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FATIGUE MITIGATION EFFECTS OF EN-ROUTE NAPPING ON
COMMERCIAL AIRLINE PILOTS FLYING INTERNATIONAL ROUTES

by

Thomas P. Bunting

Bachelor of Science, Saint Louis University, 1986

A Thesis

Submitted to the Graduate Faculty

of the

University of North Dakota

in partial fulfillment of the requirements

for the degree of

Master of Science

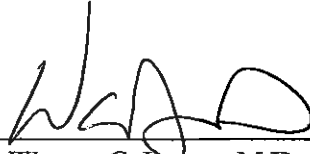
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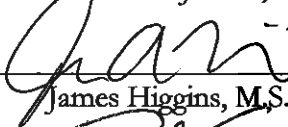
2016

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



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November 24, 2016

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Flying International Routes

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Thomas P. Bunting

December 1, 2016

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ABSTRACT

The introduction of ultra-long range commercial aircraft and the evolution of the commercial airline industry has provided new opportunities for air carriers to fly longer range international route segments while deregulation, industry consolidation, and the constant drive to reduce costs wherever possible has pressured airline managements to seek more productivity from their pilots. At the same time, advancements in the understanding of human physiology have begun to make their way into flight and duty time regulations and airline scheduling practices. In this complex and ever changing operating environment, there remains an essential need to better understand how these developments, and other daily realities facing commercial airline pilots, are affecting their fatigue management strategies as they go about their rituals of getting to and from their homes to work and performing their flight assignments. Indeed, the need for commercial airline pilots to have access to better and more effective fatigue mitigation tools to combat fatigue and insure that they are well rested and at the top of their game when flying long-range international route segments has never been greater.

This study examined to what extent the maximum fatigue states prior to napping, as self-accessed by commercial airline pilots flying international route segments, were affected by a number of other common flight assignment related factors. The study also examined to what extent the availability of scheduled en-route rest opportunities, in an onboard crew rest facility, affected the usage of en-route napping as a fatigue mitigation strategy, and to what extent the duration of such naps affected the perceived benefits of such naps as self-accessed

by commercial airline pilots flying international route segments. The study utilized an online survey tool to collect data on crew position, prior flight segments flown in the same duty period, augmentation, commuting, pre-flight rest obtained in the previous 24 hour period, fatigue state at report time, circadian rhythm disruptions, assigned rest periods in an onboard crew rest facility, experiencing spontaneous sleep episodes, and napping metrics. The study also reports on some common en-route fatigue mitigation strategy themes, as reported by the study participants and how these relate to the survey question responses of survey participants. Study results suggest that there are significant relationships between fatigue states prior to napping and augmentation, fatigue states when reporting for duty, assignment to en-route rest in an onboard crew rest facility, and having experienced spontaneous sleep episodes. The study results also suggest that there is not a significant relationship between being assigned scheduled rest periods in an onboard crew rest facility and the usage of en-route napping as part of an individual pilot's fatigue mitigation strategy. Finally, the study results suggest that short duration naps, averaging less than 30 minutes, are most commonly being employed by the subject population to beneficial effect.

CHAPTER I
INTRODUCTION



Figure 1. Spirit of Saint Louis.
(Kids.britannica.com)

“The exhausted pilot, on a long-haul night flight across the Atlantic, desperately fought to stay awake and control his aircraft. He conversed with images appearing before him, knowing his fate if he succumbed to the fatigue that threatened to overwhelm him. The pilot? Charles Lindbergh, on his New York-Paris flight” (Fiorino, 2001, p. 82). Fatigued pilots and ocean crossings are not a new thing as can be seen from Charles Lindbergh’s experience. While

the dramatic technological advancements represented by today's modern jet transports insures a much swifter and more comfortable ocean crossing than Lindberg experienced flying the Spirit of Saint Louis, the limitations of our human physiology remain today much as they were during Lindbergh's day. As a result, there are still occasions today when fatigued pilots, plying the skies, are struggling to remain awake and alert.

Understanding the nature and effects of en-route napping as a fatigue mitigation strategy for international airline pilots is an essential area of needed research to further the state of knowledge in this era of ultra-long range commercial aircraft operations. Some research has been performed that has analyzed various aspects of pilot fatigue. Areas such as sleep deprivation (Caldwell, J., Prazinko, B., and Caldwell, L. 2002), scheduling practices (Lamond, N., Petrilli, R. M., Dawson, D., and Roach, G. D. 2006), the use of stimulants (Cornum, R., Caldwell, J., and Cornum, K. 1997), and other human factors aspects related flight performance has been studied (Caldwell, J. 1997). Many of these studies have, at least in part, relied on subjective self-assessments of the pilot participants. Further study is needed to better quantify the fatigue mitigation effects of en-route napping in the presence or absence of a variety of other factors while conducting long-range international flight segments.

While the benefit of sleep as a countermeasure against fatigue is generally accepted in aviation venues (Hartzler, Beth M. 2014), this benefit is often weighed against the costs required to provide it (FAA 2010-2). Regulators, aircraft operators, and pilot organizations have continued to struggle to find the right balance between insuring that well rested and attentive pilots are always at the flight controls and the costs to the traveling public associated with providing this benefit. Indeed, the National Transportation Safety Board (NTSB) often cites fatigue as a contributing factor in its accident investigations. The crash of Colgan Flight

3407 is a recent example of this phenomenon. Legislators and regulators have taken notice. For example, the United States Congress, passed Public Law 111-216, the Airline Safety and Federal Aviation Administration Extension Act of 2010, that among other things, called for the Federal Aviation Administration (FAA) to issue regulations, based on the best available scientific information, to specify limitations on the hours of flight and duty time allowed for pilots to address problems relating to pilot fatigue. The FAA extensively reviewed comments on its Notice of Proposed Rule Making, Docket No. FAA-2009-1093; Notice No. 10-11, as it attempted to issue the first major revision of Federal Aviation Regulation (FAR) Part 121 pilot flight and duty time regulations in many years. The stakes in this review were high, as previously alluded to. The cost of bringing existing pilot flight and duty time regulations and attendant rest requirements into line with scientific principles related to fatigue had to be weighed against the cost to aircraft operators to incorporate these changes into their scheduling practices. Ultimately, these costs will have to be borne by the traveling public. The FAA eventually published its final rule on Flightcrew Member Duty and Rest Requirements, 14 CFR Parts 117, 119, and 121 [Docket No. FAA-2009-1093; Amdt. Nos. 117-1, 119-16, 121-357] RIN 2120-AJ58, in the Federal Register on January 4, 2012. The effective date of the rule was January 14, 2014.

Problem

The effects of fatigue, boredom proneness, highly automated aircraft cockpits (Bhana, 2010), and circadian rhythm disruptions that can occur on long range international flights (Henderson, 1990) may conspire to reduce the cognitive skills and abilities of pilots just as they near their destinations and enter the high workload approach and landing phases of flight. At some international flag carriers, en-route napping is now being used by pilots flying long haul international route segments, with or without augmentation and / or scheduled rest periods

(ICAO, 2011) as one strategy to mitigate pilot fatigue. While en-route napping is currently not permitted by the FAA, new rules that went into effect in January 2014 provide a framework whereby air carriers may be authorized to permit this practice as part of an air-carrier submitted (and FAA approved) Fatigue Rest Management System (FRMS) (FAA, 2010-2).

In this era of ultra-long range commercial aircraft operations, it is important to more fully understand the nature and potential beneficial effects of en-route napping, as a fatigue mitigation strategy. Properly implemented, as part of a comprehensive FRMS program, en-route napping holds the promise of becoming an effective fatigue mitigation tool commercial airline pilots can employ as they seek to maximize the preservation of their cognitive skills when flying long haul international flight segments. More studies are needed to expand the body of knowledge in this area and to quantify how effective en-route napping is as a fatigue countermeasure under a variety of circumstances typically encountered by commercial airline pilots.

Imperatives

In aviation, the consequences of inaction can be grave. As technological advancements have made the machinery more capable and more reliable, the human factors issues have become more significant determinates with respect to safety of flight concerns (NTSB, 2010). Many factors can and do contribute to the manifestations of pilot fatigue (Caldwell, 1997). These factors can vary from day to day, flight to flight, and individual to individual. According to Strauss (2006), fatigue has been characterized as “a threat to aviation safety because of the impairments in alertness and performance it creates”. He goes on to say that, fatigue can manifest itself by the commission of “errors of omission, followed by errors of commission, and microsleeps” (Strauss, 2006). Until recently, the state of pilot flight and duty time regulations and typical airline scheduling practices could be characterized as mostly a

one-size fits all approach. While some negotiated pilot agreements had historically taken minimum regulatory requirements to higher levels, for example, requiring relief pilots for certain international flight segments of less than 8 hours (current FAR Part 121 requires augmentation only on flights greater than 8 to 9 hours, depending on report time), even some of those provisions fell by the wayside as some airline managements used the bankruptcy process to abrogate pilot agreements containing those provisions (United Airlines, 2005). This was an example where financial considerations to lower costs trumped the safety concerns of pilots.

Research Questions

1. To what extent is self-assessed maximum fatigue state prior to napping, as reported by commercial airline pilots flying international route segments, affected by crew position, prior flights flown during the same duty period, single or double augmentation, commuting, amount of sleep obtained in the previous 24 hour period, self-assessed rested state when reporting for duty, flying during normal bedtime hours, the availability of scheduled en-route rest periods in an onboard crew rest facility, and / or experiencing spontaneous sleep episodes(s)?
2. Does the availability of scheduled en-route rest opportunities, in an onboard crew rest facility, affect the usage of en-route napping, as a fatigue mitigation strategy, as self-assessed by commercial airline pilots flying international route segments?
3. Does the duration of en-route napping affect the fatigue mitigation benefits of en-route napping, as self-assessed by commercial airline pilots flying international route segments?

Literature Review

The Role of Fatigue in Aviation Accidents

Fatigue has played a role in a number of air tragedies including the crash of Colgan Flight 3407 on February 12, 2009 (NTSB, 2010). In that crash, the pilots of a Bombardier DHC-8-400 lost control of the aircraft on approach into Buffalo NY. In the investigation that followed, the NTSB (2010) found in part:

At the time of the accident, the captain would have been awake for at least 15 hours if he had awakened about 0700 and for a longer period if he had awakened earlier. The accident occurred about the same time that the captain's sleep opportunities during the previous days had begun and the time at which he normally went to sleep. The captain had experienced chronic sleep loss, and both he and the first officer had experienced interrupted and poor-quality sleep during the 24 hours before the accident. (p. 120)

In reaching a conclusion on the of probable cause in this accident, the NTSB (2010) stated:

Because the effects of fatigue can exacerbate performance failures, its role in the pilots' performance during the flight cannot be ruled out. The NTSB concluded that the pilots' performance was likely impaired because of fatigue, but the extent of their impairment and the degree to which it contributed to the performance deficiencies that occurred during the flight cannot be conclusively determined. (p. 122)

Until recently, the state of pilot flight and duty time regulations, as contained in the FAR, had remained essentially unchanged for decades. Originally conceived during the era of piston powered commercial aircraft, these regulations have been long overdue for a major revision that takes into account what has been learned over those decades regarding the causes of pilot fatigue and its effects on human cognitive performance.

The NTSB has known for quite some time that fatigue is a threat to aviation safety. In February 2006, the NTSB issued Safety Recommendation A-06-10 which states in part, as a recommendation to the FAA, “Modify and simplify the flight crew hours-of-service regulations to take into consideration factors such as length of duty day, starting time, workload, and other factors shown by recent research, scientific evidence, and current industry experience to affect crew alertness” (NTSB, 2010, p.122).

In June 2008, the NTSB issued Safety Recommendations A-08-44/-45 that stated in part:

Develop guidance, based on empirical and scientific evidence, for operators to establish fatigue management systems, including information about the content and implementation of these systems (A-08-44). Develop and use a methodology that will continually assess the effectiveness of fatigue management systems implemented by operators, including their ability to improve sleep and alertness, mitigate performance errors, and prevent incidents and accidents (A-08-45) (NTSB 2010, p. 126).

Regulatory Background

In February 2009, the NTSB suggested that the FAA develop guidance on fatigue management systems for all components of the aviation industry. The NTSB asked the FAA to commit to a schedule indicating when guidance for other aviation operations would be forth coming. “Safety Recommendations A-08-44 and -45 were classified “Open—Acceptable Response” pending receipt of this schedule and one for the development and implementation of methodologies to continually assess the effectiveness of fatigue management systems” (NTSB, 2010, p.126).

In July 2009, the FAA established an aviation rulemaking committee on flight and duty time limitations and rest requirements for Part 121 and 135 operations. According to the

FAA, the committee developed recommendations to consolidate and replace existing regulations for Parts 121 and 135. The new regulations would take advantage of the current state of fatigue science, support the development of FRMS, and harmonize fatigue mitigation initiatives with International Civil Aeronautics Organization (ICAO). The FAA stated that it was reviewing the recommendations and that it would publish a notice of proposed rulemaking (NPRM) in December 2009 based on the committee's work (NTSB, 2010, p.74).

