chronological age variable was derived and labeled as Age: Above or Below 40 (the age of 40 years was chosen because it is the approximate midpoint of a pilot's career). A total flight time variable was derived and labeled as Flt Hours: Above or Below 5000 (the total flight time of 5000 hours was chosen because it is the approximate value at which many regional airline pilots transition to the major airlines). A regional airline flight time variable was derived and labeled as Rgl Hours: Above or Below 3000 (the regional airline flight time of 3000 hours was chosen because it is the approximate value at which many regional airline pilots transition to the major airlines). The remaining two demographic variables were analyzed without derivation.

The critical value for the K-S test is referred to as Z by SPSS. This value is synonymous with the statistic D utilized by Siegel (1988). The critical Z at alpha=.05 was determined by SPSS for each of the five demographic variables, and has been presented with the Z values for questions 1-11, in Tables 6 and 7.
Table 6
K-S Test for Questions 1-6

<table>
<thead>
<tr>
<th>Variable</th>
<th>m + n</th>
<th>Critical Z (α = .05)</th>
<th>Q_01</th>
<th>Q_02</th>
<th>Q_03</th>
<th>Q_04</th>
<th>Q_05</th>
<th>Q_06</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age: Above or Below 40</td>
<td>6+72</td>
<td>.578</td>
<td>.392</td>
<td>.458</td>
<td>.196</td>
<td>.883</td>
<td>.392</td>
<td>.261</td>
</tr>
<tr>
<td>Fit Hours: Above or Below 5000</td>
<td>25+53</td>
<td>.330</td>
<td>.205</td>
<td>.361</td>
<td>.345</td>
<td>.442</td>
<td>.743</td>
<td>.174</td>
</tr>
<tr>
<td>Rgl Hours: Above or Below 3000</td>
<td>29+49</td>
<td>.319</td>
<td>.342</td>
<td>.517</td>
<td>.201</td>
<td>1.141</td>
<td>1.048</td>
<td>.297</td>
</tr>
<tr>
<td>Flight Deck Position</td>
<td>40+38</td>
<td>.308</td>
<td>.192</td>
<td>.720</td>
<td>.436</td>
<td>.796</td>
<td>.941</td>
<td>.889</td>
</tr>
<tr>
<td>Gender</td>
<td>76+2</td>
<td>.974</td>
<td>.220</td>
<td>.257</td>
<td>.110</td>
<td>.129</td>
<td>.863</td>
<td>.147</td>
</tr>
</tbody>
</table>

Table 7
K-S Test for Questions 7-11

<table>
<thead>
<tr>
<th>Variable</th>
<th>m + n</th>
<th>Critical Z (α = .05)</th>
<th>Q_07</th>
<th>Q_08</th>
<th>Q_09</th>
<th>Q_10</th>
<th>Q_11</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age: Above or Below 40</td>
<td>6+72</td>
<td>.578</td>
<td>.686</td>
<td>.392</td>
<td>.523</td>
<td>.098</td>
<td>.163</td>
</tr>
<tr>
<td>Fit Hours: Above or Below 5000</td>
<td>25+53</td>
<td>.330</td>
<td>.743</td>
<td>.395</td>
<td>.404</td>
<td>.603</td>
<td>.376</td>
</tr>
<tr>
<td>Rgl Hours: Above or Below 3000</td>
<td>29+49</td>
<td>.319</td>
<td>.814</td>
<td>.339</td>
<td>.078</td>
<td>1.081</td>
<td>.862</td>
</tr>
<tr>
<td>Flight Deck Position</td>
<td>40+38</td>
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<td>.703</td>
<td>.500</td>
<td>.633</td>
<td>1.481</td>
<td>.743</td>
</tr>
<tr>
<td>Gender</td>
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<td>.974</td>
<td>.239</td>
<td>.294</td>
<td>.478</td>
<td>.771</td>
<td>.551</td>
</tr>
</tbody>
</table>

The K-S significance of the five dichotomous variables presented in Tables 6 and 7 is discussed in the Conclusions Chapter of this text.
Subjective Items

These self report items were conservatively treated as ordinal data. The subjects were provided with the opportunity to address personal fatigue-related issues, including sleep requirements, sleep actually achieved, and the impact of fatigue on their performance in the cockpit.

Item 17

The first subjective item addressed the personal issue of sleep normally required to be fully rested. The average response was consistent between airline #1 and airline #2, and slightly higher within airline #3, as presented in Figure 12.

![Figure 12](image)

Figure 12. How many hours of sleep do you need to be fully rested?
Item 18

This item asked the subjects to provide the average number of hours that they are able to sleep while on a nine-hour rest period provided some time between the hours of 2100 and 0900 local time. The average responses were relatively consistent between the groups as shown in Figure 13.

Figure 13. How many hours are you able to sleep (average), while on a nine-hour rest period provided between the hours of 21:00 and 09:00 (local)?
Item 19

Continuous Duty Overnights typically result in the crew's rest period being provided some time between the hours of 0900 and 2100. The number of hours of sleep reported by the participants is not surprisingly much lower during this time period, than the time period specified in the previous item. Group #2 reported a significantly lower number than group #1 and group #3, as displayed in Figure 14.

Figure 14. How many hours are you able to sleep (average), while on a nine-hour rest period provided between the hours of 0900 and 2100 (local)?
Item 20

The actual time available for rest is less than the duration of the rest period provided to the flight crew. Therefore the researcher expected the participant’s responses to this item to be significantly higher than the responses provided to item 17 (which inquired of the subject’s normal sleep requirements). This was the case, with all three groups reporting significantly higher values to this item, compared to item 17, as presented in Figure 15.

