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Crew Factors in Flight Operations XV: Alertness Management in General Aviation Education Module

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February 2002

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PREFACE

This report is based significantly on the NASA Technical Memorandum (TM):

Rosekind, M.R., Gander, P.H., Connell, L.J., and Co, E.L. (2001). *Crew Factors in Flight Operations X: Alertness Management in Flight Operations*. (NASA Technical Memorandum No. 2001-211385). Moffett Field, CA: National Aeronautics and Space Administration.

The NASA TM cited above is a general Education and Training Module addressing fatigue in commercial flight operations. It is the basis for this document, an Education and Training Module that has been tailored to address general aviation (GA) operations specifically, including fatigue research findings concerning corporate pilots.

The original acknowledgements highlight the numerous individuals that made many significant contributions to the NASA Ames Fatigue Countermeasures Group and the original Education and Training Module. These acknowledgements are now extended to include Dr. Philippa H. Gander, and Linda J. Connell for their many critical contributions to the NASA Ames Fatigue Countermeasures Group, the original Education and Training Module, and this module tailored for general aviation operations. Additionally, we wish to thank the following individuals for their invaluable comments and suggestions in molding this publication to be as operationally relevant as possible; Robert Vandel (Flight Safety Foundation), Joe “Jay” Evans (National Business Aircraft Association, Inc.), and John Steuernagle (Aircraft Owner’s and Pilot’s Association).

General aviation encompasses a broad range of operations, pilots, and equipment. Therefore, members of the GA community can benefit from education material that addresses issues specific to them. This module is intended to help all those involved in general aviation including pilots, fixed base operators (FBO’s), flight instructors, dispatchers, maintenance technicians, policy makers, and others to understand the physiological factors underlying fatigue, how flight operations affect fatigue, and what can be done to counteract fatigue and maximize alertness and performance in their operations.

INTRODUCTION

In 1980, in response to a congressional request, NASA Ames Research Center created a Fatigue/Jet Lag Program to examine whether “there is a safety problem, of uncertain magnitude, due to transmeridian flying and a potential problem due to fatigue in association with various factors found in air transport operations.”¹ Since 1980, the Program has pursued the following three goals: (1) to determine the extent of fatigue, sleep loss, and circadian disruption in flight operations; (2) to determine the effect of these factors on flight crew performance; and (3) to develop and evaluate countermeasures to reduce the adverse effects of these factors and to maximize flight crew performance and alertness. It has been a priority since the Program’s inception to return the information acquired through its extensive research to the operators—the line pilots, air carriers, and others. In 1991, the Program underwent a name change, becoming the NASA Ames Fatigue Countermeasures Group, to highlight the increased focus on the development and evaluation of fatigue countermeasures. (For a more complete description of the Group, see footnote below.) With this increased emphasis on countermeasures, it became important to organize and disseminate what had been learned about fatigue, sleep, and circadian rhythms in flight operations.

There is now enough scientific and operational data to create this Education and Training Module on strategies for alertness management for members of the general aviation community. The overall purpose of this module is to promote aviation safety, performance, and productivity. It is intended to meet three specific objectives: (1) to explain the current state of knowledge about the physiological mechanisms underlying fatigue; (2) to demonstrate how this knowledge can be applied to improving flight crew sleep, performance, and alertness; and (3) to offer strategies for alertness management.

This module is presented in three distinct sections. The first section addresses fatigue factors in general aviation. It provides report examples from the Aviation Safety Reporting System (ASRS) and National Transportation Safety Board (NTSB) reports to demonstrate that fatigue is a safety issue in the general aviation community. It discusses the causes of fatigue with specific focus on sleep and sleep loss, circadian rhythms and flight operations. It provides basic information on sleep, sleepiness, circadian rhythms and how flight operations affect these physiological factors. It explains the effects of fatigue on alertness, performance and flying. It identifies fatigue related factors in operational environments under FARs Part 91 and 135. The second section identifies some widely held misconceptions about fatigue and explains why they are false. Finally, the third section provides recommendations for alertness management strategies in Part 91 and 135

¹*Pilot Fatigue and Circadian Desynchronization*. (1980). Report of a workshop held in San Francisco, CA, on August 26–28, 1980. NASA Technical Memorandum No. 81275. Moffett Field, CA: National Aeronautics and Space Administration.

²Rosekind, M.R., Gander, P.H., Miller, D.L., Gregory, K.B., McNally, K.L., Smith, R.M., and Lebacqz, J.V. (1993). NASA Ames Fatigue Countermeasures Program. *FAA Aviation Safety Journal*, 3(1), 20–25.

flight operations. This Education and Training Module is intended to be offered as a comprehensive resource that can be utilized in a number of different ways. It can be used as a reference by an individual or provided as a live presentation by a trained individual. The full presentation may require at least 60 min to complete. Those with less time may choose to emphasize certain highlights that are pertinent to them. The Module's interactive format will provide a forum for discussions of how this information and the recommended strategies can be applied in specific flight operations.

The information contained in the slide graphics constitutes the main body of this publication. The appendixes at the end of the module include the complete ASRS reports used for the examples provided throughout the main body of this publication. Brief introductions to sleep disorders and to relaxation techniques are presented in appendixes A and B, respectively. Appendix C contains summaries of relevant NASA publications, including studies in short-haul, long-haul, and helicopter operations, and the NASA/FAA study on planned cockpit rest in long-haul flying. Appendix D provides a list of representative publications from the NASA Ames Fatigue Countermeasures Group, and Appendix E contains cited literature and a list of general readings on sleep, sleep disorders and circadian rhythms.

The format of this publication is designed for two purposes: (1) to facilitate training and (2) to provide a reference for those who use the information. For trainers, the slides provide presentation material, while the text provides some guidelines as to what information should be addressed when presenting the module. For those applying the information, the text elaborates on the slide graphics for later reference. In addition to this publication, a set of "Principles and Guidelines for Duty and Rest Scheduling in Corporate and Business Aviation" has been published by the Flight Safety Foundation through the work of a task force of over 30 representatives from the aviation community and the Group³.

As previously stated, this Education and Training Module by the NASA Ames Fatigue Countermeasures Group is designed to provide education and training information on fatigue, sleep, and circadian rhythms in flight operations, and to recommend strategies for managing alertness in general aviation. As future scientific and operational advances are made, this module will evolve to incorporate the latest findings, information, and recommendations. Therefore, any comments, questions, or requests regarding this module would be greatly appreciated. Please address them to: Fatigue Countermeasures Group, NASA Ames Research Center, MS 262-4, Moffett Field, California 94035-1000.

³ Flight Safety Foundation. (1997). Principles and Guidelines for Duty and Rest Scheduling in Corporate and Business Aviation (Flight Safety Digest, Vol.16, No.2). Arlington, VA: Author.

Alertness Management in General Aviation



NASA Ames Research Center
Human Factors Research and Technology Division

Fatigue Countermeasures Group



This education and training module is intended for all segments of general aviation (GA) including pilots, Fixed Base Operator (FBO) managers and employees, flight instructors, dispatchers, schedulers, maintenance crews, safety and policy personnel, and others involved in operational environments that challenge human physiological capabilities because of the presence of fatigue, sleep loss, and circadian disruption.

The goal of this training module is to help individuals understand the physiological factors underlying fatigue, recognize the effects of fatigue on performance, and be informed of alertness management strategies that may help to both prevent and counter fatigue.

The module can be read through completely or accessed for specific pieces of information. It is meant to communicate the basics about fatigue in aviation to those who experience it. The module also provides many examples extracted from the Aviation Safety Reporting System (ASRS) and National Transportation Safety Board (NTSB) accident reports to emphasize the importance of being aware of such fatigue related issues. The appendixes at the end of the module include the actual ASRS report examples referenced in this document in addition to lists of publications that can be consulted for more detailed and thorough treatments of various aspects of sleep, fatigue, circadian rhythms, and related topics.

Objectives

- Explain the current state of knowledge about the physiological mechanisms underlying fatigue
- Demonstrate the importance of fatigue in GA ops
- Describe the effects of fatigue on flight performance
- Identify fatigue factors in GA operations
- Dispel common misconceptions about fatigue
- Demonstrate how to apply this knowledge to improve sleep, performance, and alertness of pilots and recommend alertness management strategies

Fatigue Countermeasures Group



In response to a 1980 congressional request, NASA Ames Research Center initiated a Fatigue/Jet Lag Program to examine fatigue, sleep loss, and circadian disruption in aviation. Research has examined fatigue in a variety of flight environments, including corporate aviation, using a range of measures ((from self-report to performance to physiological). In 1991, the program evolved into the Fatigue Countermeasures Group, emphasizing the development and evaluation of strategies to maintain alertness and performance in operational settings. Over the years, the Federal Aviation Administration (FAA) has provided support for fatigue research and other Group activities. From the inception of the Group, a principal goal was to return the information learned from research and other Group activities to the operational community.

The objectives of this Education and Training Module are to:

1. Explain what is known about the physiological mechanisms that underlie fatigue.
2. Demonstrate the significance of fatigue in GA safety by examining several fatigue-related incidents and accidents.
3. Describe how fatigue affects alertness and performance.
4. Identify fatigue-related factors in specific operational environments (including recreational/private pilot, flight instruction, on-demand operations, corporate aviation).
5. Address several common misconceptions about fatigue and sleepiness, examining and dispelling them based on scientific data.
6. Apply the available knowledge of fatigue to flight operations, and offer some specific fatigue countermeasure recommendations.

Overview

- Fatigue Factors in General Aviation
- Common Misconceptions
- Alertness Management Strategies

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The module is divided into three parts. First, there is a description of fatigue factors in flight operations, which includes: A) a demonstration that fatigue in aviation, and general aviation in particular, is of national interest; B) a discussion of the principal causes of fatigue (i.e., sleep and sleep loss, circadian rhythms and their disruption, and the effects of flight operations on these physiological factors); C) a description of how fatigue affects performance and flying; and D) a discussion of specific fatigue factors in GA operations. Second, some common misconceptions regarding fatigue in aviation are presented, and application of the information provided in the first part demonstrates why these notions are incorrect. Third, a variety of countermeasures are presented, including preventive approaches that can be used before flying or between flights, as well as operational countermeasures that can be used during flights.

I. Fatigue Factors in General Aviation

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Section A of this part (Part I) will demonstrate the importance of fatigue issues in aviation overall, and specifically in general aviation. Section B will discuss the two main physiological factors that affect fatigue: 1) sleep and sleep loss, and 2) circadian rhythms. With the principles of these physiological factors as a background, Section C will then describe how GA flight operations affect fatigue, and Section D will address specific effects of fatigue on performance and flying.

Fatigue Factors in General Aviation: A. Fatigue is a Safety Issue in General Aviation

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This section demonstrates the importance of fatigue in aviation, and specifically in general aviation, by providing examples of fatigue-related incidents and accidents, and actions taken by the industry to address fatigue.

According to an NTSB Accident Report, a privately owned Cessna 177B collided with terrain after loss of control in Cheyenne, Wyoming on April 11, 1996 (NTSB ID No. SEA96MA079). The three occupants, a 7-year-old girl, her father, and the flight instructor, all perished. Among other findings, the NTSB concluded that the pilot in command (PIC) suffered from fatigue on the day before the accident and that extensive fatigue education could have assisted the PIC in recognizing his fatigue level (and fatigue related consequences), possibly enhancing the safety of the trip. As a result of this fatigue-related conclusion, the NTSB recommended to the Department of Transportation (DOT) that “the dissemination of educational materials on the hazards of fatigue in the GA community needs to be increased and expanded.” This example provides evidence that fatigue is not only a concern in long-haul, short-haul, and overnight cargo operations but extends to the general aviation communities as well (see NASA representative publications in Appendix C).

This module will cite several real-life examples, focusing mainly on general aviation to demonstrate the significance of fatigue in several aviation communities. These examples are accompanied by descriptions of the factors contributing to the accident or incident. Also included in this module are results from a survey conducted in corporate aviation that demonstrate the extent to which fatigue is perceived as a significant safety issue in these specific environments.

Fatigue Accidents in Commercial Aviation

- Guantanamo Bay, Cuba (August 18, 1993)
 - AIA Flight 808--McDonnell Douglas DC-8
 - No fatalities
- Nimitz Hill, Guam (August 6, 1997)
 - Korean Air Flight 801--Boeing 747-300
 - 228 fatalities

Fatigue Countermeasures Group



According to the NTSB, several major aviation accidents have been associated with fatigue.

For example, fatigue was cited by the NTSB as a probable cause and contributing factor in the crash of American International Airways Flight 808, a DC-8-61, in Guantanamo Bay, Cuba on August 18, 1993, about 1/4 mile from the approach end of the runway (NTSB/AAR-94/04). At the time of the crash, the flight crew had been on duty for 18 hours (9 hr flight time). It was concluded that the flight crew was fatigued and suffered from sleep loss and circadian disruption, which all contributed to a negative effect on their performance during a critical phase of flight. As a result, the NTSB suggested a review and update of the FAA flight/duty time limitations, which would consider the most current research on fatigue and sleep loss.

A more recent example of a fatigue-related aviation accident is the crash of Korean Air Flight 801 on August 6, 1997 (NTSB/AAR-00/01). The Boeing 747-300 crashed into high terrain about 3 miles southwest of the airport after being cleared to land. Of 258 souls on board, the accident resulted in 228 deaths. The NTSB determined the probable cause to be the captain's failure to adequately brief and execute the non-precision approach, and the first officer's and flight engineer's failure to effectively monitor and cross-check the captain's execution of the approach. Contributing to these failures was the captain's fatigue level.

While fatigue is more widely recognized in commercial aviation than in general aviation, fatigue plays at least as significant a safety role in GA operations.

Is Fatigue a Concern in Flight Operations?

- National Transportation Safety Board (NTSB)
 - “...it is time for an aggressive Federal program to address the problems of fatigue and sleep issues in transportation safety”
 - “...educate pilots about the detrimental effects of fatigue and strategies for avoiding fatigue and countering its effects”
 - Fatigue cited as probable cause/contributing factor in aviation accidents
- Federal Aviation Administration (FAA)
 - An objective of the National Plan for Aviation Human Factors

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The following three sources indicate that fatigue is a concern acknowledged at a national level. Additionally, numerous studies have demonstrated fatigue-effects in flight crews, including accumulated sleep loss, alertness and performance decrements, and unintended episodes of falling asleep during flight (see NASA representative publications in Appendix C).

The National Transportation Safety Board (NTSB) has stated the following in Safety Recommendations I-89-1, I-89-2, and I-89-3: “Based on its experience in accident investigation, the Safety Board believes it is time for an aggressive Federal program to address the problems of fatigue and sleep issues in transportation safety.” On January 19, 1994, based on a Safety Study Review, the NTSB recommended that the FAA “Require U.S. 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.” A parallel recommendation was made regarding Part 135 carriers. For the first time, the NTSB cited fatigue as a probable cause in the Guantanamo Bay aviation accident. Through the research and other activities of the NASA Ames Fatigue Countermeasures Group, the FAA, and the NTSB, aviation is ahead of most other modes of transportation in examining the issue of fatigue, and especially in developing potential countermeasures.

The FAA’s National Plan for Aviation Human Factors identifies fatigue as an area for continued basic and applied research. These are only three examples of highly visible national agencies that acknowledge and call for continued activities addressing the issue of fatigue in aeronautical operations.

In Part 91 Flight Operations?

- NASA Aviation Safety Reporting System (ASRS)
 - ASRS Database Report Set:
Commuter and Corporate Flight Crew Fatigue Reports
- Flight Safety Foundation
 - Principles and Guidelines for Duty and Rest
Scheduling in Corporate and Business Aviation

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Fatigue in Part 91 flight operations, specifically, has gained national recognition as a safety issue as well.

The NASA Aviation Safety Reporting System (ASRS) has created an ASRS Database Report Set of “Commuter and Corporate Flight Crew Fatigue Reports.” The Report Set contains a sampling of reports referencing commuter and corporate flight crew fatigue issues and duty periods. ASRS updates the report set and maintains the 50 most recent relevant ASRS Database records.

The Flight Safety Foundation collaborated with the NASA Ames Fatigue Countermeasures Group to develop a set of Principles and Guidelines for Duty and Rest Scheduling in Corporate and Business Operations^{*}. This document was created to proactively address scheduling aspects of fatigue specific to corporate operations.

* The document is listed in the Reference section of this technical memorandum.

Fatigue Accidents in General Aviation

- Cheyenne, Wyoming (April 11, 1996)
 - Cessna Skyhawk 177B
 - 3 occupants, 3 fatalities
- Dublin, California (September 13, 1987)
 - Mooney M20J
 - 1 occupant, 1 fatality
- Golovin, Alaska (July 18, 1989)
 - Cessna Turbo Centurion II
 - 8 occupants, no fatalities

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In addition to the Cessna 177B accident in Cheyenne, Wyoming, the NTSB has identified fatigue as a contributing factor in other Part 91 operations. In September 1987, a Mooney M20J impacted terrain during an ILS approach (NTSB ID No. LAX87FA335). The NTSB concluded that the pilot failed to properly fly an IFR procedure due to weather conditions, night flying conditions, fatigue, and lack of total instrument time.

In July 1989, a pilot was rushing to get home for a scheduled engagement. The pilot was on an irregular schedule and had obtained very little sleep in the days before the accident flight. Taxiing the Cessna Turbo Centurion II, the pilot misidentified a taxiway for the runway and started takeoff roll. When the pilot realized the error, the aircraft was too slow to fly but too fast to stop, and the aircraft overran the runway into an embankment. With 8 people on board and only 6 seats in the aircraft, one child sat on an adult's lap while the other sat between the 2 front seats without a seat belt. Fortunately, there were no fatalities. The NTSB cited poor judgement and inadequate planning as the cause of the accident. Fatigue, self-induced time pressure, weather, and uneven terrain contributed to the accident (NTSB ID No. ANC89LA125).

What Can Be Done About Fatigue?

- Change the FARs
 - Takes an act of Congress (almost)
 - May reduce flexibility
- Research fatigue issues that support FAA efforts
- Apply strategies to better cope with the current situation

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This module will clearly demonstrate that fatigue in flight operations is a complex issue with no one simple answer. Rather, every component of the aviation system that can be addressed to improve alertness and performance in flight operations should receive attention. Several examples are provided here.

The Federal Aviation Regulations (FARs) could provide one means of incorporating what is now known about the physiological mechanisms that produce fatigue. This can be a long process and one that can be complex in its own right. Also, regulating flight, duty, and rest requirements in general aviation may afford limited flexibility compared to the general aviation community addressing fatigue through education, application of strategies, and exercising good judgment.

Another approach is to conduct research that provides scientific data to be used by policymakers concerned with regulatory issues or interpretation of the FARs. The research can be the basis for a variety of actions, including the production of Advisory Circulars (ACs).

In another possible approach, the information provided in this presentation can be used right now by any individual challenged by the physiological demands of flight operations. The basic information and countermeasure recommendations can be used by all in the aviation industry who want to improve the ability to cope with their existing situation.

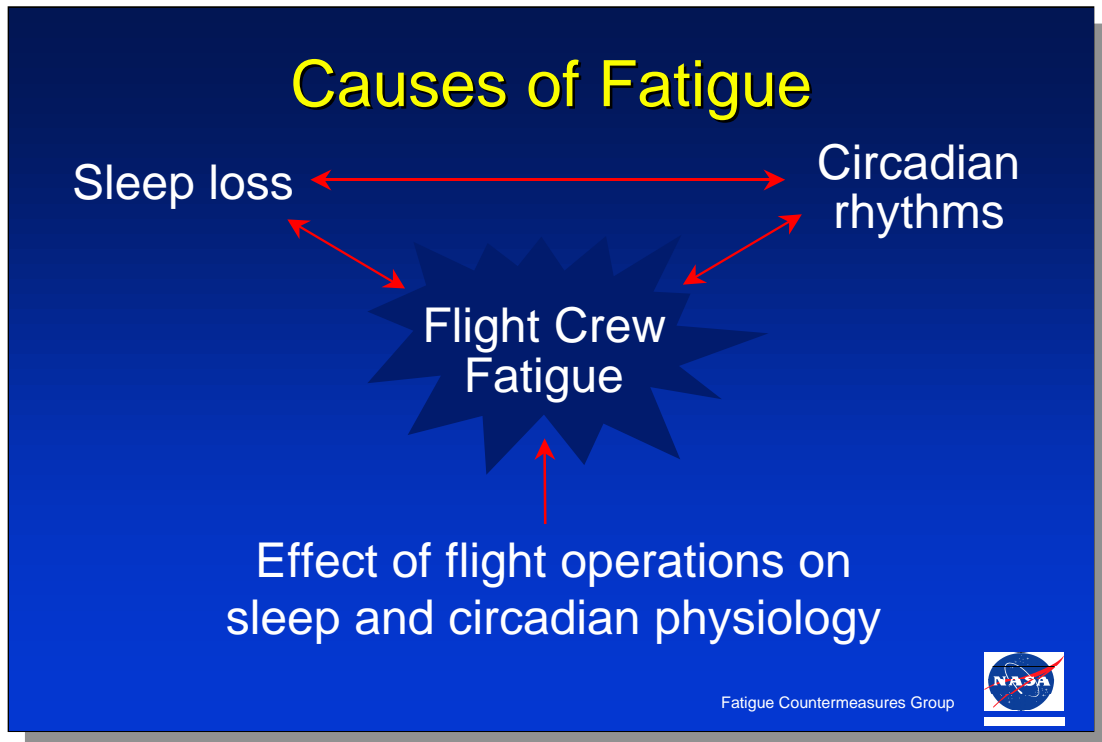
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- Since 1980, research on fatigue, sleep, and circadian rhythms in different flight environments, including general aviation
- Testing and implementation of alertness strategies
- Input to FAA
 - Example: In-flight test of naps as a strategy in 3-person long-haul crews; FAA in NPRM process
- Scientific and technical publications

Fatigue Countermeasures Group



The information listed here provides some insight into the research and activities that created the foundation for the development of this Education and Training Module. Since 1980, the NASA Ames Fatigue Countermeasures Group, in collaboration with the FAA, has conducted fatigue research; recently, it has emphasized the testing and implementation of countermeasures. An example of these activities is the NASA/FAA study of planned cockpit rest, which demonstrated the effectiveness of a controlled in-flight nap to improve subsequent alertness and performance during critical phases of flight. The FAA is reviewing a mechanism to sanction the use of “Controlled Rest on the Flight Deck” for commercial air transport operators. Another important ongoing Group contribution is the production of scientific and technical publications, as well as industry articles, reporting study results and other information related to fatigue and potential countermeasures. Some representative Group publications suggested for further reading are provided in appendix D. Many publications can be downloaded from the Group’s web site at <http://human-factors.arc.nasa.gov/zteam/pubs.html> or can be requested by contacting the Group at the address located in the Introduction section (page viii).



Fatigue is really a catchall term for a variety of different subjective experiences, for example, physical discomfort after overworking a particular group of muscles, concentration difficulties during a monotonous task, difficulty appreciating potentially important signals following long or irregular work hours, or simply difficulty staying awake. In the context of flight operations, crewmember fatigue becomes important if it reduces efficiency or otherwise degrades performance. Subjective fatigue can be affected by motivation or by the amount of stimulation coming from the environment.

However, there are two systematic physiological causes of fatigue (and poorer performance)—sleep loss and circadian rhythms—both of which are affected by flight operations. It is also important to note that flight operations can result in sleep loss and circadian disruption, and can therefore be a source of fatigue in its own right. Flying can affect fatigue more acutely in situations with high workload or challenging environmental conditions.

Fatigue Factors in General Aviation: B. The Physiology of Fatigue: Sleep & Sleep Loss

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This section provides basic information about the complex physiological process of sleep and the effects of sleep loss and sleepiness. The information, based on scientific research, will help provide a more complete understanding of the need for and importance of sleep.

Sleep Physiology: Two States of Sleep

- NREM (non-rapid eye movement) sleep
 - Physiological and mental activity slowed
 - Light sleep (stages 1 and 2); deep sleep (stages 3 and 4)
- REM (rapid eye movement) sleep
 - Physiological and mental activity increased
 - An active brain (dreaming) in a paralyzed body

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It is widely believed that sleep is a time when the brain and the body shut off and then re-engage upon awakening. Actually, sleep is a highly complex physiological process during which the brain and body alternate between periods of extreme activity and quiet, but are never “shut off.” Sleep is composed of two distinct states: NREM, or non-rapid eye movement, and REM, or rapid eye movement, sleep. These two sleep states are as different from each other as they are from wakefulness.

During NREM sleep, physiological and mental activities slow (e.g., heart rate and breathing rate slow and become regular). NREM sleep is divided into four stages, with the deepest sleep occurring during stages 3 and 4. There is usually very little mental activity during NREM stages 3 and 4. If awakened during this deep sleep, an individual may take sometime to wake up and then continue to feel groggy, sleepy, and perhaps disoriented for 10–15 minutes. This phenomenon is called sleep inertia.

REM sleep is associated with an extremely active brain that is dreaming, and with bursts of rapid eye movements (probably following the activity of the dream). During REM sleep, the major motor muscles of the body are paralyzed. If awakened during REM sleep, individuals can often provide detailed reports of their dreams.

Sleep Architecture: NREM/REM Cycle

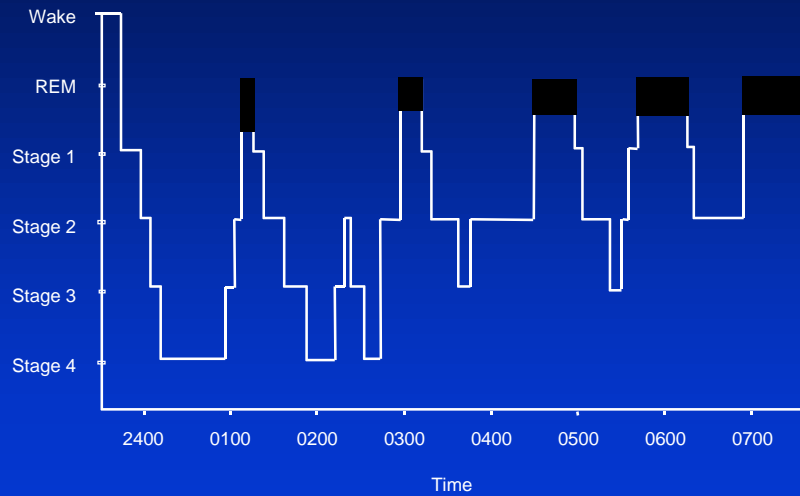
- NREM and REM alternate throughout each sleep period
- Most deep sleep occurs in first half of sleep period
- REM periods longer, more regular later in sleep period

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Over the course of a typical night, NREM and REM sleep occur in a cycle, with about 60 minutes of NREM sleep followed by about 30 minutes of REM sleep. This 90-minute cycle repeats itself throughout a typical sleep period. However, most deep sleep (i.e., NREM stages 3 and 4) occurs in the first third of the night, and REM periods are shorter early in the night and then become longer and occur more regularly later in the sleep period. Overall, about 25% of sleep time is spent in REM sleep and about 50% is spent in NREM stage 2.

Histogram of Normal Sleep



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This graph portrays a typical night of sleep for a normal adult. It exemplifies the sleep architecture discussed on the previous slide: REM (indicated by darkened bars) and NREM alternating throughout the period; most deep sleep occurring in the first half of the sleep period; and REM periods becoming longer and more regular later in the sleep period.

Sleep Physiology

- Amount and structure of sleep changes over the life span

Sleep becomes less deep, more disrupted, and total nocturnal sleep decreases

Daily percentage sleep loss is 3.5 times greater in long-haul flight crewmembers aged 50–60 than in those aged 20–30

- Quantity vs quality of sleep

Getting 8 hours of disrupted sleep can have effects similar to too little sleep

After sleep loss, sleep is deeper rather than longer

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The amount and structure of sleep change profoundly over the life span. With increased age, sleep becomes less deep (most NREM stages 3 and 4 disappears) and more disrupted (awakenings increase), and the total amount of nocturnal sleep decreases. It is not that older individuals need less sleep, but it appears that with age, our ability to obtain a consolidated and continuous period of nocturnal sleep decreases. These changes can be seen in individuals starting as early as 50 years of age. This normal part of the aging process is reflected in a recent finding from a NASA study. Long-haul flight crewmembers aged 50–60 had a daily percentage sleep loss 3.5 times greater during trip schedules than those aged 20–30 years.

The quality of sleep can be as critical as the quantity of sleep in restoring an individual. If an individual obtains 8 hours of sleep but the sleep is disrupted tens or hundreds of times, then upon awakening, the individual may feel as if only a few hours of sleep were obtained. There are many diverse reasons for disrupted sleep, from environmental causes (e.g., noise, light) to physical sleep disorders. For example, there is a sleep disorder called “periodic leg movements during sleep” that involves one or both legs twitching throughout sleep (see appendix A for further information). With each leg twitch, the sleeper is awakened briefly. Hundreds of these brief awakenings can occur during one sleep period. The sleeper can be completely unaware of the twitches or awakenings but feel sleepy and tired even after 8 hours of this fragmented sleep.

Another commonly held belief is that after sleep loss, an individual has to “make up” that sleep by sleeping a number of hours equal to those lost. Scientific laboratory studies have demonstrated that following sleep deprivation, recovery sleep is deeper (more NREM stages 3 and 4), rather than extended. During recovery sleep, an individual might sleep somewhat longer, but the most notable feature is the increase in deep sleep.