In September 2009, the FAA announced that it had been working with various stakeholders on the development of risk based fatigue mitigation strategies that could be employed on ultra-long range flights (flights over 16 hours duration) as well as other commercial flight operations. The FAA indicated that the work of these groups clearly indicated a need to adopt operating specifications that employed a risk-based approach to fatigue in long-range operations. The FAA also indicated that the aviation rule making committee it had established had taken a science based approach in the development of proposals for new pilot rest and flight and duty time requirements that would cover both FAR Part 121 and FAR Part 135 flight operations. The FAA went on to say that it intended to issue a NPRM in December of that year (NTSB, 2010, p. 74).

In December 2009, in testimony before the Subcommittee on Aviation, U.S. Senate Committee on Commerce, Science, and Transportation, the FAA Administrator stated that the FAA's review of the aviation rulemaking committee's recommendations on flight and duty time limitations and rest requirements would require additional time and as a result, an NPRM would not be forthcoming that month but would be published as soon as possible (NTSB 2010).

In September 2010, the FAA finally published NPRM 10-11 on Flight Crew Member Duty and Rest Requirements. The proposed rulemaking provided for some improvements in

applying fatigue science, but as is often had been the case, the rule making process suffered the effects of heavy lobbying by stakeholders on all sides of the issues. The FAA stated in part:

In some areas, the FAA proposes to relax current requirements, while in others, it strengthened them to reflect the latest scientific information. The agency proposed to provide credit for fatigue-mitigating strategies, such as sleep facilities, that some certificate holders are currently providing with no regulatory incentive. The agency also tentatively decided that certain operations conducted under the existing rules were exposing flight crewmembers to undue risk. (FAA 2010, p. 10)

Precisely because the regulatory process provides an opportunity for all parties to comment and the political process being what it is, NPRM 10-11, as with all recent efforts to make progress in this area, was bogged down by the process and was in danger of dying a slow death at the hands of election year political considerations, industry lobbying, and a cumbersome review process that requires multiple agencies of the government to evaluate the efficacy of the proposed rule. Sorting out the validity of vastly higher cost estimates for implementation of the new rules by industry, as was represented by industry lobbying groups like the Airline For America (A4A), which represented air carriers, was an important yet time consuming process (FAA, 2010-2, p. 115).

Studies Advance Knowledge in Aviation Fatigue Science

While the new Flightcrew Member Duty and Rest Requirements took effect in January 2014 (FAA 2010-2), progress still needs to continue on mitigating pilot fatigue. Scientific research and accident investigations have demonstrated the negative effects of fatigue on human performance, including reduced alertness and degraded mental and physical performance (Hartzler, Beth M. 2014). For example, breakdowns in vigilance can occur, response times can slow and become inaccurate, decision-making and risk assessment can

degrade, and motivation can decrease. In addition, task management and prioritization can be affected by fatigue, and some reports have indicated a reduction in leadership behavior with increased fatigue as well (Caldwell, 1997).

While there has been some research performed that has looked at various aspects of sleep deprivation (Fiorino, 2009), scheduling practices (Lamond, et al., 2006), the use of stimulants (Corum, et al., 1997), and other human factors aspects on the flight performance of pilots (Stauss 2006), these studies have not clearly defined the extent to which and under what circumstance en-route napping is an effective fatigue mitigation tool as self-assessed by commercial airline pilots flying international flight segments.

Petrilli, Roach, Dawson, and Lamond (2006) sought to investigate pilot sleep habits, subjective fatigue, and sustained attention before and after international flights. They also studied subjective fatigue and attentiveness and their relationships with sleep patterns and duty periods. The methodology used, self-rated fatigue and sustained attention using a psychomotor vigilance task (i.e., PVT) before and after international flights, provided some insights into how a follow on study might be designed to extend the state of knowledge in this area. The investigators used both linear regression and ANOVA models and found some significant results relating to PVT performance deterioration as a function of flight duration.

Signal, Van den Berg, Travier, and Gander (2004) stated that, “While pre-flight and layover sleep is important, in-flight sleep is considered the most effective fatigue countermeasure, as sleep periods can occur close to operational events and may have the greatest direct influence on fatigue counteraction”.

Lamond, Petrilli, Dawson, and Roach (2006) studied how the duration of layovers while flying international pilot flight patterns affected pilot fatigue and impaired performance. Objective and subjective input was obtained through pilot data recording and a psychomotor

vigilance task (PVT) testing. Wrist worn activity monitors were used to provide objective measures of pilot activity and sleep periods. The focus of this study to investigate the benefits of restorative sleep on flight crew performance as measured by the PVT. While a number of confounding factors prevented the investigators from reaching some conclusions that were otherwise supported by anecdotal evidence, they did clearly establish that longer layovers between international flight segments that provided two full nights of restorative sleep produced significant benefits in pilot performance.

Fiorino (2009) reported how young healthy men responded to cognitively demanding and long-duration task performance, which was measured under sleep deprivation and following recovery. Results indicated that complex and long duration cognitive performance gradually degrades in young healthy men when their sleep is restricted to four hours per sleep episode over five consecutive evenings. This degradation is characterized by a strong time-on task effect and large individual variation differences between subjects. Individuals deprived of sufficient sleep over this period required at least two 8-hour sleep opportunities to fully recover.

Jonsson and Ricks (1995) investigated several areas involving how pilots process information displayed to them in modern cockpits and sought to develop tools and techniques to accurately measure cognition in this venue. They looked at how pilots cognitively process flight-deck information, how they prioritize such information, how consistent these processes are across a sample of different pilot subjects, and whether or not these processes vary as a function of changes in flight context or situational context. Techniques employed included Multidimensional Preference Analysis, spatial analysis, prioritization mapping and cluster analysis. Findings included close correlation between pilot subjects in perceived importance of

some categories of information and tight cluster patterns of perceptions of some cognitive processes.

Kandelaars, Fletcher, Dorrian, Baulk, and Dawson (2006) studied the development of predictive bio-mathematical models to predict performance / alertness of long haul airline pilots in an operational environment based upon both biological and social criteria. The study utilized both activity monitors as well as diary entries to follow the pilot's regimen and importantly for my purposes, specifically looked at the effects of in-flight napping on alertness performance. A key point and a telling one is the realization that in an operational environment, pilots often do not sleep at the most biologically opportune times but rather at other times that are driven by a variety of social, operational and external factors. While much of this study's modeling is devoted towards predicting sleep during layover periods, it nonetheless provides some useful data points that may be helpful in the design of follow up studies.

Rabinowitz, Breitbart, and Warner (2009) investigated pilot fatigue, sleep and cognitive effectiveness in a deployed military aviation environment and utilizes several scheduling and evaluation tools to confirm the predictive value of these tools with respect to pilot performance and alertness under a variety of conditions. A wrist worn device called an Actigraph was utilized to provide an objective approximation of sleep periods based upon wrist movements and a testing protocol known as SynWin was used to provide cognitive test scores. Results were then back tested through the algorithms of a predictive fatigue model to determine that models fidelity. While the focus of this study was primarily the validation of the predictive fatigue model as a scheduling tool, many contemporaneous insights with respect to the importance of not only sleep quantity but also sleep quality and the absence of sleep disturbances provide avenues for further study.

Ancoli-Israel, Cole, Alessi, Chambers, Moorcroft and Pollak (2003) found that actigraphy correlates well with traditional polysomnography (PSG) when it comes to determining sleep periods from wake periods. Actigraphy is also much easier to implement, can be conducted over longer periods, and utilizes non-evasive easily worn actigraphs, however, the devices used in the study did not provide as much fidelity with respect to event start and stop time as with PSG.

Rosekind, Gregory and Mallis (2006) investigated the efficacy of implementing an Alertness Management Program (AMP) at a major airline. The AMP might be considered an early model of what some of the components of a FRMS might look like and included education, alertness strategies, scheduling, and healthy sleep modules. Study participants were monitored and tested pre-intervention, to get a baseline and then with implementation of the AMP intervention strategies. The study results showed improvements in the intervention participants with respect to fatigue management. It is important to note that one of the main aspects of the AMP was the introduction of additional sleep opportunities for the intervention participants, which resulted in an actual increase in sleep time achieved for those participants.

Petrie, Powell, and Broadbent (2004) investigated strategies employed by Air New Zealand pilots to manage fatigue while flying regional and international routes. Pilots who reported that they routinely napped during the day prior to flying an overnight flight reported significantly lower levels of general fatigue. A little more than half of the pilots reported napping in the cockpit over the previous 12 months with cockpit napping also being associated with lower levels of reported fatigue.

Roach, Darwent, and Dawson (2010) studied long haul commercial airline pilots flying international route segments. The pilots were monitored using wrist activity monitoring devices and by keeping diaries. One interesting finding was that the sleep obtained during

flight in an on board rest facility during an authorized rest break had only 70% of the restorative power as did the same amount of sleep in a normal home bed sleeping setting. These findings if, confirmed, have important implications for the future design of FRMS programs.

Review Summary

The history of aviation presents ample evidence that fatigue is an insidious danger to the safety of flight. Accident investigators have continued to categorize and define how fatigue has been a contributing factor in their findings of probable cause of aviation accidents. Advancements in our understanding of the insidious effects of fatigue on the safety of flight have been documented in a number of studies, including those cited herein. Aviation regulatory authorities have taken notice and have begun to incorporate our expanded understanding of human physiology and the role it can play in the safe conduct of commercial aviation into their regulatory requirements (“Nap Time” 2011). At the same time, industry representatives, professional pilot organizations and other aviation stakeholders have engaged in an exchange of ideas and advocacy in attempt to champion their particular positions with respect to instituting best practices to address the inherent risks that fatigue poses to the safe conduct of commercial aviation activities.

Recent regulatory action and the engagement of industry, professional pilot, and other aviation organizations have created both the need and the opportunity for the further development of effective tools that pilots can utilize to prevent and / or mitigate fatigue events. Previous studies reviewed herein suggest that commercial pilots flying international routes experience levels of fatigue that can vary from pilot to pilot and from flight to flight. The actions each pilot takes in preparation for reporting for duty and the actual conditions pilots experience on each flight segment vary widely and can be affected by a whole host of

conditions and circumstances. In this regard, with respect to fatigue, each flight segment is unique for each pilot and a one size fits all approach to fatigue mitigation may not be the best approach.

FAR Part 117 has introduced a more science based approach to the scheduling practices and rest requirements of commercial airline pilots operating under FAR Part 121. While these new rules reflect advancements in our understanding of human physiology in an aviation environment, they also reflect compromises that come into play by way of a regulatory process that must take into account the competing views of various aviation stakeholder groups. While pilots are now required to certify their fitness to fly prior to beginning each flight duty assignment, they still lack some of the necessary tools, training, and understanding required to effectively evaluate not only their fitness to fly at the moment, but also how likely that fitness will hold up over the many hours they may be required to maintain that state of fitness. Having a science based tool kit of effective fatigue mitigation strategies and the training and regulatory environment that permits its proper use is a key provision incorporated within the framework of FAR Part 117 in that the regulation provides a pathway for air-carriers to create and seek FAA approval of Fatigue Rest Management Systems (FRMS) that are deemed to provide an equivalent (or improved) level of safety. Such FRMS programs could incorporate fatigue mitigation tools and strategies that currently are not permitted under FARs. With this in mind, this study examines to what extent en-route napping is currently being used by commercial airline pilots flying international routes and the potential benefits of en-route napping, under a variety of circumstances, as part of an effective fatigue mitigation strategy.

CHAPTER II

METHODOLOGY

This study investigated the usage and effectiveness of en-route napping as a component of fatigue mitigation strategies as employed by commercial airline pilots flying international route segments. The study utilized a Qualtrics web based online survey tool containing mostly objective questions regarding metrics that are applicable to the conduct of international flight operations. Several of the questions asked the study participants to self-assess their fatigue state at different stages of a typical international flight assignment. One (1) open ended question asked the participants to discuss their own effective fatigue mitigation strategies.

Study Goals

The primary goal of the study was to investigate the extent to which en-route napping is being employed as a fatigue mitigation tool, how effective it is, and how its usage and effectiveness may be impacted by other factors that may typically be present in the conduct of international flight operations. A secondary goal was to determine to what extent the availability of scheduled en-route rest opportunities in an onboard crew rest facility and nap duration affected the usage and effectiveness of en-route napping as a fatigue mitigation strategy. A tertiary goal was to categorize the study participants open ended comments regarding their own effective fatigue mitigation strategies.

Study Population

For this study, all pilot participants were FAR 121 qualified commercial airline pilots (or their ICAO equivalents) employed by major domestic or international air carriers conducting international passenger or cargo flight operations. Each pilot participant was currently qualified in his or her respective aircraft type and crew position and included captains, first officers and relief pilots. Each pilot participant voluntarily participated in the study and received no compensation for his or her participation. The pilots were solicited to volunteer to participate in the study through email, flyers and word of mouth methods. The survey tool was designed to be simple to complete online. The participants were informed that no identifying information would be collected, and that their identities would remain strictly anonymous. Participants were also informed that the survey was being conducted by the study's principal investigator, an experienced international airline pilot, as part of thesis research for a masters degree program, and that the study results would be used for educational purposes and to promote safety in aviation.