Figure 15. How many hours should the minimum rest period be, in order to allow adequate sleep for the minimization of fatigue?
Item 21(a)

This item provided the subjects with the opportunity to report the percentage of time in which they have flown fatigued during their previous 80 hours of flight time (typically a period of approximately 30 days). Fatigue is a matter of degree, and this item did not attempt to specify a certain degree of fatigue. The pilots from airline #2 reported the highest percentage as shown in Figure 16.

![Figure 16. What percentage of time have you felt fatigued during your last 80 hours of flight time?](image-url)
Item 21(b)

This item provided the subjects with the opportunity to report the number of fatigue related errors committed during their previous 80 hours of flight time. Errors are a matter of degree, and this item did not attempt to specify a certain severity of error. The pilots from airline #3 reported the highest average number, as shown in Figure 17.

![Bar Chart](Image)

**Figure 17.** How many fatigue related errors have you made during your last 80 hours of flight time?
Item 21(c)

This item was a follow-up question related to item 21(b). The researcher anticipated that many of the errors reported in item 21(b) would be minor. Therefore, this item specifies only those errors that resulted in a decreased level of safety. Group #3 reported the highest average number, as presented in Figure 18.

![Figure 18](image_url)

**Figure 18.** How many of these errors resulted in a decreased level of safety?
Item 21(d)

This item was a follow-up question related to items 21(b) and 21(c), and requested the participants to report the number of errors that led to a violation of the FARs during their previous 80 hours of flight time. The researcher realized that a question referring to FAR violations is a sensitive issue, and was not surprised that several of the participants chose to skip this particular item. The responses provided by the three groups were somewhat consistent, and are displayed in Figure 19.

![Figure 19](image)

Figure 19. How many of these errors led to a violation of the FARs?
Item 22(a)

This item provided the subjects with the opportunity to report the percentage of time in which they have flown fatigued during their previous 500 hours of flight time (typically a period of approximately 180 days). Fatigue is a matter of degree, and this item did not attempt to specify a certain degree of fatigue. The pilots from airline #2 reported the highest percentage as shown in Figure 20.

![Bar Chart]

**Figure 20.** What percentage of time have you felt fatigued during your last 500 hours of flight time?
Item 22(b)

This item provided the subjects with the opportunity to report the number of fatigue related errors committed during their previous 500 hours of flight time. Errors are a matter of degree, and this item did not attempt to specify a certain severity of error. The pilots from airline #2 reported the highest average number, as shown in Figure 21.

Figure 21. How many fatigue related errors have you made during your last 500 hours of flight time?
Item 22(c)

This item was a follow-up question related to item 22(b). The researcher anticipated that many of the errors reported in item 22(b) would be minor. Therefore, this item specifies only those errors that resulted in a decreased level of safety. Group #2 reported the highest average number, as presented in Figure 22.

![Bar chart showing average number of safety decrements last 180 days for Regional Airline, with values 9, 13, and 8 for regions 1.00, 2.00, and 3.00, respectively.]

**Figure 22.** How many of these errors resulted in a decreased level of safety?
Item 22(d)

This item was a follow-up question related to items 22(b) and 22(c), and requested the participants to report the number of errors that led to a violation of the FARs during their previous 500 hours of flight time. Once again, the researcher realized that a question referring to FAR violations is a sensitive issue, and was not surprised that several of the participants chose to skip this particular item. Group #1 reported the highest average number, as presented in Figure 23.

![Figure 23](image)

**Figure 23.** How many of these errors led to a violation of the FARs?
Subjective Data Correlations

The Spearman rank order correlation, also known as Spearman’s rho, was selected as an appropriate nonparametric statistic to identify potential correlations among the subjective data. The resultant correlation matrix is Appendix G.

Some of the correlations that were determined to be significant by the Spearman’s rho test were expected by the researcher and are not significant to this study. For example the correlations between age, experience, and flight deck position were determined by SPSS to be significant (a=.05), however they do not warrant specific consideration, and have been omitted from the correlation matrix. The net result was 15 statistically significant correlations:

1. Errors Last 30 Days - - Fatigued Last 30 Days.
2. Errors Last 30 Days - - Safety Decrements Last 30 Days.
4. FAR Violations Last 30 Days - - Minimum Rest Period.
5. FAR Violations Last 30 Days - - Safety Decrements Last 30 Days.
6. FAR Violations Last 30 Days - - Fatigued Last 30 Days.
7. Minimum Rest Period - - Safety Decrements Last 180 Days.
8. Errors Last 180 Days - - Safety Decrements Last 180 Days.
10. FAR Violations Last 180 Days - - Minimum Rest Period.
11. FAR Violations Last 180 Days - - Fatigued Last 180 Days.
12. FAR Violations Last 180 Days - - Safety Decrements Last 180 Days.
13. Fatigued Last 180 Days - - Minimum Rest Period.
15. Minimum Rest Period - - Sleep Achieved 2100-0900.
Qualitative Data

The last page of the instrument provided a space for the participant’s comments. Many of the participants chose to provide qualitative remarks. The final number of instruments which contained comments were as follows:

(a) The pilots at the first airline included comments in 10 of 26 = 39%; (b) the pilots at the second airline included comments in 11 of 24 = 46%; and (c) the pilots at the third airline included comments in 13 of 29 = 45%. The total comment rate was 34 of 79 = 43%.