Sleep Physiology

- Effects of medications

Can delay sleep onset, disrupt sleep architecture, alter total sleep time

- Effects of environmental factors

Noise, temperature, light, etc. may interfere with good sleep

- Effects of alcohol

Suppresses REM, leads to withdrawal effects and more disrupted sleep

Short-haul pilots increase consumption threefold on trips

Can interact with sleep loss to increase sleepiness

Fatigue Countermeasures Group



There are many medications (non-sleeping pill), both prescribed and over-the-counter, that can adversely affect sleep. Depending on the specific action of these medications, they may delay sleep onset, disrupt the sleep architecture, or alter total sleep time.

Environmental factors may also interfere with good sleep. Noise, light, low or high temperatures, and a variety of other factors can decrease the quantity and quality of sleep. With FAA support, NASA has examined the effects of environmental factors on sleep in on-board crew rest facilities.

Alcohol has a profound effect on the usual sleep cycle. After more than a couple of glasses of wine or a couple of beers (with individual variations), alcohol can essentially eliminate all of the REM sleep in the first half of a sleep period. This can lead to subsequent alcohol withdrawal effects in the second half of the sleep period, including sleep fragmentation. Unfortunately, the most widely used sleep aid in the United States is alcohol. Ironically, although often used to promote relaxation and the ability to fall asleep, it will generally have major disruptive effects on the subsequent sleep. One NASA study found that short-haul pilots increased their alcohol consumption threefold during trips compared with home consumption. The pilots used alcohol within FAR guidelines to unwind after long duty days that included multiple flight segments and to promote sleep onset before an early wake-up for the subsequent duty day. Alcohol also interacts in a synergistic fashion with sleepiness. A sleep-deprived individual who is already sleepy will demonstrate more severe performance and alertness impairment following alcohol consumption.

Sleep Physiology

- Sleep disorders can disturb sleep and waking alertness

Sleep problems can be diagnosed and treated by sleep-disorder specialists

- Sleeping pills

Some help you fall asleep, stay asleep, which may improve your waking alertness

Some alter sleep structure, create dependency, have carryover effects that may decrease waking alertness and performance

Only recommended at the prescribed dose for short periods of time

May have potentially serious side effects

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There are physical sleep disorders that can disturb sleep and impair waking alertness and performance. (See Appendix A for some examples, such as sleep apnea.) These sleep disorders can have profound effects on waking function, and yet occur with the sleeper essentially unaware of their existence. Sleep problems can be diagnosed and treated effectively by accredited sleep disorders specialists and clinics.

Appendix A also provides some general information about sleeping pills. Some prescription sleeping pills may facilitate falling asleep and staying asleep, with subsequent improvements in waking alertness and performance. However, many sleeping pills alter sleep structure dramatically, create drug dependence, and have carryover effects that decrease waking alertness and performance. Proper use of these medications typically means taking the lowest dose, and that for only a few days. Many sleeping pills can have potentially serious side-effects, and none should be taken except under the care and guidance of a physician. An example of the potential effects of an over-the-counter sleep aid is described by a Cessna Centurion pilot who believes that the prolonged effects of taking a sleep aid caused confusion and sloppy flying (ASRS Accession No. 372194).

Sleep is a Vital Physiological Function

- Sleep loss is additive, results in a cumulative sleep debt
- Sleep loss leads to increased sleepiness
- Consequences of sleepiness
 - Decreased physical and mental performance
 - Decreased positive and increased negative mood
 - Increased vulnerability to performance decrements

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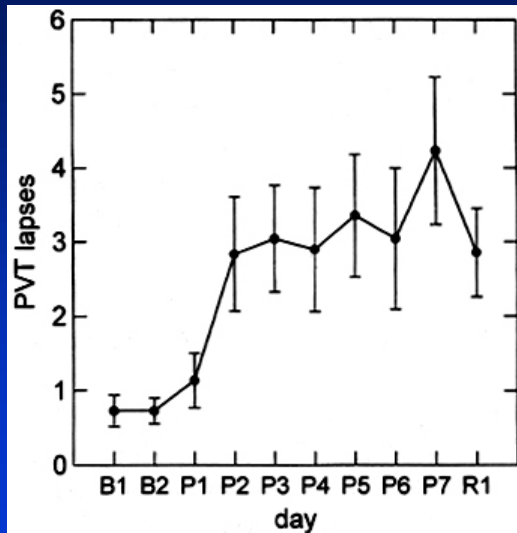


Like food and water, sleep is a physiological need vital to human survival and critical to human existence. Sleep loss can be additive and can result in a cumulative sleep debt. Estimates suggest that in the United States, most people get 1–1.5 hours less sleep than they need. During a regular 5-day work week a typical individual might accumulate a 7.5-hours sleep debt, equal to a full night of sleep loss, going into a weekend. In today's society, many individuals actively attend to their nutrition and exercise to promote good health. Unfortunately, the first physiological need that suffers when individuals are faced with everyday pressures and demands is sleep. Losing sleep becomes a way of squeezing more hours and minutes into the day, which demonstrates a lack of concern for meeting this vital physiological need.

Sleep loss leads to increased waking sleepiness. Many people equate sleepiness with being lazy or acknowledge it only humorously. Sleepiness can have severe consequences for us as individuals and as a society. Sleepiness can degrade essentially every aspect of human performance. Sleep loss and sleepiness can decrease physical, psychomotor, and mental performance, and can increase negative mood and decrease positive mood. Therefore, a principal consequence of sleepiness is an increased vulnerability to performance decrements. It is important to consider this as a performance vulnerability because, like the effects of alcohol on performance and memory, sleepiness can lead to a reduced safety margin and an increased potential for operational incidents and accidents. Sleep loss and sleepiness resulting from extended duty or altered work/rest schedules have been suggested as contributory factors in many accidents and catastrophes. Many people put themselves at personal risk by driving when too sleepy, sometimes experiencing a near incident or an actual accident.

Sleep loss can result in a cumulative sleep debt. Sleepiness should be taken seriously. The vulnerability can be minimized, thus potentially avoiding an incident or accident.

Effect of Partial Sleep Loss on Vigilance



Sleep duration:

- Baseline (B): 7.4 hr
- Nights 1-7 (P): 5.0 hr
- Recovery (R): 7.9 hr

Mean of PVT trials at 1000, 1600, 2200 hrs for 16 subjects

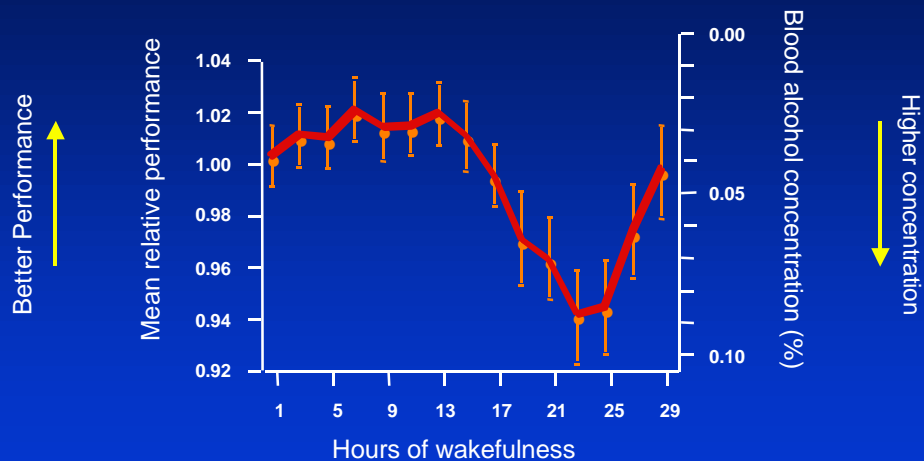
From Dinges et al., 1997; reprinted with permission from Sleep

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Partial sleep loss and cumulative sleep debt affect waking alertness. Dinges and colleagues (1997) conducted a study that measured cumulative sleepiness and psychomotor vigilance performance. Sixteen subjects participated in the study. Subjects were assigned to two nights of baseline sleep (the averages for 16 subjects on both nights were consistent at 7.4 hrs), seven nights of 5 hrs sleep restriction, and a recovery night (when subjects slept as much as they wanted up to 10hrs). The psychomotor vigilance test (PVT), a visually-based sustained attention task, which consisted of 10-minute trials, was used to measure performance during baseline nights, restricted sleep nights, and the recovery night. Increasing performance-impairment or decreasing alertness is reflected as slower response times on the PVT. The average performances on the PVT trials for all subjects, recorded at 1000, 1600, and 2200 hrs, are shown on the above graph. The average number of PVT lapses (i.e., reaction times ≥ 500 milliseconds) was less than one on both baseline nights (B1 and B2) and significantly increased to three lapses after the second sleep restriction night (P2). Responses were much slower during the 7 days of restricted sleep (≈ 3), especially after day 7 (≈ 4). After a recovery night of sleep (R1), PVT performance improved and lapses decreased, however, sleep was not completely recovered, and PVT performance was (< 3) still significantly different from the baseline measures (< 1). These findings show that after a short period of partial sleep loss, performance lapses increase and stabilize until sleep is completely recovered.

Fatigue, Alcohol, & Performance Impairment



From Dawson & Reid, 1997; adapted with permission from Nature

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Dawson and Reid (1997) conducted one of the first studies that attempted to compare levels of performance impairment caused by reduced sleep (i.e., sustained wakefulness) and levels of performance impairment due to alcohol intoxication. Forty subjects participated in the study and were randomly divided into two groups. One group maintained a 28-hour sustained wakefulness, and the other group consumed 10–15g alcohol at 30-minute intervals until their average blood alcohol concentration reached a level of 0.10%. Computer-based measures of cognitive psychomotor performance were recorded at half-hour intervals.

As shown in the graph above, the effects of sleep loss on performance are similar to those of alcohol intoxication. After 17 hours (number of hours of wakefulness: horizontal axis) of sustained wakefulness, performance impairment levels (left vertical axis) were (≈ 0.98) similar to the performance impairment levels of 0.05% blood alcohol concentration (right vertical axis). After 21 hours of sustained wakefulness, performance impairment levels were (≈ 0.94) similar to the performance impairment levels of 0.09% blood alcohol concentration. These findings indicate that performance decreases significantly in both conditions, sustained wakefulness and alcohol intoxication. The only difference between these conditions is that the performance impairment effects of alcohol intoxication appear more abruptly than the performance impairment effects of sustained wakefulness.

Sleepiness: Two Distinct Components

- Physiological sleepiness
 - Lose sleep, get sleepy
 - Underlying biological process
 - Only reversed by sleep
- Subjective sleepiness
 - How you feel; what you report
 - Can be concealed or altered by environmental stimulation, physical activity, caffeine, etc.

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Two distinct components of sleepiness have been described. Physiological sleepiness parallels other vital physiological functions like hunger and thirst. Deprived of food or water, the brain signals that these vital physiological needs have not been met by developing feelings of hunger and thirst. When physiologically deprived of sleep, the brain's signal is sleepiness. Just as the only way to reduce or eliminate hunger or thirst is to eat or drink, when an individual is physiologically sleepy, only sleep will reverse this vital need.

Subjective sleepiness is an individual's introspective assessment of the feeling and a self-report of that status. An individual can rate current sleepiness on a scale from "wide awake and alert" to "extremely sleepy, ready to nod off." However, this self-reported rating can be strongly affected by a variety of factors, such as environmental stimulation. The level of underlying physiological sleepiness can be concealed by an environment in which an individual is physically active, has consumed caffeine, or is engaged in a lively conversation. Whereas these factors may affect the self-reported rating of sleepiness (usually individuals will report greater alertness than is warranted), they do not affect the underlying sleep need expressed by the level of physiological sleepiness.

Subjective vs Physiological Sleep and Alertness

- It can be difficult to reliably estimate your own sleep and alertness, especially if you are already sleepy
- The good news:
 - Tendency to overestimate time to fall asleep and underestimate total sleep time
 - It may not be as bad as you think
- The bad news:
 - Tendency to report greater alertness than indicated by physiological measures
 - It may be worse than you think

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It is usually difficult for most individuals to reliably estimate their own sleep or their waking alertness, especially if they are already sleepy.

Overall, there is a tendency for individuals to subjectively overestimate how long it takes to fall asleep and underestimate total sleep time, relative to physiological measures. Generally, people fall asleep faster and sleep longer than they think. So when an individual experiences a bad night of sleep, it may not have been as bad as it seemed.

However, the tendency is for individuals to subjectively rate themselves as more alert than is indicated by physiological measures. That is, most individuals are more likely to be sleepier than they report or experience.

Factors Affecting Sleepiness

- Prior sleep/wakefulness
- Circadian phase (time of day)
- Age
- Medical conditions
- Medications
- Alcohol
- Environmental/work conditions

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The factors listed above have been demonstrated to affect waking sleepiness and, therefore, could be considerations in worsening or improving sleepiness.

Prior sleep/wakefulness refers to how long you have been awake. As you remain awake past 16 hours on your regular schedule, your probability of experiencing fatigue begins to increase. Many people experience significant cognitive impairment as they approach 24 hours without sleep. Beginning a flight after a long day of work increases your chances of becoming seriously fatigued.

Circadian phase refers to what time it is according to the biological clock in your brain (see the next section for more on circadian rhythms). Flying in the late night to early morning hours puts you at an increased risk for fatigue. Our bodies are programmed to sleep at night and to be awake during the day. Reversing this schedule, as shift workers often must do, can result in falling asleep at the wheel or controls during the nighttime and being unable to obtain adequate recovery sleep during the day.

The ability to obtain consolidated nighttime sleep gradually diminishes with age. As a result, older people are more likely to experience daytime sleepiness and should be particularly cautious when flying during the mid- to late afternoon and late at night.

Not surprisingly, medical conditions and medications can also affect sleepiness. The effects of alcohol and environmental conditions have already been discussed. Work conditions may affect sleepiness by creating an environment conducive to sleep or, conversely, to alertness. For example, a dimly lit work area may contribute to sleepiness, while a brightly lit room may help maintain alertness.

Fatigue Factors in General Aviation: B. The Physiology of Fatigue: Circadian Rhythms

Fatigue Countermeasures Group



This second section provides basic information about circadian rhythms and how they apply to fatigue, jet lag, and shift work. Circadian rhythms are the second physiological factor that affects fatigue in flight operations.

Circadian Rhythms

- *Circa* = about; *dies* = day
- A circadian clock in the brain coordinates daily cycles:

Sleep/wake	Performance
Temperature	Hormones
Digestion	Etc.
- Without any timing information from the environment, the biological day is about 24.2 hours

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Over evolutionary time, the daily cycles in the physical environment (produced by the Earth's rotation) have become hard-wired into our neuronal circuitry in the form of a biological clock in the suprachiasmatic nucleus of the hypothalamus located in the brain. However, since the beginning of the industrial revolution, we have developed a cultural environment in which there is ever-increasing pressure for around-the-clock operations and services. The expedient (but incorrect) assumption that we can and do function equally at any time of the day or night underlies many activities in our society, from medical diagnosis and treatment to many hours-of-service regulations.

When people live alone in environments from which all possible time cues have been carefully excluded (deep caves, underground bunkers, or specially designed apartments), they begin to live "days" that are generally longer than 24 hours. Regardless of how long someone's subjective "day" becomes in a time-free environment, the circadian clock still enforces an approximately 24.2-hour cycle in many functions. Some people even develop "days" as long as 50 hours with, for example, 36 hours of wakefulness followed by 14 hours of sleep.

The circadian clock can be thought of as analogous to the conductor of a symphony orchestra. Many different systems in the body, down to the level of individual cells, are capable of generating circadian rhythms independently, just as the members of an orchestra must each be capable of playing their own part. However, if they are not all synchronized appropriately, the harmony rapidly degenerates into cacophony.

Time of Day & Circadian Phase

- In general, the body is programmed to be awake during the day, asleep at night
- In a usual 24-hour day, there are two times of increased sleepiness: 3–5 a.m. and 3–5 p.m.
- Performance and alertness can be affected during a 2 a.m. to 6 a.m. window

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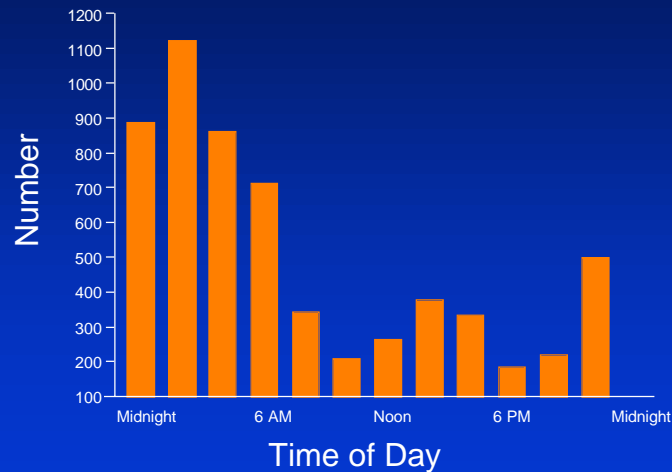


Overall, humans are physiologically programmed to be awake during the day and asleep at night.

Additionally, two periods of maximal sleepiness occur in a usual 24-hour period. The period 3–5 a.m. is a circadian low point for temperature, performance, and alertness. During this time, the brain triggers sleep and sleepiness. The other period of increased sleepiness is roughly 3–5 p.m. Most individuals have experienced an afternoon wave of sleepiness. These windows can be used to schedule sleep periods or naps because the brain provides a period of maximal sleepiness and an increased opportunity for sleep.

Performance and alertness can be decreased during the nocturnal window, which is from 2 a.m. until 6 a.m.. For some, however, the afternoon window of sleepiness may occur between 2 p.m. and 4 p.m. This highlights some of the differences among individuals.

Fatigue-Related Accidents



From Mitler et al., 1988; adapted with permission from Sleep

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The data graphed above present combined findings from studies conducted in Israel, Texas, and New York (M. M. Mitler, et al, 1988). The graph shows a composite temporal distribution of 6,052 single-vehicle traffic accidents caused by the driver “falling asleep at the wheel.” Two major peaks in incidence occur between the hours of midnight and 7 a. m. (especially between 1 a.m. and 4 a.m.) and between 1 p.m. and 4 p.m. The data agree with vehicular studies performed in Germany and the Netherlands, as well as with studies among locomotive drivers of the German Federal Railways, where accidents occurred most within the same peak hours.

Circadian Synchronization

The circadian clock is synchronized (reset) daily by:

- Bright light (sunlight)
- Work/rest schedules
- Regular social factors

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Unless timing information is received from the environment, the human circadian clock tends to run slow. The specific environmental time cues which synchronize it to a 24-hour day are known by the German term “zeitgebers,” meaning “time-givers.” Currently, two common zeitgebers have been identified: exposure to bright light and social factors.

Bright light (more than about 2500 lux—normal indoor light is generally less than 500 lux) affects the circadian clock by means of a direct neural pathway from the eye. The principle behind synchronization of the circadian clock by light/dark cycles is reasonably well understood and can be summarized as follows.

1. Light exposure in the subjective morning advances subsequent circadian cycles.
2. Light exposure in the middle of the subjective day has minimal effect.
3. Light exposure in the subjective evening delays subsequent circadian cycles.

To synchronize a circadian clock with an innate period of 25 hours to a 24-hour day requires that the clock be advanced by 1 hour per day. An appropriate exposure to sunlight every morning would achieve the necessary resetting. Conversely, to synchronize a clock with an innate period of 23 hours would require a delay of 1 hour per day, in other words, an appropriate exposure to sunlight every evening. While these examples illustrate the mechanism of synchronization, they are highly simplistic. In practice, synchronization of an individual’s circadian clock to a 24-hour day depends on a complex combination of zeitgeber inputs. There is some evidence that the human circadian clock may be synchronized by certain social factors, including the work/rest schedule. However, the specific aspects of the social environment that constitute time cues have not yet been identified, and the mechanisms by which they affect the clock remain unknown.

Circadian Desynchronization

- Circadian clock cannot adapt immediately to duty/rest schedule changes or new environmental times
- Jet lag (crossing time zones)
 - Circadian clock is out of step with the environment
 - Different circadian rhythms adjust at different rates
- Night work/day sleep
 - Conflict between body and environmental synchronizers

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When the circadian clock is out of time with the environment, the result is known as circadian desynchronization. Two common causes of this phenomenon are jet lag and shift work.

Crossing time zones produces a zeitgeber disruption regularly encountered by flight crews and frequent transmeridian travelers. The circadian clock resynchronizes only gradually to a new environmental time. Circadian rhythms in different functions adjust more or less quickly, depending on the tightness of their coupling to the clock and on their interactions with other physiological functions, each adapting at its own rate. Thus, after a transmeridian flight, not only is the circadian clock out of step with the local zeitgebers, but also different physiological functions are out of step with one another.

The basic problem with shift work (e.g., night operations) is that it requires people to override the circadian clock, which pre-programs us for daytime activity and nighttime sleep. The work/rest schedule itself may reset the clock of the shift worker to some extent. However, the competing zeitgeber inputs from the day/night cycle and our predominantly day-oriented society continually push it back toward its usual diurnal orientation. Thus, at best, the circadian rhythms of shift workers usually are only partially adapted to their current work/rest schedule. In addition, most shift workers revert to being day-active on their days off. This continuously changing orientation can result in chronic desynchronization of the circadian clock relative to the environment, and persistent internal desynchronization among different physiological systems.

Effects of Circadian Desynchronization

- Jet lag and shift work can result in:
 - Disturbed sleep
 - Increased waking (work-time) sleepiness
 - Decreased physical and mental performance
 - Increased reports of fatigue
 - More negative mood
- Be aware of these effects if flying after schedule or time zone changes

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Circadian desynchronization from jet lag and shift work can result in a variety of symptoms.

Recent overviews of studies with shift workers indicate that 60% of them have sleep complaints, whereas only 20% of day workers have similar complaints; 75% of night workers experience sleepiness on every shift, and 20% report falling asleep.

Shift workers (particularly rotating shift workers) have a higher incidence of sick leave, more frequent visits to health care facilities at the work site, and more general health complaints than day workers. Night shift workers have higher incidences of gastrointestinal disorders, including general stomach discomfort and ulcers, than do day workers. These symptoms probably result from the interaction of several factors, including circadian desynchronization and the increased domestic and social stresses that often accompany shift work.

If you experience jet lag or a reversed work/rest schedule, keep in mind that circadian disruption can result in decreased alertness and performance, which in turn, can affect skills critical for flying.

Fatigue Factors in General Aviation:

C. Effects of Flight Operations on Fatigue

Fatigue Countermeasures Group



The previous section discussed the principal physiological factors that create fatigue. This section identifies how flight operations, and General Aviation operations in particular, play a role in creating pilot fatigue.

How Flying Affects Fatigue

- Prolonged wakefulness
- Irregular sleep/wake schedules
- Night or late afternoon flying
- Monitoring role
- Workload
- Physical environment

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While many general aviation pilots have the benefit of flexible flight schedules and minimal outside pressure to begin or complete a flight, there are nevertheless several aspects of flying that can contribute to fatigue. The factors listed above will be discussed in the following pages, but this does not exclude other aspects of flight operations that may also contribute to fatigue.

Effect of Flight Operations on Sleepiness

- Extended flights or flying after a workday
 - Prolonged wakefulness
 - Fatigue from multiple flights, long day
- Restricted time for sleep (early wake-up, late night)
 - Sleep loss, cumulative sleep debt

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Flight operations can contribute to fatigue through their effect on sleep. A long flight or flying after a full day of work can create fatigue by extending wakefulness and decreasing sleep. This, in turn, can involve circadian disruption. An example of fatigue associated with sleep loss is the incident described in an ASRS report, in which both pilots of a Jetstream-32 had been on long multiple flight legs on the previous day and were restricted to a reduced rest schedule; the following day's flight was scheduled in the morning, when both pilots were still fatigued, and they departed without takeoff clearance (ASRS Accession No. 368250). In another example, an NTSB report identified fatigue as a contributing factor that affected the situational awareness of a Cessna-182 pilot. Having had only 2-3 hours of sleep the night before, the pilot failed to select the correct fuel tank, which resulted in total loss of engine power, and then failed to maintain proper airspeed (NTSB ID No. MIA92LA 095).

Extended physical and mental effort over multiple flights or from working all day and then flying may also contribute to fatigue, as indicated in an ASRS report of two pilots in a Barron 58 who reported that they both fell asleep during the last of a multiple-leg cargo run. (ASRS Accession No. 359360).

The time available for sleep may be restricted by a variety of constraints, such as early wake-up times (e.g., to start the workday) or late nights. Busy schedules can result in lost sleep over several nights, which accumulates into a sleep debt.

In another ASRS report, the pilot of a Piper Arrow IV, after a long working day, was fatigued and positionally disoriented, misidentified the ground checkpoint, descended too early for an approach to land, and violated class C airspace (ASRS Accession No. 401150).

Effect of Flight Operations on Sleepiness

- Night or late afternoon flying
 - Body programmed to be sleepy
 - Window of circadian low: 3–5 a.m.
 - Additional window of sleepiness: 3–5 p.m.
- Low workload/monitoring role
 - Boredom, complacency
 - Can unmask sleepiness during periods of low activity

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Flight operations can affect fatigue through their impact on the body's circadian rhythms. Flying at night or in the late afternoon requires overriding the body's programmed periods of maximal sleepiness. During the window of circadian low (from about 3–5 a.m.), individuals are particularly vulnerable to low levels of alertness and performance. An additional window of increased sleepiness occurs from about 3–5 in the afternoon. One example of an accident during the window of circadian low involved the pilot of a Cessna 172RG, who was fish spotting for a boat during the night. The pilot made a final call to the boat at about 0300 to say he was returning to base, but while the boat captain expected to hear from the pilot one more time at 0330, no further contact was made. When the pilot failed to arrive at the base, a search was initiated, which revealed the downed aircraft on a nearby island. Fatigue was cited as a factor (NTSB ID No. LAX91LA032).

During long, continuous, or low-workload operations, pilots may experience boredom and complacency, especially when an individual is in a passive monitoring role. For example, when auto-pilot or a automated navigation system is engaged, there is an opportunity for these factors to increase the likelihood for physiological sleepiness to emerge (i.e., the person may fall asleep). This was reported as a factor when a Beech Debonair pilot, flying through the night, fell asleep and awoke 30 nm out to sea penetrating the Air Defense Identification Zone (ADIZ) and a restricted area while low on fuel (ASRS Accession No. 464691).

Effect of Flight Operations on Fatigue

- Workload
 - High physical or cognitive workload
 - Continuous workload
- Physical environment
 - Temperature, humidity, pressure
 - Noise, vibration, turbulence

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Flight operations also can affect fatigue directly. For example, heavy workload or extended periods without a break may contribute to fatigue. While the role of workload in fatigue is complex and has not been clearly defined, anecdotal evidence and common sense suggest that high workloads may compound fatigue, particularly over the course of a long day of flying. According to an ASRS report, increased workload combined with long working days induced fatigue in the pilot of a Caravan I 208A who failed to lower the landing gear before touchdown (ASRS Accession No. 418627). In another ASRS report, the flight instructor and student flew a missed approach that was different than the instructions issued by ATC (ASRS Accession No. 430444). FAR 61.195(a) states that flight instruction may not exceed 8 hr in any 24 hr consecutive period. Although the CFI did not exceed the 8 hr limit of flight instruction, pre and post flight briefings with students added up to 10-12 hr work days for the previous 13 days.

Certain aspects of the flight deck environment can create discomforts that can exacerbate fatigue as well. Flight crews from various operational environments, including long-haul and short-haul commercial air transport, regional airlines, and corporate aviation have identified specific environmental factors as contributing to fatigue, such as high temperatures and dry air on the flight deck, noise, vibration, and turbulence.

Survey of Fatigue in Corporate/Executive Operations

- To identify operational factors that contribute to fatigue (mostly Part 91 ops, some Part 135)
- 107-question survey, voluntary & anonymous
- 1,488 pilots from U.S. corporate flight departments

Fatigue Countermeasures Group



While there are few scientific data concerning fatigue in general aviation (especially recreational flying), corporate/executive aviation—much of which operates under FAR Part 91—has been examined in a survey study conducted by the NASA Ames Fatigue Countermeasures Group.

The specific operational requirements of corporate aviation create unique challenges regarding human fatigue. The objective of the survey study was to identify factors that may contribute to fatigue in corporate operations.

A retrospective survey of 107 questions was disseminated to professional pilots from U.S. corporate flight departments. The number of pilots in individual flight departments ranged from 1 to 200, and the overall company size ranged from 1 to 675,000. The survey addressed 7 main topics: general demographics, sleep at home, flight experience, duty and rest patterns, fatigue during operations, and work environment, with a separate 7-question section for management pilots that focused on scheduling. Participants were 1,488 corporate flight crewmembers who voluntarily and anonymously completed the survey.