Study Design

The study was constructed utilizing a mixed methods design. A web-based online survey tool was created for data collection. The survey tool was designed to be simple to complete in just a few minutes by pilots after the completion of an international flight segment. Upon opening the online survey tool, participants were greeted with an explanation of the study's purpose, ground rules, and instructions on how to complete the survey. The survey tool included fourteen (14) questions, thirteen (13) of which were quantitative in nature with a final open ended qualitative question at the end of the survey to provide participants an opportunity to share their own observations on the study subject. There was no time limit for

completing the survey, however, participants were required to complete the survey in one online session. Survey participants were advised that they could participate in the survey more than once provided that they submitted only one (1) survey per international flight segment.

Sampling Methods

The study survey was designed to be hosted by an online survey tool provider so that study participants could easily complete the survey via the Internet. Once participants completed and saved their survey tool responses, the data collected was saved onto the host computer servers where it will be retained until completion of the survey period. A dataset containing survey responses collected through September 14, 2016 was exported as an IBM SPSS formatted file for further analysis.

Data Analysis Plan

IBM SPSS software (release version 24) and the Qualtrics web based survey tools were utilized to conduct statistical testing and analysis on the collected datasets. For research question one (1), a univariate analysis of variance model (ANOVA) was utilized along with descriptive statistics and related tests to determine if there were significant relationships between reported self-assessed fatigue state after napping and the other study metrics. For research question two (2), an independent samples T-Test model was utilized along with descriptive statistics and related tests to determine if there was a significant relationship between the availability of en-route rest opportunities in an onboard crew rest facility and the usage of en-route napping as a fatigue mitigation strategy. For research question three (3), a linear regression model with ANOVA and Pearson's R correlation model were utilized along with descriptive statistics and related tests to determine if there was a significant relationship between the duration of en-route naps and the self-assessed effectiveness of those naps. In addition, themes were generated and reported on from the open ended responses of survey

participants to survey question fourteen #14 which asked the participants to share their thoughts on their own effective fatigue mitigation strategies. Results were reported as significant where the alpha level was $p < .05$.

Table 1. Variable Attributes.

Variable Name	Variable Description	Data Type	Values	Source
INTFT	This Flight is an International Route Segment	Nominal	1-Yes 2-No	Survey Tool
POSIT	Flightcrew Position Assigned	Nominal	1-Captain 2-First Officer 3-Relief Pilot	Survey Tool
SEGMS	Number of prior Flight Segments flown in this duty period	Interval	0-None 1-One 2-Two 3-Multiple	Survey Tool
AUGMT	Augmentation	Nominal	0-None 1-Single 2-Double	Survey Tool
COMUT	Going to Work requires Air Travel	Nominal	1-Yes 2-No	Survey Tool
SLEEP	Hours Slept prior to Duty	Interval	0-24	Survey Tool
REST	Self-Assessed Fatigue State when Reporting to Duty	Likert	1-Low 2-Moderate 3-High	Survey Tool
CIRCD	Back Side of the Clock Flight	Nominal	1-Yes 2-No	Survey Tool
FACLT	Assigned En-Route Rest in an Onboard Crew Rest Facility	Nominal	1-Yes 2-No	Survey Tool
SLEPTM	Minutes spent Sleeping in an Onboard Crew Rest Facility	Interval	___Numeric	Survey Tool (Derived)
SPONT	Spontaneous Sleep Episodes	Nominal	1-Yes 2-No	Survey Tool
NAPTM	Minutes spent Napping during the Flight	Interval	___Numeric	Survey Tool
FLTFT	Self-Assessed Maximum Fatigue State prior to Napping	Likert	1-Low 2-Moderate 3-High	Survey Tool
NAPPY	Pilot Reported some Naptime	Nominal	1-Yes 2-No	Survey Tool (Derived)
NAPFT	Self-Assessed Maximum Fatigue State after Napping	Likert	1-Low 2-Moderate 3-High	Survey Tool
NAPBN	Self-Assessed Fatigue State Improvement after Napping	Nominal	0-No Improvement 1-One Level 2-Two Levels	Survey Tool (Computed)
OPED	Comments on Effective Fatigue Mitigation Strategies	Nominal	Text	Survey Tool

Study Validity

The Study topic and survey tool questions were designed by the researcher based upon a review of pertinent studies related to the study subject and the researcher's professional experience. Experts from industry and academia reviewed and validated the study methods utilized.

Study Limitations

1. Pilot participants in the study were allowed to participate during more than one flight segment. Although the study does not involve skills testing so practice effects should not be an issue, the possibility exists that answers given on subsequent flight segments may be affected by the experience of completing a survey on prior flight segments.
2. Limiting the study population to only commercial airline pilots flying international flight segments may limit the applicability of the study results to other pilot populations.
3. Since the study did not collect demographic or personal information from the participants, any variations in effects associated with this type of information was not measured or considered in the results.
4. Not all study participants answered all study questions. During data analysis, cases containing unanswered questions were excluded, as appropriate, from statistical tests to the extent that the variable data in question was required to perform a particular test. This resulted in smaller sample sizes for some tests vs others. For all tests conducted, the number of cases used ($n=X$) is noted in the test results. In addition, data conventions to deal with invalid data and / or to create computed or derived variable values (see Table 2) were applied to create a "Modified Dataset" that was utilized to perform certain statistical tests. While these modifications were deemed necessary and appropriate by the Principal Researcher of this study

based upon the statistical models used to perform certain tests and many years of professional operating experience under FAR 121, they are modifications of the raw survey data.

5. Maintaining the strict anonymity of study participants resulted in some inherent limitations. For example, the specific data types collected by the survey tool were limited by this aspect of the study's design as no demographic or flight specific information was collected and no conclusions can be drawn of how widely distributed the survey tool's reach was with respect to various air carriers and pilot groups as a result. The anonymity of the study participants also prevents any possibility of follow up or clarification of any of the responses given by study participants.

Ethical Standards

This research has been approved and authorized by the Institutional Review Board of the University of North Dakota, Division of Research & Economic Development. The study participants were informed of the nature and purpose of the study and provided their implied consent by their decisions to voluntarily participate in the study. No inducements were offered to study participants and their participation was voluntary and without compensation. No attempt by the researcher was made to determine if any of the survey tool responses provided represented violations of any company policy or regulatory requirements and the survey tool was specifically designed to eliminate any possibility that any survey response could be linked to any particular individual, air carrier, flight, regulatory authority. No personal or demographic data related to survey participants or their air-carriers was collected and their identities are to remain strictly anonymous. The data collected in this study is to be used solely for educational research purposes but may be made available to third parties for the purpose of improving aviation safety.

CHAPTER III

RESULTS

Introduction

This study was conducted by soliciting participants from the target population to take an online survey containing 14 questions. No personal demographic or airline specific information was solicited. The survey was open to currently qualified international airline pilots operating international route segments under FAR Part 121. Pilot participants were allowed to submit more than Survey, however, only one survey per international flight segment was requested. The first thirteen (13) survey questions collected generic quantitative data. The last survey question collected qualitative data regarding the survey participant's thoughts on their own en-route fatigue mitigation strategies. This qualitative data was then examined and categorized into common themes which are summarized later in this Chapter.

Surveys for one hundred and thirty-two ($N = 132$) flight segments were submitted by the survey participants which constitute the "Raw Dataset" as reported herein. One (1) survey was removed, due to this participant indicating that the flight in question was not an international flight segment as required, in the creation of a "Modified Dataset" ($N = 131$) that was used to perform certain statistical testing.

Data Conventions

As might be expected, not every survey participant answered every question that was asked of them in the Survey. Answers left blank were not considered for analysis of the variable(s) in question in either dataset. Additionally, some pilots provided invalid answers to

some questions, for example, answering zero (“0”) minutes to a question regarding the duration of a nap. In the Modified Dataset, invalid answers were not considered for analysis of the variable(s) in question as above, or were reported separately with an accompanying explanation for re-categorizing them. Table 2 below summarizes the details of the data conventions that were utilized for analysis of the Modified Dataset. IBM SPSS version 24 software was utilized for statistical testing.

Table 2. Data Conventions.

Variable	Analysis Logic	Count (<i>n</i>)
NAPTM	‘0’ Minute Answers Treated as Not Answered	53
	NAPTM \geq 60 Minutes Reported as SLEPTM	9
NAPBN	Change in Fatigue State - Derived NAPBN = FLTFT - NAPFT	As Reported
NAPPY	Pilot Reported some NAPTM (yes / no) - Computed Yes = NAPTM > 0 mins & < 60 mins - Derived	As Reported
INTFT	Pilot Reported Flight was not International Segment	1

The data conventions outlined above were applied to create the Modified Dataset. The Modified Dataset categorized the collected data in a format that permitted the use of appropriate statistical models. Statistical analysis using these models was then performed to address the research questions as proposed in this research project. The unmodified Raw Dataset was used to display all of the actual survey data responses of the survey participants and this unmodified data is presented next.

Survey Data as Reported by Survey Participants (Raw Dataset)

Table 3 and Figure 2 depict survey participant responses to survey question (1). All but one of the survey participants reported that the flight segment being flown was an international flight segment.

Table 3. Survey Question #1.

Was this flight an international flight segment?

Answer	%	Count
Yes	99.24%	131
No	0.76%	1
Total	100%	132

INTFT	Minimum	Maximum	Mean	SD	Variance	Count
Was this flight an international flight segment?	1.00	2.00	1.01	0.09	0.01	132

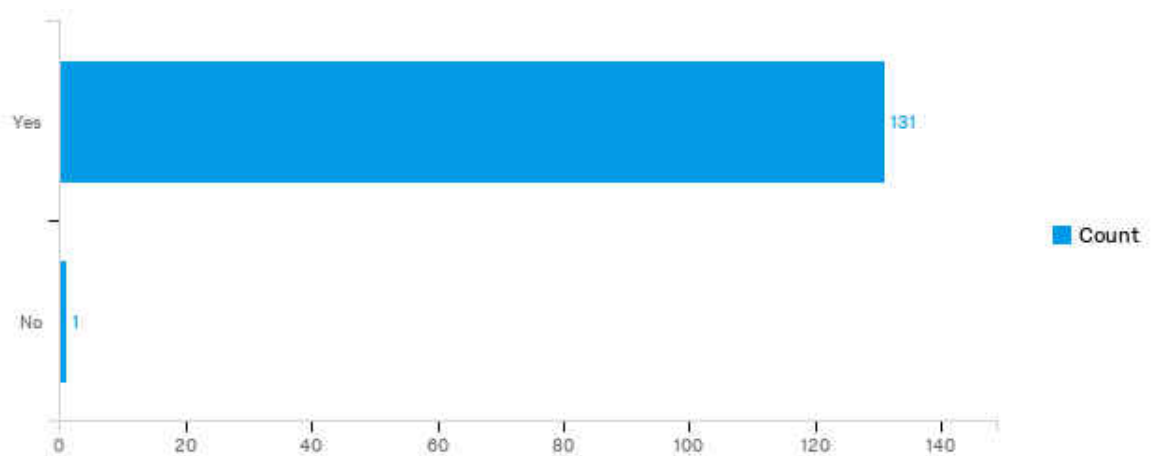


Figure 2. Bar Graph of International Flight Segment.

Table 4 and Figure 3 depict survey participant responses to survey question (2). 36.36% of the survey participants were Captains, 40.91% were First Officers, and 22.73% were Relief Pilots.

Table 4. Survey Question #2.

What was your crew position on this flight?

Answer	%	Count
Captain	36.36%	48
First Officer	40.91%	54
Relief Pilot	22.73%	30
Total	100%	132

POSIT	Minimum	Maximum	Mean	SD	Variance	Count
What was your crew position on this flight?	1.00	3.00	1.86	0.76	0.57	132

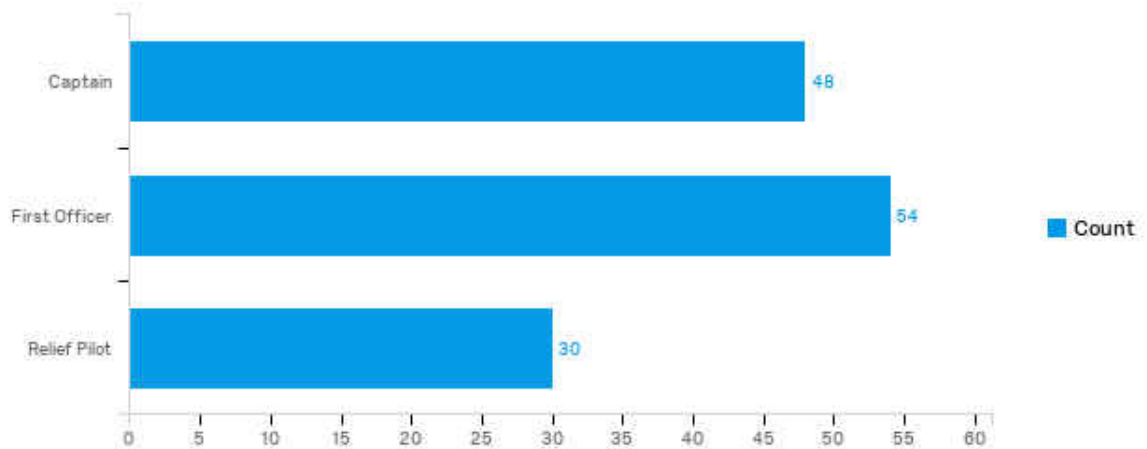


Figure 3. Bar Graph of Crew Position.