In 1994, Miles and Huberman provided support for the use of qualitative data in a growing number of basic disciplines and applied fields:

Qualitative data are sexy. They are a source of well-grounded, rich descriptions and explanations of processes in identifiable local contexts. With qualitative data one can preserve chronological flow, see precisely which events led to which consequences, and derive fruitful explanations. . . . Words, especially organized into incidents or stories, have a concrete, vivid, meaningful flavor that often proves far more convincing to a reader. . . than pages of numbers. (p. 1)

Many of the comments provided by the participants were very similar to the NASA ASRS excerpts already included in Chapter II. Therefore, the researcher has provided the following selected excerpts in an attempt to avoid redundancy:

We are a 121 Flag Carrier with an exemption to operate under the duty time/flight time rules of 135.265. One level of safety has not been achieved. . . . Our rest starts not at the hotel, but calling off duty at the airport. By the time one gets to the hotel (or home) and has dinner the sleep is reduced by 30% of the scheduled rest. Also, remember that travel to & from the airport is considered rest under FAR 135. (Group 1, Case 1)

Rest periods should not be reduced. (Group 1, Case 4)
I think that the way regional airlines are allowed to schedule is insane if safety is the issue. I often fly 12 leg days with just 9 hours of rest with another 14 hour duty day following - totally unsafe! I'm exhausted, especially on the 3rd and 4th day of a series. (Group 1, Case 7)

If the commuters all had to switch to Part 121 to achieve “one level of safety,” then why are they allowed to operate under Part 135 rest requirements? (Group 1, Case 8)

... What about fatigue during initial, recurrent, or upgrade training? I still do not know how I managed to function after training until 4 or 5 AM every day, trying to sleep a couple of hours, study again, then head out to fly at 1 AM. ... There are no written rest requirements for airline training duty times! (Group 1, Case 9)

What are the effects of crewmembers who are fatigued and starving? (Group 1, Case 10)

Stand up overnights are the worst type of flying. (Group 2, Case 28)

Too tired to write comments. (Group 2, Case 29)

Maybe you should send a copy of the results to the FAA. They seem to think that because it is legal it is safe. The regional airlines use this to their advantage. (Group 2, Case 31)

Most regional airlines won’t do anything about the rest problem until an aircraft crashes or the FAA changes the rules. (Group 2, Case 32)

After the second CDO rest period, my fatigue seems to increase rapidly. By the 4th CDO in a row, I am a zombie! (Group 2, Case 33)

Fatigue is, without a doubt, a real problem at regional airlines. (Group 2, Case 36)

While on a 4 day trip during 4 days of intense weather a go-around was initiated. Confusion led to a loss of control and unusual attitude. In 13,000 hours of flying I have never “lost it.” This was completely due to fatigue [and] was in a CRJ with 50 people in back. Co-pilot took control and I thanked him later. I know my personal abilities are above average but in this case I was... dead tired. This is a very serious issue. (Group 2, Case 37)
I feel that fatigue is the single most dangerous part of the regional airline industry. The lack of adequate rest is intensified by the lack of adequate breaks for a balanced diet. It is common for us to have 10 or more hours between breaks long enough to eat a meal. (Group 3, Case 51)

Many duties magnify even minor fatigue. . . (Group 3, Case 53)

When I am fatigued, I make more mistakes. . . (Group 3, Case 54)

. . . I believe CDOs should be illegal. (Group 3, Case 57)

Fatigue is like the weather, everyone studies it and talks about it, but no one does anything about it. (Group 3, Case 59)

I think something has to be done about duty days extending beyond 14 hours. Our company makes us continue past 14 hours whenever weather or maintenance has delayed us. It's up to us to finally say "when." (Group 3, Case 60)

Rest regulations are obviously inadequate, hence the need for union contracts to address (or try to address) this problem. Inadequate rest at the regional level is unfortunately a fact of life. One that is in dire need of attention!! (Group 3, Case 61)

I feel that the number of departures/arrivals correlates to my fatigue. . . . The added mental awareness required for departures/arrivals is tiresome. . . extra rest would help out. (Group 3, Case 63)

As with the NASA ASRS reports, it cannot be assumed that these statements represent an unbiased perspective of the considered issues. Nevertheless, the high frequency of comments that mentioned CDOs, reduced rest, and inadequate FARs as causes of fatigue, indicate that these are recurrent trouble spots within the regional airline industry. The quantitative and qualitative data will be further discussed in the conclusions provided in Chapter V of this text.
 CHAPTER V

CONCLUSIONS

The original research questions, restated, are: Within the U.S. regional airline industry, (a) What are the causes of pilot fatigue? and (b) What is the impact of fatigue on pilot performance? Review of the literature and the analysis of the quantitative and qualitative data from the surveys has allowed the formulation of some answers to these research questions, which have been provided within the following conclusions:

1. The practice of scheduling pilots for trips planned with “reduced rest” (less than the normally required 9 hours), stretches human limitations and leads to pilot fatigue. “We have seen repeated instances of poor scheduling of work and rest periods in all transportation modes that have or might have affected adversely the performance of operating personnel” (NTSB, 1996, p.11). Of the participants who expressed an opinion on this subject, 96% either “agreed” or “strongly agreed” that trips scheduled with “reduced rest” cause a high level of fatigue, and a decreased level of safety. The K-S test revealed that age, flight experience, and flight deck position influenced the participant’s responses to this item. As typical covariates, these age and experience differences are not unusual within aviation (Hawkins, 1993). Visual inspection of the data indicated that 100% of the “older” (at or above 40 years of age) participants either “agreed” or “strongly agreed” with this item. This may be a reflection of the previously mentioned study conducted by the NASA Ames Research Center which found that:
age was significantly correlated with an increased number of awakenings, a higher percentage of light drowsy (i.e., restless) sleep, a lower percentage of deep (slow-wave) sleep, and lower sleep efficiency. This was particularly true for those crewmembers over 50 years of age. (The Royal Aeronautical Society, 1989, p.5.4)

The "high time" (total flight time at or above 5000 hours and/or regional airline flight time at or above 3000 hours) participants and Captains may have been more willing to admit that fatigue has an impact on their performance, than the "low time" (total flight time below 5000 hours and/or regional airline flight time below 3000 hours) participants and First Officers.