Survey of Fatigue in Corporate Ops: Fatigue as an Issue

- 74% corporate pilots considered fatigue a “moderate” or “serious” concern
- 61% reported crew fatigue common
- 85% rated fatigue a “moderate” or “serious” safety issue when it occurs
- 71% have “nodded off” in the cockpit

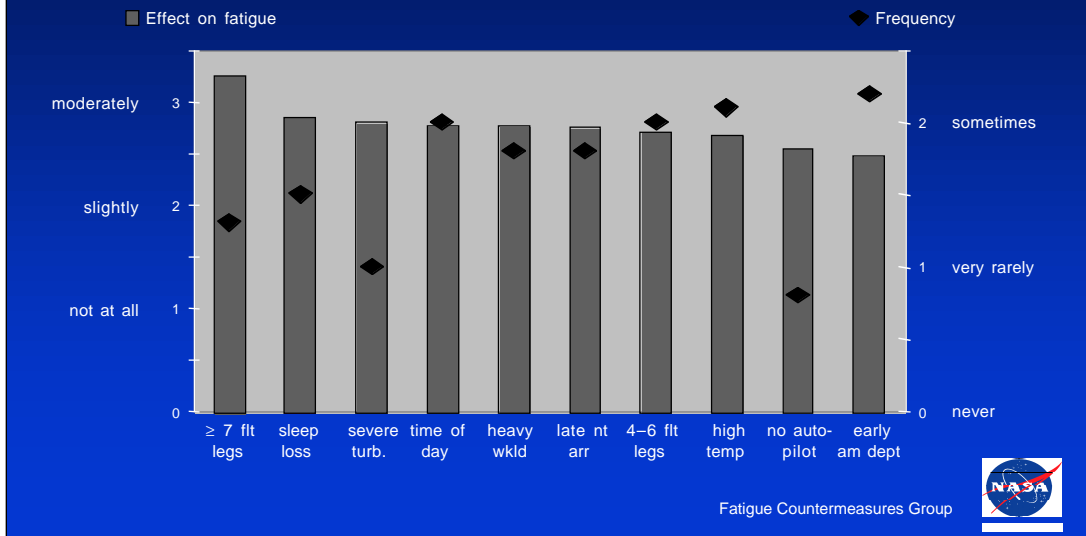
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Overall, the corporate pilots portrayed fatigue as a significant concern in their flight environment. Almost three-quarters of the subjects (74%) indicated that they considered fatigue a “moderate” or “serious” concern in corporate flight operations, while 2% did not consider it a concern at all. Sixty-one percent described crew fatigue as a common occurrence in regional operations. Further, most (85%) indicated that, when crew fatigue occurs, it is a “moderate” or “serious” safety issue. Almost three-quarters of the subjects (71%) acknowledged having nodded off during a flight at some time.

Pilots may have duties beyond their scheduled flight time and it is important to be aware of fatigue during any flight. This includes maintenance checks as well. A Cessna Citation was damaged after the aircraft became airborne and veered off the runway during a high speed taxi check (ASRS Accession No. 436477).

Survey of Fatigue in Corporate Ops: Operational Factors Affecting Fatigue



In the survey, corporate pilots were asked to rate 34 factors on the extent to which each affected fatigue levels using a four-point scale from “not at all” to “seriously,” and to assess the frequency each factor was experienced using a five-point scale from “0 = never” to “4 = very often (5–7/wk).” The figure shows the 10 factors with highest average ratings, with the mean fatigue rating on the left axis (bars) and the mean frequency rating on the right axis (diamonds).

The 10 highest rated factors identified operational factors were (multiple flight segments, severe turbulence), physiological factors (sleep loss), scheduling (time of day of operations, late night arrivals, early morning departures), workload factors (heavy workload, no auto pilot), and environmental factors (high ambient temperatures).

Examining the fatigue effect rating in conjunction with the frequency of occurrence, four of the top ten factors that received frequency ratings of “sometimes” or higher were (“time of day of operations,” “flying 4–6 flight segments,” “high ambient temperature,” and “early morning departures”).

Survey of Fatigue in Corporate Ops: Fatigue Factors Identified

- Scheduling (e.g., long duty days, time-of-day)
- Operational factors
 - Workload (general workload, no auto-pilot)
 - Environmental/weather (high temp., turbulence)
- Physiological state (sleep loss, illness)

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Overall, fatigue factors identified throughout the survey can be categorized as scheduling factors, operational factors, and physiological state.

Specific scheduling issues identified as fatigue factors included long duty days; early morning departures, late night arrivals, and time of day of operations; rest; multiple flight legs, long breaks between flights, and consecutive duty days.

Operational factors identified by corporate crews included workload as well as environmental and weather conditions. Ninety-six percent of the pilots reported that they had additional responsibilities, peripheral to their flight duties, including maintenance, flight planning, baggage handling, aircraft servicing, and dispatch. Other workload-related factors are instrument meteorological conditions, level of automation, and the amount of time spent in high-workload flight phases (e.g., takeoff and landing). Environmental and weather conditions may contribute to fatigue by increasing workload or by creating physical discomfort.

Physiological condition also can affect a pilot's fatigue level. Sleep loss has been shown to decrease alertness and degrade performance. Illness was identified as another factor that contributed to fatigue.

Characteristics of General Aviation

- Diverse pilot group
- Broad range of operations
- Equipment varies greatly

Fatigue Countermeasures Group



General aviation, as its name suggests, encompasses a wide range of pilots, operations, and equipment. Each of these factors can influence fatigue by affecting the characteristics of specific operations.

Who are GA pilots?

- Professionals and recreational pilots
- Various certificates & ratings
 - Student, rec., private, comm., CFI/I, etc.
 - Instrument, multi-engine, type-ratings, etc.
- Varying degrees of skill and experience
- Different levels of currency/proficiency

Fatigue Countermeasures Group



General aviation pilots may be full-time professionals or part-time recreational flyers, and they may hold any of various certificates and ratings. Additionally, general aviation includes brand new pilots as well as those with tens of thousands of hours, and all skill levels. While some GA pilots fly daily and others fly only occasionally, the varying levels may affect flight proficiency.

Pilot Characteristics May Affect:

- Workload— perceived & actual (experience, proficiency, skill)
- Knowledge/use of fatigue countermeasures (training)

which may, in turn, affect fatigue

Fatigue Countermeasures Group



Factors such as skills level, experience, proficiency, and quality of training have the potential to influence the ways in which fatigue affects a pilot, and in turn, the way in which a pilot addresses fatigue. However, NO pilot, regardless of certificates, ratings, and sheer skill, no matter how experienced or professional, is immune to the effects of fatigue. Major airlines (both U.S. and international), regional airlines, corporate flight departments, and military operators have been increasingly aware of the benefits of addressing fatigue and alertness issues with their flight crews and others central to their operations. The most effective pilots in any segment of aviation recognize their physiological limitations and take necessary action to address them.

The ASRS examples provided in this module are a sample of the pilot population flying under Part 91 and 135 that have experienced some form of fatigue during a flight. These pilots average 3,360 hr of total flight time with a minimum reported total flight time of 132 hr and a maximum reported flight time of 17,000 hr.

Broad Range of Operations

- Pleasure, personal transportation
- Flight instruction
- Various commercial (aerial photography, surveying, crop dusting, etc.)
- Corporate/business aviation

Fatigue Countermeasures Group



Similarly, general aviation encompasses a wide range of flight operations. GA pilots fly for pleasure, for transportation, and for a living. Various commercial operations are regulated by FAR Part 91.

Corporate aviation, in particular, has specific operational requirements, which may differ dramatically from other general aviation operators, and are, therefore, outside the scope of this module. As stated in the preface, corporate operators may benefit more from the information in the original education and training module (Rosekind, et al, 2001), referenced in Appendix D.

Specifics of Operation May Affect:

- Time of day of flight
- Flexibility of schedule
- Physical environment (e.g., weather, terrain)
- Flight environment (e.g., traffic, radar coverage)
- Workload (e.g., automation, single-pilot ops)

which may, in turn, affect fatigue

Fatigue Countermeasures Group



The specific operation determines many circumstances surrounding the flight. Both time of day of the flight and the flexibility of that time will depend on the operation. Scheduled operations may provide limited flexibility. On-demand operations face both limited predictability and limited flexibility. Even without set schedules, self-induced time pressures can affect decisions made by GA pilots.

For example, a student and his instructor flew the outbound legs of a two-day cross country flight from Nebraska to Arizona, where the instructor was to pick up another aircraft (NTSB ID No. CHI95FA149). Each had slept about 4 hours the previous night. The aircraft was not ready, but the student, who had logged 19 total flight hours, was in a rush to return by the following morning, so the two decided that the student would return alone. The student departed at about 1230 and refueled three times, but at about 0100, the aircraft disappeared from radar 12 nm SE of the destination airport and crashed, killing the student pilot. Investigation revealed that there was no fuel in the engine, carburetor, or fuel lines, and the NTSB determined that factors contributing to the accident included inadequate supervision by the CFI, inadequate emergency procedure training by the CFI, darkness, the student's lack of experience, and fatigue. This accident exemplifies the roles of both time-of-day and flexibility of schedule in fatigue.

In addition to time of day and flexibility of schedule, factors such as weather, traffic, and workload depend on the type, purpose, and location of the flight. These factors have been identified as contributing to pilot fatigue in studies on commercial flight crews. Consider the specific items identified by corporate pilots in the survey study described earlier, which included scheduling, environmental and weather factors, and workload. Also, the pilot of this ASRS example made it home through marginal VFR conditions. However, the pilot could have conducted the flight in safer conditions if the decision was made to wait just another 1.5 hr longer (ASRS Accession No. 414968).

Equipment Varies

- Range of technology
 - General (e.g., no. & type of engines)
 - Instrumentation, Navigation
 - Automation (e.g., auto-pilot, electric trim)
- Age of aircraft & other equipment
- Quality of maintenance

Fatigue Countermeasures Group



The equipment used for the variety of general aviation operations represents a wide range of technology, age, and condition. GA equipment may be a vintage aircraft with minimal instrument gauges, a single-engine rental subjected to thousands of hard landings, or a new highly automated jet twin with a dedicated maintenance crew.

Automation can help a pilot in many ways, yet when the systems are controlling the flight, it can be easy to fall asleep and this is especially true in the early morning hours. Take for example this Mitsubishi MU-2 pilot on a non-revenue flight who's last memory was scanning the instruments and upon awakening finds that the destination (Dallas, Texas) was overshoot by about 100 nm (ASRS Accession No. 455508).

The quality of maintenance is important to any flight. Maintenance delays can also be a factor in terms of the need to keep a flexible schedule as described by this ASRS report in which a 4 hr electrical system repair in the early morning hours delayed the flight (ASRS Accession No. 346351). Approximately 1.5 hr after takeoff with calm air, little radio traffic, and the drone of the engines in the background allowed this pilot to fall asleep. After awakening, the pilot estimated being asleep for 150 nm. Although the flight arrived at the destination without further incident, this example is a reminder that the following statement is clearly **WRONG** that the environment is safe if no accidents occur.

Equipment Differences May Affect:

- Physical environment (noise, vibration, temperature)
- Workload (level of automation)
- Vigilance required (dependability, redundancy)

which may, in turn, affect fatigue

Fatigue Countermeasures Group



The aircraft and associated equipment can contribute to many of the fatigue factors identified by commercial and corporate flight crews. The cockpit environment may vary dramatically among aircraft, with different levels of noise, vibration, and temperature. Certain flight deck environments may necessitate headsets or other additional equipment. The instrumentation, navigation equipment, and level of automation can strongly influence workload. Finally, the condition of the aircraft, quality of maintenance, and level of redundancy can affect the degree of vigilance required of the pilot regarding potential equipment failure. Reliable, well-maintained aircraft with some redundancy widen the safety margin.

The effects of the equipment used for flight operations on environment, workload, and vigilance can affect fatigue levels.

Fatigue Factors in General Aviation: D. Effects of Fatigue on Flight Operations

Fatigue Countermeasures Group



Just as flight operations have specific effects on fatigue, fatigue, in turn, can affect flight operations. The general effects of fatigue on human alertness, performance, and other parameters translate into specific results in flight operations.

How Fatigue Affects Flying

Fatigue can have a negative affect on:

- Alertness & vigilance
- Performance
- Decision-making
- Communication
- Mood
- And more

Fatigue Countermeasures Group



Numerous scientific studies, both in the laboratory and during flight operations, have established that fatigue can decrease alertness, degrade performance, reduce communication, worsen mood, and negatively affect virtually all aspects of human functioning.

Examples of these effects are readily found in incident and accident reports. An example of decreased alertness and degraded performance is an NTSB report of an accident that occurred in July 1985 at Erie, PA, which resulted in two fatalities. The pilot had not slept for approximately 30 hours prior to the flight (NTSB ID No. NYC85FA189). Reduced vigilance was shown in another report when the pilots nearly entered class B/C airspace without clearance and initiated a rapid descent of approximately 2000 FPM to avoid the airspace (ASRS Accession No. 374650). Poor decision due to lack of sleep was reported by a pilot who, while departing from an uncontrolled field, misjudged the closure rate and cut off the aircraft in final approach (ASRS Accession No. 370486). Poor communication occurred during an IFR training approach in which ATC cleared a Cessna 172 for a low approach but the 2 pilots proceeded to perform a touch and go requiring ATC to vector the other aircraft in trail to another runway (ASRS Accession No. 378060). Another incident described in an ASRS report exemplifies negative mood, when the first officer began to argue with the captain, shouting and using profanity, during the second leg of a multiple-flight day. Once on the ground, the captain repeatedly asked to discuss the conversation before the first officer apologized, explaining that he was “tired and grumpy”. (ASRS Accession No. 364877). These reports clearly show how fatigue can decrease alertness, degrade performance, worsen mood, and reduce effective communication.

Effects of Fatigue on Flying Corporate Ops Survey Results

- Degraded cognitive function (e.g., judgment/decision-making)
- Slowed reaction time
- Decreased alertness (e.g., situational awareness, perception)
- Concentration
- Mood (e.g., complacency, irritability)
- Errors (e.g., missed radio calls/checklist items, sloppiness)
- Degraded flying skills (e.g., stick & rudder)

Fatigue Countermeasures Group



In the survey on fatigue in corporate operations, flight crewmembers identified specific ways in which fatigue affected the performance of their duties. Consider the importance of skills such as judgment and decision-making, reaction time, situational awareness, perception, and basic stick-and-rudder coordination to a safe flight. In an emergency, these factors could become critical.

Specific Operational Considerations for General Aviation

The specific characteristics of various operations may create different areas of vulnerability to fatigue

Fatigue Countermeasures Group



The normal challenges of various flight operations may be compounded by the effects of fatigue. Consider, for example, the specific requirements of flying at night, in adverse weather conditions, or cross-country.

Specific Operational Considerations for General Aviation

- Night flying
 - Spatial disorientation
 - Navigation (esp. VFR)
- IFR flight
 - Workload
 - Monitoring role

Fatigue Countermeasures Group



A pilot's response to the challenges of flying at night may be complicated by fatigue. For example, in the absence of a visible horizon, spatial disorientation may occur. Decreased situational awareness or perception from fatigue could contribute to the disorientation or could delay or prevent awareness of it and corrective action. Likewise, these fatigue effects may make navigation more difficult while flying at night, when a pilot has a less complete picture of the surrounding area.

Flight under instrument flight rules (IFR) can pose specific challenges to a fatigued pilot as well. Periods of high workload alternating with periods of continuous monitoring present opposite challenges. Fatigue factors such as increased errors and missed checklist items can make high workload more difficult. Conversely, very low workload periods of passive monitoring can unmask sleepiness, making it difficult to maintain vigilance or even wakefulness.

Specific Operational Considerations for General Aviation

- VFR flight
 - Vigilance (e.g., separation, non-radar)
 - Flight plan optional
- Solo operations
 - No back-up/double check
 - No nap opportunity

Fatigue Countermeasures Group



Even flight under visual flight rules (VFR) creates special considerations for a fatigued pilot. On VFR flights, pilots are solely responsible for maintaining their separation from other aircraft, terrain, and clouds, which requires a high level of vigilance. Decreased alertness and situational awareness may hamper a VFR pilot's ability to maintain vigilance over long periods of time. If fatigued enough, an individual may experience attentional lapses, during which no information is perceived. Further, VFR pilots may not file a flight plan, which means that no one else in the airspace system is keeping track of their location.

Solo operations mean that if the pilot is experiencing the effects of fatigue, there is no one available to provide back-up, to double-check information and decisions, to catch errors or missed radio calls— even simply to interact and provide stimulation. Also, unless two pilots are at the controls of an aircraft that requires only one pilot, there is no opportunity to obtain a strategic nap.

Specific Operational Considerations for General Aviation

- Cross-country
 - Workload at certain points
 - Monitoring in cruise
- Flight instruction
 - Vigilance
 - Multi-tasking

Fatigue Countermeasures Group



Cross-country flying often entails periods of high workload (e.g., takeoff, course changes, approach/landing) interspersed with long periods of monitoring. Each condition has challenges to a pilot experiencing fatigue. When workload is high, fatigue effects such as slowed reaction time and errors may have greater consequence. When workload is minimal and the pilot is passively monitoring, symptoms of sleepiness may become more apparent. In other words, with no activity to provide stimulation, it may be difficult to maintain wakefulness.

Flight instruction requires a high level of vigilance as well as continuous multi-tasking. In addition, a flight instructor must be prepared to take control of the aircraft from the student if necessary. Fatigue effects such as decreased attention and situational awareness, as well as slowed reactions, may challenge an instructor's ability to meet these demands. For example, an NTSB report cited fatigue as a contributing factor when a flight instructor forgot to refuel the airplane because he was tired and distracted with critiquing his student's instrument approach skills at multiple airports (NTSB ID No. FTW00LA188).

An example of how the type of flight operation, and the effect of fatigue on flight operations can be combined to create a potentially unsafe environment as described in an ASRS report of a CFI and student during a night cross-country flight. The day began 14 hr prior to the incident flight. An erroneous fuel gauge and attempts to contact a local FBO for refueling created a need for the CFI to manage a potential in-flight emergency. However this combination of events allowed the student to fly into Class D airspace without first establishing two way radio communication with ATC (ASRS Accession No. 373590).

II. Common Misconceptions

Fatigue Countermeasures Group



There are many misconceptions about fatigue in flight operations. Several commonly held misconceptions will be presented and then addressed using the information previously presented and additional scientific data.

Common Misconceptions

- “I know how tired I am”
- “I’ve lost sleep before and I did just fine”
- “I’m motivated enough to just push through it”

Why not?

- It is difficult to reliably estimate your own alertness and performance

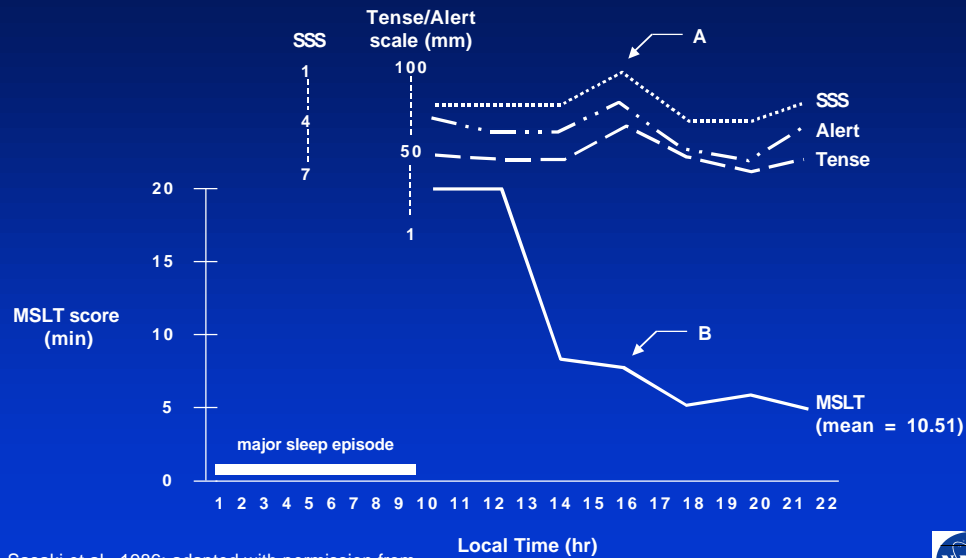
Fatigue Countermeasures Group



One widely held belief is that individuals can accurately and reliably estimate their alertness and performance. Many people believe that being motivated, well-trained, and professional or having previous experience with sleep deprivation prepares them to combat the physiological consequences of sleep loss. As previously presented, individuals (especially sleepy individuals) do not reliably estimate their alertness and performance. An example of how subjective assessment may play a role in flight operations is provided by a Cessna 182 pilot who damages the aircraft by veering off the runway during an attempt to land (ASRS Accession No. 437812).

The following data from a long-haul pilot also illustrates the point.

Subjective vs Physiological Sleepiness



Sasaki et al., 1986; adapted with permission from Aviation, Space, and Environmental Medicine

Fatigue Countermeasures Group



These data were obtained in a NASA collaborative study that examined layover sleep and waking sleepiness during layovers in international long-haul flight crews. This pilot was asked to rate his overall level of sleepiness throughout the day while simultaneously having it measured with an objective test of physiological sleepiness. The test of physiological sleepiness is called the Multiple Sleep Latency Test (MSLT) and is a laboratory standard for objective evaluation of physiological sleepiness. Essentially, the test defines sleepiness by the speed of falling asleep: the sleepier the individual, the sooner sleep onset will occur; the more alert the individual, the longer it will take for sleep onset to occur, if it does at all. Measurements of brain, eye, and muscle activity can quantify the speed of falling asleep to within half a second. Individuals have 20 minutes to fall asleep in a quiet, dark room. If they do not fall asleep, their score is 20 and they are considered very alert. If they fall asleep immediately, their score is 0 and they are considered very sleepy. This test has been used in thousands of studies involving sleep-disorder patients and sleep deprivation. Individuals who are sleep deprived experimentally or who have a sleep disorder that causes waking sleepiness will fall asleep on this test within 5 minutes on almost every opportunity. This MSLT score of 5 or less often is referred to as being in the “twilight zone.”

The pilot’s subjective sleepiness scores (SSS = Stanford Sleepiness Scale) are portrayed on the top half of the graph. The letter A indicates the point when the pilot reported his greatest level of alertness. The bottom half of the graph portrays his MSLT scores. The letter B indicates the point directly under A. At this time (when the pilot reported being most alert), his MSLT score is approaching the twilight zone, and on subsequent MSLT tests, it borders on the twilight zone. This demonstrates the discrepancy between the self-report of sleepiness and the level of physiological sleepiness. Although reporting peak levels of alertness, this pilot was approaching the twilight zone and a high level of physiological sleepiness.

Fatigue Signs and Symptoms

- Forgetful
- Poor decisions
- Slowed reaction time
- Reduced vigilance
- Poor communication
- Fixated
- Apathetic
- Lethargic
- Bad mood
- Nodding off

Fatigue Countermeasures Group



It is necessary to recognize fatigue in order to address it. Because it is difficult for individuals to estimate their own alertness and fatigue levels, more objective criteria may be helpful to assessing fatigue levels in yourself or others. If you recognize these signs, fatigue may be the cause, and alertness strategies should be employed.

Common Misconceptions

“The answer is simple...”

- “There is a quick fix, a magic bullet”
- “One cure will work for everyone, all aircraft, all flight schedules”

Why not?

- Sleep and circadian physiology are complex
- People are not the same
- Different flight schedules present different demands

Fatigue Countermeasures Group



The misconception that there is a “magic bullet” that will cure the fatigue, jet lag, sleep loss, circadian disruption, and sleepiness engendered by flight operations must be dispelled before fatigue issues can be effectively addressed. The previous sections have demonstrated the complexities of the physiological systems and the diversity of fatigue effects resulting from the range of GA flight operations. Also, people are not the same, and the range of individual differences in response to these effects must also be considered.

The idea that there is no magic bullet should be remembered whenever assessing the latest “cure” for jet lag. Be skeptical and weigh the claims in consideration of the physiological information previously presented.

III. Alertness Management Strategies

Fatigue Countermeasures Group



Important Considerations

- The following recommendations are intended to help you apply what is currently known
- Tailor them to your own needs
- The best effects may result from combining multiple strategies rather than relying on a single strategy

Fatigue Countermeasures Group



It will be continually emphasized that the following strategies are only recommendations and should be tailored to an individual's particular needs and activities. You should experiment with different strategies and evaluate their effectiveness in the context of your own physiology and specific flight operations. The best effects may result from combining strategies rather than relying on an individual strategy.

Alertness Management Strategies

- Preventive strategies

Used before duty and on layovers to reduce adverse effects of fatigue, sleep loss, and circadian disruption during flight operations

- Operational strategies

Used in flight to maintain alertness and performance

Fatigue Countermeasures Group



The following is an approach to differentiating alertness management strategies. Preventive strategies focus on the underlying physiology by attempting to manage and maximize sleep and minimize the effects of circadian disruption. These strategies are used at home before a trip or during a layover. Operational strategies are in-flight measures that help to maintain alertness and performance. These strategies do not necessarily affect the underlying physiological mechanisms, but focus more on managing fatigue during operations. Primarily, these short-term strategies help to conceal or attenuate underlying physiological sleepiness.

Preventive Strategies: Sleep Scheduling and Quantity

At home

- Get the best sleep possible before a day of flying
- Try to get at least 8 hours
- Use strategic naps

Fatigue Countermeasures Group



Consider the previous information regarding the effects of sleep loss on performance and flight operations. Try to stay “in the black” (i.e., with no sleep debt). If you anticipate a full day of flying or you are planning a long cross-country, try to get sleep satiated by getting as much sleep as possible for one or two nights beforehand. Use strategic naps before flying or between flights to supplement your sleep.

Preventive Strategies: Strategic Napping

Before flying or between flights:

- A nap can acutely improve alertness
- If immediately before flying, limit nap to 45 minutes
- If you sleep too long and go into deep sleep, it may take longer for you to become fully awake
- Nap can be longer at other times
- Some sleep is better than none; even a short nap will decrease the length of continuous wakefulness before a flight

Fatigue Countermeasures Group



An extensive scientific literature clearly demonstrates the effectiveness of naps in improving subsequent alertness and performance. One important consideration when taking a nap just before flying is to minimize the chances of going into deep NREM sleep (stages 3 and 4). If awakened out of deep sleep, an individual may continue to feel groggy, sleepy, or disoriented for 10–15 minutes. This phenomenon is called sleep inertia. Therefore, if taking a nap just before flying, limiting its duration to 45 minutes or less will decrease the chances of having significant amounts of deep sleep. A brief nap can be an important way to decrease the length of continuous wakefulness. It is usually much better to get some sleep than none at all.

If you nap at times other than immediately before flying, then the nap can be longer. In this case, a nap longer than 2 hours is likely to get an individual through at least one NREM/REM cycle.

Strategic napping can be an extremely effective countermeasure in improving subsequent alertness and performance. Some individuals call these “power” naps. In flight operations, “NASA naps” have been demonstrated to be an effective acute fatigue countermeasure.

Preventive Strategies: Good Sleep Habits

- Keep a regular sleep/wake schedule; protect sleep time
- Develop and practice a regular pre-sleep routine
- Use bedroom only for sleep; avoid work, worry, exercise
- If hungry, eat a light snack; do not eat or drink heavily before bedtime
- Avoid alcohol or caffeine before going to bed
- Use physical/mental relaxation techniques as needed to fall asleep
- If you don't fall asleep in 30 minutes, get out of bed

Fatigue Countermeasures Group



The following recommendations are generally considered important for maintaining good sleep habits. They apply to everyone. First, keep a regular sleep and wake schedule as much as possible. At home before trips, try to keep sleep time protected and minimize other responsibilities. A regularly practiced pre-sleep routine can be used to teach your mind and body that it is time to relax and fall asleep. A set of cues can be established to condition pre-sleep relaxation and can then be used anywhere and anytime before going to sleep. It is important to avoid work or worry in the bedroom and to prevent the association of the bed with activities contrary to relaxation and sleep.

Going to bed hungry can delay falling asleep. Eating a heavy meal also can disrupt sleep, because the stomach is busy digesting food. If hungry or thirsty at bedtime, eat a light snack or have a small quantity of something to drink. As previously mentioned, alcohol should be avoided immediately before going to bed because of disruptive effects on sleep. Caffeine consumption should also be limited. Caffeine in coffee, tea, and colas can prevent sleep onset and disrupt subsequent sleep. Some individuals are sensitive to the caffeine in chocolate, and even a chocolate dessert after dinner is enough to interfere with their sleep. Many mild pain relievers also contain caffeine; read the label for ingredient information. Be sure to stop caffeine intake several hours before planned bedtime.

A variety of mental and physical relaxation techniques are proven to promote sleep onset and good sleep. Appendix B describes some of these techniques in more detail. Like any skills, these techniques can be practiced; then they can be used in a wide range of applications, essentially anywhere. If unable to fall asleep in 30 minutes, don't lie in bed trying to fall asleep. Instead, get out of bed and engage in some activity conducive to relaxation and sleep.

Preventive Strategies: Good Sleep Habits

- Sleep environment
 - Dark room (if necessary, use mask, heavy curtains)
 - Quiet room (turn off phone, use earplugs)
 - Comfortable temperature
 - Comfortable sleep surface
- Lifestyle
 - Exercise regularly (but not too near bedtime)
 - Eat a balanced diet

Fatigue Countermeasures Group



Sleep environment can affect both the quantity and quality of sleep obtained. In general, darkness, quiet, a relatively cool temperature, and a comfortable sleep surface have been shown to promote sleep. However, a wide range of individual differences exist concerning the preferred sleep environment. Therefore, the best environment is one that allows the sleeper the maximum amount of control. Disruptive environmental factors should be minimized.

Laboratory studies suggest that regular exercisers may have increased amounts of NREM stages 3 and 4. However, exercising too close to bedtime can disrupt subsequent sleep. Although physically tiring, exercise elevates heart and breathing rates, and is generally activating physiologically. Usually, it is not possible to immediately wind down and fall asleep after exercise. A balanced diet and regular exercise are critical components for overall good health.

Operational Strategies

- “...each required flight crewmember shall... be at the crewmember station unless the absence is necessary to perform duties in connection with the operation of the aircraft or in connection with physiological needs...” (FAR § 91.105)
- What can you do in your cockpit seat?
 - Engage in conversations with others
 - Do something that involves physical action
 - Stretch, move

Fatigue Countermeasures Group



Operational countermeasures are challenged by FARs that require crewmembers to remain seated at their duty stations with their seat belts fastened. This poses a challenge because one of the most successful techniques for combating sleepiness, according to the earliest sleep-deprivation experiments, is physical activity. Whenever possible, engage in physical activity, even if it is only stretching. Take regular stretch breaks and while seated, remain as active as possible—even writing helps. Engage in conversations with others and be sure to participate; don't just nod and listen.