Table 5 and Figure 4 depict survey participant responses to survey question (3).

90.15% of the survey participants reported no previous flight segments that day while 9.85% of the survey participants reported one (1) previous flight segment that day.

Table 5. Survey Question #3.

Prior to this flight, how many flight segments did you fly today?

Answer	%	Count
None	90.15%	119
One	9.85%	13
Two	0.00%	0
More than two	0.00%	0
Total	100%	132

SEGMS	Minimum	Maximum	Mean	SD	Variance	Count
Prior to this flight, how many flight segments did you fly today?	1.00	2.00	1.10	0.30	0.09	132

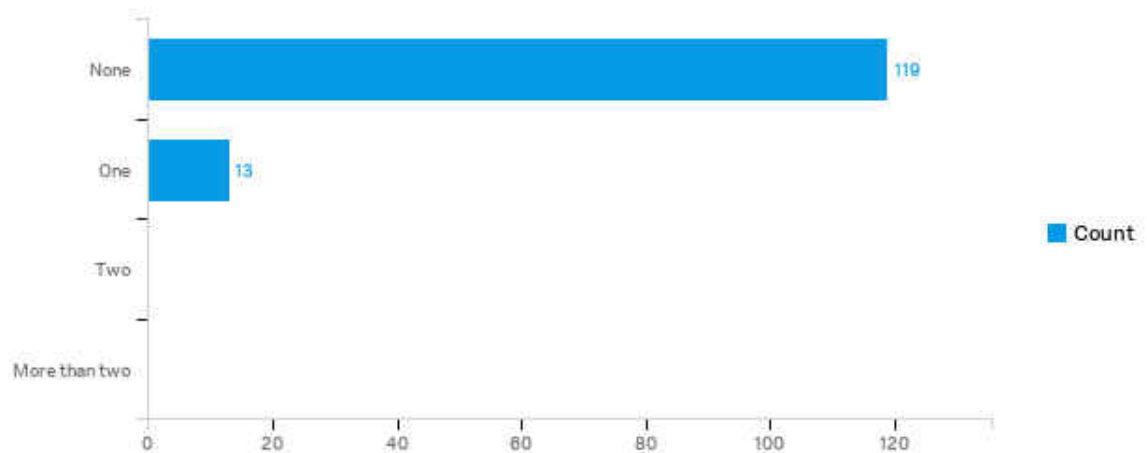


Figure 4. Bar Graph of Prior Flight Segments.

Table 6 and Figure 5 depict survey participant responses to survey question (4). 13.64% of the survey participants reported that this flight segment was un-augmented, 48.48% of the survey participants reported that this flight segment included (1) relief pilot, and 37.88% of the survey participants reported that this flight segment included (2) relief pilots.

Table 6. Survey Question #4.

Was this flight augmented?

Answer	%	Count
No Augmentation	13.64%	18
Single Augmented	48.48%	64
Double Augmented	37.88%	50
Total	100%	132

AUGMT	Minimum	Maximum	Mean	SD	Variance	Count
Was this flight augmented?	1.00	3.00	2.24	0.68	0.46	132

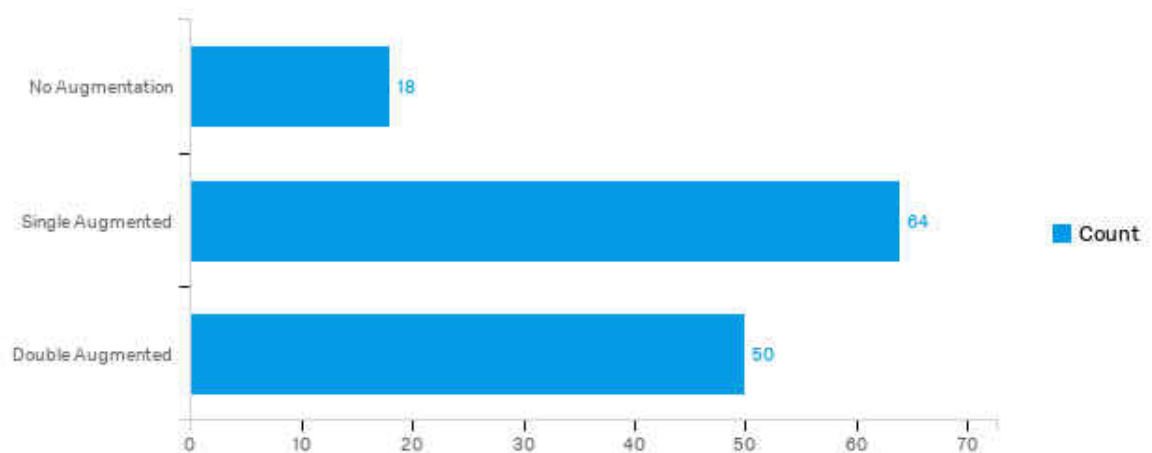


Figure 5. Bar Graph of Augmentation.

Table 7 and Figure 6 depict survey participant responses to survey question (5).

44.27% of the survey participants reported that they commuted to this flight assignment while 55.73% of the survey participants reported that they did not commute to this flight assignment.

Table 7. Survey Question #5.

Did you commute to this flight assignment?

Answer	%	Count
Yes	44.27%	58
No	55.73%	73
Total	100%	131

COMUT	Minimum	Maximum	Mean	SD	Variance	Count
Did you commute to this flight assignment?	1.00	2.00	1.56	0.50	0.25	131

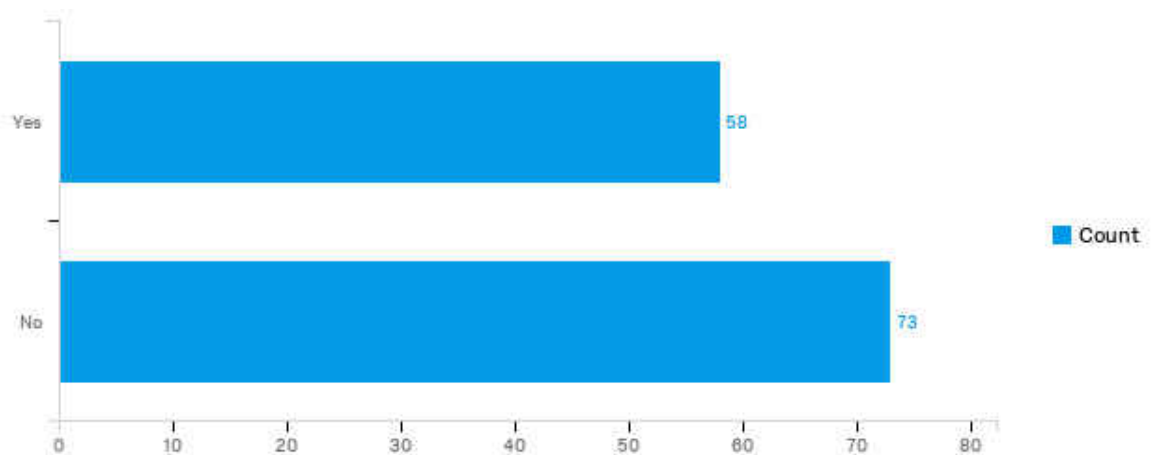


Figure 6. Bar Graph of Commuting.

Table 8 and Figure 7 depict survey participant responses to survey question (6).

Survey participants reported that they slept between 3.5 hours and 15 hours during the 24-hour period prior to reporting for duty for this flight segment, with the average time slept reported as 7.55 hours.

Table 8. Survey Question #6.

During the 24-hour period prior to reporting for duty, how many hours did you sleep?
Example: 10:00pm - 6:30am = 8.5

SLEEP	Minimum	Maximum	Mean	SD	Variance	Count
During the 24-hour period prior to reporting for duty, how many hours did you sleep? Example: 10:00pm - 6:30am = 8.5	3.50	15.00	7.55	1.45	2.11	132

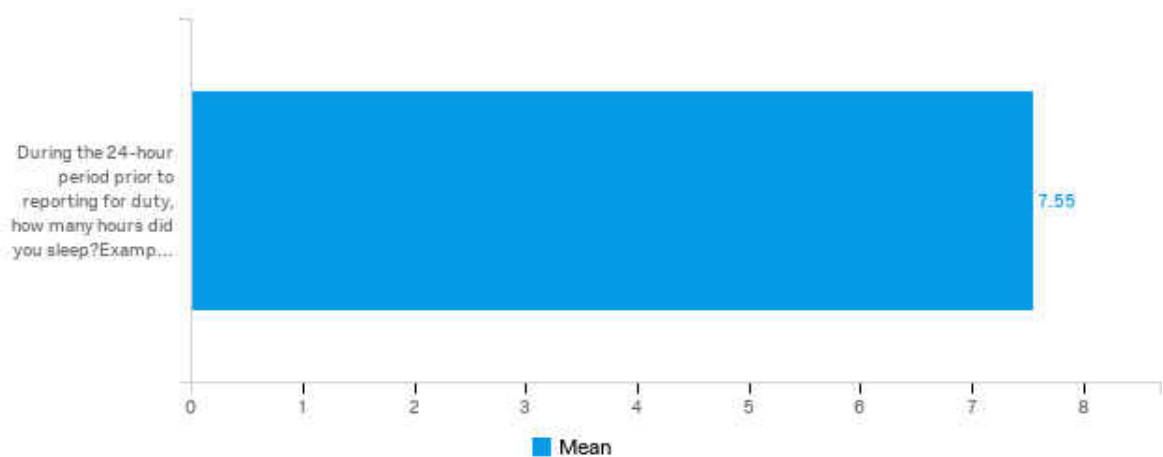


Figure 7. Bar Graph of Hours Slept prior to Duty.

Table 9 and Figure 8 depict survey participant responses to survey question (7). 75% of the survey participants rated their level of fatigue when reporting for this flight segment as Low, 24.24% of the survey participants rated their level of fatigue when reporting for this flight segment as Moderate, and .76% of the survey participants rated their level of fatigue when reporting for this flight segment as High.

Table 9. Survey Question #7.

Rate your level of fatigue when you reported for this flight segment.

Answer	%	Count
Low	75.00%	99
Moderate	24.24%	32
High	0.76%	1
Total	100%	132

REST	Minimum	Maximum	Mean	SD	Variance	Count
Fatigue State at Report Time ²	1.00	3.00	1.26	0.45	0.21	132

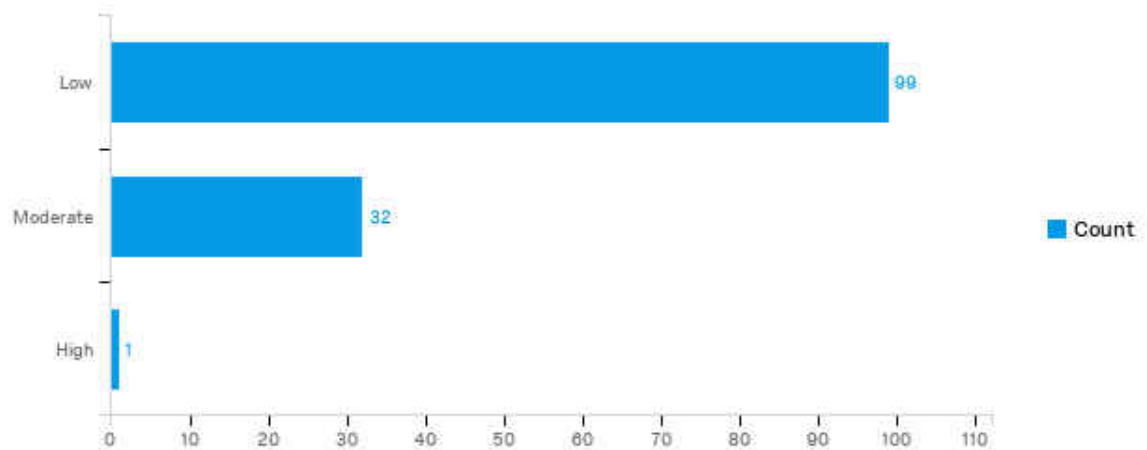


Figure 8. Bar Graph of Fatigue State at Report Time.

Table 10 and Figure 9 depict survey participant responses to survey question (8).

81.82% of the survey participants reported that this flight segment overlapped normal bedtime hours while 18.18% of the survey participants reported that this flight segment did not overlap normal bedtime hours.

Table 10. Survey Question #8.

Did this flight segment overlap your normal bedtime hours?