2. Continuous duty overnights are one of the primary detriments to adequate pilot rest in the regional airline industry. In response to the statement that CDOs cause a high level of fatigue, and a decreased level of safety, 90% of the participants either “agreed” or “strongly agreed.” The K-S test revealed that flight deck position influenced the participant’s response to this item. The First Officers may feel that they are invincible to the debilitating effects of fatigue, perhaps as a result of having not flown as many CDOs as the Captains have flown. The Spearman’s rho test identified a significant correlation between the number of hours of sleep achieved by pilots scheduled for CDOs and the number of pilot errors that resulted in a decreased level of safety during the participant’s previous 80 hours of flight time.

3. The pilots assigned to 24-hour reserve are in violation of the FARs every time they fly a trip. “Because a reserve pilot has a present responsibility to work if called, that pilot is not free from restraint and, consequently, is not receiving the rest specified in the regulation” (FAA, 1993, p. 1). Of the participants who expressed an opinion on this subject, 100% either “agreed” or “strongly agreed” that reserve duty is not rest, and therefore, a pilot on 24-hour reserve status has not received a rest period as required by FAR 121.471. The
K-S test revealed that experience and flight deck position influenced the participant’s responses to this item. As previously mentioned, the airlines chosen for this study either have reserve “windows” or no reserve duty at all. The Captains and “high time” participants have likely been in the industry longer than the First Officers and “low time” participants, and may have been previously employed by air carriers that schedule pilots for 24-hour reserve duty. Also, the Captains and “high time” subjects may simply possess a greater knowledge of the FARs and the issues faced by fellow pilots at other airlines.

4. Fatigue is induced by a high number of departures and arrivals in a single duty day. Of the participants who expressed an opinion on this subject, 96% either “agreed” or “strongly agreed” that duty days that include six or more departures and arrivals, should be preceded, and followed by a rest period two hours longer than normal. The K-S test revealed that flight deck position and experience influenced the participant’s responses to this item. The Captains may actually experience greater fatigue than the First Officers, as a result of a high number of departures and arrivals. The Captain is typically responsible for taxiing the aircraft before takeoff and after landing. This may take an hour or more at some of the nation’s largest airports. During taxi, the First Officer typically has to complete paperwork and make passenger announcements (which usually takes 3-5 minutes), after which the only remaining duty is to assist the Captain. Again, the “high time” participants may have been more willing to admit that fatigue has an impact on their performance, than the “low time” participants. The “low time” participants may still be on probation (typically a period of one year from date of hire, during which the pilot’s employment may be terminated without cause and without union representation), and therefore, may have been reluctant to “complain” about fatigue.
5. It was apparent in the literature and data, that a tired flight crew is more likely to commit errors that result in the degradation of safety. Ninety-two percent of the participants either “agreed” or “strongly agreed” that fatigue-related human errors result in a decreased level of regional airline safety. The K-S test revealed that flight experience and flight deck position influenced the participant’s opinions on this topic. Again, the First Officers and “low time” participants may feel that they are invincible to the effects of fatigue, perhaps as a result of not yet experiencing a significant number of fatigue-related errors or incidents. The Spearman’s rho test identified a significant correlation between the percentage of time the participants flew fatigued in the previous 80 hours of flight time, and the number of pilot errors they committed, as well as the number of times they violated an FAR. The same correlations existed for the corresponding items which addressed the previous 500 hours of flight time.

6. Scientific knowledge on the subjects of sleep, circadian physiology, sleepiness/alertness, and the performance degradation associated with these factors, has increased significantly over the past 40 years. A substantial amount of work has revealed many of the cognitive and motor skill mistakes that a tired, fatigued person makes when attempting to make decisions or perform complex tasks. Scientific research has been conducted in operational environments, including the field and flight simulators. The results of these studies confirm that fatigue resulting from sleep loss, circadian disruption, and excessive flight and duty periods, has impaired the performance of flight crews (Dinges, Graeber, Rosekind, Samel, & Wegmann, 1996).

7. “In some respects, a pilot may be his or her own worst enemy in failing to perceive the onset of hazard-enabling fatigue” (Enders, 1989, p. 1). If a pilot does recognize that his fatigue state has reached an unsafe level, he must then
confront his employer. Refusing a trip often results in a delay, while the crew schedulers attempt to find a reserve pilot to cover the trip. The chief pilot is typically notified, and the fatigued pilot is then called-in for a meeting with his supervisor. The pilot's pay is often reduced by the number of flight hours missed as a result of the fatigue call. An advisory letter which states that refusing a trip due to fatigue constitutes unsatisfactory job performance, is often placed in the pilot's personnel file. Many airlines have a policy of “three strikes, you're out.” In other words, three advisory letters will result in immediate termination of employment.