Operational Strategies

- Strategic caffeine consumption
 - Use caffeine to acutely increase alertness
 - Don't use it when already alert (e.g., right after a nap)
 - Avoid caffeine near bedtime
- Be sensible about nutrition and stay hydrated

Fatigue Countermeasures Group



Caffeine, a stimulant, can be consumed strategically to acutely increase alertness. It is best not to continually consume caffeine before, during, and after a flight. Instead, determine the potential periods when caffeine could be used to combat a specific period of sleepiness (e.g., 3–5 a.m. or 3–5 p.m.). Avoid using it when already alert, for example, immediately after a nap. Though affected by several variables (e.g., body size, previous food intake), caffeine will usually take 15–30 minutes to take effect and then last for up to 3–4 hours. Therefore, continually consuming caffeine throughout the day could interfere with subsequent sleep. Stop caffeine consumption far enough in advance of a planned bedtime so that it will no longer be active.

Be sensible about nutrition. Whenever possible, maintain a balanced diet. On long flights, try to carry appropriate snacks as needed. Drink plenty of fluids and stay hydrated. Remember that caffeine is a diuretic and therefore has a dehydrating effect.

Operational Strategies

Divert if necessary:

If you are still getting sleepy, don't try to "push through" — PICK A PLACE TO LAND SAFELY.

Fatigue Countermeasures Group



In studies of professional long-haul flight crews, pilots experienced short, uncontrolled periods of sleep (i.e., they nodded off) in flight, even during approach and landing phases, when motivation to maintain wakefulness would presumably be high. During such "lapses," a pilot cannot take in or react to any information from the environment. Clearly, this can have a detrimental effect on flight safety.

If you are at a remote airport or on a cross-country flight, and want to get home, it may be tempting to try to "push through" your fatigue and continue the flight. A pilot of a Piper Arrow IV took this course of action after inadvertently deviating from the assigned route issued by ATC and flew into deteriorating weather conditions (ASRS Accession No. 439978).

Suppose you have tried operational countermeasures and you still feel sleepy. If you haven't taken off, stay on the ground. Try taking a nap and reassess how you feel afterward. If you are in the air, and you are nodding off, find an appropriate airport at which to land.

If You Remember Nothing Else...

- Physiological mechanisms underlie fatigue
- Improve current situation — do it yourself now
- Sleepiness can have severe consequences — take it seriously
- People are different — tailor this information to your own needs
- There is no one simple answer — these are recommendations; find out what works for you

Fatigue Countermeasures Group



The critical messages to take home...

References

ASRS Reports

IHS:262-7

MEMORANDUM FOR: Recipients of Aviation Safety Reporting System Data

SUBJECT: Data Derived from ASRS Reports

The attached material is furnished pursuant to a request for data from the NASA Aviation Safety Reporting System (ASRS). Recipients of this material are reminded of the following points, which must be considered when evaluating these data.

ASRS reports are submitted voluntarily. The existence in the ASRS database of reports concerning a specific topic cannot, therefore, be used to infer the prevalence of that problem within the National Airspace System.

Reports submitted to ASRS may be amplified by further contact with the individual who submitted them, but the information provided by the reporter is not investigated further. Such information may or may not be correct in any or all respects. At best, it represents the perception of a specific individual who may or may not understand all of the factors involved in a given issue or event.

After preliminary processing, all ASRS reports are de-identified. Following de-identification, there is no way to identify the individual who submitted a report. All ASRS report processing systems are designed to protect identifying information submitted by reports, such as, names, company affiliations, and specific times of incident occurrence. There is, therefore, no way to verify information submitted in an ASRS report after it has been de-identified.

The National Aeronautics and Space Administration and its ASRS contractor, Battelle Memorial Institute, specifically disclaim any responsibility for any interpretation which may be made by others of any material or data furnished by NASA in response to queries of the ASRS database and related materials.

Linda J. Connell, Director
Aviation Safety Reporting System

CAVEAT REGARDING STATISTICAL USE OF ASRS INFORMATION

Certain caveats apply to the use of ASRS statistical data. All ASRS reports are voluntarily submitted, and thus cannot be considered a measured random sample of the full population of like events. For example, we receive several thousand altitude deviation reports each year. This number may comprise over half of all the altitude deviations that occur, or it may be just a small fraction of total occurrences. We have no way of knowing which.

Moreover, not all pilots, controllers, air carriers, or other participants in the aviation system, are equally aware of the ASRS or equally willing to report to us. Thus, the data reflect **reporting biases**. These biases, which are not fully known or measurable, distort ASRS statistics. A safety problem such as near midair collisions (NMACs) may appear to be more highly concentrated in area “A” than area “B” simply because the airmen who operate in area “A” are more supportive of the ASRS program and more inclined to report to us should an NMAC occur.

Only one thing can be known for sure from ASRS statistics—they represent the **lower measure** of the true number of such events that are occurring. For example, if ASRS receives 881 reports of track deviations in 1999 (this number is purely hypothetical), then it can be known with certainty that at least 881 such events have occurred in 1999.

Because of these statistical limitations, we believe that the **real power** of ASRS lies in the **report narratives**. Here pilots, controllers, and others, tell us about aviation safety incidents and situations in detail. They explain what happened, and more importantly, **why** it happened. Using report narratives effectively requires an extra measure of study, the knowledge derived is well worth the added effort.

ACN: 346351

Time

Date : 199608

Day : Fri

Local Time Of Day : 0001 To 0600

Place

Locale Reference.ATC Facility : CVG

State Reference : OH

Altitude.MSL.Bound Lower : 19000

Altitude.MSL.Bound Upper : 19000

Environment

Flight Conditions : VMC

Aircraft / 1

Controlling Facilities.ARTCC : ZID

Make Model : 998.90

Person / 1

Function.Flight Crew : Single Pilot

Experience.Flight Time.Total : 8100

Experience.Flight Time.Last 90 Days : 240

Experience.Flight Time.Type : 240

ASRS Report : 346351

Person / 2

Function.Controller : Radar

Events

Anomaly.Non Adherence : Clearance

Independent Detector.Other.Flight CrewA : Unspecified

Resolatory Action.None Taken : Anomaly Accepted

Resolatory Action.None Taken : Detected After The Fact

Narrative :

SHOWED UP AT MY PLANE AT XA20L AND AT XB10 TAXIED OUT FOR TKOF. MY BATTERIES OVERHEATED, SO I TAXIED BACK. I THEN SPENT THE NEXT 3 1/2 HRS RUNNING BTWN THE PLANE AND THE PHONE TO COMMUNICATE WITH OUR MAINT PEOPLE. I WAS NOT AT AN FBO AND THERE WAS NO PLACE TO SIT ON THIS CARGO RAMP, EXCEPT IN THE PLANE BUT I DIDN'T WANT TO SIT THERE BECAUSE I WAS WORRIED ABOUT CARBON MONOXIDE FROM THE GPU WHICH A MECH HAD RUNNING WHILE HE WORKED ON THE PLANE. AFTER LITERALLY STANDING AROUND AND RUNNING TO THE PHONE FOR ALMOST 4 HRS, I GOT INTO THE PLANE TO FLY TO CVG, THE PLANE HAD ITS BATTERY PROBS FIXED. I WAS ALREADY TIRED, AND UNDER STRESS FROM WATCHING THE BATTERIES VERY CLOSELY. I DID NOT WANT A BATTERY OVERHEAT IN THE AIR! ABOUT 1 1/2 HRS INTO THE FLT, EVERYTHING WAS NORMAL AND FOR THE FIRST TIME IN 5 HRS I WAS AT PEACE. NOW IT WAS ABOUT XE15 CENTRAL TIME WHEN NORMALLY I WOULD BE SOUND ASLEEP IN THE PLT'S BREAKROOM IN CVG. IT WAS VERY QUIET ON THE RADIO. I HAD NO COPLT AND NO NOISE OTHER THAN THE DRONING SOUND OF THE TURBINE ENGS. I WAS SO TIRED AND IT WAS SO CALM I JUST FELL ASLEEP. I ESTIMATE I SLEPT FOR ABOUT 150 MI. I WOKE UP AND VERY QUICKLY REALIZED WHAT HAD HAPPENED. I REESTABLISHED RADIO CONTACT WITH CTR AND PROCEEDED TO MY DEST WITHOUT FURTHER INCIDENT. THE MAIN FACTORS THAT CONTRIBUTED TO MY SLEEPINESS WERE: FLYING WHEN I WOULD NORMALLY BE ASLEEP, HAVING TO STAND AROUND FOR HRS WHILE MY PLANE WAS BEING WORKED ON, AND NOT HAVING A COPLT WHICH I USUALLY DO. I ALSO BELIEVE I MAY HAVE HAD SOME CARBON MONOXIDE POISONING FROM THE GPU, IT RAN FOR THE WHOLE TIME AND IT REALLY, REALLY POLLUTED THE AREA.

Synopsis :

SINGLE PLT OF A TURBOPROP TWIN CARGO FLT FALLS ASLEEP FOR APPROX 150 MI AND WAKES UP AND CONTINUES TO DEST WITHOUT FURTHER INCIDENT.

ACN: 359360

Time

Date : 199701

Day : Fri

Local Time Of Day : 0601 To 1200

Place

Locale Reference.Airport : MSY

State Reference : LA

Altitude.MSL.Bound Lower : 4000

Altitude.MSL.Bound Upper : 4000

Environment

Flight Conditions : VMC

Aircraft / 1

Controlling Facilities.TRACON : MSY

Make Model : 123.24

Person / 1

Function.Flight Crew : First Officer

ASRS Report : 359360

Person / 2

Function.Oversight : PIC

Function.Flight Crew : Captain

ASRS Report : 357857

Person / 3

Function.Controller : Approach

Events

Anomaly.Other Spatial Deviation : Track Or Heading Deviation

Anomaly.Non Adherence : FAR

Anomaly.Non Adherence : Published Procedure

Independent Detector.Other.ControllerA : Unspecified

Resolatory Action.Controller : Issued New Clearance

Resolatory Action.Controller : Provided Flight Assist

Consequence.FAA : Investigated

Narrative :

THE PIC AND MYSELF BOARDED THE COMPANY'S BE58 BARON FOR A CARGO RUN. OUR FIRST STOP WAS IN FULTON COUNTY, GA. THE FLT AND LNDG WAS UNEVENTFUL. OUR PREFLT BRIEFING AND WX RPTS SHOWED THAT THE DAY'S FLTS WOULD BE CONDUCTED IN VMC CONDITIONS. OUR SECOND LEG WAS A STOP IN MOBILE, AL. AGAIN, THE FLT AND LNDG WAS CONDUCTED IN VMC AND WAS UNEVENTFUL. OUR THIRD LEG WAS A STOP IN NEW ORLEANS, LA. AFTER OUR TKOF FROM MOB, APPROX 20 MINS INTO THE FLT, I ADVISED THE PIC THAT I WAS GETTING TIRED. I ADVISED HIM THAT I WAS GOING TO REST MY EYES FOR A LITTLE WHILE. HE SAID THAT THAT WOULD BE FINE AND I PROCEEDED TO DO SO. THE NEXT THING I REMEMBER WAS WAKING UP ON FINAL APCH INTO MSY. ONCE AGAIN, THE FLT AND LNDG WAS UNEVENTFUL. HOWEVER, LATER I WAS ADVISED THAT THE FLT WAS EVENTFUL. WHILE I WAS RESTING, THE PIC WAS FLYING AND ABOUT 30 MI OUT FROM MSY, THE PIC FELL ASLEEP. THE PIC REMEMBERS TALKING TO APCH CTL. HE THEN STATED THAT HE TURNED THE AUTOPLT ON AND STARTED READING A BOOK. THEN HE TURNED THE HEATER ON. WE OVERFLEW MSY ARPT, AND APPROX 30 MI ON THE OTHER SIDE OF MSY ARPT, WE WERE WOKEN UP TO THE CALLS OF MSY APCH CTL. WE THEN WERE GIVEN VECTORS BACK TO THE ARPT AND THE REST OF THE FLT AND LNDG WAS UNEVENTFUL. IT WAS A VERY MISFORTUNATE OCCURRENCE. I DO FEEL VERY STRONGLY THAT WE WERE VERY LUCKY. WE BOTH LEARNED A VALUABLE LESSON FROM IT. NO ONE WAS HURT OR AFFECTED BY OUR MISTAKE. I WAS VERY GLAD TO KNOW THIS. I THINK A PROB LIKE THIS CAN BE AVOIDED BY SIMPLY COMMUNICATING WITH EACH OTHER. ALSO, STAYING FIT, AND HAVING ENOUGH REST IS IMPORTANT AS WELL. IT IS A MISTAKE THAT WILL NOT HAPPEN AGAIN AS FAR AS I AM CONCERNED. IF ONE IS FLYING AND GETS TIRED, THAT PERSON SHOULD COMMUNICATE TO THE OTHER PERSON. THEN AT THAT POINT, IT BECOMES A TEAM EFFORT ON A HIGHER LEVEL. SLEEP IS SOMETHING EVERYONE NEEDS. FROM THIS LESSON, IT'S SOMETHING THAT WE NEED TO DO MORE JOB EFFECTIVELY. CALLBACK CONVERSATION WITH RPTR REVEALED THE FOLLOWING INFO: RPTR CALLED REQUESTING IDENT STRIP SINCE FAA AND COMPANY ARE INVESTIGATING THE INCIDENT. THE COMPANY HAS PUT THE CREW ON RESTR. FAA IS STILL INVESTIGATING ALL ASPECTS. SUPPLEMENTAL INFO FROM ACN 357857: THE SUN WAS RIGHT ABOVE THE HORIZON AND ALL THESE FACTORS CONTRIBUTED TO MY FALLING ASLEEP. THE MASSIVE HEAT, THE RISING SUN, AND THE BOOK. I STARTED TO GET TIRED. I HAD ALSO TURNED DOWN THE VOLUME FROM THE RADIO, SO MY COPLT WOULDN'T HEAR THE RADIO AND WAKE UP FROM THE TRANSMISSIONS. I SHUT MY EYES FOR A COUPLE OF SECONDS, OPENED THEM AGAIN, SHUT THEM AGAIN. THAT'S WHEN I FELL ASLEEP. AND SINCE THE RADIO ALSO WAS TURNED DOWN, I COULDN'T HEAR WHEN THE APCH CTLR TRIED TO TALK TO US. WITH THE HEADWIND WE HAD, I ASSUME THAT I FELL ASLEEP FOR ABOUT 25 MINS. WE LANDED IN MSY, CALLED THE TWR (ON THE CTLR'S REQUEST) AND EXPLAINED WHAT HAD HAPPENED. THIS WILL NEVER HAPPEN AGAIN, EVER!!!

Synopsis :

BE58 FLC ON EARLY MORNING FLT FALLS ASLEEP AND OVERFLIES THE ARPT.

ACN: 364877

Time

Date : 199610

Day : Fri

Local Time Of Day : 1201 To 1800

Place

Locale Reference.Airport : BUR

State Reference : CA

Environment

Flight Conditions : IMC

Aircraft / 1

Controlling Facilities.TRACON : LAX

Make Model : Commercial Fixed Wing

Person / 1

Function.Oversight : PIC

Function.Flight Crew : Captain

Experience.Flight Time.Total : 6239

Experience.Flight Time.Last 90 Days : 201

Experience.Flight Time.Type : 444

ASRS Report : 364877

Person / 2

Function.Flight Crew : First Officer

Person / 3

Function.Controller : Departure

Events

Anomaly.Other Spatial Deviation : Track Or Heading Deviation

Anomaly.Non Adherence : Clearance

Anomaly.Non Adherence : Published Procedure

Independent Detector.Other.ControllerA : Unspecified

Resolatory Action.Controller : Issued New Clearance

Consequence.FAA : Reviewed Incident With Flight Crew

Narrative :

THIS SERIES OF INCIDENTS OCCURRED ON OCT XX 1996. THE FIRST WAS WHILE ON ILS FINAL APCH TO RWY 19R AT SANTA ANA, CA. I WAS FLYING WITH A PLT WHO HAD BEEN HIRED BY MY COMPANY TO PERFORM FO DUTIES FOR 1 DAY. WE WERE IN THE NEW MODEL ASTRA SPX. DURING THE COURSE OF CONCLUDING OUR SECOND LEG OF 5 SHORT FLT'S PLANNED FOR THE DAY, HE BECAME ARGUMENTATIVE. HE SOON BECAME AGGRESSIVE, AND HIS ATTITUDE ESCALATED TO THE POINT THAT HE INITIATED A VERBAL OUTBURST TOWARD ME. THIS LASTED FOR OVER A MIN AND INCLUDED SEVERAL USES OF PROFANITY AND CALLING ME NAMES, ALL IN A LOUD VOICE. HE SAID THAT I WAS A LOUSY PLT, THAT HE HAD ALWAYS HATED FLYING WITH ME, AND THAT HE WOULD NEVER FLY WITH ME AGAIN. THIS WAS DONE WITH 3 PAX ON BOARD. THE PAX COULD HEAR NORMAL CONVERSATION FROM THE COCKPIT, AS WELL AS THE SHOUTING. THE PAX INCLUDED A REGIONAL SALES MGR FROM MY COMPANY AND 2 REPRESENTATIVES OF ONE OF MY COMPANY'S CUSTOMERS. I SAID FIRMLY, BUT AS CALMLY AS I COULD, 'LET'S TALK ABOUT THIS ON THE GND.' I HAD TO SAY THIS 6 TIMES BEFORE HE FINALLY STOPPED SHOUTING AT ME, AND BEGAN TO FOCUS ON HIS DUTIES AT HAND. AFTER LNDG AND AFTER OUR PAX HAD LEFT THE CABIN, I CLBED OUT THE SEAT AND WAITED FOR HIM I SAID, 'LET'S TALK.' HE SAID HE DIDN'T WANT TO TALK TO ME. I SAID, 'I WANT TO TALK TO YOU.' WE PROCEEDED TO WALK IN FRONT OF THE ACFT 50 FT AND I TRIED TO HAVE A CONVERSATION WITH HIM. HE BEGAN TO SHOUT OBSCENITIES AT ME AGAIN AND TO CALL ME NAMES. I JUST LET HIM GO ON FOR A COUPLE OF MINS. FINALLY I SAID 'I WANT YOU TO LISTEN TO ME FOR 60 SECONDS, AND YOU TELL ME WHEN MY 60 SECONDS STARTS.' AFTER ANOTHER OUTBURST HE SAID, 'OKAY,' AND BECAME SILENT. I SAID, 'WHAT YOU JUST DID IN THAT COCKPIT WAS 100 TIMES WORSE THAN ANYTHING THAT YOU THINK I MAY BE WRONG ABOUT.' HE BECAME SILENT, LOOKED AT ME HARD AND WALKED AWAY. HE LATER CAME UP TO ME AND SAID HE WAS SORRY. HE SAID THAT HE WAS JUST TIRED AND GRUMPY. I SAID THAT HE SEEMED TO HAVE SOME UNRESOLVED ISSUES THAT WERE BOTHERING HIM AND THAT I WOULD BE AVAILABLE TO TALK THEM OUT WITH HIM, BUT NOT IN THE COCKPIT. ON A SUBSEQUENT FLT AN HR LATER, HE COPIED OUR CLRNC FROM BURBANK, CA, BACK TO SANTA ANA. AS I COMPLETED PROGRAMMING THE FMS, I ASKED HIM TO REVIEW WHAT WAS IN THE FMS AND DISPLAYED ON THE MULTI-FUNCTION DISPLAY AND TO CONFIRM THAT IT WAS ACCURATE AND COMPLETE. HE SAID THAT IT WAS. AS WE COMPLETED THE ELMOO 5 DEP FROM BURBANK, APCHING THE ELMOO TRANSITION FIX, THE AUTOPLT COMMANDED A R TURN TOWARD SANTA ANA, FOLLOWING THE FMS PROGRAMMING. THE SOCAL APCH CTLR CAME ON THE AIR AND TOLD US TO TURN L TO 50 DEG HDG, AND HE CONTINUED TO GIVE US VECTORS TO ILS FINAL APCH INTO SANTA ANA. THE CTLR ASKED US TO CALL A PHONE NUMBER WHEN ON THE GND. I CALLED THE CTLR AND WAS INFORMED AS TO THE SERIOUSNESS OF THE MISTAKE WHICH HAD OCCURRED. THE R TURN WOULD HAVE PUT US IN DIRECT CONFLICT WITH THE DOWNWIND TFC INTO LAX. I SINCERELY APOLOGIZED FOR THE ERROR, AND TOLD THE CTLR THAT I HAD A COMS PROB WITH THE RENTAL PLT THAT WAS WITH ME THAT DAY. HE SUGGESTED THAT MY COMPANY TAKE IMMEDIATE STEPS TO CORRECT THE PROB. I ASSURED HIM THAT WE WOULD. HE DECLINED TO ISSUE A VIOLATION AGAINST MY LICENSE, THOUGH I SENSED IT WAS A VERY CLOSE CALL FOR HIM. THE RENTAL PLT IN THIS CASE USED TO WORK FOR MY COMPANY. HE WAS SENIOR TO ME WHEN I CAME TO WORK FOR THE COMPANY, 3 MONTHS PRIOR TO HIS DEP. THAT WAS 10 MONTHS PRIOR TO THIS INCIDENT. PERHAPS HE HAD DIFFICULTY UNDERSTANDING WHAT HIS ROLE WAS IN THIS PARTICULAR SIT, HOWEVER, NOTHING CAN EXCUSE HIS LOSS OF SELF CTL AND COMPOSURE IN THE COCKPIT. THIS WAS MADE EVEN MORE DANGEROUS AND DAMAGING BECAUSE WE WERE ON FINAL INST APCH, IN THE WX, WITH CUSTOMERS ON BOARD. ONE OF THE LESSONS THAT CAN BE GLEANED FROM THIS IS THAT WE PLTS NEED TO TAKE A MOMENT TO THINK ABOUT WHAT OUR ROLE IS FOR A GIVEN DAY, IF WE FIND OURSELVES DEALING WITH AN UNUSUAL SIT. WE MUST INSIST ON GOOD COCKPIT COMS AND COORD, REGARDLESS OF WHO IS THERE WITH US. AND I'M AFRAID WE MUST ALSO CONSIDER THE POSSIBILITY THAT THE PLT THAT WE THINK IS THERE TO HELP US, MAY NOT HAVE THAT OBJECTIVE.

Synopsis :

HEADING TRACK POS DEV DURING A GROSS NAV ERROR IN A CORPORATE ACFT.

ACN: 368250

Time

Date : 199705

Day : Sat

Local Time Of Day : 1201 To 1800

Place

Locale Reference.Airport : SBN

State Reference : IN

Environment

Flight Conditions : VMC

Aircraft / 1

Make Model : 168.92

Person / 1

Function.Oversight : PIC

Function.Flight Crew : Captain

Experience.Flight Time.Total : 3500

Experience.Flight Time.Last 90 Days : 200

Experience.Flight Time.Type : 900

ASRS Report : 368250

Person / 2

Function.Flight Crew : First Officer

Experience.Flight Time.Total : 3623

Experience.Flight Time.Last 90 Days : 138

Experience.Flight Time.Type : 138

ASRS Report : 368155

Person / 3

Function.Controller : Local

Events

Anomaly.Incursion : Runway

Anomaly.Non Adherence : Clearance

Anomaly.Non Adherence : FAR

Independent Detector.Other.ControllerA : Unspecified

Resolatory Action.None Taken : Detected After The Fact

Narrative :

SBN TWR INFORMED US THAT WE HAD DEPARTED WITHOUT TKOF CLRNC. THE FO AND I WERE (OBVIOUSLY) UNDER THE IMPRESSION THAT WE HAD BEEN CLRED TO GO. SINCE BOTH THE FO AND I ARE BOTH RESPONSIBLE, ACCOMPLISHED PLTS WITH NO HISTORY OF PREVIOUS INCIDENTS OR ACCIDENTS, I CAN ONLY ASSUME THAT FATIGUE PLAYED A ROLE IN THIS DAY'S EVENTS. I HAD BEEN SCHEDULED TO FLY 9 LEGS ON THE PREVIOUS DAY, ALL OF WHICH CONTAINED SIGNIFICANT WX FLYING, INST APCHS, AND NO AUTOPLT. THE DUTY DAY WAS ALMOST 14 HRS LONG. THE NIGHT PREVIOUS, I HAD HAD 8 HRS AND 2 MINS OF REDUCED REST WHICH WAS FURTHER REDUCED SINCE OUR CREW HOTEL IS LOCATED 20 MINS AWAY FROM THE ARPT. THE DAY OF THIS INCIDENT, I HAD RPTED FOR DUTY AT EARLY MORNING HRS AND HAD BEEN ON DUTY FOR 10 HRS WHEN THE INCIDENT OCCURRED. THERE IS NO DOUBT IN MY MIND THAT THE COMPANY'S SCHEDULING PRACTICES AND THE FAA'S REST REQUIREMENTS CONTRIBUTED TO THIS EVENT. SUPPLEMENTAL INFO FROM ACN 368155: FATIGUE WAS INVOLVED DUE TO THE PRIOR NIGHT'S REDUCED REST AFTER A LONG DUTY DAY WITH MULTIPLE FLT LEGS AND SEVERAL DIFFERENT CAPTS. THIS REDUCED REST INCLUDED 2 LONG TAXI RIDES TO AND FROM THE HOTEL. AFTER THE REDUCED REST, AGAIN I FLEW MULTIPLE FLT LEGS WITH SEVERAL DIFFERENT CAPTS, AGAIN, IN ADVERSE WX CONDITIONS.

Synopsis :

AN ACR BA32 FLC, APPARENTLY TOOK OFF WITHOUT A TKOF CLRNC FROM SBN. FLC COMPLAIN OF FATIGUE.

ACN: 370486

Time

Date : 199706

Day : Sun

Local Time Of Day : 1201 To 1800

Place

Locale Reference.Airport : MTW

State Reference : WI

Environment

Flight Conditions : VMC

Aircraft / 1

Make Model : Any Unknown or Unlisted Aircraft Manufacturer

Aircraft / 2

Make Model : PA-23-250 Aztec

Person / 1

Function.Flight Crew : Single Pilot

Experience.Flight Time.Total : 1100

Experience.Flight Time.Last 90 Days : 60

Experience.Flight Time.Type : 600

ASRS Report : 370486

Person / 2

Function.Flight Crew : Single Pilot

Events

Anomaly.Other Spatial Deviation : Uncontrolled Traffic Pattern Deviation

Anomaly.Conflict : NMAC

Anomaly.Non Adherence : FAR

Anomaly.Non Adherence : Published Procedure

Independent Detector.Other.Flight CrewA : Unspecified

Resolatory Action.Flight Crew : Took Evasive Action

Narrative :

XA30 JUN/XA/97, AFTER MTW SPECIAL EVENT, I WAS DEPARTING RWY 35 (ACTIVE). HEARD A PLANE CALL 4 MI FINAL FOR RWY 35 AND SAW HIM DISTANT. FELT I HAD PLENTY OF TIME TO DEPART. HE APPARENTLY WAS CLOSER THAN I THOUGHT (AN AZTEC) AND I ESSENTIALLY CUT HIM OFF. HE HAD TO GAR. I HAD SLEPT POORLY THE NIGHT BEFORE AND HAD BEEN IN THE SUN ALL DAY. FATIGUE WAS CERTAINLY A FACTOR IN MY MISJUDGEMENT. IN FUTURE, I WILL NOT DEPART AN UNCTLED FIELD WITH ANYONE ON FINAL. ALSO, WILL NOT FLY WITH LACK OF SLEEP AGAIN.

Synopsis :

A GA SMA PLT RPTS TAKING OFF ON A RWY TO WHICH ANOTHER ACFT WAS MAKING AN APCH. THE OTHER ACFT, ON SHORT FINAL APCH, HAD TO GAR PASSING OVERHEAD THE RPTR.