Answer	%	Count
Yes	81.82%	108
No	18.18%	24
Total	100%	132

CIRCD	Minimum	Maximum	Mean	SD	Variance	Count
Did this flight segment overlap your normal bedtime hours?	1.00	2.00	1.18	0.39	0.15	132

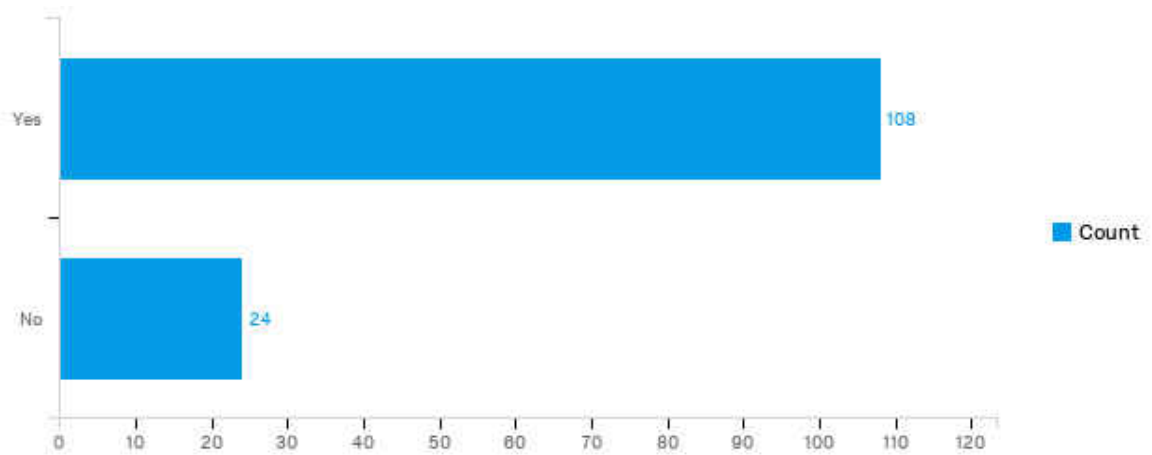


Figure 9. Bar Graph of Circadian Rhythm Disruption.

Table 11 and Figure 10 depict survey participant responses to survey question (9). 77.27% of the survey participants reported that they were assigned to an en-route scheduled rest period in a private crew rest facility (bunks) while 22.73% of the survey participants reported that they were not assigned to an en-route scheduled rest period in a private crew rest facility (bunks).

Table 11. Survey Question #9.

Were you assigned a scheduled rest period in a private crew rest facility (bunks) onboard this flight?

Answer	%	Count
Yes	77.27%	102
No	22.73%	30
Total	100%	132

FACLT	Minimum	Maximum	Mean	SD	Variance	Count
Were you assigned a scheduled rest period in a private crew rest facility (bunks) onboard this flight?	.001	2.00	1.23	0.42	0.18	132

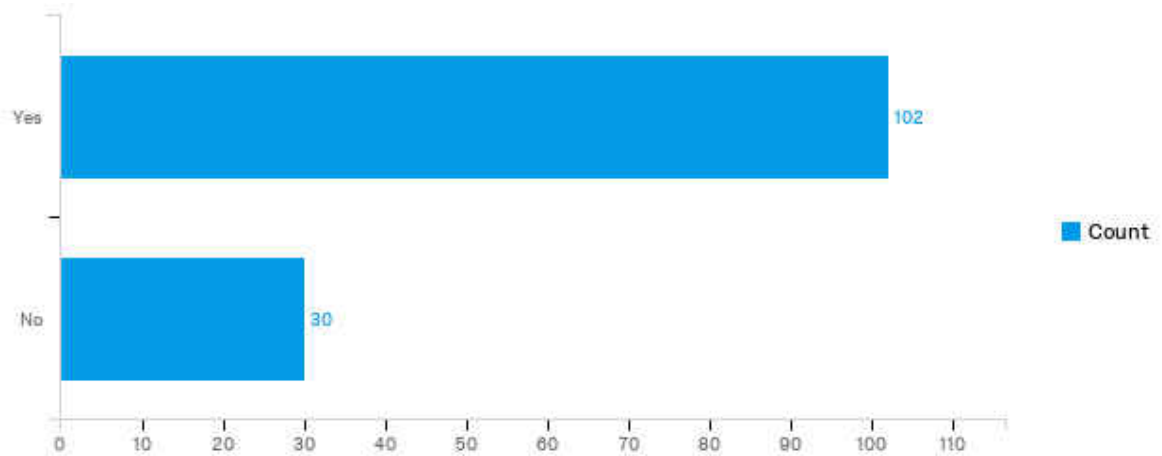


Figure 10. Bar Graph of Assigned Rest in En-Route Crew Rest Facility.

Table 12 and Figure 11 depict survey participant responses to survey question (10). 28.79% of the survey participants reported that they experienced unplanned spontaneous sleep episodes during this flight segment while 71.21% of the survey participants reported that they did not experience unplanned spontaneous sleep episodes during this flight segment.

Table 12. Survey Question #10.

During this flight, did you experience any unplanned spontaneous sleep episodes (nodding off)?

Answer	%	Count
Yes	28.79%	38
No	71.21%	94
Total	100%	132

SPONT	Minimum	Maximum	Mean	SD	Variance	Count
During this flight, did you experience any unplanned spontaneous sleep episodes (nodding off)?	1.00	2.00	1.71	0.45	0.21	132

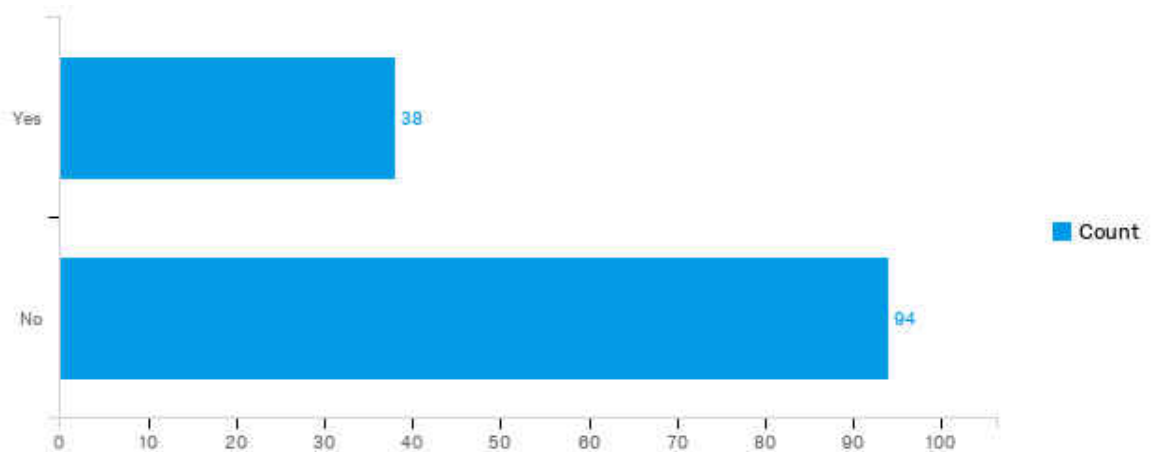


Figure 11. Bar Graph of Spontaneous Sleep Episodes.

Table 13 and Figure 12 depict survey participant responses to survey question (11). Survey participants reported naptimes ranging between zero (0) minutes and one hundred and eighty (180) minutes this flight segment, with the average time spent napping reported as 16.88 hours $N=97$. Note: For the Modified Data Set, which is used in the statistical analysis testing of the survey data for the purposes of answering the research questions later in this Chapter, the data conventions contained in Table (2) were applied and only naptimes > 0 minutes and < 60 minutes were considered valid $N=35$ with $M=14.77$ minutes.

Table 13. Survey Question #11.

Approximately how many minutes did you nap during this flight? (Do not include time spent sleeping during scheduled rest periods in a crew rest facility)

NAPTM	Minimum	Maximum	Mean	SD	Variance	Count
Approximately how many minutes did you nap during this flight? (Do not include time spent sleeping during scheduled rest periods in a crew rest facility)	0.00	180.00	16.88	37.39	1397.70	97

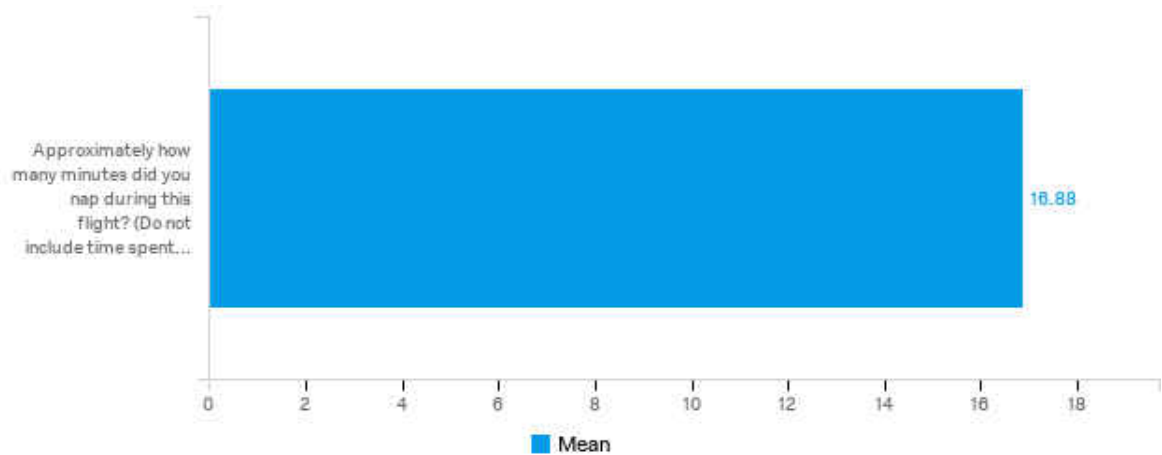


Figure 12. Bar Graph of Minutes spent Napping.

Table 14 and Figure 13 depict survey participant responses to survey question (12). 34.57% of the survey participants rated their level of fatigue prior to napping during this flight segment as Low while 45.68% of the survey participants rated their level of fatigue prior to napping during this flight segment as Moderate, and 19.75% of the survey participants rated their level of fatigue prior to napping during this flight segment as High.

Table 14. Survey Question #12.

Rate your maximum level of fatigue prior to napping during this flight.

Answer	%	Count
Low	34.57%	28
Moderate	45.68%	37
High	19.75%	16
Total	100%	81

FLTFT	Minimum	Maximum	Mean	SD	Variance	Count
Fatigue State prior to napping?	1.00	3.00	1.85	0.72	0.52	81

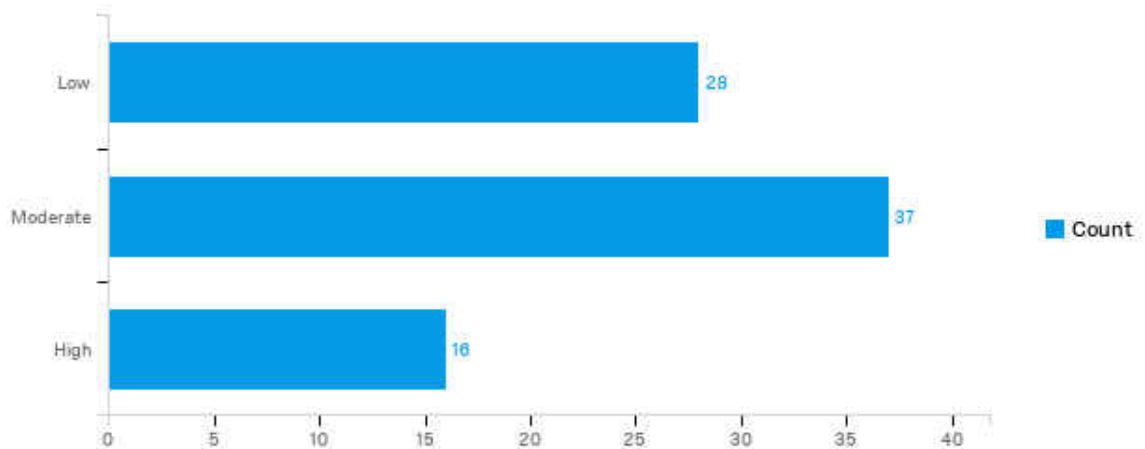


Figure 13. Bar Graph of Maximum Fatigue State prior to Napping.

Table 15 and Figure 14 depict survey participant responses to survey question (13). 65.38% of the survey participants rated their level of fatigue after napping during this flight segment as Low, 34.62% of the survey participants rated their level of fatigue after napping during this flight segment as Moderate, and 0% of the survey participants rated their level of fatigue after napping during this flight segment as High.

Table 15. Survey Question #13.

Rate your maximum level of fatigue after napping during this flight?

Answer	%	Count
Low	65.38%	51
Moderate	34.62%	27
High	0.00%	0
Total	100%	78

NAPFT	Minimum	Maximum	Mean	SD	Variance	Count
Fatigue State after napping?	1.00	2.00	1.35	0.48	0.23	78

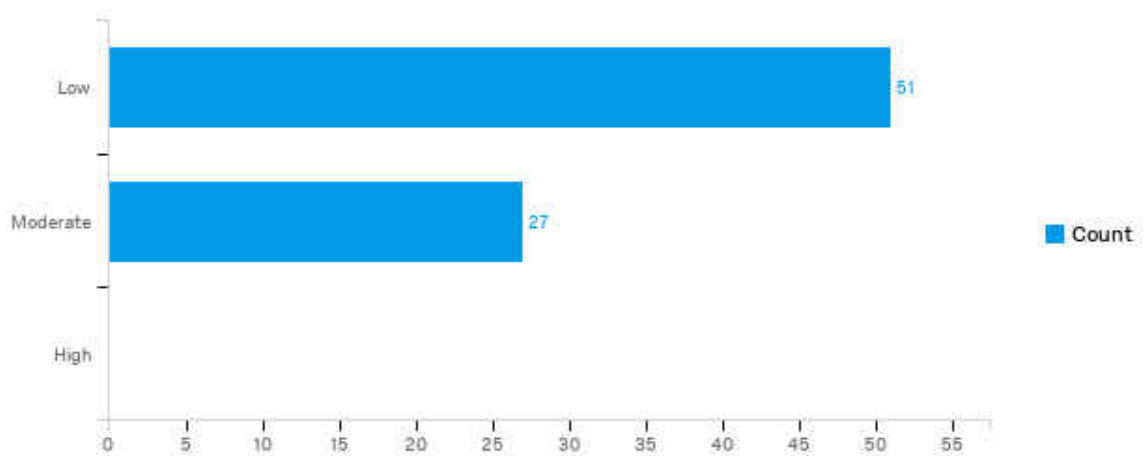


Figure 14. Bar Graph of Maximum Fatigue State after Napping.

was counted for that theme. Some responses contained multiple themes. Responses which did not mention any of the seven (7) primary themes were counted and categorized as the eighth theme, “Other”. Additional frequency bar graphs were then generated to show the relationships between the primary fatigue mitigation strategy themes mentioned by survey participants and their answers to other survey questions.