8. The fatigue problem is likely to intensify in the coming years. Human error has become the primary cause of the majority of airplane accidents. By 1993, pilot error was the cause of 66% of all major airline accidents, 79% of all regional airline accidents, and 88% of all general aviation accidents (Moore-Ede, 1993). With the current accident rate and the projected increase of the worldwide airline fleet, there will be a major accident every week by the year 2010 (Weener, 1990). Adequate pilot rest is one of the primary issues that needs to be addressed in order to decrease the accident rate (Pasztor, 1996).
CHAPTER VI
RECOMMENDATIONS

Fatigue may be the leading factor that detrimentally impacts pilot performance. It is clear that there is no single “cure” for the problems relating to pilot fatigue. The aviation industry is comprised of thousands of individuals working for hundreds of diverse organizations, each with their own unique operational demands. Scheduling practices, personal strategies for pilots, FARs regarding duty and rest, and the design of technology are all areas in which the research results may be applied to their greatest benefit. The goal should be to apply the research results in an effort to lower the accident rates by maximizing flight crew alertness and performance. The following recommendations may reduce or eliminate some of the causes of pilot fatigue, thereby helping to improve regional airline safety:

1. The FAA should revise the rest requirements provided in the FARs, so as to prohibit the practice of scheduling pilots for “reduced rest.”

2. Airline management should ensure that CDOs are eliminated wherever possible. This will probably increase the hotel costs; however, this may be off-set by increased utilization of flight crews. Pilots assigned to CDOs for an entire month, are typically paid for 15-45 hours more than they had flown during that month.

3. The FAA should consistently enforce the Assistant Chief Counsel’s interpretation which states that reserve “duty” is not “rest” (FAA, 1993). This would limit reserve duty to a 15-hour “window” within any 24-hour period.
4. The FAA should revise the FARs so that duty days that include six or more departures and arrivals, are preceded and followed by a rest period two hours longer than normal.

5. The FAA should create FARs that would provide an incentive for the airlines to schedule a rest period that provides pilots with an adequate amount of time available for rest (TAR), embracing the hours between 2200 and 0600 local time. The airline industry is a 24-hour operation, and the FAA should certainly not prohibit an airline from scheduling a pilot for a duty period between the hours of 2200 and 0600 (CDO). An appropriate FAR may include the following: (a) a tour of duty or period of reserve time at home, shall be preceded and followed by a rest period; (b) the rest period shall be at least equal in duration to the longer of the two associated duty periods, but not less than 10 consecutive hours when the pilot is provided with a hotel room (within 15 minutes normal driving time from the airport), or not less than 12 consecutive hours when the rest period is provided at the pilot’s permanent home domicile; and (c) the rest period shall be extended by 2 additional hours if it does not embrace all of the hours between 2200-0600 local time, or if either associated duty period includes six or more departures and arrivals. A mandatory 2-hour rest period extension (as proposed in this recommendation) may create enough incentive for the airline’s scheduling departments to provide pilots with rest periods at night, embracing the hours between 2200-0600 local time, whenever operationally feasible. This may reduce or perhaps eliminate CDOs.

6. The significant body of scientific knowledge regarding cognitive fatigue needs to be applied to the daily operations of the airline industry. Varying work demands and the innovative use of flight deck automation, are two of the areas that researchers have recently studied (Dinges et al., 1996).
7. The flight crews need to have the issue of fatigue addressed during their initial and recurrent training. A study conducted by Weitzel (1997) revealed that 98% of the total respondents (a sample of air carrier line captains, and individuals involved with aviation higher education and air carrier training and management) either moderately or strongly agreed that all aviation students should be educated/trained concerning the causes and the consequences of human fatigue. Techniques and strategies on maintaining peak alertness and safe performance throughout their shifts, should be presented. The goal should be to make them as knowledgeable about their own bodies, as they are about the airplanes they fly. The NTSB issued the following recommendation to the FAA in 1994:

Require U.S. air carriers operating under 14 CFR Part 121 to include, as part of pilot training, a program to educate pilots about the detrimental effects of fatigue, and strategies for avoiding fatigue and countering its effects. (NTSB, 1994, p. 68)

Some airlines do currently provide a few minutes of fatigue training during initial ground school, however this seems to fall short of the intent of the NTSB recommendation. The NTSB should persist with their recommendation, and emphasize to the FAA that such a program will greatly assist pilots in the recognition of their own personal symptoms of fatigue, and the development of personal strategies to help them cope with their very demanding work schedules.

8. Further research should be conducted on the design and use of new technologies to improve pilot performance and alertness. The FAA and the airlines should help to promote this research. The airlines can assist by making their simulators available to the researchers, and the personnel in the airline’s training departments could provide research assistance.
REFERENCES


Holley, D. C. (1974). Circadian desynchronization and the sleep-wake cycle. Department of Biological Sciences, San Jose State University, CA.


APPENDICES
APPENDIX A

AIA WRECKAGE AT UGM
(Photo Courtesy NTSB)
APPENDIX B
AIA CVR TRANSCRIPT
The following exchange of conversation was recorded by the CVR:

? : unidentified crewmember
* : unintelligible word
# : expletive
( ) : questionable insertion
(( )) : editorial insertion

16:41:53 Captain otta make that one zero approach just for the heck of it, to see how it is. why don’t we do that, lets tell ’em we’ll take one zero. if we miss it we’ll just come back around and land on two eight.

16:42:04 First Officer OK.

16:42:52 to 16:44:41 miscellaneous discussion about proper traffic pattern entry, weather, and descent checklist.