ACN: 372194

Time

Date : 199706

Day : Tue

Local Time Of Day : 0601 To 1200

Place

Locale Reference.Airport : PHX

State Reference : AZ

Altitude.MSL.Bound Lower : 6000

Altitude.MSL.Bound Upper : 6200

Environment

Flight Conditions : VMC

Aircraft / 1

Controlling Facilities.TRACON : PHX

Make Model : Centurion/Turbo Centurion 210c

Person / 1

Function.Flight Crew : Single Pilot

Experience.Flight Time.Total : 3500

Experience.Flight Time.Last 90 Days : 20

Experience.Flight Time.Type : 300

ASRS Report : 372194

Person / 2

Function.Controller : Departure

Events

Anomaly.Other Spatial Deviation : Track Or Heading Deviation

Anomaly.Altitude Deviation : Overshoot

Independent Detector.Other.Flight CrewA : Unspecified

Resolutive Action.Flight Crew : Returned to Intended Course or Assigned Course

Narrative :

ON THE EVENING OF JUN/XX/97 I HAD BEEN THROUGH A SERIES OF HIGH STRESS EVENTS REGARDING MY JOB AND HAD NOT BEEN SLEEPING VERY WELL FOR SEVERAL DAYS. WIFE COMPLAINED THAT I WAS KEEPING HER AWAKE AT NIGHT WITH MY RESTLESSNESS AND ISSUED US BOTH 2 EXCEDRIN PM AROUND XA30 CLAIMING IT WOULD HELP US BOTH GET SOME REST. AROUND XB30 A FRIEND CALLED AND ASKED IF I COULD DO HIM A FAVOR AND FLY HIM TO PHX AS X ACR WAS UNABLE TO HONOR HIS TICKET. WE COULD USE HIS BUSINESS PARTNER'S T210 (WHICH I HAVE FLOWN SEVERAL TIMES) FOR THE TRIP AND AS I HAD SOME BUSINESS OF MY OWN I COULD DO I AGREED IT WOULD BE A MUTUALLY BENEFICIAL TRIP AND AGREED TO MEET HIM FOR AN XK30 DEP THE NEXT MORNING. I SET MY ALARM FOR XI30, SLEEPING WELL I WOKE UP FEELING WELL RESTED, REFRESHED AND READY TO GO. I ARRIVED AT THE ARPT EARLY, DID A VERY THOROUGH PREFLT AND WE DEPARTED ON TIME WITH GREAT FLYING CONDITIONS. THE FLT TO PHX WAS UNEVENTFUL, HOWEVER, I MISSED A FEW LITTLE THINGS THAT I NORMALLY DO INSTINCTIVELY, LIKE MIXTURE LEANING AND CLOSING COWL FLAPS UNTIL WAY AFTER THEY SHOULD HAVE BEEN TAKEN CARE OF. I REQUESTED THE CODED APCH FOR PHX AND LANDED UNEVENTFULLY A BIT DISTURBED THAT I OVERSHOT MY INTENDED LAND SPOT BY ALMOST 500 FT -- AGAIN NOT A BIG DEAL, BUT UNUSUAL FOR ME. I TENDED TO MY BUSINESS THERE AT PHX AND DEPARTED AROUND XQ00 -- THIS IS WHERE THINGS GOT WORSE. MY FATHER WAS WITH US AND REQUESTED INSTRUCTION ON THE RETURN FLT. HE IS NONCURRENT AND WOULD LIKE TO REGAIN HIS CURRENCY. AFTER RECEIVING CLRNC, GND REQUESTED WE TAXI WITHOUT DELAY TO THE RWY AND BE READY TO GO. WE BEGAN A RAPID TAXI AS I RAN THE CHKLIST AND DAMN NEAR LET THE ACFT TAXI ONTO THE ACTIVE RWY, APPLYING THE BRAKES AND SKIDDING TO A STOP JUST AS THE NOSE OF THE ACFT INTERCEPTED THE HOLD LINE. NO HARM BUT EMBARRASSING JUST THE SAME. AFTER CORRECTIONS WERE MADE WE DEPARTED PHX AND I MISSED A GYRO SETTING OF ALMOST 20 DEGS AND CLBED THROUGH AN ASSIGNED ALT BY ALMOST 200 FT. AFTER CLRING THE CLASS B AIRSPACE, EVERYTHING WENT WELL, BUT I WAS VERY EMBARRASSED BY MY LACK OF PERFORMANCE. FOR DAYS I AGONIZED OVER THE MORNING EVENTS TRYING TO FIGURE OUT WHY I HAD PERFORMED SO BADLY, EVEN WAKING UP AT NIGHT WITH IT ON MY MIND. ON THE EVENING OF JUN/XY/97 AGAIN I TRIED THE SLEEPING AID. THE NEXT DAY WAS VERY SIMILAR TO THAT OF JUN/XX/97. I WALKED INTO AN OPEN DOOR, PULLED OUT IN FRONT OF A CAR AT AN INTXN, FORGOT TO TAKE MY COFFEE CUP OF THE ROOF, ETC. EVEN MY SECOND DAY WAS NOT A REAL CONFIDENCE BUILDER HAVING MADE WAY TOO MANY TYPING ERRORS IN THIS MEMO. FINALLY, I PUT THE 2 EVENTS TOGETHER AND GOT A COMMON DENOMINATOR (THE SLEEPING AID). THIS STUFF SOLD OVER THE COUNTER AND SEEMED TO HAVE NO SIDE EFFECTS, BUT ITS TRUE PHYSIOLOGICAL EFFECTS LINGER FOR MUCH LONGER THAN I WOULD EXPECT AND ARE SO STEALTHY AS TO BE UNPERCEIVED. SO THIS MORNING, I THOUGHT IT WOULD BE A GOOD IDEA TO WRITE A NASA RPT TO MAYBE HELP KEEP SOMEONE ELSE FROM MAKING THE SAME MISTAKE. I WILL NOT TRUST THIS TYPE OF MEDICATION AGAIN.

Synopsis :

C210 ACFT. RPTR PLT BELIEVES PROLONGED EFFECT FROM TAKING SLEEPING AID CAUSED CONFUSION AND SLOPPY FLYING.

ACN: 373590

Time

Date : 199707

Day : Thu

Local Time Of Day : 1801 To 2400

Place

Locale Reference.ATC Facility : WRB

State Reference : GA

Altitude.MSL.Bound Lower : 1400

Altitude.MSL.Bound Upper : 1400

Environment

Flight Conditions : VMC

Aircraft / 1

Controlling Facilities.TRACON : MCN

Controlling Facilities.TRACON : WRB

Make Model : Any Unknown or Unlisted Aircraft Manufacturer

Person / 1

Experience.Flight Time.Total : 955

Experience.Flight Time.Last 90 Days : 168

Experience.Flight Time.Type : 120

ASRS Report : 373590

Person / 3

Function.Controller : Approach

Person / 4

Function.Controller : Local

Events

Anomaly.Aircraft Equipment Problem : Less Severe

Anomaly.Non Adherence : FAR

Anomaly.Non Adherence : Published Procedure

Independent Detector.Other.ControllerA : Unspecified

Resolatory Action.None Taken : Detected After The Fact

Narrative :

ON A VFR NIGHT XCOUNTRY FROM RYY TO MCN, I ACCIDENTALLY FLEW INTO WARNER ROBINS AFB AIRSPACE (CLASS D) WITHOUT ESTABLISHING 2-WAY COMS. WE HAD CONTACTED MCN APCH, APPROX 30 MI OUT AND HAD STARTED OUR DSCNT FROM 5500 FT MSL TO TFC PATTERN ALT WHEN I NOTICED THAT THE FUEL GAUGE OF OUR L TANK WAS ONLY INDICATING 1/4 OF A TANK AND THE L ONE WAS INDICATING EMPTY. AS I HAD PERSONALLY PREFLTD THE AIRPLANE (MY STUDENT WAS LATE) AND HAD IT TOPPED OFF TO 24.5 GALLONS, I KNEW THERE WAS NO WAY THE 1 HR FLT COULD HAVE CAUSED SUCH A FUEL CONSUMPTION AND I BECAME WORRIED ABOUT A POSSIBLE UNSECURED GAS CAP OR A STUCK DRAIN THAT MAY HAVE CAUSED US TO DUMP FUEL. AS WE WERE APCHING MCN WE ASKED APCH IF THERE WAS A POSSIBILITY TO GET FUEL AFTER XA00. THEY UNSUCCESSFULLY TRIED TO CONTACT THE LCL FBO AND TOLD US TO SWITCH TO UNICOM. THE FBO TOLD US THERE WAS NO WAY TO GET FUEL AND WE CAME BACK ON THE APCH FREQ TO HEAR THE CTLR TELL US THAT 'RADAR SVCS WERE TERMINATED AND TO SQUAWK VFR.' AT THIS MOMENT, MY PREOCCUPATION TO FIND FUEL/DETERMINE THE ORIGIN OF THE PROB, CAUSED ME TO STOP MONITORING MY STUDENT FOR APPROX 2 MINS. IN THE MEANTIME, WE LEFT THE ARPT UNDER OUR L WING AND FLEW INTO WARNER ROBINS AFB AIRSPACE. I REALIZED THE PROB WHEN I SAW THE AFB BEACON LIGHTS AND THE VOR/DME INDICATED WE HAD PASSED MIDDLE GEORGIA. INITIATED A TURN BACK TO THE N WHEN THE FSS CALLED ON MIDDLE GEORGIA FREQ INDICATING HE HAD RECEIVED A CALL FROM THE RADAR SVCS INDICATING WE WERE FLYING TOWARDS THE AFB. WE LANDED SAFELY AT MIDDLE GEORGIA AND FOUND OUT THE GAUGE WAS THE CULPRIT AND HAD 17 GALLONS LEFT. WE FLEW BACK WITHOUT ANY FURTHER PROB. THE PROB WAS CAUSED BY A MINOR DYSFUNCTION PERCEIVED AS A POSSIBLE THREATENING SIT, BY THE INTERRUPTION OF RADAR SVCS, BY THE RELUCTANCE TO DECLARE AN EMER AND ASK FOR HELP, ALSO FATIGUE (THE FLT STARTED 14 HRS AFTER THE BEGINNING OF THE WORKING DAY) PLAYED A ROLE AND I FELT MY DECISION MAKING ABILITIES/RESPONSE TIME WERE SLOWED DOWN, CAUSING ME TO STOP MONITORING MY STUDENT AND HAVE THE NAVIGATIONAL TASK/LOCATION OF THE ARPT LOSE PRIORITY FOR A FEW MINS AT A CRITICAL MOMENT AS MIDDLE, GA, AND ROBINS AFB AIRSPACE ARE SO CLOSE TO ONE ANOTHER.

Synopsis :

SMA ACFT ON NIGHT TRAINING FLT, DISTR BY ERRONEOUS FUEL GAUGE, INSTRUCTOR PLT ALLOWED TRAINEE TO FLY INTO CLASS D AIRSPACE WITHOUT CLRNC.

ACN: 374650

Time

Date : 199707

Day : Sun

Local Time Of Day : 1201 To 1800

Place

Locale Reference.Airport : SQL

State Reference : CA

Altitude.MSL.Bound Lower : 3000

Altitude.MSL.Bound Upper : 3000

Environment

Flight Conditions : VMC

Aircraft / 1

Controlling Facilities.TRACON : OAK

Make Model : PA-34-220t Turbo Seneca Iii

Person / 1

Function.Flight Crew : Single Pilot

Experience.Flight Time.Total : 1600

Experience.Flight Time.Last 90 Days : 25

Experience.Flight Time.Type : 400

ASRS Report : 374650

Person / 2

Function.Observation : Observer

Function.Flight Crew : Single Pilot

Events

Anomaly.Non Adherence : FAR

Independent Detector.Other.Flight CrewA : Unspecified

Resolatory Action.Flight Crew : Exited Penetrated Airspace

Narrative :

THE IFR FLT WAS NEARING THE END OF ITS JOURNEY FROM ASPEN TO SAN CARLOS (SQL). THE FLT HAD GONE WELL AND ABOUT 4 HRS HAD ELAPSED. THE WX WAS GOOD, AND THE CREW (PF AND PNF) HAD FLOWN MANY TIMES TOGETHER USING CRM. PRIOR TO REACHING SUNOL INTXN, THE FLT WAS VECTORED FOR A VISUAL APCH. WE RECEIVED A VERY EARLY HDOF TO SAN CARLOS, PERHAPS 20 MI OUT. THIS WAS WELL BEFORE REACHING THE CLASS B/C COMPLEX IN THE SAN FRANCISCO BAY AREA. THE FLT HAD BEEN HIGH, USING A SLOW DSCNT RATE (300-500 FPM) TO PRACTICE DSCNT PLANNING, CAPITALIZE ON THE SPD GAINED IN THE DSCNT, AND MAKE IT COMFORTABLE FOR THE PAX. NO CONSIDERATION HAD BEEN GIVEN BY THE PF (ME) TO CLASS B/C AVOIDANCE BECAUSE WE WERE IFR. UPON ESTABLISHING CONTACT WITH SAN CARLOS TWR, THE PNF ACCEPTED THE SUGGESTION TO CANCEL IFR. THIS MAY HAVE ARISEN DUE TO THE VFR STYLE OF INITIATING CONTACT BY THE PNF (IE, 'OVER COYOTE HILLS, FOR LNDG WITH CURRENT ATIS' VERSUS 'WITH YOU ON THE VISUAL APCH'). THE FLT WAS DSNding THROUGH APPROX 3000 FT AT THAT TIME. THE PNF CANCELED IFR, BUT AT THAT POINT WE WERE ABOUT TO PENETRATE THE CLASS B AND/OR OAKLAND CLASS C AIRSPACE, BUT IT DID NOT REALLY REGISTER WITH EITHER PLT AT THAT TIME. I SAW OUR POS ON THE GPS-DRIVEN ARGUS MAP, AND SUDDENLY REALIZED WE WERE ABOUT TO PENETRATE THE CLASS B/C AIRSPACE, AND WE DID NOT HAVE A CLRNC NOR WERE WE IN COM WITH BAY OR OAK TWR. I INITIATED A RAPID DSCNT (APPROX 2000 FPM) TO AVOID AND/OR EXIT THE CLASS B/C AIRSPACE. I DO NOT REALLY KNOW IF A VIOLATION OCCURRED OR NOT. HOWEVER, WHETHER AN AIRSPACE VIOLATION OCCURRED OR NOT, I BELIEVE AN UNSAFE CONDITION EXISTED BY VIRTUE OF A SUDDEN, RAPID DSCNT AT LOW ALT AT THE EDGE OF BUSY AIRSPACE. WHILE I AM NOT AWARE OF ANY OTHER AIRPLANES IN THE VICINITY AT THE TIME, I MUST CONFESS I DID NOT LOOK FOR THEM PRIOR TO DSNding, EITHER. THE AIRSPACE ISSUE TOOK PRECEDENCE IN MY THINKING OVER POSSIBLE COLLISION AVOIDANCE. IN MY VIEW, THE CONTRIBUTING FACTORS WERE: FATIGUE -- AFTER 4 HRS IN THE AIR, NEITHER PLT COMPREHENDED THE IMPLICATIONS OF SWITCHING FROM IFR TO VFR AT THAT POINT IN SPACE. NONSTANDARD PROCS -- BAY HANDED THE FLT OFF TO SQL MUCH EARLIER THAN USUAL. (A NORMAL HDOF WOULD HAVE OCCURRED IN SUCH A WAY THAT WE WOULD HAVE ALREADY BEEN IN THE CLASS B/C AIRSPACE WHEN HANDED OVER TO SQL TWR). ALSO, THE PNF USED NONSTANDARD PHRASEOLOGY WHEN CONTACTING THE TWR. LACK OF CREW COORD -- THE PNF SHOULD HAVE ASKED THE PF PRIOR TO CANCELING IFR.

Synopsis :

PLT OF A PIPER PA34-200 MAY HAVE INADVERTENTLY PENETRATED CLASS B AIRSPACE DURING A VISUAL DSCNT TO AN UNDERLYING ARPT CAUSED WHEN THE PNF CANCELED THEIR IFR CLRNC. THE RPTING PLT DISCOVERED HIS MISTAKE AND MADE A RAPID DSCNT TO AVOID OR GET OUT OF THE CLASS B AIRSPACE.

ACN: 378060

Time

Date : 199708

Day : Wed

Local Time Of Day : 1201 To 1800

Place

Locale Reference.Airport : GSP

State Reference : SC

Altitude.MSL.Bound Lower : 1400

Altitude.MSL.Bound Upper : 1600

Environment

Flight Conditions : VMC

Aircraft / 1

Make Model : Skyhawk 172/Cutlass 172

Person / 1

Experience.Flight Time.Total : 1500

Experience.Flight Time.Last 90 Days : 120

Experience.Flight Time.Type : 500

ASRS Report : 378060

Events

Anomaly.Incursion : Landing Without Clearance

Anomaly.Non Adherence : Clearance

Independent Detector.Other.ControllerA : Unspecified

Resolatory Action.None Taken : Detected After The Fact

Narrative :

A STUDENT AND I WERE ON AN IFR TRAINING FLT XCOUNTRY TO GREER, GSP, SC. PROBS HAD ARISEN WITH THE ATC FROM THE BEGINNING OF THE FLT. WE WERE ON AN IFR FLT PLAN BUT ATC WAS CONFUSING IN ITS CLRNCS BY GIVING US MIXED VFR AND IFR CLRNCS. AFTER STRAIGHTENING OUT THE FLT PLAN, WE WERE CLRED FOR A PRACTICE ILS RWY 21 APCH INTO GSP AND HANDED OFF TO THE TWR. TWR CLRED US FOR THE OPTION PRIOR TO GS INTERCEPTION AND WE PROCEEDED WITH THE APCH. THE STUDENT BECAME OVERWHELMED WITH ALL THE TASKS AT HAND, INCLUDING COMS. I WAS BUSY EXPLAINING THE APCH AS HE FLEW IT AND WAS MONITORING COMS WITH THE TWR. SOMEWHERE DURING THIS TIME, TWR APPARENTLY RADIOED TO US AND 'ADVISED' US TO DO A LOW PASS. MY STUDENT HAD MADE A QUICK RADIO STATEMENT, BUT COULDN'T REMEMBER WHAT WAS SAID. DECISION HT WAS REACHED AND WE DID A VERY QUICK TOUCH AND GO AS PER THE PREVIOUS CLRNC THAT I HAD RECEIVED. AFTER WE LIFTED OFF, TWR INSTRUCTED A FLT BEHIND US TO TURN TO THE W SO HE COULD BRING HIM IN BEHIND ANOTHER ACFT BEHIND HIM. AT THIS TIME, TWR CAME ON THE RADIO AND TOLD US TWICE THAT HE HAD 'ADVISED' US TO DO A LOW APCH ONLY. CONTRIBUTING FACTORS: ATC'S APPARENT LACK OF COORD WITH OUR ACTIVATED AND PRE-FILED IFR FLT PLAN, UNCLR RADIO INSTRUCTIONS AND READBACKS FROM BOTH ATC AND OUR ACFT, FATIGUE EXHIBITED IN BOTH PLTS. POSSIBLE CORRECTIVE ACTIONS: BETTER ATC INSTRUCTIONS, BETTER PLT SITUATIONAL AWARENESS (MYSELF). THE PRACTICE APCH COULD HAVE BEEN SPED UP BY ATC OR MYSELF TO ACCOMMODATE TFC FLOW.

Synopsis :

DURING AN INST RATING TRAINING FLT, INSTRUCTOR PLT ALLOWED TRAINEE TO MAKE A TOUCH AND GO UPON COMPLETION OF AN ILS APCH CONTRARY TO TWR INSTRUCTIONS FOR A LOW PASS ONLY. INSTRUCTOR PLT WAS BUSY GIVING INSTRUCTIONS TO TRAINEE AND DID NOT HEAR THE TWR INSTRUCTIONS RESULTING IN TWR MOVING ANOTHER ACFT IN TRAIL TO ANOTHER RWY.

ACN: 401150

Time

Date : 199804

Day : Wed

Local Time Of Day : 1201 To 1800

Place

Locale Reference.ATC Facility : FGP

State Reference : NC

Altitude.MSL.Bound Lower : 5500

Altitude.MSL.Bound Upper : 5500

Environment

Flight Conditions : VMC

Aircraft / 1

Controlling Facilities.TRACON : FAY

Make Model : PA-28 Cherokee Arrow Iv

Person / 1

Function.Flight Crew : Single Pilot

Experience.Flight Time.Total : 1400

Experience.Flight Time.Last 90 Days : 30

Experience.Flight Time.Type : 14

ASRS Report : 401150

Person / 2

Function.Controller : Approach

Events

Anomaly.Other Spatial Deviation : Track Or Heading Deviation

Anomaly.Non Adherence : FAR

Independent Detector.Other.Flight CrewA : Unspecified

Resolatory Action.Flight Crew : Returned to Intended Course or Assigned Course

Consequence.FAA : Reviewed Incident With Flight Crew

Narrative :

AFTER COMPLETING BUSINESS IN WINSTON-SALEM, NC, I MADE THE DECISION TO PROCEED TO MY HOME FIELD, EVEN THOUGH I HAD ALREADY BEEN UP AND WORKING SINCE EARLY MORNING, AND WAS VERY TIRED. I HAD DONE ONLY SUPERFICIAL PREFLT PLANNING, HAVING JUST FLOWN THE RTE ON THE WAY TO INT. THE ONLY PROFESSIONAL DECISIONS I MADE WERE TO CHK WX AND FILL MY TANKS WITH GAS, GIVING ME APPROX 4 HRS FLYING TIME. WHILE ENRTE CRUISING AT 5500 FT MSL I MISIDENTED A GND CHKPOINT, WITHOUT REALIZING THAT I HAD NOT BEEN MAINTAINING PROPER HEADING CTL. THIS LED ME TO TRY AND INTERCEPT THE 255 DEG RADIAL ON ISO WHICH WOULD TAKE ME TO MY HOME FIELD, EVEN THOUGH I WAS NOT ON COURSE. FURTHERMORE, WHILE BEING ON THE CORRECT RADIAL, BUT WITHOUT DME OR A CROSS RADIAL, I DSNDDED TOO EARLY FOR APCH TO LAND. WHEN I REALIZED THAT I WAS NOT WHERE I THOUGHT I WAS, I FINALLY FOUND AN NDB STATION TO FIX MY POS WITH THE ISO 255 DEG RADIAL. PREVIOUSLY I HAD BEEN UNABLE TO IDENT THE NDB'S ON MY COURSE. SINCE I WAS GETTING ISO WITH A GOOD IDENT (I HAD SUSPECTED COM/ICS PROBS EARLIER) I THOUGHT THE NDB RECEIVER WAS BAD, RATHER THAN THINKING I WAS OFF COURSE. THE FGP NDB TOLD ME THAT WHILE I WAS ON THE ISO 255 DEG RADIAL, I WAS VERY CLOSE TO FAYETTEVILLE. ENRTE TO THIS POS IT IS VERY POSSIBLE THAT I PASSED THROUGH RESTR AIRSPACE (R-5311) WHERE PARACHUTE OPS, AMONG OTHER THINGS, ARE CONDUCTED, AND THAT I VIOLATED CLASS C AIRSPACE. NOT KNOWING MY EXACT POS BEFORE THIS IT IS HARD TO TELL. AFTER FINALLY FIXING MY POS, I RELUCTANTLY CHKED IN WITH FAYETTEVILLE APCH TO SEE IF I HAD BEEN CAUSING ANY PROBS, BUT WHEN I CHKED IN WITH THEM THEY SIMPLY REPLIED THAT I WAS LEAVING THEIR AIRSPACE AND TO CHANGE FREQS. WHEN I GOT ON THE GND I CALLED THE RADAR FACILITY AT FAYETTEVILLE TO ASK IF ANYONE HAD RPTED A STRAY ACFT, AND I CALLED AGAIN LATER TO MAKE SURE. BOTH TIMES I SPOKE WITH THE SAME CTLR AND SHE SAID THERE HAD BEEN NO VIOLATIONS THAT THEY WERE AWARE OF. MY FATIGUE, DESIRE TO GET HOME, AND LACK OF PREFLT PLANNING CONTRIBUTED TO POSITIONAL DISORIENTATION (BEING LOST), AND COULD HAVE RESULTED IN AN AIRSPACE VIOLATION.

Synopsis :

A TIRED PA28 PLT MISIDENTED A VISUAL CHKPOINT AND STARTED HIS DSCNT FOR A LNDG FAR TOO SOON. HE RPTS THAT HE MAY HAVE VIOLATED A RESTR AREA AND CLASS C AIRSPACE.

ACN: 414968

Time

Date : 199809

Day : Thu

Local Time Of Day : 1801 To 2400

Place

Locale Reference.Airport : DED

State Reference : FL

Environment

Flight Conditions : Marginal

Aircraft / 1

Make Model : Any Unknown or Unlisted Aircraft Manufacturer

Person / 1

Function.Flight Crew : Single Pilot

Experience.Flight Time.Total : 9300

Experience.Flight Time.Last 90 Days : 40

Experience.Flight Time.Type : 1520

ASRS Report : 414968

Events

Anomaly.Inflight Encounter : VFR In IMC

Anomaly.Inflight Encounter : Weather

Anomaly.Non Adherence : FAR

Independent Detector.Other.Flight CrewA : Unspecified

Resolatory Action.None Taken : Anomaly Accepted

Narrative :

TOOK OFF FROM EVB WITH SOME MORE WX MOVING IN FROM THE E. WX WAS ABOUT 1500 FT BROKEN WITH VISIBILITY OF 5-6 MI. FROM TFC PATTERN ALT (800 FT MSL) FLEW VFR TOWARD HOME ARPT OF DED, JUST 18 MI TO THE W. FOLLOWED HWY 44 TO THE W OF EVB STAYING BELOW THE CLOUDS, WHICH WERE LOWERING THE FURTHER W I FLEW. ENRTE, I HAD THOUGHTS OF RETURNING TO EVB AND GETTING AN IFR CLRNC TO DED OR AT LEAST PICKING UP ONE ENRTE. BUT, WITH REASONABLE VISIBILITY AND NEARNESS TO MY HOME ARPT, I PRESSED ON. AS I REACHED A RACETRACK AT THE INTXN OF HWYS 44 AND 451, I COULD SEE THE ARPT ENVIRONMENT, A LIGHTER AREA AMONG THE VAST LANDSCAPE OF TREES ABOUT 7 MI AWAY, SO I SET COURSE DIRECT FOR THE ARPT, WHICH WOULD PUT ME ALIGNED WITH THE INBOUND FOR RWY 30. AS I APCHED THE INTERSTATE 4, ABOUT 4 MI OUT, MY ALT HAD DECREASED TO 650 FT MSL AND I ANNOUNCED ON THE UNICOM FREQ THAT I WAS INBOUND AND ALIGNED WITH THE NDB FOR RWY 30. A RESPONSE ON THE UNICOM FREQ SAID THAT A CONVAIR HAD JUST MADE A MISSED APCH TO RWY 30 AT DED. WITH MY LOWER ALT AND ALIGNMENT WITH RWY 30, I FLEW TO THE N TOWARD AN AREA OF HIGHER CEILING AND SOME SUNLIGHT BREAKING THROUGH. THIS WOULD MANEUVER ME FOR A DOWNWIND FOR RWY 12, MORE ALIGNED WITH THE PREVAILING WIND. ON THIS HDG I SAW THE CONVAIR BREAK OUT INBOUND TO DED AND DECLARING A FINAL APCH FOR RWY 30. AT THIS POINT I BECAME UPSET WITH MYSELF FOR BEING AIRBORNE IN THIS SIT WITHOUT AN IFR CLRNC WHILE AN IFR ACFT WAS SHOOTING AN APCH TO THE SAME ARPT. AS THE CONVAIR WAS ON ITS LNDG ROLLOUT, I WAS ON DOWNWIND FOR RWY 12. AS IT DEPARTED THE END OF RWY 30, I MADE MY BASE LEG AT 650 FT MSL AND SUBSEQUENTLY LANDED ON RWY 12. PROB: FLYING INTO MARGINAL CONDITIONS WAS A DUMB THING TO DO -- ESPECIALLY SINCE OTHER IFR AIRPLANES MIGHT BE DSNDRG OUT OF THE OVCST RIGHT ONTO ME, NOT AWARE THAT I AM DOWN THERE SCUD RUNNING. I COULD HAVE CAUSED A MIDAIR, AND IT REALLY RATTLED ME. I WAS A NEAR BASKET CASE OF CONCERN AND SELF- DAMNATION ON THE WAY HOME AND STILL FEEL TERRIBLE ABOUT IT. MAKING IT WORSE, ABOUT 1 1/2 HRS LATER THE SKY CONDITIONS WERE VFR, THE STARS WERE CLRLY VISIBLE! I HAD LOST ALL CLR THINKING AND PATIENCE -- I JUST COULDN'T WAIT! WHY DID IT HAPPEN: I AM NOT A SCUD RUNNER TYPE OF PLT. IN FACT, I HAVE FELT SCORN FOR SUCH AVIATION BEHAVIORS IN THE PAST. ALL OF THE FACTORS INFLUENCING THE SIT WERE STRICTLY HUMAN FACTORS -- TIRED AFTER A LONG DAY, GET HOMEITIS, WANTED TO GET IT OVER WITH, AND AN EMOTIONALLY STRESSFUL SIT OCCURRING IN MY PERSONAL LIFE AT THAT TIME, WHICH GAVE ME A PRESSURED FEELING TO PRESS ON AND GET HOME. I SHOULD HAVE SIMPLY CALLED DAB APCH (THE CTLING AGENCY FOR DED) AND ASKED FOR AN IFR CLRNC TO DED. THE NEARNESS TO THE HOME FIELD AND NOT TOO BAD VISIBILITY SUCKERED ME TO PRESS ON AND NOT USE ANY GOOD JUDGEMENT. I'LL NOT BE DOING THIS SORT OF THING AGAIN!

Synopsis :

PLT OF AN SMA FLYING WESTWARD VFR ENCOUNTERS DETERIORATING WX BUT CONTINUES FLT WHILE THINKING HE SHOULD FILE IFR. ON CONTACTING UNICOM HE LEARNS OF A CONVAIR ON IFR APCH WHO JUST WENT MISSED. SIGHTING THE ACFT HE MAKES A DOWNWIND FOR OPPOSITE DIRECTION LNDG.