Figure 16 depicts fatigue mitigation strategy themes derived from survey participant key word responses to survey question (14).

Fatigue Mitigation Strategies

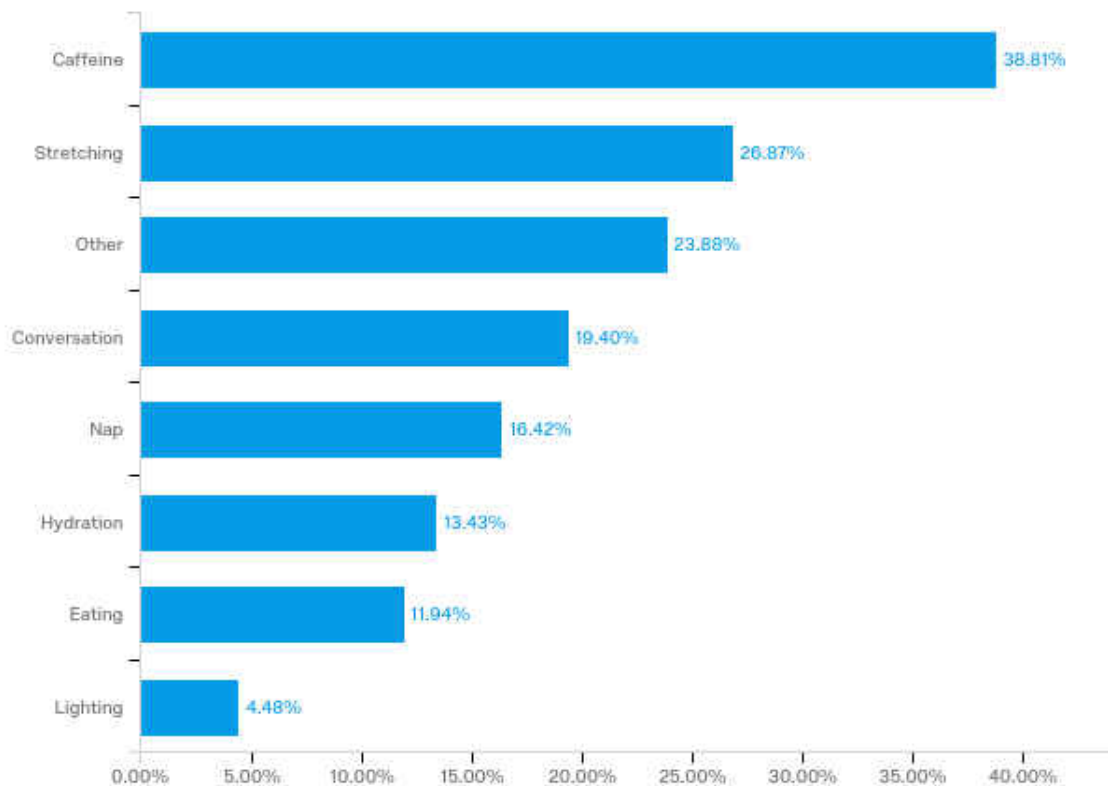


Figure 16. Bar Graph of Primary Themes derived from Survey Question #14.

Survey participants reported that Caffeine was by far their favorite fatigue mitigation countermeasure mentioned in 38.81% of the question #14 survey responses which included

comments about consuming various caffeinated drinks. Coffee was frequently mentioned however, some of the comments included just the word “caffeine” or mentioned consuming a number of other caffeinated drinks. Stretching came in as the second most favored fatigue mitigation countermeasure as 26.87%. This was followed by the catch all category “Other”, which came in at third place. Comments attributed to the catch all category Other came in at 23.88%. Conversation came in fourth overall at 19.40%, while Nap was the fifth most mentioned fatigue mitigation countermeasure reported by the survey participants at 16.42%. Hydration came in sixth at 13.43%, Eating came in seventh at 11.94%, and Lighting came in last at 4.48%.

Fatigue Mitigation Strategies by Crew Position

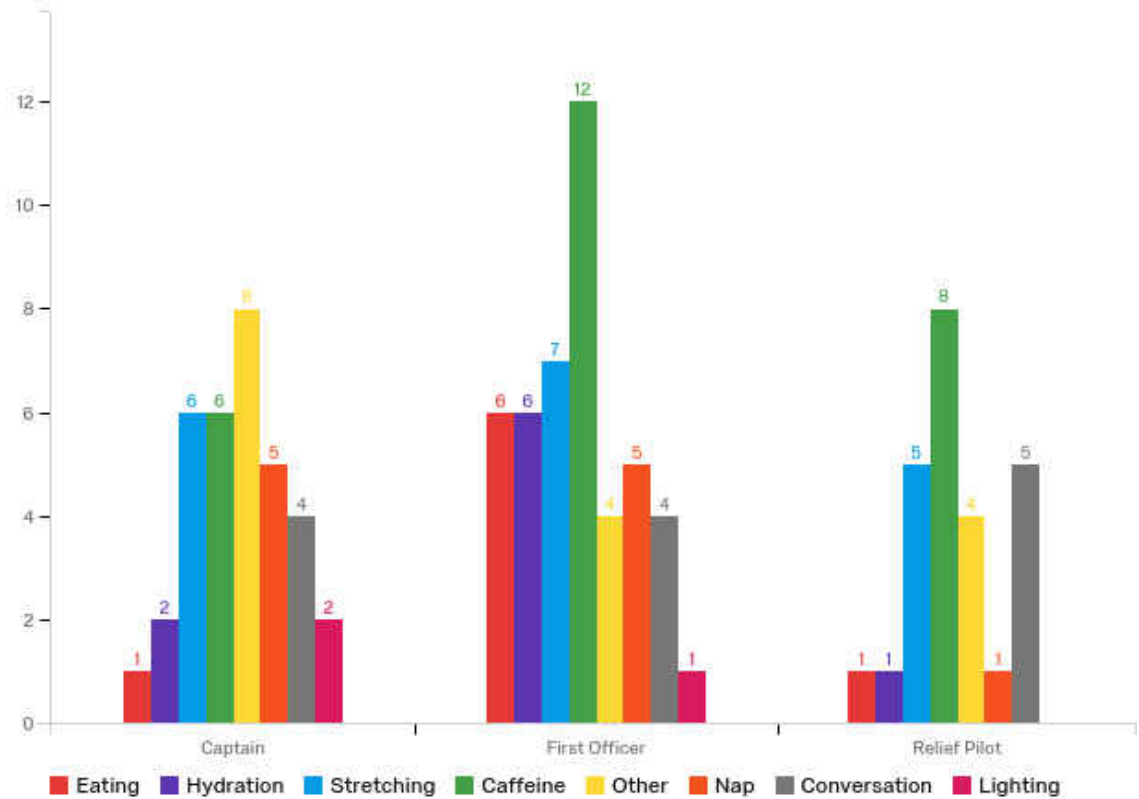


Figure 17. Bar Graph of Primary Themes vs Crew Position.

Favored fatigue mitigation strategies varied somewhat by Crew Position. For Captains, the most mentioned category was Other, while Stretching and Caffeine came in tied for second place. Nap came in at third, followed by Conversation at fourth, Lighting and Hydration tied for fifth, and Eating coming in last.

For First Officers, the most mentioned category was Caffeine while Stretching came in at second place. Eating and Hydration came in tied for third, followed by Nap at fourth, Other and Conversation tied for fifth, with Lighting coming in last.

For Relief Pilots, the most mentioned category was Caffeine, while Stretching and Conversation came in tied for second place. Other came in third, followed by Eating, Hydration, and Nap all tied at fourth.

Fatigue Mitigation Strategies by Augmentation

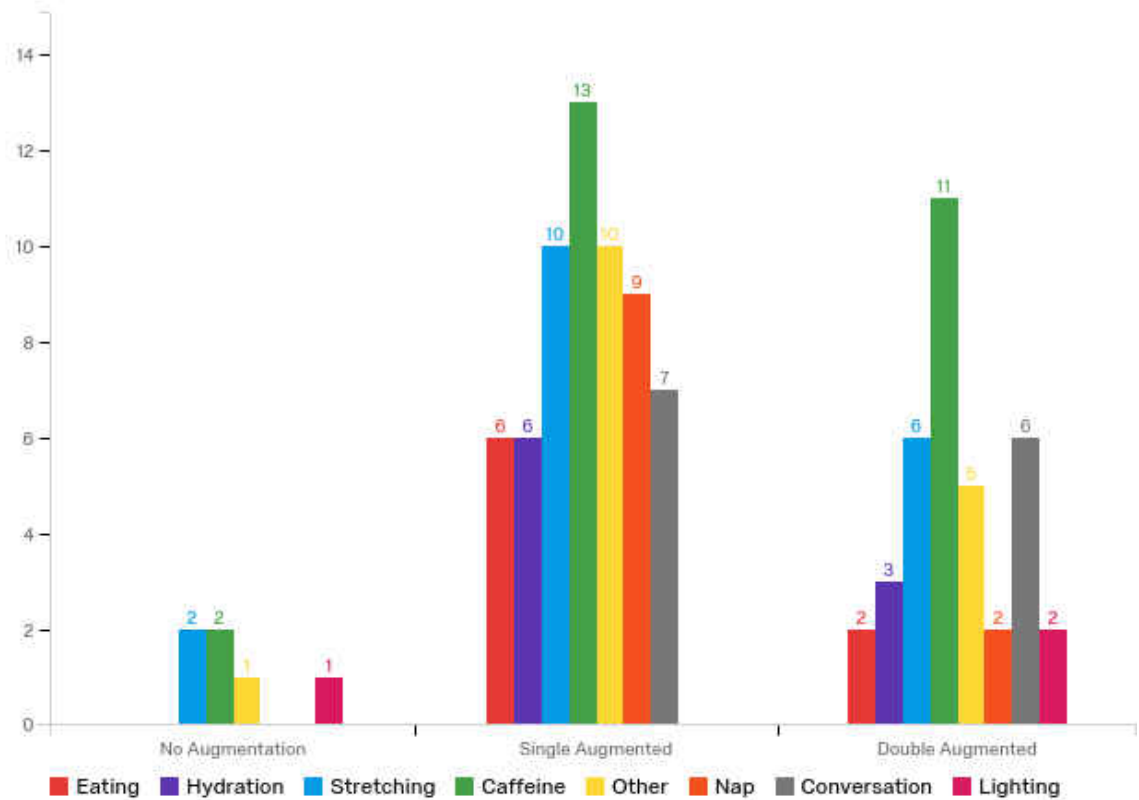


Figure 18. Bar Graph of Primary Themes vs Augmentation.

Favored fatigue mitigation strategies varied somewhat by levels of Augmentation. For flights with no augmentation, the most mentioned categories were Stretching and Caffeine, while Other and Lighting came in tied for second place. The remaining categories were not mentioned.

For single augmented, the most mentioned category was Caffeine while Stretching and Other came in tied at second place. Nap came in third, Conversation fourth, with Eating and Hydration coming in tied for last place.

For double augmentation, the most mentioned category was Caffeine, while Stretching and Conversation came in tied for second place. Other came in third, followed by Hydration coming in at fourth. Eating, Nap, and Lighting came in tied for last place.