16:44:50 Flight Engineer just don’t do no rolls on final.

16:44:53 First Officer wanna make sure you’re wings level and you’re on center line because you have those uh, VASIs there, for catching.

16:45:12 to 16:51:56 miscellaneous discussion about aircraft position, weather and approach checklist.

16:52:17 First Officer I think you’re gettin’ in close, before you start your turn.

16:52:20 Flight Engineer yeah, the runway’s right here man.

16:52:21 Captain yeah, I got it. yeah, I got it.

16:52:22 Flight Engineer you’re right on it.

16:52:23 Captain * going to have to really honk it. let’s get the gear down **.
16:52:25 to 16:53:19 miscellaneous discussion about location of runway and captain requesting flaps 50.

16:53:22 Flight Engineer slow. airspeed.

16:53:25 First Officer check the turn.

16:53:28 Captain where’s the strobe.

16:53:29 Flight Engineer right over there.

16:53:31 Captain where.

16:53:33 First Officer right inside there, right inside there.

16:53:35 Flight Engineer you know, we’re not getting our airspeed back there.

16:53:37 Captain where’s the strobe.

16:53:37 First Officer right down there.

16:53:41 Captain I still don’t see it.

16:53:42 Flight Engineer # we’re never goin’ to make this.

16:53:45 Captain where do you see a strobe light?

16:53:48 First Officer right over here.

16:53:57 Captain where’s the strobe?

16:53:58 First Officer do you think you’re gonna make this?

16:53:58 Captain yeah...if I can catch the strobe light.

16:54:01 First Officer five hundred, you’re in good shape.

16:54:06 Flight Engineer watch the, keep your airspeed up.

16:54:09 ((Sound similar to stall warning))

16:54:10 Unidentified crew (don’t), stall warning.
<table>
<thead>
<tr>
<th>Time</th>
<th>Speaker</th>
<th>Message</th>
</tr>
</thead>
<tbody>
<tr>
<td>16:54:11</td>
<td>Captain</td>
<td>I got it.</td>
</tr>
<tr>
<td>16:54:12</td>
<td>First Officer</td>
<td>stall warning.</td>
</tr>
<tr>
<td>16:54:12</td>
<td>Flight Engineer</td>
<td>stall warning.</td>
</tr>
<tr>
<td>16:54:13</td>
<td>Captain</td>
<td>I got it, back off.</td>
</tr>
<tr>
<td>16:54:13</td>
<td>Unidentified crew</td>
<td>max power ((concurrent with previous statement))</td>
</tr>
<tr>
<td>16:54:15</td>
<td>Unidentified crew</td>
<td>there it goes, there it goes.</td>
</tr>
<tr>
<td>16:54:16</td>
<td>Unidentified crew</td>
<td>oh no.</td>
</tr>
<tr>
<td>16:54:17</td>
<td>((sounds of several screams)).</td>
<td></td>
</tr>
<tr>
<td>16:54:20</td>
<td>End of Recording</td>
<td>(pp. 100-125).</td>
</tr>
</tbody>
</table>
APPENDIX C

NOTICE OF PROPOSED RULE MAKING (NPRM 95-18)
Proposed Flight Time Limitations and Rest Requirements
(Air Line Pilots Association, 1996)

- Normal scheduled rest period - 10 hours. May be reduced to 9 hours for circumstances beyond the control of the carrier, but may not be scheduled to be reduced.

- Normal scheduled duty day - 14 hours. May be extended to 16 hours for circumstances beyond the control of the carrier. If the duty day is extended beyond 14 hours, the rest period may not be reduced.

- Flight time limits - Block to block
  2 Pilots - 10 scheduled flight hours, maximum 14 scheduled hours of duty.
  3 Pilots - 12 scheduled flight hours, maximum 16 scheduled hours of duty; subsequent rest period must be 14 hours minimum.
  3 Pilots - 16 scheduled flight hours (requires inflight rest facility) - maximum 18 scheduled hours of duty; subsequent rest period must be 18 hours minimum.
  4 Pilots (International only) - Maximum 18 scheduled flight hours (requires inflight rest facility) - maximum 24 scheduled hours of duty; subsequent rest period must be 22 hours minimum.

- 36 continuous hours free of duty every 7 days.

- Weekly flight time limits - 32 hours

- Monthly flight time limits - 100 hours

- Annual flight time limits - 1200 hours (not specifically stated, but implied).

- Detailed provisions for reserve to assure rested crews.

- Part 91 flight time, such as ferry flights, will be included in these limits.

- There are definitions which will help with an understanding of the rule
### Proposed Duty Period Limitations for Reserve Pilots

*(Air Line Pilots Association, 1996)*

<table>
<thead>
<tr>
<th>Number of hours notification prior to report time</th>
<th>Maximum scheduled duty period</th>
</tr>
</thead>
<tbody>
<tr>
<td>Less than 4 hours</td>
<td>6 hours</td>
</tr>
<tr>
<td>4 or more hours but less than 6</td>
<td>8 hours</td>
</tr>
<tr>
<td>6 or more hours but less than 8</td>
<td>10 hours</td>
</tr>
<tr>
<td>8 or more hours but less than 10</td>
<td>12 hours</td>
</tr>
<tr>
<td>10 or more hours</td>
<td>same as maximum allowed for non reserve pilots</td>
</tr>
</tbody>
</table>
Hotel Cost Analysis

Normal rest period provided at outstation (necessitates laying over two crews)