ACN: 418627

Time

Date : 199810

Day : Tue

Local Time Of Day : 1801 To 2400

Place

Locale Reference.Airport : LNR

Locale Reference.ATC Facility : LNR

State Reference : WI

Environment

Flight Conditions : IMC

Aircraft / 1

Make Model : Caravan 1 208A

Aircraft / 2

Make Model : Any Unknown or Unlisted Aircraft Manufacturer

Component / 1

Aircraft Component : Gear Extend/Retract Mechanism

Aircraft Reference : X

Problem : Improperly Operated

Component / 2

Aircraft Component : Indicating and Warning - Landing Gear

Aircraft Reference : X

Problem : Improperly Operated

Component / 3

Aircraft Component : VHF

Aircraft Reference : X

Problem : Improperly Operated

Person / 1

Function.Flight Crew : Single Pilot

Experience.Flight Time.Total : 2200

Experience.Flight Time.Last 90 Days : 120

Experience.Flight Time.Type : 105

ASRS Report : 418627

Person / 2

Function.Other Personnel : FBO Personnel

Function.Other Personnel : Unicom Operator

Person / 3

Function.Flight Crew : Single Pilot

Events

Anomaly.Conflict : Ground Critical

Anomaly.Non Adherence : Published Procedure

Independent Detector.Other.Flight CrewA : Unspecified

Resolatory Action.None Taken : Detected After The Fact

Consequence.Other : Aircraft Damaged

Narrative :

DURING THE 5TH FLT OF A 12-HR DUTY DAY THAT INCLUDED 4 PREVIOUS IFR APCHS TO MINIMUMS AT DIFFERENT AND UNFAMILIAR ARPTS, I FAILED TO LOWER THE LNDG GEAR ON OUR AMPHIBIAN CESSNA CARAVAN. THIS COSTLY MISTAKE OCCURRED DURING AN IFR APCH THAT FOLLOWED A MISSED APCH TO THE TRI-COUNTY REGIONAL ARPT IN LONE ROCK, WI. THE ACFT INCURRED MINOR DAMAGE TO THE FLOATS AS IT SKIDDED ALONG THE RWY ON THE KEELS OF BOTH FLOATS. FORTUNATELY NO ONE WAS HURT IN THIS INCIDENT. THE ACFT WAS BACK ON ITS LNDG GEAR WITHIN A COUPLE OF HRS, AND IN GOOD ENOUGH SHAPE TO FLY THE NEXT MORNING TO A MAINT FACILITY TO HAVE THE FLOATS REMOVED AND THE ACFT WAS RETURNED TO SVC. THIS WAS A SHORT FLT FROM A NEARBY PVT STRIP TO THE LONE ROCK ARPT. ZAU CLRED ME FOR THE LNR GPS RWY 27 APCH AS WELL AS FOR A FREQ CHANGE TO ARPT ADVISORIES. I PROCEEDED DIRECT TO MINGS INTXN AND FLEW THE APCH AS PUBLISHED. AT THE MISSED APCH POINT I HAD GND CONTACT BUT COULD NOT SEE THE RWY ENVIRONMENT SO I EXECUTED THE MISSED APCH PROC. I RETRACTED THE LNDG GEAR AND BEGAN TO CLB. I ADVISED ZAU OF MY SIT AND THAT I WANTED TO GO TO THE HOLDING POINT AND THAT, AFTER TALKING TO SOMEONE ON THE GND AT LNR, I WOULD POSSIBLY TRY AGAIN. I WAS CLRED TO MINGS INTXN TO HOLD AS PUBLISHED. THE LONE ROCK UNICOM WAS UNATTENDED, HOWEVER, I WAS IN CONTACT WITH OUR OTHER COMPANY ACFT ON THE GND AWAITING MY ARR. THEY ADVISED ME THAT FOR SOME REASON THE RWY LIGHTS WERE AT LOW INTENSITY AND THAT IS PROBABLY WHY I HAD TO MISS. THEY SAID THAT THE LIGHTS WERE ONCE ON HIGH, BUT PERHAPS I HAD TURNED THEM DOWN INADVERTENTLY DURING THE APCH WHEN I CLICKED THE MIKE 7 TIMES TO TURN THEM ON. THEY TOLD ME THAT THEY WOULD MONITOR THE LIGHTS AND ENSURE THAT THEY WERE AT FULL INTENSITY IF I WANTED TO MAKE ANOTHER ATTEMPT. ARRIVING AT MINGS, I TOLD CTR THAT I WOULD LIKE TO TRY THE APCH AGAIN. ONCE AGAIN I WAS CLRED FOR THE APCH AND BEGAN TO FLY IT AS PUBLISHED. ONCE ESTABLISHED INBOUND, I BECAME CONCERNED ABOUT THE RWY LIGHT STATUS AND MADE SEVERAL ATTEMPTS TO CONTACT THE ACFT ON THE GND BUT THEY DID NOT ANSWER. THEY WERE NO LONGER MONITORING THE FREQ. ABOUT 3/4 MI FROM THE MISSED APCH POINT, I HAD THE RWY IN SIGHT AND BEGAN MY DSCNT FOR LNDG. I WOULD SOON LEARN THAT DURING THE SECOND APCH, I FAILED TO LOWER THE LNDG GEAR AT THE FINAL APCH POINT. I IMMEDIATELY ADVISED LCL TFC ON THE CTAF, AND ALSO ZAU, THAT A DISABLED ACFT WAS ON THE RWY AT THE LONE ROCK ARPT AND A NOTAM WAS ISSUED. SEVERAL FACTORS, INCLUDING MY PREOCCUPATION WITH THE RWY LIGHT STATUS, CONTRIBUTED TO THIS INCIDENT AND I HAVE LEARNED VERY IMPORTANT LESSONS FROM THEM ALL. FIRST OF ALL, I FAILED TO RESET THE ELECTRONIC 'HEADS UP' CHKLIST TO THE BEFORE LNDG CHKLIST SECTION DURING THE MISSED APCH AND INSTEAD REVERTED TO A MENTAL CHKLIST THAT FAILED TO IDENT THE IMPROPER CONFIGN. IN THE FUTURE, I WILL TAKE THE TIME TO RESET THE CHKLIST TO THE CURRENT PHASE OF FLT OR AT LEAST REVERT TO THE PAPER CHKLIST TO DO MY BEST TO NEVER FLY PAST THE FINAL APCH POINT AGAIN WITHOUT ENSURING THE ACFT IS CORRECTLY CONFIGURED FOR LNDG. THE CARAVAN IS NORMALLY A FIXED GEAR AIRPLANE AND WE FLY IT IN THAT CONFIGN 7 MONTHS OUT OF THE YR, SO STRICT ATTN TO THE CHKLIST IS NECESSARY TO AVOID THIS MISTAKE AGAIN. SECOND, I FAILED TO HEED THE ADVICE OF THE ACFT'S LNDG GEAR ADVISORY SYS. IT MAKES AN AUDIO ANNOUNCEMENT THAT EITHER THE 'GEAR IS UP FOR WATER LNDG' OR THAT THE 'GEAR IS DOWN FOR RWY LNDG.' DURING THE APCH, I WAS AWARE THAT THE ADVISORY WAS SOUNDING OFF BUT FAILED TO DIFFERENTIATE BTWN THE WATER LNDG VERSUS RWY LNDG ANNOUNCEMENTS. THE ADVISORY CAN BE CANCELED BY DEPRESSING THE 'GEAR ADVISORY' ANNUNCIATOR/SWITCH AND THE PLT MAY HAVE TO CANCEL IT SEVERAL TIMES DURING AN APCH WITH STEPDOWN DSCNTS FOLLOWING PWR REDUCTIONS EVEN AFTER SELECTING THE CORRECT LNDG GEAR CONFIGN. FROM NOW ON, I WILL BE SURE TO LISTEN CAREFULLY AND CONFIRM THE CORRECT CONFIGN BEFORE SILENCING IT IN THE FUTURE. ON TOP OF EVERYTHING ELSE, FATIGUE CERTAINLY AFFECTED MY PERFORMANCE DURING THIS FLT. THIS WAS AN UNUSUALLY BUSY FLYING DAY FOR ME. I WAS NOT UNDER ANY PRESSURE TO COMPLETE THIS TRIP AND I FELT REASONABLY ALERT AND COMPETENT TO DO SO. HOWEVER, THE LONG DAY, COUPLED WITH THE INCREASED WORKLOAD OF SEVERAL IFR APCHS TO MULTIPLE UNFAMILIAR ARPTS AT NIGHT AND AS A SINGLE PLOT, TOOK ITS TOLL THAT TERMINATED IN THIS INCIDENT. I AM VERY LUCKY THAT THE SIT WAS NOT WORSE. IN THE FUTURE, I WILL CAREFULLY CONSIDER MY PHYSICAL AND MENTAL CONDITION VERSUS THE TASK AT HAND BEFORE MAKING THE DECISION TO CONTINUE OR STAY PUT FOR THE NIGHT.

Synopsis :

AN AMPHIBIOUS C208 LANDS WITH ITS LNDG WHEELS RETRACTED FOR A RWY LNDG.

ACN: 430444

Time

Date : 199903

Day : Sat

Local Time Of Day : 1201 To 1800

Place

State Reference : AK

Altitude.MSL.Single Value : 3000

Environment

Flight Conditions : VMC

Aircraft / 1

Controlling Facilities.ARTCC : ZAN.ARTCC

Make Model : Skyhawk 172/Cutlass 172

Person / 1

Experience.Flight Time.Total : 1850

Experience.Flight Time.Last 90 Days : 125

Experience.Flight Time.Type : 450

ASRS Report : 430444

Person / 2

Experience.Flight Time.Total : 132

Experience.Flight Time.Last 90 Days : 19

Experience.Flight Time.Type : 44

ASRS Report : 430182

Person / 3

Function.Controller : Radar

Events

Anomaly.Other Spatial Deviation : Track Or Heading Deviation

Anomaly.Altitude Deviation : Excursion From Assigned Altitude

Anomaly.Non Adherence : Clearance

Anomaly.Non Adherence : FAR

Anomaly.Non Adherence : Published Procedure

Independent Detector.Other.ControllerA : 3

Independent Detector.Other.Flight CrewA : 1

Resolatory Action.Flight Crew : Became Reoriented

Resolatory Action.Controller : Provided Flight Assist

Consequence.FAA : Investigated

Consequence.FAA : Reviewed Incident With Flight Crew

Supplementary

Problem Areas : Flight Crew Human Performance

Narrative :

3000-5000 FT, APPROX 5 MI W OF HOMER ARPT, AK. DUAL INST TRAINING FLT ON THE LOC/DME BACK COURSE RWY 21 APCH. DURING OUR PREFLT BRIEFING OF THE APCHS THAT WE WERE GOING TO EXECUTE, WE TALKED ABOUT THE HAZARDS OF THE HOMER MISSED APCH PROC, WHICH INVOLVES HOLDING 17 DME OUT OVER THE OPEN WATER AT 2600 FT. WE DISCUSSED ASKING CTR FOR AN AMENDED MISSED APCH PROC WHICH INVOLVED CLBING TO 5000 FT AND THEN TO THE HOMER VOR TO CONTINUE TO OUR NEXT DEST FOR AN ADDITIONAL APCH. BEFORE WE WERE CLRED FOR THE APCH, CTR ASKED WHAT OUR INTENTIONS WERE AND WE STATED THAT WE WANTED TO SHOOT THE APCH, DO A TOUCH-AND-GO, AND THEN EXECUTE THE MISSED APCH. IT WAS ACCEPTED AND WE WERE THEN CLRED. BECAUSE OF THE WINDS WE ENDED UP DOING A CIRCLING APCH FOR THE TOUCH-AND-GO AND THEN TURNED DOWNWIND TO CONTINUE IN THE DIRECTION OF THE MISSED APCH PROC, WHICH FURTHER COMPLICATED OUR SIT. THE PROB AROSE WHEN WE ACCEPTED OUR CLRNC I FORGOT TO ASK FOR THE AMENDED DEP PROC THAT I HAD DISCUSSED PREVIOUSLY WITH MY STUDENT. WHEN THE TIME CAME TO DO THE MISSED APCH, WE EXECUTED THE MISSED APCH PROC THAT WE HAD TALKED ABOUT PRIOR TO THE FLT, NOT THE ONE THAT WE HAD ACCEPTED FROM CTR. BIG MISTAKE. WE WERE THEN ADVISED THAT WE HAD COMMITTED A PLTDEV AND TALKED TO THE CTR SUPVR UPON LNDG. THE FACTORS THAT I FEEL LED TO MY MISCOM/MISTAKE WERE: 1) LIGHT TO MODERATE TURB ENCOUNTERED DURING THE WHOLE APCH. 2) MY PREOCCUPATION WITH TALKING TO MY STUDENT EXPLAINING THE NECESSARY CORRECTIONS FOR THE APCH. 3) HVY FLT SCHEDULE FOR THE PRECEDING 13 DAYS. 4) INSTRUCTOR FATIGUE. AFTER THINKING ABOUT THIS FOR A WHILE I FEEL THAT THE SIGNIFICANT CONTRIBUTING FACTOR LEADING TO THIS EVENT WAS FATIGUE. I HAD NOT EXCEEDED MY 8 HRS OF FLT TIME WITHIN 24 CONSECUTIVE HRS, BUT HAVE BEEN WORKING DOING PREFLT/POSTFLT BRIEFS AND GND INSTRUCTION LEADING UP TO 10-12 HR WORK DAYS FOR THE PAST 13 DAYS. SITTING DOWN AND THINKING ABOUT THIS, I HAVE DECIDED TO RESTRICT MY WORK DAY TO 8 HRS OF ACTUAL FLT AND GND INSTRUCTION.

Synopsis :

A PVT PLT TRAINING FOR HIS INST RATING IN A C172 FAILED TO PROPERLY FLY THE MISSED APCH PROC THAT ATC EXPECTED.

ACN: 436477

Time

Date : 199905

Day : Thu

Local Time Of Day : 1201 To 1800

Place

Locale Reference.Airport : LGB.Airport

State Reference : CA

Environment

Flight Conditions : VMC

Aircraft / 1

Make Model : Challenger C1601

Person / 1

Function.Oversight : PIC

Function.Flight Crew : Captain

Experience.Flight Time.Total : 17000

Experience.Flight Time.Last 90 Days : 200

Experience.Flight Time.Type : 1200

ASRS Report : 436477

Person / 2

Function.Observation : Observer

Person / 3

Function.Observation : Observer

Events

Anomaly.Aircraft Equipment Problem : Critical

Anomaly.Excursion : Runway

Anomaly.Non Adherence : FAR

Anomaly.Non Adherence : Published Procedure

Independent Detector.Other.Flight CrewA : 1

Resolatory Action.None Taken : Insufficient Time

Resolatory Action.None Taken : Unable

Consequence.FAA : Investigated

Consequence.Other : Aircraft Damaged

Supplementary

Problem Areas : Flight Crew Human Performance

Narrative :

THE FOLLOWING NARRATIVE DESCRIBES A GND INCIDENT ONLY. I WAS ACCOMPANIED IN THE ACFT BY MECHS OCCUPYING THE R SEAT AND THE JUMP SEAT. THE PURPOSE WAS TO ATTEMPT, DURING A HIGH SPD TAXI, TO DUPLICATE A RPTED THRUST REVERSER DEPLOYMENT PROB. ALL CHKLISTS WERE READ BY THE MECH IN THE R SEAT AND THE ACTIONS WERE CONFIRMED BY ME. DURING THE HIGH SPD TAXI AND SUBSEQUENT THRUST REVERSER DEPLOYMENT, THE ACFT PITCHED UP AND BECAME AIRBORNE. THE ACFT VEERED OFF THE RWY AND SETTLED ONTO THE PARALLEL SOD INFIELD. THE R MAIN GEAR AND NOSE GEAR COLLAPSED. THE ACFT SUSTAINED DAMAGE THAT, AT THIS TIME, APPEARS REPAIRABLE. THE INJURIES TO THIS WRITER AND THE MECHS ARE MINOR. FACTORS TO CONSIDER: AS TO WHETHER THE GND SPOILERS WERE ARMED OR THE FLT SPOILERS WERE DEPLOYED AFTER CLOSING THE THROTTLES, I SIMPLY DO NOT REMEMBER. THESE ACTIONS ARE NORMALLY INGRAINED AND THEREFORE ROUTINE, BUT I HAVE NO MEMORY OF EITHER. NOT HAVING A QUALIFIED PLT IN THE R SEAT WAS A DEFINITE FACTOR. THE OVERLOOKING OF ANY CHKLIST ITEMS WOULD HAVE BEEN BROUGHT TO MY ATTN BY ANOTHER PLT. THE ACFT HAS A VERY REAL PROB (NOSE PITCH UP) DURING THRUST REVERSER DEPLOYMENT. I'VE HAD SEVERAL UNSOLICITED PHONE CALLS CONFIRMING THIS. THIS CHARACTERISTIC SHOULD BE STRESSED DURING INITIAL AND RECURRENT TRAINING. FATIGUE AND STRESS WERE DEFINITE, AND MAYBE THE OVERRIDING FACTORS. I HAD BEEN STRESSED IN DEALING WITH PERSONNEL PROBS WITHIN MY ORGANIZATION. I KNEW I WAS TIRED BUT, AS MANY MGRS DO, DECIDED THE JOB MUST GET DONE.

Synopsis :

A CL601 DURING A HIGH SPD TAXI FOR MAINT TROUBLESHOOTING AT LGB BECAME AIRBORNE AND SUFFERED DAMAGE AFTER EXITING THE RWY.

ACN: 437812

Time

Date : 199905

Day : Sun

Local Time Of Day : 1201 To 1800

Place

Locale Reference.Airport : SUS.Airport

State Reference : MO

Altitude.AGL.Single Value : 0

Environment

Flight Conditions : VMC

Aircraft / 1

Make Model : Skylane 182/Rg Turbo Skylane/Rg

Person / 1

Function.Flight Crew : Single Pilot

Experience.Flight Time.Total : 205

Experience.Flight Time.Last 90 Days : 11

Experience.Flight Time.Type : 4

ASRS Report : 437812

Events

Anomaly.Excursion : Runway

Independent Detector.Other.Flight CrewA : 1

Resolatory Action.Flight Crew : Executed Go Around

Consequence.Other : Aircraft Damaged

Supplementary

Problem Areas : Flight Crew Human Performance

Narrative :

AT SUS ARPT WITH 3 PAX ON BOARD, INCLUDING THE PLT. APCHING N RWY (RWY 8L), FACING XWIND THAT VARIED FROM 170-210 DEGS AT 10-15 KTS. ON FINAL APCH I HAD AIRSPD OF 70-80 KTS, WHICH KEPT INCREASING THE CLOSER I GOT TO THE GND. ALSO, I FELT THAT I HAD TO CRAB INCREASINGLY, AS I GOT CLOSER TO THE RWY. LIKewise, I HAD TO INCREASE L RUDDER IN ORDER TO KEEP PLANE IN LINE WITH THE RWY. ON TOUCHDOWN, WE BOUNCED ONCE AND ON RECOVERING, BROUGHT THE PLANE TO THE RWY ON ALL 3 GEAR. AIRSPD WAS STILL HIGH AND THE PLANE QUICKLY VEERED TO THE L. IN A FRACTION OF TIME WE WERE OFF THE RWY CONCRETE AND INTO THE GRASS. AIRSPD STILL HOT, I PUT IN FULL THROTTLE AND WE WERE AIRBORNE MOMENTS LATER. ON CLBOU WE HEARD A SOUND OF IMPACT (THINKING OF RWY LIGHTS) AND GOT BACK INTO THE PATTERN. ON A LOW PASS-OVER, WE GOT THE TWR TO VERIFY THAT OUR LNDG GEAR APPEARED NORMAL, THEN LANDED WITHOUT A HITCH. ON DISEMBARKING, A QUICK INSPECTION OF THE PLANE REVEALED SUBSTANTIAL DAMAGE TO THE LEADING EDGE OF BOTH SIDES OF THE TAIL WING, SOME SCRAPING TO THE UNDER CARRIAGE OF THE FUSELAGE, AND 2 INCHES CUT INTO THE TIP OF THE PROP BLADE. APPARENTLY WE HAD FLOWN INTO THE TOP OF A TEMPORARY FENCE LOCATED 20-30 FT TO THE L OF RWY 8L. ON TAKING OFF FROM THE GRASS, WE HAD IMPACTED THE METAL SUPPORTS FOR THE ORANGE PLASTIC FENCING. THIS EXPLAINS THE RECTANGULAR INDENTATIONS LEFT IN THE TAIL WINGS. HUMAN PERFORMANCE CONSIDERATIONS: 1) DECISION TO GO AROUND SHOULD HAVE BEEN MADE LONG BEFORE TRAVERSING INTO THE GRASS, OR EVEN ATTEMPTING THE LNDG. 2) ONCE ON THE GND, WE SHOULD HAVE STAYED ON THE GND, EVEN IF IT WOULD HAVE MEANT DAMAGING THE ENG, GEAR, ETC. 3) UNRECOGNIZED PLT FATIGUE. A) HAD COMPLETED 7 TKOFS AND LNDGS AT COLUMBIA, MO, WITHIN 3 HRS PRIOR TO INCIDENT. B) HUNGER (LOW BLOOD SUGAR). HAD NOT EATEN SINCE PREVIOUS NIGHT. THIS FACTOR MAY HAVE DULLED JUDGEMENT AND DECISION MAKING SWIFtnESS. C) PLT FELT EXHAUSTED BUT DID NOT THINK IT WAS EXCESSIVE OR OUT OF THE ORDINARY, AS TO BE ALARMED OR CONCERNED.

Synopsis :

RELATIVELY LOW TIME SMA PLT DOES GAR AFTER VEERING OFF RWY ON LNDG ATTEMPT.

ACN: 439978

Time

Date : 199906

Day : Sat

Local Time Of Day : 0601 To 1200

Place

Locale Reference.ATC Facility : BWI.TRACON

State Reference : MD

Environment

Flight Conditions : Marginal

Aircraft / 1

Controlling Facilities.TRACON : BWI.TRACON

Make Model : PA-28 Cherokee Arrow Iv

Person / 1

Function.Oversight : PIC

Function.Flight Crew : Single Pilot

Experience.Flight Time.Total : 1600

Experience.Flight Time.Last 90 Days : 25

Experience.Flight Time.Type : 400

ASRS Report : 439978

Person / 2

Function.Controller : Approach

Function.Controller : Radar

Events

Anomaly.Other Spatial Deviation : Track Or Heading Deviation

Anomaly.Inflight Encounter : Weather

Anomaly.Non Adherence : Clearance

Anomaly.Non Adherence : FAR

Independent Detector.Other.ControllerA : 2

Resolatory Action.Flight Crew : Diverted To Another Airport

Resolatory Action.Flight Crew : Exited Adverse Environment

Resolatory Action.Flight Crew : Landed As Precaution

Resolatory Action.Controller : Issued New Clearance

Resolatory Action.Controller : Provided Flight Assist

Supplementary

Problem Areas : Flight Crew Human Performance

Problem Areas : Weather

Narrative :

RETURNING FROM CMH TO W29 DEST WAS BELOW A CLOUD DECK. FORECAST HAD BEEN FOR GOOD VFR. WAS NOT IFR CURRENT AND DECLINED OFFER OF IFR CLRNC FROM ATC (BALTIMORE APCH). RETURNED TO THE NW OF THE CLASS B AIRSPACE AND DSNDED BELOW THE CLOUD DECK IN VFR CONDITIONS. WHILE RETURNING TO W29 I THOUGHT WE WERE CLRED TO BALTIMORE THEN W29. APPARENTLY, THE VFR CLRNC WAS TO FORT MEADE THEN W29. THE CTLR ADVISED ME OF THE MISTAKE AND ISSUED A VECTOR TO FORT MEADE. I AM ASSUMING THAT I DID MAKE A MISTAKE. WHILE TRYING TO GET THE NAV TO THE NEW DEST WORKED OUT WE MISSED A FREQ CHANGE. ALL OF THIS WAS HAPPENING WHILE TRYING TO STAY VFR. IN ALL FAIRNESS THE CTLRS WERE GREAT. I WAS RETURNING FROM COLUMBUS AFTER WORKING THE LAST 4 DAYS AT A TRADE SHOW. I WAS UP AT EARLY AM THAT MORNING TO RETURN TO BALTIMORE. WX WAS CHKED BEFORE DEPARTING AND ENRTE. ALL RPTS WERE FOR GOOD VFR. BY THE TIME I REACHED THE ANNAPOLIS AREA CEILING WAS DOWN TO 1000 FT WITH RAIN AND DECIDED ENOUGH WAS ENOUGH. LANDED AT THE LEE ARPT ABSOLUTELY EXHAUSTED. I WAS SURPRISED AT MY FATIGUE. I DO FEEL THAT I MADE GOOD DECISIONS IN STAYING VFR, STAYING LEGAL AND LNDG WHEN I DID. UNFORTUNATELY I MAY HAVE MISSED OR MISUNDERSTOOD A CLRNC AND FREQ CHANGE.

Synopsis :

A COMMERCIAL INST RATED PLT FLYING A PA28 FROM CMH TO W29 ENCOUNTERS WX ENRTE RESULTING IN PRECAUTIONARY LNDG AT ANP. PLT HAD COM PROBS AND POSSIBLY DEVIATED FROM ATC CLRNCS WHILE TRYING TO MAINTAIN VMC CONDITIONS.

ACN: 455508

Time

Date : 199911

Day : Fri

Local Time Of Day : 0001 To 0600

Place

Locale Reference.Airport : DAL.Airport

State Reference : TX

Altitude.MSL.Single Value : 11000

Environment

Flight Conditions : VMC

Aircraft / 1

Controlling Facilities.ARTCC : ZFW.ARTCC

Make Model : MU-2

Person / 1

Function.Flight Crew : Single Pilot

Experience.Flight Time.Total : 1900

Experience.Flight Time.Last 90 Days : 150

Experience.Flight Time.Type : 500

ASRS Report : 455508

Person / 2

Function.Controller : Radar

Events

Anomaly.Other Spatial Deviation : Track Or Heading Deviation

Anomaly.Altitude Deviation : Undershoot

Anomaly.Non Adherence : Clearance

Anomaly.Non Adherence : FAR

Independent Detector.Other.ControllerA : 2

Independent Detector.Other.Flight CrewA : 1

Resolatory Action.Flight Crew : Became Reoriented

Resolatory Action.Controller : Issued New Clearance

Consequence.FAA : Investigated

Consequence.FAA : Reviewed Incident With Flight Crew

Supplementary

Problem Areas : Flight Crew Human Performance

Narrative :

TKOF FROM SAT AT APPROX AB15 TO DAL. ENRTE, AT APPROX 70 MI S OF DAL, HAVING RECEIVED DAL ATIS AND IN CONTACT WITH ZFW, MY LAST MEMORY IS THAT OF SCANNING MY INSTS AND STANDING BY FOR DSCNT TO DAL. MY NEXT IS THAT OF BEING APPROX 100+ MI N OF DAL ON SAME DIRECT COURSE AND ALT. UPON REGAINING MY BEARINGS, I IMMEDIATELY TRIED TO CONTACT ZFW ON FREQ. AFTER MAKING CONTACT, I INITIATED A 180 DEG COURSE REVERSAL DIRECT BACK TO DAL. I QUERIED CTR AS TO IF EVERYTHING WAS ALL RIGHT AND THAT THERE WERE NO PROBS AS A RESULT OF THIS SIT. THEY SAID NO. I APOLOGIZED FOR THE SIT AND WAS HANDED OFF TO DAL APCH WHICH REQUESTED ME TO CALL BY TELEPHONE WHEN I LANDED. I IMMEDIATELY COMPLIED, AND ALSO EXPLAINED THE SIT, THAT TO MY RECOLLECTION I SIMPLY FELL ASLEEP FOR THAT TIME PERIOD. I AGAIN APOLOGIZED AND QUERIED AS TO IF OTHER ACFT WERE AFFECTED BY MY MISTAKE. AGAIN THE CTLR SAID NO. I HAVE FREELY VOLUNTEERED THIS INFO AND HAVE FULLY COOPERATED WITH THE DAL FSDO TO RESOLVE THIS INCIDENT. IN MY OPINION, TO PREVENT AN OCCURRENCE OF THIS EVENT IN THE FUTURE, A PLT SHOULD PAY HEED TO HIS NEED FOR REST, RATHER THAN ATTEMPTING TO PUSH HIMSELF TO COMPLETE A NON REVENUE (PART 91) OR ANY FLT WHERE HE COULD JEOPARDIZE HIS SAFETY AND THAT OF THE CIVILIAN POPULACE. I, MYSELF, WILL RECOGNIZE FATIGUE AND OBTAIN NOT JUST 'REST' BUT 'QUALITY REST.' TO MY FELLOW AVIATORS I WILL ALSO EMPHASIZE THEY, TOO, TAKE THIS TO HEART -- NOT ONLY FOR THEMSELVES, BUT FOR THEIR FAMILIES AS WELL -- JUST AS I HAVE.

Synopsis :

AN MU2 ATX PLT RPT ON FALLING ASLEEP DURING AN EARLY MORNING REPOSITIONING FLT FROM SAT TO DAL, TX.