Fatigue Mitigation Strategies by Commuting

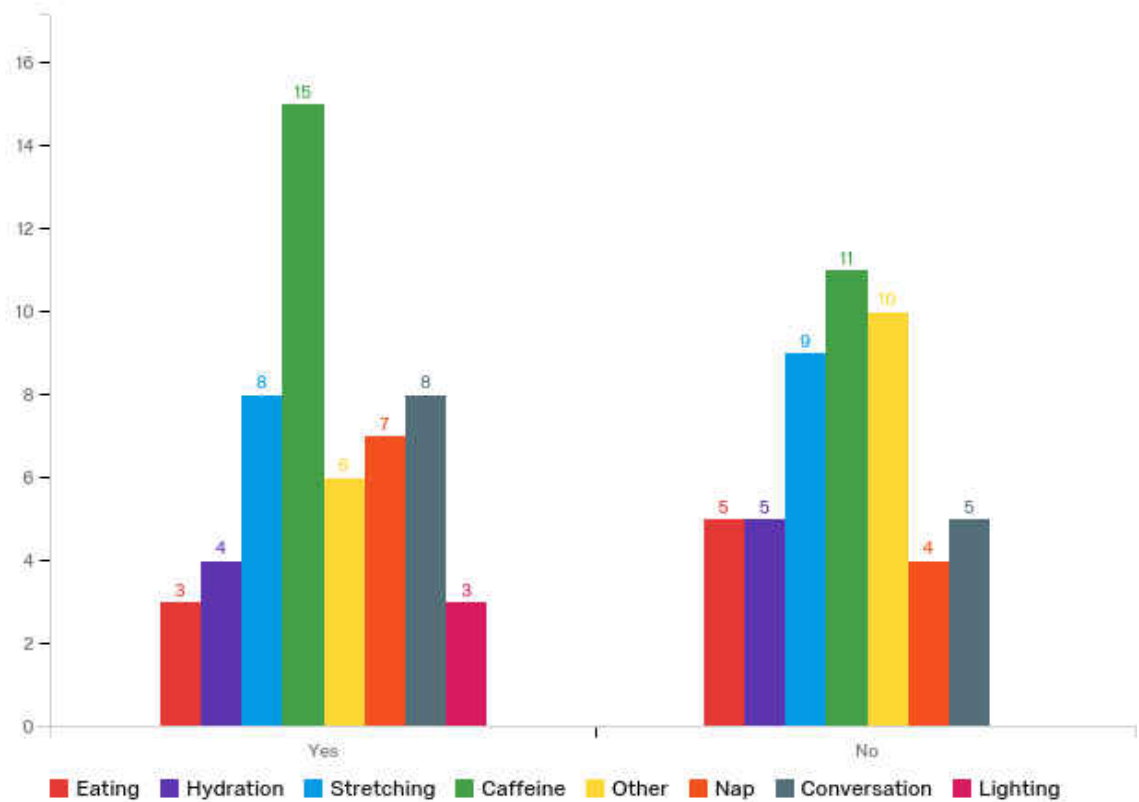


Figure 19. Bar Graph of Primary Themes vs Commuting.

Favored fatigue mitigation strategies varied somewhat by Commuting. For pilots commuting to work by air, Caffeine was the most mentioned category, while Stretching and Conversation came in tied for second place. Nap came in third, Other came in fourth, Hydration came in at fifth, while Eating and Lighting came in tied for last place.

For pilots not commuting to work by air, Caffeine was the most mentioned category, with Other coming in at second place. Stretching came in third, with Eating, Hydration, and Conversation coming in tied for fourth place. Nap came in last.

Fatigue Mitigation Strategies by Circadian Disruption

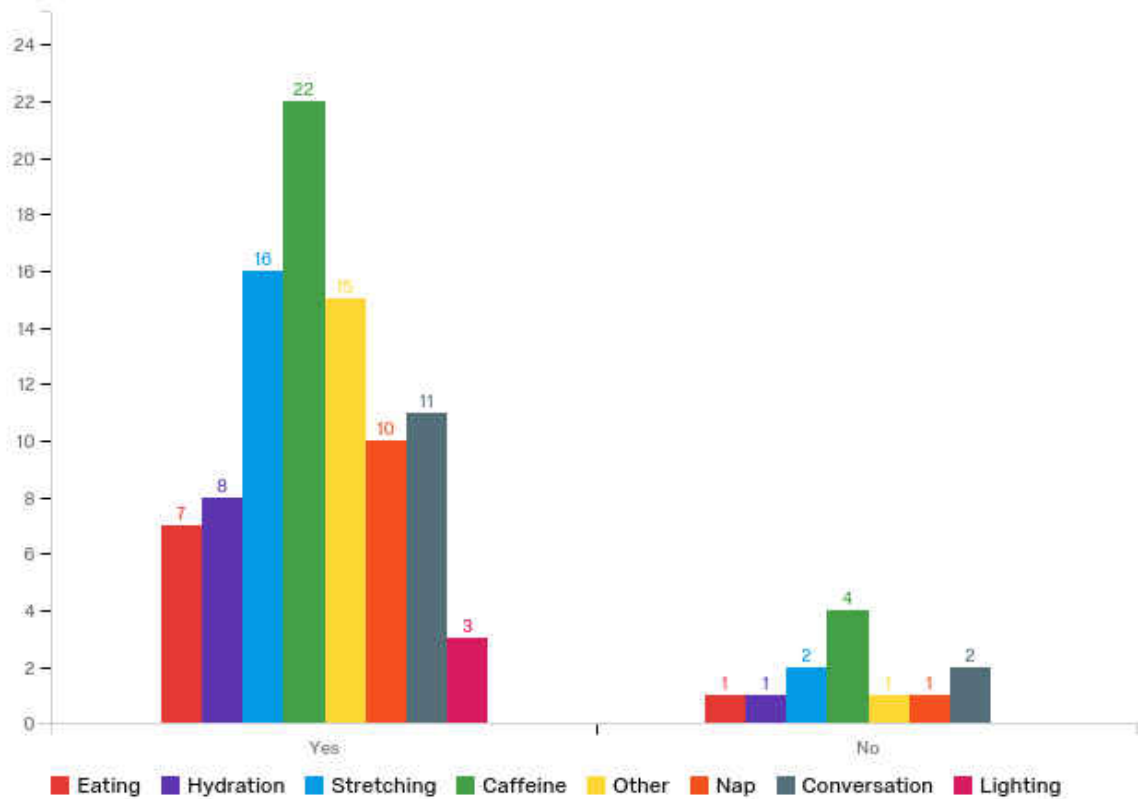


Figure 20. Bar Graph of Primary Themes vs Circadian Disruption.

Favored fatigue mitigation strategies varied somewhat by Circadian Disruption. For pilots who indicated that the flight segment overlapped their normal bedtime hours, Caffeine was the most mentioned category, while Stretching came in second and Other came in third

place. Conversation came in fourth, Nap came in at fifth, Hydration came in at sixth, Eating came in at seventh, and Lighting came in at last place.

For pilots who indicated that the flight segment did not overlap their normal bedtime hours, Caffeine was the most mentioned category, while Stretching came in at second place. Conversation came in third while Eating, Hydration, Other and Nap came in tied for last place.

Fatigue Mitigation Strategies by Scheduled Rest in Onboard Crew Rest Facility

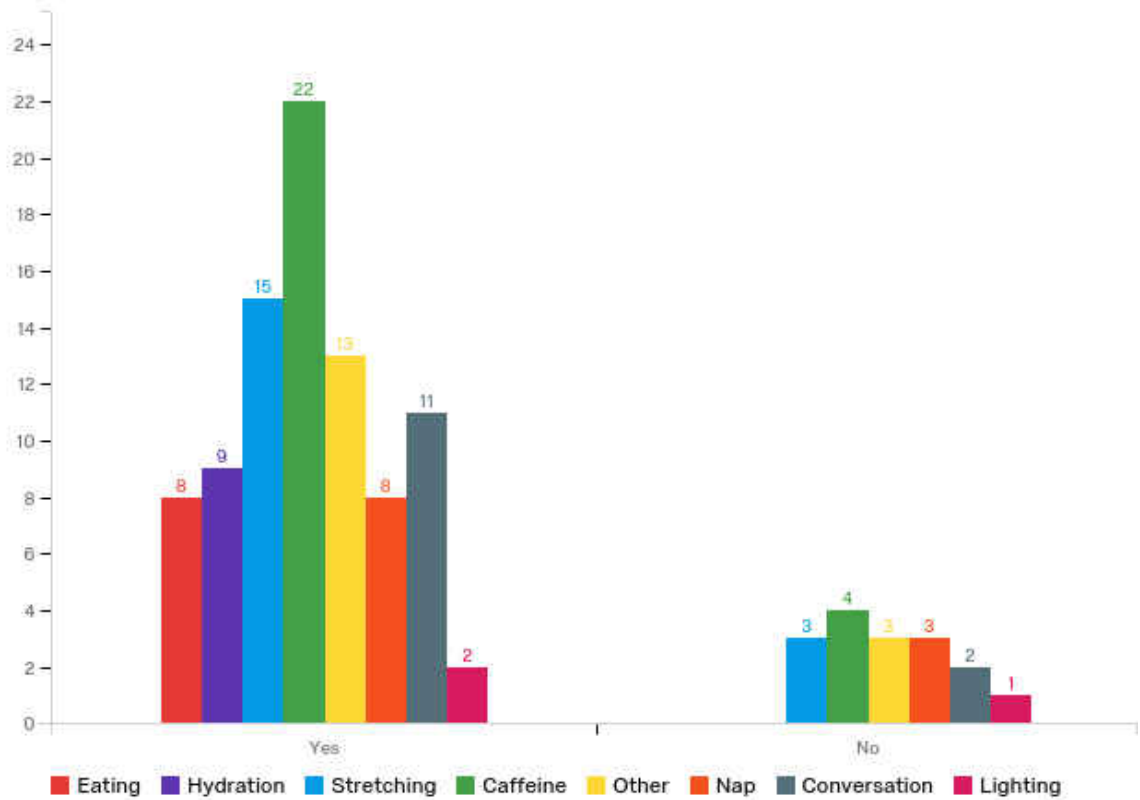


Figure 21. Bar Graph of Primary Themes vs Scheduled Rest in an Onboard Crew Rest Facility.

Favored fatigue mitigation strategies varied somewhat by assignment to En-route Rest in an Onboard Crew Rest Facility. For pilots scheduled for such rest, Caffeine was the most mentioned category, while Stretching came in second and Other came in at third place.

Conversation came in at fourth, Hydration came in at fifth, Nap and Eating came in tied at sixth, and Lighting came in at last place.

For pilots not scheduled for such rest, Caffeine was the most mentioned category, while Stretching, Other and Nap came in tied at second place. Conversation came in third with Lighting coming in at last place.

Fatigue Mitigation Strategies by Spontaneous Sleep Episodes

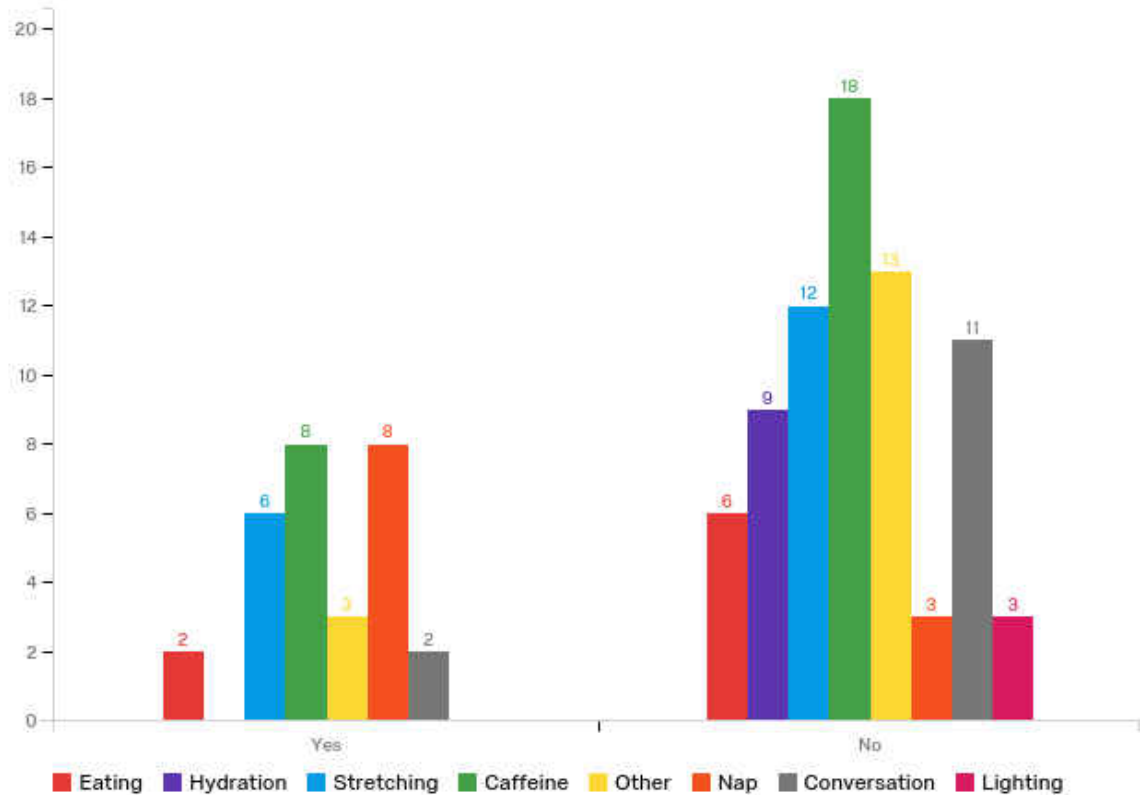


Figure 22. Bar Graph of Primary Themes vs Spontaneous Sleep Episodes.

Favored fatigue mitigation strategies varied somewhat by having experienced Spontaneous Sleep Episodes. For pilots experiencing spontaneous sleep episodes, Caffeine and Nap were the most mentioned category, while Stretching came in second and Other came in at third place. Eating and Conversation came in tied for last place.

For pilots not experiencing spontaneous sleep episodes, Caffeine was the most mentioned category, with Other coming in second and Stretching coming in at third place.