6 rooms/night for 30 days @ $29./night/room = $5220.00

Continuous duty overnight (only one crew laid over)

3 rooms/night for 30 days @ $29./night/room = $2610.00

Hotel Savings $2610.00

Crew Salary Analysis

Actual crew salary for 30 days

Captain: $60./hr x 75 hours = $4500.00
First Officer: $25./hr x 75 hours = $1875.00
Flight Attendant: $20./hr x 75 hours = $1500.00

$7875.00 = $7875.00

Crew salary based on number of hours flown

Captain: $60./hr x 40 hours = $2400.00
First Officer: $25./hr x 40 hours = $1000.00
Flight Attendant: $20./hr x 40 hours = $800.00

$4200.00 = $4200.00

Over-pay due to continuous duty overnight crew only flying 40 hours per month $3675.00

Summary

Over-pay due to continuous duty overnight crew only flying 40 hours per month $3675.00

Hotel Savings $2610.00

Monthly net loss per crew assigned to continuous duty overnights $1065.00
APPENDIX E

FIELD SURVEY COVER LETTER AND QUESTIONNAIRE
Dear Colleague:

I am presently on furlough from Pan Am and working on a Master's degree in Aviation Safety at Embry-Riddle. I realize that your schedule is probably very hectic, however I would greatly appreciate your response to the attached survey.

I flew with the regional airlines for approximately six years, and feel that the industry has an outstanding safety record. The excellent training provided by the regional airlines, combined with a very dedicated, professional group of pilots and management has led to this outstanding safety record.

This study is concerned with the impact of mental fatigue on pilot performance. An aviation psychologist has stated that mental fatigue is typically associated with tasks demanding intense concentration, rapid or complex information processing, and other high level cognitive skills. Wherever this survey refers to fatigue, please consider it from this concept of cognitive or mental fatigue.

You will find an attached envelope for you to return the completed survey. I would appreciate your response by January 31, 1998. Please do not include your name or the name of your employer. Please feel free to skip any question that you would rather not answer. The data gathered will be analyzed and incorporated in a Master’s thesis, which should be completed by the end of the summer. The resulting conclusions and recommendations will be made available to interested parties within the industry. I would be happy to send you a summary of the results. Please send your request, along with a self-addressed, stamped envelope, to the address provided below (please do not include your request with the survey, in order to ensure your anonymity). Thank you very much for your cooperation.

Sincerely yours,

Douglas S. Mikkelsen
133A Golden Eye Dr.
Daytona Beach, FL 32119
Please respond to the following statements by circling one of the five choices:

1=Strongly Disagree, 2=Disagree, 3=Undecided, 4=Agree, 5=Strongly Agree

1. Fatigue has a negative impact on pilot performance.  
   Strongly Disagree Disagree Undecided Agree Strongly Agree
   1 2 3 4 5

2. Fatigue is a contributing factor to human errors on the flight deck.  
   Strongly Disagree Disagree Undecided Agree Strongly Agree
   1 2 3 4 5

3. These fatigue-related human errors result in a decreased level of regional airline safety.  
   Strongly Disagree Disagree Undecided Agree Strongly Agree
   1 2 3 4 5

4. These fatigue-related human errors have led to violations of FARs.  
   Strongly Disagree Disagree Undecided Agree Strongly Agree
   1 2 3 4 5

5. The existing FARs pertaining to flight time limitations and rest requirements, do not provide adequate rest for the prevention of fatigue.  
   Strongly Disagree Disagree Undecided Agree Strongly Agree
   1 2 3 4 5

6. Continuous Duty Overnights (Stand-ups, High-speeds) cause a high level of fatigue, and a decreased level of safety.  
   Strongly Disagree Disagree Undecided Agree Strongly Agree
   1 2 3 4 5

7. The intent of the “reduced rest” provision in the FARs has been abused by regional airline schedules (trips are scheduled with reduced rest).  
   Strongly Disagree Disagree Undecided Agree Strongly Agree
   1 2 3 4 5

8. 24-hour reserve causes a high level of fatigue, and a decreased level of safety.  
   Strongly Disagree Disagree Undecided Agree Strongly Agree
   1 2 3 4 5

9. Departures and arrivals demand intense concentration, and contribute to a higher level of fatigue.  
   Strongly Disagree Disagree Undecided Agree Strongly Agree
   1 2 3 4 5

10. Duty days that include six or more departures and arrivals, should be preceded and followed by a rest period two hours longer than normal.  
    Strongly Disagree Disagree Undecided Agree Strongly Agree
    1 2 3 4 5
Please respond to the following questions in the space provided.

11. Please select your current position.
   ___ Regional Airline Captain ___ Regional Airline F.O.

12. Please provide your approximate total flight time. __________

13. Please provide your approximate total regional airline flight time. ______

14. Your gender. ___ Male ___ Female

15. Your age. ___ Years

16. How many hours of sleep are adequate for the minimization of fatigue? ____

17. How many hours are you able to sleep (average), while on a nine-hour rest period provided between the hours of 21:00 and 09:00 (local)? _____

18. How many hours are you able to sleep (average), while on a nine-hour rest period provided between the hours of 09:00 and 21:00 (local) (CDO)? ____

19. How many hours should the minimum rest period be, in order to allow adequate sleep for the minimization of fatigue? _____

20(a). What percentage of time have you felt fatigued during your last 80 hours of flight time? ____%

   (b). How many fatigue related errors have you made during your last 80 hours of flight time? _____

   (c). How many of these errors resulted in a decreased level of safety? _____

   (d). How many of these errors led to a violation of the FARs? _____

21(a). What percentage of time have you felt fatigued during your last 500 hours of flight time? ____%

   (b). How many fatigue related errors have you made during your last 500 hours of flight time? _____

   (c). How many of these errors resulted in a decreased level of safety? _____

   (d). How many of these errors led to a violation of the FARs? _____
This space is for your comments. Please provide the question number that your comments refer to (where appropriate).