ACN: 464691

Time

Date : 200002

Day : Sun

Local Time Of Day : 0001 To 0600

Place

State Reference : GA

Environment

Flight Conditions : VMC

Aircraft / 1

Make Model : Bonanza 33

Person / 1

Function.Flight Crew : Single Pilot

Experience.Flight Time.Total : 1050

Experience.Flight Time.Last 90 Days : 45

ASRS Report : 464691

Person / 2

Function.Controller : Radar

Events

Anomaly.Airspace Violation : Entry

Anomaly.Non Adherence : FAR

Independent Detector.Other.Flight CrewA : 1

Resolatory Action.Flight Crew : Became Reoriented

Resolatory Action.Flight Crew : Exited Penetrated Airspace

Resolatory Action.Flight Crew : Regained Aircraft Control

Resolatory Action.Flight Crew : Returned To Intended or Assigned Course

Supplementary

Problem Areas : Flight Crew Human Performance

Narrative :

AT APPROX XA30 ON FEB/SAT/00, I DEPARTED ATHENS, GA, TO RETURN HOME TO SAVANNAH. THERE WAS NO WX OR TURB, OR ANY TFC OBSERVED ENRTE. I FLEW A DIRECT RTE AT 5500 FT MSL WITH THE AUTOPLT ENGAGED. ABOUT 30 NM OUT, WITH THE CITY IN SIGHT, I FELL ASLEEP. I AWOKE APPROX 20 MINS LATER. I WAS 30 NM OUT TO SEA, HAD PENETRATED THE ADIZ, AND HAD CROSSED INTO A RESTR AREA. ADDITIONALLY, I HAD BEGUN THE FLT WITH JUST UNDER AN HR'S RESERVE OF FUEL, SO I WAS DANGEROUSLY LOW ON FUEL. I HAD PREVIOUSLY BEEN UNABLE TO FALL ASLEEP IN AN ACFT, EVEN ON OVERNIGHT INTL FLTS AS A PAX. RECENTLY, I'VE BEEN TRAINING FOR A MARATHON. AT NIGHT I GO TO SLEEP INSTANTLY, AND THAT'S WHAT HAPPENED IN THE AIRPLANE. ADDITIONALLY, I HAD GAINED 500 FT WHILE ASLEEP. I IMMEDIATELY TURNED THE ACFT TOWARDS SAV, AND MADE STRAIGHT-IN FOR RWY 27. I PRAYED, MADE ANNOUNCEMENTS ON UNICOM, AND LANDED WITHOUT FURTHER INCIDENT (ALTHOUGH WITH FUEL BELOW MINIMUMS). THIS ORDEAL WAS CAUSED BY A PHYSIOLOGICAL CHANGE IN THE PLT AS A RESULT OF EXTREME AND FREQUENT PHYSICAL EXERTION. LACK OF INTERACTION AND MONOTONY CONTRIBUTED TO MY FALLING ASLEEP. I HAD ASSUMED THAT BECAUSE I HAD BEEN UNABLE TO SLEEP ON AN ACFT WHEN IT WAS DESIRABLE, I'D BE UNABLE TO WHILE FLYING. I WAS WRONG.

Synopsis :

PLT OF A BEECH DEBONAIR, BE33, FELL ASLEEP WITH THE AUTOPLT ON DURING THE LAST PORTION OF A MIDDLE OF THE NIGHT VFR XCOUNTRY FLT, AND OVERFLEW HIS DEST BEFORE AWAKENING AND SUCCESSFULLY RETURNING TO HIS DEST. HOWEVER, WHILE OVERFLYING HIS DEST, HE FLEW FOR 20 MINS ASLEEP RESULTING IN PENETRATING A WARNING AREA AND UNITED STATES ADIZ AIRSPACE.

Appendix A

Brief Introduction to Sleep Disorders and Sleeping Pills

Physical Sleep Disorders

There are several physical sleep disorders that can disturb sleep and cause excessive sleepiness during wakefulness. Two examples are described that illustrate why it is important to know about the existence of these medical disorders: sleep apnea and nocturnal myoclonus.

These are only two examples of sleep disorders, physiological conditions that can disrupt the quantity and quality of sleep and can have subsequent consequences during wakefulness. Sleep disorders often can exist without the knowledge of the individual sufferer and may produce waking difficulties that one would not typically relate to a sleep problem (e.g., high blood pressure, morning headaches, fighting sleep in many situations). It is imperative that health care professionals, especially accredited sleep-disorder specialists, be used to accurately determine the cause of sleep disturbances or the related waking difficulties, so that individuals receive appropriate and effective treatment.

Sleep Apnea

The sleep apnea syndrome (SAS) is a sleep disorder in which individuals cannot sleep and breathe at the same time. Apnea (a = not, pnea = breathing) is a pause in the regular pattern of breathing. Essentially, apneic individuals fall asleep and then periodically stop breathing. When this occurs, little or no oxygen is available to the brain or body. Usually, when the oxygen level in the blood drops below a certain level and carbon dioxide levels rise, the brain arouses the individual who then begins to breathe again. This awakening is often associated with a gasp for air or a snore as the individual resumes breathing. Depending on the severity of the disorder, this cycle of pauses in breathing and awakening to breathe can continue throughout the sleep period. Sleep apnea is a potentially lethal disorder—if the brain does not respond during an apnea, death can occur. There are two aspects of apneic episodes that affect the severity of the disorder: the duration of the apnea and the frequency (the number that occur during a given sleep period). Most apnea episodes usually last under 30 sec, though they can range from 15 sec up to 2 or 3 min in duration. Apneas may occur only a few times per hour of sleep or hundreds of times across a sleep period. In a very mild case, there may be only 5 or 10 apnea episodes per hour, whereas in a severe case there may be 50 to 80 per hour of sleep (i.e., 300 or 400 episodes during an average sleep period).

Many physical and behavioral problems can be caused by sleep apnea, for example, excessive sleepiness and cardiovascular difficulties such as hypertension. Currently, sleep-disorder specialists believe that a combination of frequent arousals from sleep (which also results in little or no deep sleep) and the oxygen deprivation lead to excessive sleepiness during wakefulness. Remember, the quality of sleep is an important factor in how refreshed and alert an individual feels after sleep. So, although someone with sleep apnea may sleep 8 hours, the sleep could be disturbed 300 or 400 times

by apnea episodes, and therefore the quality of sleep can be very poor. Very often individuals with sleep apnea are completely unaware that they have the disorder. They may have high blood pressure during the day or problems staying awake because of excessive sleepiness, but they often do not relate this to a sleep problem. Thus, even persons who are awakened hundreds of times a night because of disturbed breathing may awaken the next morning and be unaware of what has happened. Frequently, a bed partner is the first to notice the repeated pauses in breathing during sleep and, depending on their duration, may become quite concerned.

Epidemiologic studies suggest that 3–4% of the general population and 10–15% of males had sleep apnea (depending on the definition used). The occurrence of the disorder and its severity appear to increase with age. The textbook sleep apnea case is an overweight, middle-aged male who snores, has high blood pressure, and has problems staying awake during the day (e.g., fighting sleep while in meetings, reading, driving a car, watching a movie or TV). There are a variety of reasons unrelated to sleep apnea that can cause people to snore, for example, colds, deviated septa (i.e., physical problems with the structure of the nose), and allergies. However, snoring is also a primary symptom associated with the occurrence of sleep apnea. Another caution is that alcohol, sleeping pills, and sleep loss can worsen the severity of sleep apnea (both the duration and frequency of apnea events). A number of options are available to effectively treat the sleep apnea syndrome. The treatment usually depends on the severity of the disorder and can range from losing weight, to the continuous administration of oxygen during sleep, to surgery. It is critical that someone concerned about sleep apnea be evaluated by an appropriate health care professional. An individual should first consult a personal physician. Also, there are now sleep-disorder specialists who perform sleep-disorder evaluations, make diagnoses, and prescribe treatments. There are also specialized sleep-disorder clinics (accredited by the American Sleep Disorders Association) throughout the United States that provide full diagnostic and treatment services for the range of sleep disorders. These clinics are located in many university and community hospitals throughout the country.

Sleep apnea is an example of a medical disorder that can disturb sleep and cause excessive sleepiness, heart and blood pressure problems, and other difficulties during wakefulness. An individual can be completely unaware of the sleep disturbances and yet every night suffer from a disorder that can cause pathological sleepiness during the daytime. Like any medical problem, sleep apnea should be evaluated and treated by qualified medical specialists, using the approaches currently accepted for successful treatment of the disorder.

Nocturnal Myoclonus or Periodic Leg Movements

Another physical sleep disorder that can disturb the quality of sleep is nocturnal myoclonus, or periodic leg movements during sleep. This disorder is characterized by a twitching (or muscular contraction) of the lower leg muscles during sleep (though typically found in the lower legs, the arms could also twitch). The twitch can occur in one leg or both, typically last only about 0.5 sec, and appear in periodic episodes across the sleep period. There can be several hundred twitches

during any given sleep period. Periodic leg movements constitute a sleep disorder because each muscular twitch is usually associated with either an awakening or a shift from deep to light sleep. Again, someone could be getting 8 hr of sleep but have that sleep interrupted 300 times with awakenings. This poor quality sleep can translate into complaints of non-restorative sleep, awakening unrefreshed, tired, sleepy, etc. This is another sleep disorder that can go unrecognized by the individual with the periodic leg movements and one that is often noticed first by a bed partner (often the recipient of multiple kicks during sleep!). Again, it is very important that the disorder be diagnosed and treated by a knowledgeable physician or accredited sleep-disorder specialist. Although not life-threatening like sleep apnea, periodic leg movements during sleep can result in excessive daytime sleepiness.

Medications

Alcohol

The most widely used self-treatment for disturbed sleep is alcohol. As noted in the presentation materials, alcohol is a very potent REM sleep suppressant. More than a couple of beers or glasses of wine can totally suppress REM sleep in the first half of a sleep period. During the second half of the sleep period, withdrawal effects can be seen, including awakenings, a REM rebound, and generally, very poor, disrupted sleep. Although alcohol is often used to unwind, relax, and promote the ability to get to sleep, its disruptive effects on the subsequent sleep will outweigh its usefulness in promoting the onset of sleep.

Sleeping Pills

CAUTION

The other widely used approach to treating sleep disturbances is prescription sleeping pills. The use of prescription sleeping pills close to and during duty periods is not medically allowed. However, it is acknowledged that many medications available only by prescription in the United States can be obtained over-the-counter, without prescriptions, in many overseas locations. Sleeping pills should only be used under the supervision of a knowledgeable physician. The information provided here is intended only to give a basic understanding about their effects.

There are several important characteristics of sleeping pills that should be considered. The primary purpose of a sleep medication should be to promote sleep, either by facilitating sleep onset or by helping to maintain sleep (e.g., reducing frequent or long awakenings). It should maintain this positive therapeutic effect for the duration of its use (i.e., sleep should be as good on the fifth night of use as on the first). The improvement in sleep should be associated with waking benefits (e.g., increased alertness, better mood) and, at the very least, the sleeping medication should not impair

waking function. So the optimal sleeping pill should promote sleep and improve subsequent waking function. A very important consensus statement (from physicians, sleep-disorder specialists, etc.) recommends that the safest and most beneficial use of sleeping pills is obtained when they are taken for short periods of time and at the lowest effective dose.

In the past, some of the most widely used prescription sleeping pills were in a class of drugs called barbiturates. These include medications such as pentobarbital and seconal. Scientific studies in sleep laboratories have shown that the barbiturates often lose their effectiveness to promote sleep within 7–10 days and can create tolerance to, and dependence on, the medication. It is important to keep in mind that barbiturates have been found to be factors in accidental or intentional drug overdose. The barbiturates are also potent REM sleep suppressants and, like alcohol, can disrupt the regular cycle of NREM and REM sleep, creating fragmented and poor quality sleep. Eventually, these medications can actually create an insomnia problem called drug-dependent insomnia. Only after careful tapering off and eventual withdrawal of the medication can sleep return to a more normal pattern. As prescribing physicians have learned more about these sleep laboratory findings regarding barbiturates, their use

as a primary sleeping medication has rapidly declined, and they are rarely used today.

Today, the most widely prescribed sleeping pills (often called sedative/hypnotic medications) are in a class of drugs called the benzodiazepines. There are three that are commonly prescribed: Halcion (triazolam), Restoril (temazepam), and Dalmane (flurazepam). Sleep-laboratory tests of these three medications show that they promote sleep over many nights in sleep-disturbed patients. They are usually considered safer than the barbiturates because, generally, it is more difficult to accidentally or intentionally overdose with them and they can be more easily started and stopped with fewer negative effects.

The benzodiazepines, like all medications, are not without their adverse side-effects. Although the benzodiazepines do not suppress REM sleep, they can suppress NREM sleep stages 3 and 4 (the deep sleep that occurs in the first third to half of the sleep period). Reports suggest that the benzodiazepines can have side effects that affect short-term memory and, if withdrawn too rapidly, may cause a rebound anxiety or insomnia. In spite of these considerations, the benzodiazepines are widely used

as safe and effective sleeping pills when prescribed by a knowledgeable physician.

There are properties of these three benzodiazepines that distinguish their effects from one another. The primary factor is their half-life, that is, the amount of time the drug continues to work in an individual's body. Halcion is a short-acting benzodiazepine (about 2–4 hr) that helps to promote sleep onset but is no longer active by the middle to end of a sleep period. In sleep laboratory studies, Halcion has been shown to effectively improve nocturnal sleep and to be associated with improved daytime alertness. There have been several scientific studies that showed Halcion to be effective for travelers using it as an aid to improve sleep on trips that involve multiple time-zone changes.

Restoril is a medium-acting benzodiazepine (about 8 hr) that helps to maintain sleep throughout a night and is no longer active by the morning awakening. Dalmane is a long-acting benzodiazepine

(about 100 hr) that effectively promotes sleep onset and maintains sleep throughout the night. However, if used over several nights, the long half-life results in an accumulation of the medication in the body that can have effects that carry over to wakefulness. Laboratory studies have shown that after several nights of administration, the build-up of Dalmane metabolites can be associated with increased sleepiness during wakefulness. It should be noted that the specific formulations of these medications can be different overseas. For example, Restoril obtained in the United Kingdom has a half-life of 5–6 hr.

Recently, a new prescription sleep medication, Ambien (a non-benzodiazepine), has been receiving attention as a safe and effective sleep aid.

The main message is that the benzodiazepines can be used effectively to help get to sleep and stay asleep. They have different properties that should dictate the appropriate use of the medications for different people in different circumstances. Finally, all of these are prescription medications that should only be used under the care and guidance of a qualified and knowledgeable physician.

Note

The information provided here is intended only to provide examples of sleep disorders and some of the medications used to promote sleep. You should not use this information to diagnose, medicate, or treat yourself. If you have any questions about your health, potential sleep disorders, or medication, see your physician. As indicated, accredited sleep clinics and sleep-disorder specialists are available for evaluation, diagnosis, and treatment for the range of sleep disorders. Seek them out by contacting a local university or community hospital for a referral. The general readings in appendix E suggest other sources of information about sleep, circadian rhythms, and sleep disorders.

Appendix B

Brief Introduction to Relaxation Skills

Flight operations can involve hectic schedules, significant responsibilities, and stressful events. Outside of flight operations, many people's lives also are affected by these factors. Scientific studies have demonstrated that these "life stresses" can affect an individual's physical and mental health. People respond to the perceived demands and challenges of situations differently: some individuals will become physically tense, others will worry, and so on. There are many situations in which pilots need to "unwind" and relax after coming off duty. This is especially important when they are preparing for a layover sleep period. As previously mentioned, alcohol is sometimes used to relax after duty, but it can significantly disrupt the subsequent sleep period (see appendix A). However, there are alternatives to alcohol. Many people use exercise, hobbies, and many other strategies to physically and mentally relax. This section is not intended to cover the full range of those options; entire books have been written on the subjects of stress management and relaxation skills. However, it is intended to briefly introduce some information about relaxation skills that may be useful in your efforts to relax and promote sleep.

Relaxation skills can be powerful techniques for promoting physical and mental relaxation in almost any situation or environment. Many relaxation skills have been scientifically tested and their effectiveness demonstrated in many different areas, from eliminating physical problems (e.g., tension headaches) to decreasing worry and anxiety to promoting good sleep.

There are a wide variety of relaxation skills that are practiced and effectively used by many individuals. Some relaxation techniques are primarily cognitive (i.e., involve focusing the mind, internally repeating phrases, etc.), others are primarily physical (e.g., tensing and relaxing the major muscle groups of the body), though most involve both cognitive and physical components (e.g., after tensing and relaxing a muscle, mentally focusing on the relaxation).

Examples of techniques that are primarily cognitive include meditation, positive imagery, and autogenic training. Meditation is one of the oldest relaxation methods and involves sitting quietly, repeating a phrase (individually chosen), and focusing on deep relaxation. Positive imagery often begins with guided imagery; an individual chooses a specific, relaxing scene and is guided through the pleasant images associated with the experience. Autogenic training involves repeating standard phrases as an individual cognitively focuses on each of the major muscle groups of the body (e.g., "my right hand is heavy and warm").

Examples of techniques that involve more physical action include yoga, deep breathing, and progressive muscle relaxation. Yoga is also a very old method for relaxing the body and mind; it involves a set of standardized movements and a cognitive component. Rather than short breaths primarily involving chest breathing, relaxation through deep breathing uses long, slow breaths that use both the abdomen and chest. During the deep breathing a word or phrase associated with

relaxation is used to focus the mind and facilitate a deeper state of relaxation. Progressive muscle relaxation is a technique that has received much attention and is effectively used in a wide range of applications. It involves the systematic tensing and relaxing of the muscles, starting at the head and neck and moving all the way to the toes. The mind focuses on the difference between the tension and the relaxation associated with the release of the muscle.

It is important to think of these as relaxation skills. As skills, they can be taught, learned, and practiced. Practice is critical! Too often people try to quickly learn some technique and then use it in efforts to relax the next time they are in a highly stressful situation. Usually it does not work and the individual decides that the technique, and relaxation skills in general, are ineffective. Only after a skill has been mastered should it be applied, and even then it should be gradually tested for its effectiveness and usefulness in different situations. Eventually, relaxation skills are most effective when they are practiced on a regular basis and incorporated as a daily activity.

There are many different ways to learn relaxation skills and today many commercially produced resources are available. It is often useful to first read about a technique and a description of the specific skill. An external source (e.g., instructor, book, tape) that guides an individual through a particular technique can be useful in learning the skill and in focusing attention on the relaxation. Eventually, it is important to internalize and memorize the specifics of the skill. Once learned very well, an individual should be able to use his or her favorite, most effective relaxation skills in different situations and environments, without having to rely on an external source to help relax. Relaxation skills can be a powerful tool to help individuals reduce physical tension, focus and relax the mind, and promote good sleep. If you decide to try some of these new skills, keep an open mind, practice, and enjoy learning to relax.

Note

There are many outrageous and unsubstantiated claims made regarding a wide range of techniques, devices, and approaches to relaxation. Please be wary! Today, many local health care facilities, hospitals, and licensed health care providers (e.g., physicians, psychologists, nurses, social workers) provide classes on relaxation skills or stress management techniques. Do some checking to be sure that reputable (e.g., accredited or licensed) practitioners are providing the services and instruction.

The following references are recommended for further reading on relaxation skills and stress management. This is not an inclusive list of available resources but it does provide some guidance for a starting point. These books should be available at your local community library, college library, or bookstores.

Recommended Readings

Benson, H. (1976). *The relaxation response*. New York, NY: Avon Books.

Bernstein, D.A. and Borkovec, T.D. (1973). *Progressive relaxation training: A manual for helping professions*. Champaign, IL: Research Press.

Coates, T.J. and Thoresen, C.E. (1977). *How to sleep better: A drug-free program for overcoming insomnia*. Englewood Cliffs, NJ: Prentice-Hall, Inc.

Farquhar, J.W. (1978). *The American way of life need not be hazardous to your health*. Stanford, CA: Stanford Alumni Association.

Appendix C

NASA Ames Fatigue Countermeasures Program

Relevant NASA Technical Memoranda Operational Summaries from the “Crew Factors in Flight Operations” Series

This appendix comprises the operational summaries of five relevant NASA Technical Memoranda (TMs) from the Fatigue Countermeasures Program.

- Gander, P.H., Graeber, R.C., Foushee, H.C., Lauber, J.K., and Connell, L.J.
(1994). *Crew factors in flight operations: II. Psychophysiological responses to short-haul air transport operations*. (NASA Technical Memorandum). Moffett Field, CA: National Aeronautics and Space Administration. 122
- Graeber, R.C. (Ed.) (1986). *Crew factors in flight operations: IV. Sleep and wakefulness in international aircrews*. (NASA Technical Memorandum No. 88231). Moffett Field, CA: National Aeronautics and Space Administration. 125
- Gander, P.H., Barnes, R., Gregory, K.B., Connell, L.J., Miller, D.L., and Graeber, R.C. (1994). *Crew factors in flight operations VI: Psychophysiological responses to helicopter operations*. (NASA Technical Memorandum No. 108838). Moffett Field, CA: National Aeronautics and Space Administration. 129
- Gander, P.H., Graeber, R.C., Connell, L.J., and Gregory, K.B. (1991). *Crew factors in flight operations: VIII. Factors influencing sleep timing and subjective sleep quality in commercial long-haul flight crews*. (NASA Technical Memorandum No. 103852). Moffett Field, CA: National Aeronautics and Space Administration. 131
- Rosekind, M.R., Graeber, R.C., Dinges, D.F., Connell, L.J., Rountree, M.S., Spinweber, C.L., and Gillen, K.A. (1994). *Crew factors in flight operations IX: Effects of planned cockpit rest on crew performance and alertness in long-haul operations*. (NASA Technical Memorandum No. 108839). Moffett Field, CA: National Aeronautics and Space Administration 134

Crew Factors in Flight Operations II: Psychophysiological Responses to Short-Haul Air Transport Operations

Gander, P.H., Graeber, R.C., Foushee, H.C., Lauber, J.K., and Connell, L.J. (1994). *Crew factors in flight operations: II. Psychophysiological responses to short-haul air transport operations*. (NASA Technical Memorandum). Moffett Field, CA: National Aeronautics and Space Administration.

Operational Overview

This report is the second in a series on the physiological and psychological effects of flight operations on flight crews, and on the operational significance of these effects. This overview presents a comprehensive review and interpretation of the major findings. The supporting scientific analyses are described in detail in the rest of the text.

To document the psychophysiological effects of flying commercial short-haul air transport operations, 74 pilots from two airlines were monitored before, during, and after 3-day or 4-day trip patterns. All flights took place on the East Coast of the United States and data were collected throughout the year. Eighty-five percent of the pilots who had been awarded the trips selected for study agreed to participate. The population studied was experienced (average age 41.3 yr, average airline experience 14.6 yr) and averaged 68.6 hr of flying per month in all categories of aviation.

Subjects wore a portable biomedical monitor which recorded core-body temperature, heart rate, and wrist activity every 2 min. They also rated their fatigue and mood every 2 hr while awake, and recorded sleep episodes, naps, showers, exercise, duty times, food and fluid intake, voidings, cigarettes, medications, and medical symptoms in a daily logbook. A background questionnaire was administered which included basic demographic information, sleep and life-style habits, and four personality inventories. A cockpit observer accompanied the crews on the flight deck and kept a detailed log of operational events.

The trips studied were selected to provide information on the upper range of fatigue experienced by pilots in predominantly daytime and evening operations. Common features were early report times and long duty days with multiple flight segments (average 5.5 per day). Daily duty durations averaged 10.6 hr which included, on average, 4.5 hr of flight time. One third of all duty periods studied were longer than 12 hr. The mean rest-period duration, as defined by the pilots in their daily logs, was 12.5 hr. The mean rest-period duration calculated from the last wheels-on of one duty day to the first wheels-off of the next duty day was significantly longer (14.0 hr). Overnight layovers after successive duty days occurred progressively earlier across most trips.

On trip nights, subjects reported taking about 12 min longer to fall asleep, sleeping about 1.2 hr less, and waking about 1.4 hr earlier than on pretrip nights. They also rated their sleep on trips as lighter and poorer overall, and reported significantly more awakenings. In contrast, in the laboratory, sleep restriction results in more rapid sleep onset and more consolidated sleep. The longer sleep latencies and more frequent awakenings reported by pilots on trips may reflect the commonly

reported need to “spin down” after coming off duty and the disruptive effects of sleeping in unfamiliar environments. The fact that sleep during trips was reported not only as shorter but also as more disturbed, suggests that the effects of this sleep restriction on subsequent daytime sleepiness, performance, and mood may be greater than those reported in laboratory studies with similar levels of sleep restriction.

The effects of duty demands on subjective fatigue and mood are most clearly seen in the comparisons of ratings made pretrip, during flight segments, during layovers, and posttrip. During layovers, fatigue and negative affect were rated as highest and positive affect and activation as lowest. Positive affect was rated as highest during flight segments, even though fatigue ratings were higher than for either pretrip or posttrip. Posttrip recovery was indicated by return of fatigue levels to baseline, the lowest negative affect ratings, and the highest levels of activation. Significant time-of-day variations were found in fatigue, negative affect, and activation. Fatigue and negative affect were low in the first three ratings after awakening, and rose thereafter to reach their highest daily values in the final rating before sleep. As expected, activation showed the opposite time-of-day variation. No significant relationships were found between the timing, duration, or flight hours in a duty period and the fatigue and mood during layovers. This may well have been because of the high levels of individual variability in these ratings.

The use of tobacco did not change on trip days relative to pretrip and posttrip days. However, significantly more caffeine and alcohol were consumed on trips. Additional caffeine consumption occurred primarily in the early morning, associated with the earlier wake-up times on trips, and also around the time of the mid-afternoon peak in physiological sleepiness. The urge to fall asleep at this peak time would increase progressively with the accumulating sleep debt across trip days. The alcohol use was within FAR guidelines, however, the use of alcohol to relax before sleep is not recommended. Although alcohol may facilitate falling asleep, it has well-documented disruptive effects on sleep which can adversely affect subsequent waking alertness and performance. There were no significant changes in the use of medications, or in the number of reports of medical symptoms between trip days and pretrip or posttrip days. Similarly, the number of exercise sessions reported was no different on trip days than on pretrip or posttrip days.

The number and timing of meals on trip days was not significantly different from pretrip or posttrip days. However, more snacks were eaten, and they were eaten earlier, on trip days. This suggests that meals on trip days may have been smaller or less filling than meals on pretrip or posttrip days.

Heart rates during takeoff, descent, and landing were compared with values during mid-cruise for 72 pilots during 589 flight segments. Increases in heart rate were greater during descent and landing for the pilot flying. The difference between flying and not flying during descent was greater for first officers than for captains. Heart-rate increases were greater during takeoff and descent under instrument flight conditions than under visual flight conditions. On the basis of similar findings, the number of segments flown per day should be regulated.

A number of ways of reducing fatigue during short-haul air-transport operations are suggested by this study. First, since daily duty durations were more than twice as long as daily flight durations, and since about one third of all duty periods were longer than 12 hr, it would seem reasonable to

limit duty hours in addition to, flight hours in short-haul operations. There may also be some advantage to defining the rest period more precisely, since significant variability is possible within the present system of definition by contract negotiation. Second, the practice of requiring early report times makes it more difficult for pilots to obtain adequate sleep, even during relatively long layovers. This is because circadian rhythms impede falling sleep earlier than usual, except after major sleep loss. Third, in the trips studied, duty began progressively earlier across the days of the trip. Because of the difficulty of falling asleep earlier, this has the effect of progressively shortening the time available for sleep across the days of the trip. In addition, because the innate “physiological day” determined by the circadian system is longer than 24 hr, it adapts more readily to schedule delays than to advances. Thus, where possible, successive duty days should begin progressively later. Fourth, the widespread use of alcohol as a means of relaxing before going to sleep has deleterious effects on subsequent sleep. It thus seems likely that the quality of sleep on trips could be improved in many cases by providing pilots with information on alternative relaxation techniques which have been well-tested in the treatment of sleep disorders.

Crew Factors in Flight Operations: IV. Sleep and Wakefulness in International Aircrews

Graeber, R.C. (Ed.) (1986). *Crew factors in flight operations: IV. Sleep and wakefulness in international aircrews*. (NASA Technical Memorandum No. 88231). Moffett Field, CA: National Aeronautics and Space Administration.

Operational Overview

The major goals of this research were to examine the changes in sleep associated with flights across multiple time zones and, if necessary, to suggest recommendations for improving such sleep. Flight crews were studied during the first layover after long flights crossing seven to nine time zones. The basic findings can be best described in terms of flight direction and discussed with respect to strategies used by crew members to obtain sufficient sleep before operating the return flight home.

Westward Flights

There was clear evidence that crew members experienced less sleep difficulties during layovers following westward flights (LHR-SFO, FRA-SFO, SFO-NRT) than after eastward flights. Following the westward flights almost all subjects went to bed soon after arrival. During the first night, sleep appeared to be of generally good quality and not unduly disturbed except for increased wakefulness during the second half of the night. In comparison with baseline, subjects generally fell asleep faster and slept essentially the same amount as at homebase. Some even reported better sleep quality.

During the next day, the increase in alertness usually seen during the late afternoon in local individuals was not observed. Instead, drowsiness continued to increase during the remainder of the wake span. By the second night, there was already some adaptation of sleep to the new time zone as indicated by even fewer awakenings occurring during the early morning hours.

Nevertheless, on the following day, the previous day's pattern of increasing drowsiness was seen in crews who were available for testing. Most crew members successfully attempted to take a preflight nap in preparation for duty that afternoon. The same findings held for the one group of subjects whose layover lasted approximately 25 hr instead of the usual 48 hr. The only major difference was that their preflight nap occurred during the first afternoon after arrival.

The strategy of taking a nap before departure after a westward layover appears important in view of the coming night flight with its prolonged period of wakefulness. Recent research suggests that such a nap will help reduce in-flight drowsiness and avoid potential performance deficits. A second aspect of planning strategies to cope with this flight schedule emphasizes the potential importance of time of the latter part of flight in relation to the crew members' circadian rhythms. Additional results obtained from some crews during the eastward return flight suggest that alertness improves as the circadian rhythms in body temperature and heart rate begin to rise. Therefore, certain schedules may

be more desirable if they facilitate a nap before night and take advantage of the circadian rise in alertness during the latter part of the flight.

Eastward Flights

Sleep patterns were much more variable and fragmented after eastward night flights (NRT-SFO, SFO-LHR, SFO-FRA) than after westward flights across an equivalent number of time zones. There appears to have been a powerful influence which fractionated sleep, probably dependent on the difficulty which individuals experienced in shortening their day. Furthermore, the consequences of sleep pattern fragmentation were reflected in subsequent measures of daytime drowsiness.

Many crew members went to bed as soon as possible after arrival and fell asleep more quickly than observed during baseline but slept a relatively short amount of time even after a long overnight flight. Subjects tended to awake spontaneously at a time corresponding to the late morning of their home time. Overall, this strategy can be beneficial; however, the onset of the next major sleep varied considerably among individuals, with some crew members from each airline delaying sleep until it coincided with their usual bedtime at home. Similar wide-ranging differences were seen in the second night's sleep and intervening sleeps. In spite of a high degree of variability, sleep duration was usually shorter than baseline and subjectively worse.

Given the usual importance attributed by flight crews to obtaining "good" sleep immediately before a flight, these data suggest that their chance of doing so could be substantially improved by adhering to a more structured sleep schedule. In order to optimize sleep during an eastward layover of 24 hr or multiples thereof. It would be important to limit sleep immediately after arrival and prolong the subsequent wakeful period to end around the normal local time for sleep. This process would increase the likelihood that the sleep immediately preceding the next duty period would be of adequate duration for these operations. It appears that proper sleep scheduling during the first 24 hr is most critical and that crew members should develop the discipline to terminate sleep even though they could sleep longer.

Several subjects attempted the strategy of trying to maintain a sleep schedule based on home time. For the schedules under study, this practice would appear to be less desirable since it would produce a substantially shorter sleep span immediately before departure; however, this approach could not be adequately evaluated due to the relatively small number of subjects who used it.

Unless layover sleep is arranged in a satisfactory manner by an appropriate sleep-wake strategy, increased drowsiness is likely to occur during the subsequent long-haul flight. Other research suggests that under acceptable operational circumstances. Limited duration naps can be a helpful strategy to provide refreshment and improve alertness for a useful period of time. Although we do not have the appropriate data to address this issue directly, flight deck napping could be an important strategy if operationally feasible.

Individual Factors

While the subjects as a whole did not exhibit serious sleep problems, certain individual crew members did experience some difficulty. Further investigation of these data is required before any

clarifying statement can be made regarding the factors responsible for this situation. Such work is currently under way.

Age is one individual factor which appears to have been important in this study. Older persons tend to experience more difficulties obtaining undisturbed sleep, and this was seen in the aircrew during baseline and layover recordings. Less restful sleep is a feature of growing older and begins to affect individuals in middle age. Surprisingly little is known about the nature and prevalence of less restful sleep over this important span of life, but the data obtained from these flight crews has highlighted the need for normative data in a similar age group of individuals who are usually involved in highly skilled and responsible occupations. These data are now being collected and may be helpful in understanding why some individuals in this age group have difficulty in adapting to unusual hours of work and rest. This issue may be relevant to the practice of occupational medicine.

Finally, in one group of pilots, preliminary analyses suggest that other individual factors may contribute to the crew member's response to layover sleep requirements. Although this evidence is currently limited to differences in daytime sleepiness in morning- versus evening-type individuals, it underscores the potential usefulness of factors related to personality and lifestyle as predictors of individual reactions to multiple time zone flights.

Study Limitations

Although these results have direct implications for air carrier operations, they must be viewed within the context of several limitations inherent in the study design. Most important is the fact that relatively uncomplicated trip patterns were studied. All but one of these trips involved an immediate return to the home time zone after the layover. The primary data were obtained from crew members during the first layover stay following an initial outbound flight. One group of subjects provided additional data upon return to homebase.

At present, such trips are not typical of most international flight crew duty schedules, which usually involve multiple flight segments and layovers in different time zones before return home; nevertheless, the trips under examination represent an important type of schedule which is becoming more prevalent.

Although the alterations in sleep were not considered to be of operational significance in the present schedules, it is nevertheless possible that the pattern of disturbed sleep would lead to cumulative sleep loss if the schedule were longer or if complete recovery of sleep were not attained before the next trip. The latter possibility is supported, at least in part, by the observation that baseline sleep was reduced in some subjects, though this may have also been due to other factors such as early rising. Furthermore, all flights occurred during late summer or early fall, which did not permit us to examine seasonal influences, particularly the length of daylight versus darkness, which may also be an important operational factor.

Secondly, the relatively limited sample sizes may not be representative of the flight crew population as a whole. In this regard, it is clear that the groups differed considerably in age and possibly may have differed along other dimensions related to the voluntary nature of their participation. Third, spending a layover at a sleep laboratory may not be equated with staying at a crew hotel.

However, sleep log results from two participating groups of crew members suggest that sleep-wake patterns differ little under these two conditions.

Finally, a potentially more serious problem stems from the difficulty we experienced in obtaining baseline data immediately preceding the trip. Except for one airline, baseline data could only be obtained whenever the volunteers were available following at least three non-flying days. Consequently, these measurements often preceded or followed the trip by a week or more. Thus, any conclusions relating to baseline sleep must be tempered by the realization that the actual sleep obtained during the nights immediately prior to flight might have differed from that measured in the homebase laboratory and may have been confounded by the residual effect of the previous flight schedule, particularly if the preceding trip involved an eastward flight direction.

Regardless of these interpretative issues, the data revealed a high degree of similarity and consistency among the different flight crew samples despite significant differences in culture, age, and airline operational practices. Consequently, it is likely that the overall results apply to a wide spectrum of long-haul crew members and carriers.

Crew Factors in Flight Operations VI: Psychophysiological Responses to Helicopter Operations

Gander, P.H., Barnes, R., Gregory, K.B., Connell, L.J., Miller, D.L., and Graeber, R.C. (1994). *Crew factors in flight operations VI: Psychophysiological responses to helicopter operations*. (NASA Technical Memorandum No. 108838). Moffett Field, CA: National Aeronautics and Space Administration.

Operational Overview

This report is the sixth in a series on the physiological and psychological effects of flight operations on flight crews, and on the operational significance of these effects. This section presents a comprehensive review of the major findings and their significance. The rest of the volume contains the complete scientific description of the work.

Thirty-two helicopter pilots (average age 34 yr) were studied before, during, and after 4- to 5-day trips providing support services from Aberdeen, Scotland, to rigs in the North Sea oil fields. Duty days began and ended in Aberdeen. Half the trips studied took place in winter/spring, and the other half in summer/autumn. Heart rate, rectal temperature, and activity of the nondominant wrist were monitored continuously by means of portable biomedical monitors. Subjects kept daily logs of sleep timing and quality, food and fluid intake, medications taken, and medical symptoms. They also rated their fatigue and mood every 2 hr while awake. For every segment flown, they rated their workload (on a modified Bedford Scale) for each phase of flight, and rated five different environmental factors assumed to influence workload, that is, functioning of the aircraft systems (on a 5-point scale from perfect to useless); and weather conditions for landing, the landing site, letdown aids, and air-traffic control (each on a 5-point scale from very favorable to very unfavorable).

On trip mornings, subjects were required to wake up about 1.5 hr earlier than on pretrip mornings (average on-duty time 0725 local time). Although they came off duty relatively early (average 1437 local time), they averaged only 6.4 hr of sleep during layovers at home that averaged almost 17 hr.

The inability to fall asleep earlier than the habitual bedtime is due to properties of the physiological mechanisms controlling sleep. Subjects were thus unable to compensate for the early wake-ups, and therefore averaged about 50 min less sleep per night on trips than on pretrip. In the laboratory, 1 hr per night of sleep restriction has been shown to accumulate and to progressively increase daytime sleepiness. Sleep was rated as better overall posttrip than on trip nights and deeper posttrip than pretrip, as is typical during recovery from sleep loss. Delaying the start of on-duty times (by 1.5–2 hr on average) would be expected to produce a significant improvement in the amount of sleep pilots are able to obtain, and should be given serious consideration.

Pilots reported more fatigue on posttrip days than on pretrip days, suggesting a cumulative effect of duty-related activities and sleep loss. Fatigue and negative affect were higher, and activation lower, by the end of trip days than by the end of pretrip days. The inability to maintain subjective activation by the end of trip days was exacerbated by early on-duty times.

Pilots drank 42% more caffeine on trip days than on pretrip and posttrip days. More caffeine was consumed in the early morning, in association with the early wake-ups, and also around the time of the mid-afternoon peak in physiological sleepiness. The urge to fall asleep at this time would increase as the sleep debt accumulated across trip days.

There were twice as many complaints of headaches on trips as at home. Reports of back pain increased twelvefold, and reports of burning eyes increased fourfold. Helicopter pilots were three times more likely to report headaches, and five times more likely to report back pain than were pilots of fixed-wing aircraft on short-haul commercial flights. The physical environment on the helicopter flight deck was probably an important factor. Studies of the same operations, conducted in parallel, demonstrated that pilots often had skin temperatures outside the range of thermal comfort, and that vibration levels in all of the helicopters studied exceeded the “reduced comfort” boundary defined by the International Standards Organization (I.S.O. 263). The longer pilots remained on duty, the more negative their mood became. This situation could be improved with better seat design, including better isolation of the seat from floor vibration, and better flight-deck ventilation.

The predominant environmental factors affecting subjective workload assessments were different for different phases of flight. The quality of the aircraft systems (rated on a 5-point scale from perfect to useless) had a significant effect during preflight, taxi, climb, and cruise. Paying particular attention to aircraft maintenance, thereby minimizing failures, might be one way of reducing workload during these phases of flight. Landing weather was the major factor influencing workload ratings during descent and approach. However, the effect of adverse weather on workload was reduced with better landing sites and better letdown aids. The quality of the landing site and air-traffic control had a significant effect on workload ratings during landing. These findings confirm that improvements in landing sites, letdown aids, and air-traffic control can reduce subjective workload during descent, approach, and landing.

Crew Factors in Flight Operations VIII: Factors Influencing Sleep Timing and Subjective Sleep Quality in Commercial Long-Haul Flight Crews

Gander, P.H., Graeber, R.C., Connell, L.J., and Gregory, K.B. (1991). *Crew factors in flight operations: VIII. Factors influencing sleep timing and subjective sleep quality in commercial long-haul flight crews*. (NASA Technical Memorandum No. 103852). Moffett Field, CA: National Aeronautics and Space Administration.

Operational Overview

This report is the eighth in a series on physiological and psychological effects of flight operations on flight crews, and the operational significance of these effects. The Operational Overview is a comprehensive review of the major findings and their significance. The rest of this volume contains the complete scientific description of the work. The aim of this study was to document how flight crews organize their sleep during a variety of international trip patterns, and to elucidate how duty requirements, local time, and the circadian system (measured by the rhythm of body temperature) influence the choice of sleep times, sleep duration, and subjectively rated sleep quality. Duty requirements and local time can be viewed as environmental constraints on the time available for sleep, while the circadian system is a major physiological modulator of sleep quality and duration.

Self-reports of sleep (and nap) timing and sleep quality, and continuous records of rectal temperature were collected from 29 male flight crew members (average age 52 yr) during scheduled B-747 commercial long-haul operations. Data from four different trip patterns were combined.

Sleep/wake patterns on these trips were complex. On average, duty periods lasted about 10.3 hr and were followed by layovers of about 24.8 hr during which there were typically two subject-defined sleep episodes. The average pattern of sleep and wakefulness (disregarding naps) was 19 hr wake/5.7 hr sleep/7.4 hr wake/5.8 hr sleep. The average durations of the first- and second-sleep episodes in a layover were not significantly longer episodes of wakefulness. However, first-sleeps were rated as being of better quality, with less difficulty falling asleep and deeper sleep. Sleep-quality ratings improved as sleep duration increased, reinforcing the importance of allowing adequate time for sleep.

The circadian system appeared to have a greater influence on the timing and duration of first-sleep episodes than on second-sleep episodes in the layover, except when that level of accumulated sleep debt was high, e.g., after eastward flights crossing five or more time zones. In such cases, crew members typically went to sleep sooner after arriving at the layover destination, during the local afternoon, and woke up either about 2 hr later (if they reported a nap) or 3 hr later (if they reported a sleep episode). Otherwise, crew members tended to delay going to sleep until the local night and/or until the hours preceding the temperature minimum.

The timing of second-sleep onsets seemed to be related primarily to the amount of sleep already obtained in the layover and generally coincided with local night. The duration of second-sleeps was strongly influenced by the amount of time remaining in the layover. For both first- and second-sleeps, the circadian time of sleep onset was also a significant predictor of sleep duration. Longer sleep episodes began earlier with respect to the minimum of the circadian temperature cycle.

In summary, the relative importance of duty requirements, local time, and the circadian system in determining sleep timing and quality was different for first- and second-sleep episodes in a layover and was related to specific flight schedules. Nevertheless, there were clearly preferred times for sleep within the layover, determined by the circadian modulation of sleep propensity and the factors driving the preference to sleep during the local night (noise, light, meal availability, etc.).

Flight and duty-time regulations can be interpreted as a means of ensuring that reasonable minimum rest periods are respected. There has been a tendency on the part of regulatory authorities to view the entire time off duty as being time available for sleep, despite anecdotal evidence that the ease of falling asleep and the ability to remain asleep were not constant throughout the layover. This study clearly documents that in scheduled commercial long-haul operations, there are physiologically and environmentally determined preferred sleep times within a layover, i.e., the time available for sleep is less than the time off duty.

Evidence from this and other studies suggests that the timing and duration of the second-sleep episode in a layover is strongly linked to the amount of sleep already obtained in the layover. Particularly when the first-sleep is short, as is typical after eastward flights crossing five or more time zones, it is essential that the layover be long enough to permit an adequate second-sleep episode appropriately timed with respect to the temperature cycle and local time. The duration of any specific layover should be determined with regard to the local arrival time, and the sequence of flights preceding it in the trip pattern, which influences both the cumulative sleep loss and the phase of the circadian system.

Based on polygraphic studies of flight crew sleep after a single eastward flight crossing eight or nine time zones, Graeber et al. recommended that crew members should limit sleep immediately after arrival and prolong the subsequent wake period to end around the normal local time for sleep. This is intended to improve the quality of the subsequent sleep episode, in keeping with the anecdotal report that flight crews consider it important to have a good sleep immediately before a flight. Their study looked only at sleep during the first (24 hr) layover of a trip sequence. The present study suggests that the recommended strategy may not be optimal after eastward flights later in the sequence, when crew members may have already accumulated an important sleep debt, and when the position of their circadian timing system would be much less predictable.

Naps were also reported, both during the layovers and on the flight deck. Naps that represented the first-sleep episode in a layover were significantly longer (average duration 2.0 hr) than subsequent naps in the layover or flight-deck naps, and followed significantly longer episodes of wakefulness (14.7 versus 5.9 and 9.3 hr, respectively). Such first naps were not very common and were associated with the acute sleep debt imposed by overnight eastward flights crossing five or more time zones (67%) or the prolonged wakefulness associated with westward flights crossing five or more time zones (25%). Naps later in the layover tended to occur just before the next duty period

and, since they reduce the duration of continuous wakefulness before the next flight, may be useful as a strategy for reducing cumulative sleep loss.

On the flight deck, crew members were observed to be napping at least 11% of the available time. The average duration of these naps was 46 min (range 10–130 min). Recent work from our group suggests that a preplanned 40-min time interval for napping on the flight deck can reduce subsequent reaction times and the number of EEG/EOG microevents during long international flights. The optimal duration of such naps is an active research issue.

This study has significantly enhanced our understanding of how the circadian system functions in this complex operational environment. The flight schedules of the trips studied forced the sleep/wake cycle to adopt a period different from that of the underlying circadian pacemaker, although the influence of the circadian system was still seen in the selection of sleep times and in sleep durations, i.e., the two systems were not completely uncoupled. However, when the accumulated sleep debt was high, the circadian rhythm in sleep propensity could be overridden, and crew members could fall asleep at unusual times in their temperature cycles. The circadian system, in turn, effectively uncoupled from the very complex patterns of environmental synchronizing stimuli experienced by crews.

There are known to be differences between individuals in (1) the periods of their circadian pacemakers, (2) their sensitivity to environmental synchronizers, and (3) their self-selected patterns of exposure to social and sunlight cues in each time zone. At least some of these factors may be associated with certain personality profiles and probably all are age-dependent. An analysis of questionnaire data from 205 of the flight crew members in our data bases concurs with other studies suggesting that the period of the circadian pacemaker shortens with age. Age-related changes in sleep are also well documented, including shorter, less efficient nocturnal sleep and increased physiological sleepiness during the day.

The timing and quality of sleep obtained by flight crews is the product of a subtle and dynamic interplay between all of these factors and cannot be captured by any simple predictive algorithm. Based on the insights gained in this and other studies, we see two particularly promising approaches to improving en route sleep for flight crews during international commercial trip patterns. The first is education, providing crew members with basic information about sleep and the functioning of the circadian system, and how their behavior can modify both. Second, expert system technology should be used to combine our understanding of the underlying physiological systems with operational knowledge acquired from flight crew members and schedulers to develop a computerized intelligent scheduling assistant.

Crew Factors in Flight Operations IX: Effects of Planned Cockpit Rest on Crew Performance and Alertness in Long-Haul Operations

Rosekind, M.R., Graeber, R.C., Dinges, D.F., Connell, L.J., Rountree, M.S., Spinweber, C.L., and Gillen, K.A. (1994). *Crew factors in flight operations IX: Effects of planned cockpit rest on crew performance and alertness in long-haul operations*. (NASA Technical Memorandum No. 108839). Moffett Field, CA: National Aeronautics and Space Administration.

Operational Overview

This report is the ninth in a series on physiological and psychological effects of flight operations on flight crews, and on the operational significance of these effects.

Long-haul flight operations often involve rapid multiple time-zone changes, sleep disturbances, circadian disruptions, and long, irregular work schedules. These factors can result in fatigue, cumulative sleep loss, decreased alertness, and decreased performance in long-haul flight crews. Thus, operational effectiveness and safety may be compromised because of pilot fatigue. One natural compensatory response to the sleepiness and fatigue experienced in long-haul operations is unplanned, spontaneous napping and nonsanctioned rest periods. That these activities occur is supported by anecdotal, observational, and subjective report data from a variety of sources. In response to this information and to concerns for maintaining flight safety, it was suggested that a planned cockpit rest period could provide a “safety valve” for the fatigue and sleepiness experienced in long-haul flying. The cockpit rest period would allow a planned opportunity to sleep, with the primary goal being to improve subsequent levels of performance and alertness, especially during critical phases of operation such as descent and landing.

This study was co-sponsored and sanctioned by the FAA and involved the voluntary participation of two commercial airlines. The primary goal was to determine the effectiveness of a planned cockpit rest period to improve performance and alertness in nonaugmented, three-person long-haul flight operations. Twenty-one volunteer pilots participated and were randomly assigned to either a rest group (N = 12) or a no-rest group (N = 9) condition. The rest group (RG) was allowed a planned 40-min rest period during the low-workload, cruise portion of flight over water. Pilots rested one at a time, on a prearranged rotation, with two crew members maintaining the flight at all times. The no-rest group (NRG) had a 40-min planned control period identified during cruise but maintained their usual flight activities during this time. The four consecutive middle legs of a regularly scheduled transpacific trip, part of a 12-day trip pattern, were studied. Two legs were westbound day flights and two legs were eastbound night flights, with generally comparable flight and duty times.

Specific procedural and safety guidelines were successfully implemented in this initial study. However, not all of these would be necessary for a general implementation of planned cockpit rest periods in long-haul flight operations: (1) it was crucial that the rest period was planned, with first choice of rest period going to the landing pilot; (2) the rest periods were scheduled during a low-workload phase of flight and ended 1 hr before descent; (3) only one crew member was scheduled to

rest at a time with a clear planned rotation established; (4) the rest opportunity was divided into an initial preparation period (3 min), followed by the 40-min rest period, followed by a recovery period (20 min) (these times might be altered to reduce the overall length of the period); (5) the rest was terminated at a preset time by a researcher, and the resting pilot was fully briefed before reentering the operational loop; and (6) it was established that the captain would be notified immediately at the first indication of any potential anomaly. The safe and normal operation of the aircraft was given the highest priority and, therefore, no cockpit rest procedure or activity was allowed to interfere with this.

Several measures were used to examine the physiological, behavioral, performance, and subjective effects of the planned cockpit nap. Continuous ambulatory recordings of brain wave and eye movement activity were conducted to determine physiologically how much sleep was obtained during the rest period, as well as the time taken to fall asleep and the stages of sleep. (These recordings allowed differentiation of non-rapid-eye-movement (NREM) sleep and its stages and rapid-eye-movement (REM) sleep). A reaction-time/sustained-attention task (psychomotor vigilance task) was used to assess performance capability. A wrist activity monitor was worn continuously before, during, and after the trip schedule. This activity monitor provided information regarding the pilots' 24-hr rest/activity pattern and was used to examine layover sleep episodes. Subjective measures collected in the study included in-flight fatigue and alertness ratings, a daily log for noting sleep periods, meals, exercise, flight and duty periods, etc., and the NASA Background Questionnaire.

The physiological data showed that on 93% of the rest period opportunities the RG pilots were able to sleep. Generally, they fell asleep quickly (average = 5.6 min) and slept for an average of 26 min. There were six factors related to sleep quantity and quality that were analyzed: total sleep time, sleep efficiency, sleep latency, percent NREM stage 1 sleep, percent NREM stage 2 sleep, and percent NREM slow wave sleep. Each of these factors was examined for effects related to trip leg, halves of the trip, day versus night, and flight position (captain, first officer, second officer). There were two significant effects that emerged from these analyses. The day flights had significantly more light sleep than night flights, and the night flights had significantly more deep sleep than day flights. An interesting finding emerged from analysis of the physiological data collected during the NRG 40-min control period. Although instructed to continue usual flight activities, four NRG pilots fell asleep (a total of five episodes) for periods lasting from several minutes to over 10 min.

There were generally consistent findings for the variety of analytical approaches used to examine the performance data. The median sustained attention/reaction time (a performance measure) for the NRG showed a greater range of average responses across flight legs and during in-flight trials than seen in the RG. After leg 1, the pilots in the NRG showed a steady increase in median reaction time across flight legs, with significant differences by the middle and end of flights. The RG pilots maintained a generally consistent level of performance both across and within flight legs, and did not show significant increases in reaction time. There were a total of 283 lapses (i.e., a response delay > 0.5 sec) for all 21 pilots (both groups combined). For in-flight trials, the NRG (with fewer subjects) had a total of 124 lapses, whereas the RG had a total of 81. There was an increase in lapses during in-flight trials 2 and 3 (after the test period) for the NRG, though this increase did not occur during in-flight trials following the nap in the RG. Both groups had more lapses before top of descent (TOD) on night-flight leg 4 than on night leg 2. However, the number of lapses in the NRG

pilots increased twice as much as in the RG pilots. Vigilance decrement functions also revealed that on night flights the NRG pilots had a level of performance that was significantly decreased relative to the RG pilots. Generally, the performance task demonstrated decrements across flight legs and within flights for the NRG, whereas the RG maintained consistent levels of performance. These findings suggest that the planned nap prevented deterioration of vigilance performance.

Changes in brain wave and eye movement activity can reflect the subtle ways that physiological alertness/sleepiness changes. An intensive critical phase analysis was conducted to examine the effects of the cockpit nap on subsequent physiological alertness. The period from 1 hr before TOD through descent and landing was analyzed for the occurrence of brain and eye movement microevents indicative of reduced physiological alertness. During approximately the last 90 min of flight, each event greater than 5-sec duration was scored for both the NRG and RG. There was at least one such microevent identified in 78% of the NRG and 50% of the RG. Overall, there were a total of 120 microevents that occurred in the NRG (with fewer subjects) and a total of 34 microevents in the RG. The NRG averaged significantly more total microevents (6.37) than the average in the RG (2.90). This supports the conclusion that the sleep obtained during the rest period was followed by increased physiological alertness in the RG relative to the NRG.

The 24-hr rest/activity patterns, in combination with the subjective logs, demonstrated that 86% of the 21 subjects accumulated a sleep debt that ranged from 4 to 22 hr and averaged approximately 9 hr by the ninth day of the duty cycle. When the entire 36-hr duty period (layover and subsequent duty cycle) is considered, the percent of layover sleep time is 28%. This is less than the average 33% sleep time spent off-duty at home, hence the cumulative sleep debt. One subject gained sleep, and two others had no change. Further analysis demonstrated that the cockpit nap did not significantly alter the cumulative sleep debt observed in the RG. Also, 77% of the layovers involved more than one sleep episode. Generally, there were two sleep episodes, and if the first one was long, then the second one was short or did not occur. Conversely, if the first sleep episode was short, then there was almost always a second one that was long. This result demonstrated that there were multiple factors operating to control sleep timing and quantity (e.g., local time, home circadian time, prior sleep loss). This study was not designed to examine the issue of layover sleep periods, though recently, the timing of layover sleep periods, including naps, in long-haul flight operations, has been addressed.

Overall, the analysis of the subjective alertness ratings demonstrated that pilots reported lower alertness on night flights than on day flights and after the rest/control period than before it (except on leg 1). The results indicated that the nap did not affect the subjective ratings of alertness, though the objective measures clearly indicated better performance and greater alertness in the RG.

The level of physiological sleepiness experienced in long-haul flight operations was demonstrated in both subject groups. The speed of falling asleep has been used as a measure of physiological sleepiness (i.e., the more sleepy an individual, the faster he or she will fall asleep). The speed of falling asleep in the RG (5.6 min) is comparable to that seen in moderately sleep deprived individuals. A diagnostic guide for excessive sleepiness in sleep disorder patients is a sleep latency of 5 min or less. Also, there were five episodes of sleep that occurred during the control period in four NRG pilots who had been instructed to continue usual flight operations. This result reinforces previous findings that pilots are poor evaluators of their level of physiological sleepiness.

Overall, the study results provide support for differentiating fatigue countermeasures into two basic approaches. Conceptually and operationally, methods to minimize or mitigate the effects of sleep loss, circadian disruption, and fatigue in flight operations can be divided into (1) preventive strategies and (2) operational countermeasures. Preventive strategies involve those approaches that result in more long-term adjustments and effects on underlying physiological sleep and circadian processes (e.g., possibilities for further research include shifting the circadian phase before multiple time-zone changes, using bright lights or exercise to rapidly readjust the circadian clock, and maximizing the quantity and quality of sleep). These preventive strategies affect underlying physiological sleep need, sleepiness, and circadian phase in a long-term and chronic fashion. Operational countermeasures are focused strategies for reducing sleepiness and improving performance and alertness during actual operations (e.g., proved strategies include judicious use of caffeine, increased physical activity, and increased interaction). These short-acting countermeasures are not intended to reduce underlying physiological sleepiness or a sleep debt, but rather to increase performance and alertness during operational tasks. One acute, short-acting operational countermeasure that can temporarily reduce physiological sleepiness is napping. The planned cockpit nap in this study is considered to be an operational countermeasure that provided an acute, short-acting improvement in performance and alertness.

It must be acknowledged that every scientific study has specific limitations that restrict the generalizability of the results. This study involved only one trip pattern on a commercial airline carrier. The study was conducted on transpacific flights to utilize the opportunity of scheduling the planned rest periods during the low-workload portion of cruise over water. The intense physiological and performance data collection occurred during a specific and restricted middle segment (four consecutive flight legs) of the trip schedule. Therefore, the initial home-to-flight-schedule transition is quantified only with log book and activity data. Also, the highest levels of accumulated fatigue, which probably occurred during the final trip legs, were not studied except for log book and activity data. This study involved B-747 aircraft flown by three-person crews; the specific application of this countermeasure to the two-person cockpit was not addressed. There were two NASA researchers on the flight deck during the in-flight data collection periods. Although they were instructed to minimize their interactions and presence, there is no question that having two extra individuals on the flight deck may have potentially altered the regular flow of cockpit conversation and interaction. It is important to remain cognizant of these limitations when attempts are made to generalize the study results to questions that extend beyond the scope of the specific scientific issues addressed here.

In conclusion, the RG pilots were able to sleep during the planned cockpit rest period, generally falling asleep quickly and sleeping efficiently. This nap was associated with improved performance and physiological alertness in the RG compared to the NRG. The benefits of the nap were observed through the critical descent and landing phases of flight. The convergence of the behavioral performance data and the physiological data to demonstrate the effectiveness of the cockpit nap lends support to the robustness of the findings. The nap did not affect layover sleep or the overall cumulative sleep debt displayed by the most of the crew members. The nap procedures were implemented with minimal disruption to usual flight operations, and there were no reported or identified concerns regarding safety.

The planned nap appeared to provide an effective, acute relief for the fatigue and sleepiness experienced in nonaugmented three-person long-haul flight operations. The strength of the current results supports the implementation of planned cockpit sleep opportunities in nonaugmented long-haul flight operations involving three-person crews. If planned cockpit sleep opportunities were sanctioned, each airline could determine the appropriate incorporation of procedures into its specific mode of operation. If implemented, we recommend that a joint NASA/FAA follow-up study be conducted within 6–12 months to examine how planned cockpit sleep opportunities have been incorporated into airline procedures. That study would examine how the procedures were implemented and their effectiveness. This might take the form of a survey or include some field data collection. The results of that follow-up study might then lend support for further refinement of procedures and future implementation in other flight environments.

Appendix D

NASA Ames Fatigue Countermeasures Group

Representative Publications

- Co, E. L., Gregory, K. B., Johnson, M. J., Rosekind, M. R. (1999). *Crew Factors in Flight Operations XI: A Survey of Fatigue Factors in Regional Airline Operations* (NASA Technical Memorandum 208799). Moffett Field, California: NASA Ames Research Center.
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Appendix E

Cited Literature and General Readings

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