Thank you for your expertise.
APPENDIX F

COVER LETTER AND THE INSTRUMENT
Dear Colleague:

I am presently on furlough from Pan Am and working on a Master's degree in Aviation Safety at Embry-Riddle. I realize that your schedule is probably very hectic, however I would greatly appreciate your response to the attached survey.

I flew with the regional airlines for approximately six years, and feel that the industry has an outstanding safety record. The excellent training provided by the regional airlines, combined with a very dedicated, professional group of pilots and management has led to this outstanding safety record.

This study is concerned with the impact of mental fatigue on pilot performance. An aviation psychologist has stated that mental fatigue is typically associated with tasks demanding intense concentration, rapid or complex information processing, and other high level cognitive skills. Wherever this survey refers to fatigue, please consider it from this concept of cognitive or mental fatigue.

You will find an attached envelope for you to return the completed survey. I would appreciate your response by April 30, 1998. Please do not include your name or the name of your employer. Please feel free to skip any question that you would rather not answer. The data gathered will be analyzed and incorporated in a Master’s thesis, which should be completed by the end of the summer. The resulting conclusions and recommendations will be made available to interested parties within the industry. I would be happy to send you a summary of the results. Please send your request, along with a self-addressed, stamped envelope, to the address provided below (please do not include your request with the survey, in order to ensure your anonymity). Thank you very much for your cooperation.

Sincerely yours,

Douglas S. Mikkelsen
133A Golden Eye Dr.
Daytona Beach, FL 32119
Please respond to the following statements by circling one of the five choices:
1=Strongly Disagree, 2=Disagree, 3=Undecided, 4=Agree, 5=Strongly Agree

1. Fatigue has a negative impact on pilot performance. 1 2 3 4 5

2. Fatigue is a contributing factor to human errors on the flight deck. 1 2 3 4 5

3. Fatigue-related human errors result in a decreased level of regional airline safety. 1 2 3 4 5

4. Fatigue-related human errors have led to violations of FARs. 1 2 3 4 5

5. The existing FARs pertaining to flight time limitations and rest requirements, provide adequate rest for the prevention of fatigue. 1 2 3 4 5

6. Continuous Duty Overnights (Stand-ups, High-speeds) cause a high level of fatigue, and a decreased level of safety. 1 2 3 4 5

7. Trips scheduled with “reduced rest” cause a high level of fatigue, and a decreased level of safety. 1 2 3 4 5

8. Departures and arrivals demand intense concentration, and contribute to a higher level of fatigue. 1 2 3 4 5

9. Duty days that include six or more departures and arrivals, should be preceded and followed by a rest period two hours longer than normal. 1 2 3 4 5

10. Reserve “duty” is not “rest”, and therefore a pilot on 24-hour reserve status has not received a rest period as required by FAR 121.471. 1 2 3 4 5

11. 24-hour reserve causes a high level of fatigue, and a decreased level of safety. 1 2 3 4 5
Please respond to the following questions in the space provided.

12. Please select your current position.
   ___ Regional Airline Captain   ___ Regional Airline F.O.

13. Please provide your approximate total flight time. __________

14. Please provide your approximate total regional airline flight time. __________

15. Your gender.   ___ Male       ___ Female

16. Your age.   ___ Years

17. How many hours of sleep do you need, to be fully rested? _____

18. How many hours are you able to sleep (average), while on a nine-hour rest period provided between the hours of 21:00 and 09:00 (local)? _____

19. How many hours are you able to sleep (average), while on a nine-hour rest period provided between the hours of 09:00 and 21:00 (local) (CDO)? _____

20. How many hours should the minimum rest period be, in order to allow adequate sleep for the minimization of fatigue? _____

21(a). What percentage of time have you felt fatigued during your last 80 hours of flight time? _____%  

   (b). How many fatigue related errors have you made during your last 80 hours of flight time? _____

   (c). How many of these errors resulted in a decreased level of safety? _____

   (d). How many of these errors led to a violation of the FARs? _____

22(a). What percentage of time have you felt fatigued during your last 500 hours of flight time? _____%  

   (b). How many fatigue related errors have you made during your last 500 hours of flight time? _____

   (c). How many of these errors resulted in a decreased level of safety? _____

   (d). How many of these errors led to a violation of the FARs? _____
This space is for your comments.
(Please provide the question number, if your comments refer to an item from this survey).

Thank you for your expertise.
APPENDIX G
SPEARMAN'S RHO CORRELATION MATRIX
Spearman's Rho
Correlation Matrix

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<th>Above or Below 3000 Hours</th>
<th>Sleep Normally Required</th>
<th>Sleep Achieved 2100-0900</th>
<th>Sleep Achieved 0900-2100</th>
<th>Minimum Rest Period</th>
<th>Fatigued Last 30 Days</th>
<th>Errors Last 30 Days</th>
<th>Safety Decrements Last 30 Days</th>
<th>FAR Violations Last 30 Days</th>
<th>Fatigued Last 180 Days</th>
<th>Errors Last 180 Days</th>
<th>Safety Decrements Last 180 Days</th>
<th>FAR Violations Last 180 Days</th>
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