Conversation came in fourth, Hydration came in at fifth, and Eating came in at sixth place. Nap and Lighting came in tied at last place. Lighting was not mentioned.

Fatigue Mitigation Strategies by Fatigue State at Report Time

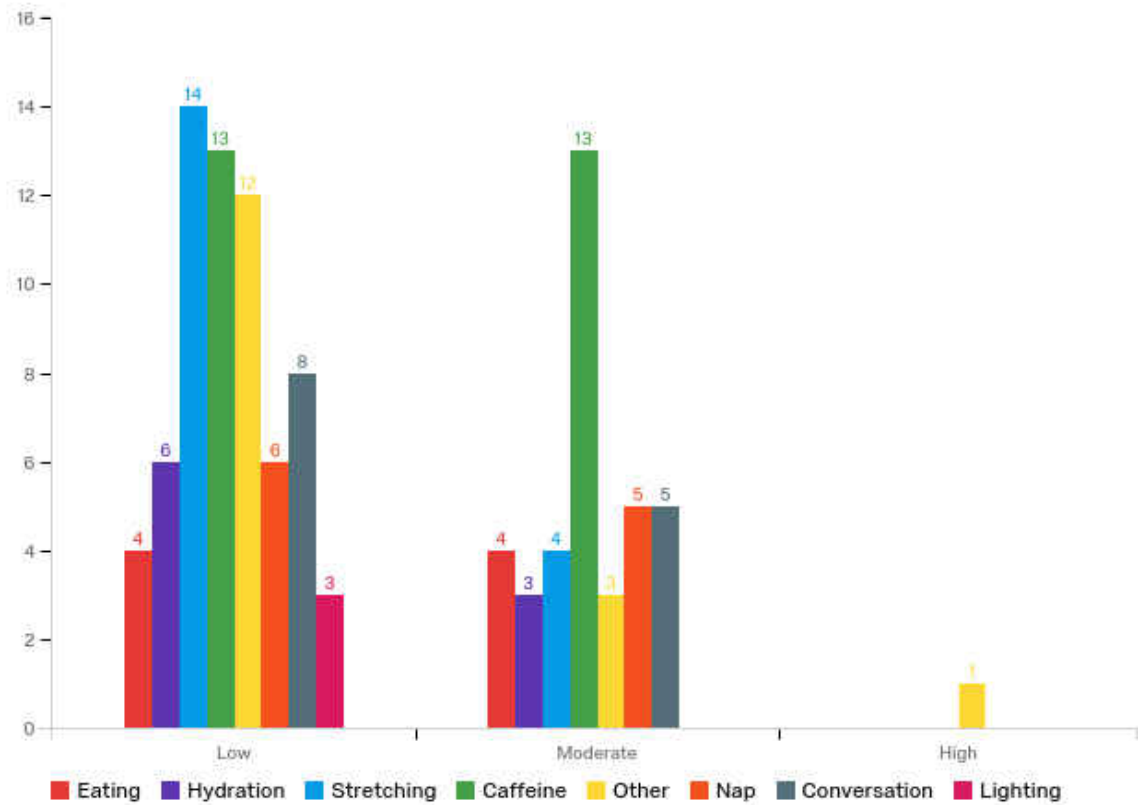


Figure 23. Bar Graph of Primary Themes vs Fatigue State at Report Time.

Favored fatigue mitigation strategies varied somewhat by Fatigue States at Report Time. For pilots reporting for duty with low fatigue, the most mentioned category was Stretching, with Caffeine coming in second and Other coming in third place. Conversation came in fourth, Hydration and Nap came in tied for fifth, Eating came in sixth and Lighting came in at last place.

For pilots reporting for duty with moderate fatigue, the most mentioned category was Caffeine while Conversation and Nap came in tied at second place. Eating and Stretching

came in third, and Hydration and Other came in tied for last place. Lighting was not mentioned

For the one pilot reporting for duty with high fatigue, Other was the only category mentioned.

Fatigue Mitigation Strategies by Fatigue State prior to Napping

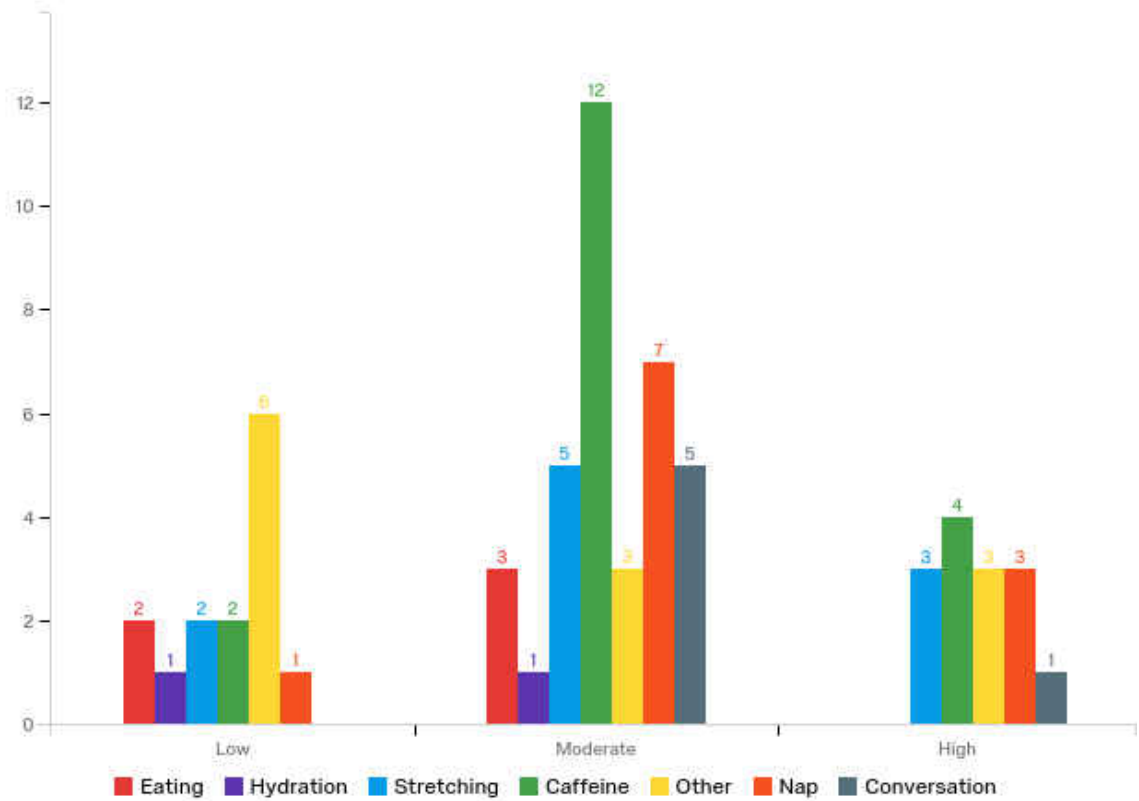


Figure 24. Bar Graph of Primary Themes vs Fatigue State Prior to Napping.

Favored fatigue mitigation strategies varied somewhat by Fatigue States prior to Napping. For pilots reporting low fatigue prior to napping, the most mentioned category was Other, with Eating, Stretching, and Caffeine coming in tied at second place. Hydration and Nap came in tied for third place. Conversation and Lighting were not mentioned.

For pilots reporting moderate fatigue prior to napping, the most mentioned category was Caffeine while Nap came in at second place. Stretching and Conversation came in tied for

third with Eating and Other coming in tied for fourth place. Hydration came in last. Lighting was not mentioned.

For pilots reporting high fatigue prior to napping, the most mentioned category was Caffeine while Stretching, Other, and Nap came in tied at second place. Conversation came in last and the remaining categories were not mentioned.

Fatigue Mitigation Strategies by Fatigue State after Napping

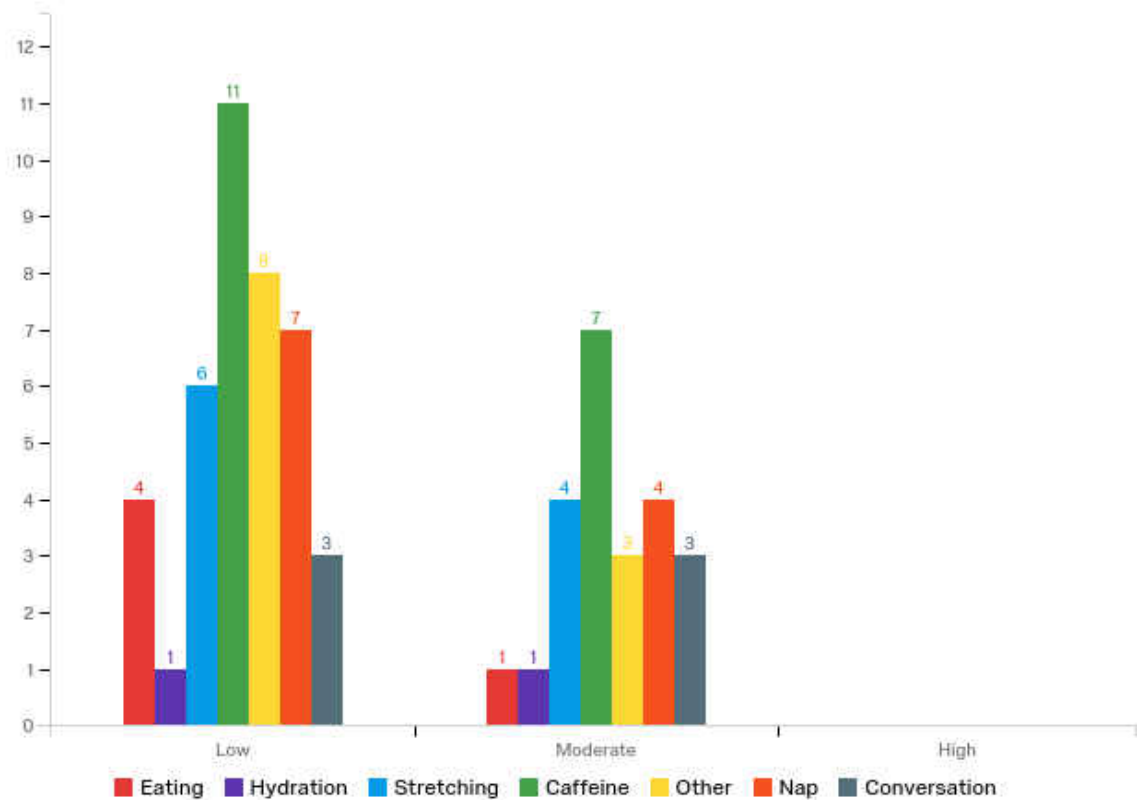


Figure 25. Bar Graph of Primary Themes vs Fatigue State after Napping.

Favored fatigue mitigation strategies varied somewhat by Fatigue States after Napping. For pilots reporting low fatigue after napping, the most mentioned category was Caffeine, with Other coming in second and Nap coming in at third place. Stretching came in fourth, followed by Eating at fifth and Conversation at sixth place. Hydration came in at last place. Lighting was not mentioned.

For pilots reporting moderate fatigue after napping, the most mentioned category was Caffeine while Stretching and Nap came in tied at second place. Other and Conversation came in tied for third place, and Eating and Hydration came in tied for fourth place. Lighting was not mentioned.

No pilots reported a high fatigue state after napping.

Research Question (1) Analysis

Research Question one (1) asked: To what extent is self-assessed maximum fatigue state prior to napping, as reported by commercial airline pilots flying international route segments, affected by crew position, prior flights flown during the same duty period, single or double augmentation, commuting, amount of sleep obtained in the previous 24 hour period, self-assessed rested state when reporting for duty, flying during normal bedtime hours, the availability of scheduled en-route rest periods in an onboard crew rest facility, and / or experiencing spontaneous sleep episodes(s)?

Table 16 depicts the results of a univariate analysis of variance test performed utilizing the Modified Data Set. This test looks at the relationships between Max Self-Assessed Fatigue State Prior to Napping (FLTFT), vs the other common factors present during commercial international flight operations as outlined in Research Question #1. Test results indicated that there were significant relationships between FLTFT and Augmentation (AUGMT), $F(2, 55) = 4.651, p = .014$, between FLTFT and Self-Assessed Fatigue State when Reporting to Duty (REST), $F(2, 55) = 4.563, p = .014$, between FLTFT and Assigned En-Route Rest in an Onboard Crew Rest Facility (FACLT), $F(1, 55) = 4.538, p = .038$, and between FLTFT and Spontaneous Sleep Episodes (SPONT), $F(1, 55) = 23.968, p = .000$. The relationships between FLTFT and the other tested variables were not statistically significant, ($p < .05$), and are not reported here.

Table 16. Univariate Analysis of Variance Test for Research Question #1.

Tests of Between-Subjects Effects

Dependent Variable: FLTFI

Independent Variables	<i>df</i>	F	<i>n</i>	<i>p</i>
POSIT	2	.720	79	.491
SEGMS	1	1.662	79	.203
AUGMT	2	4.651	79	.014*
COMUT	1	3.134	79	.082
SLEEP	12	.829	79	.621
REST	2	4.563	79	.015*
CIRCD	1	.120	79	.730
FACLI	1	4.538	79	.038*
SPONT	1	23.968	79	.000**

* $p < .05$, ** $p < .01$

Means Plot

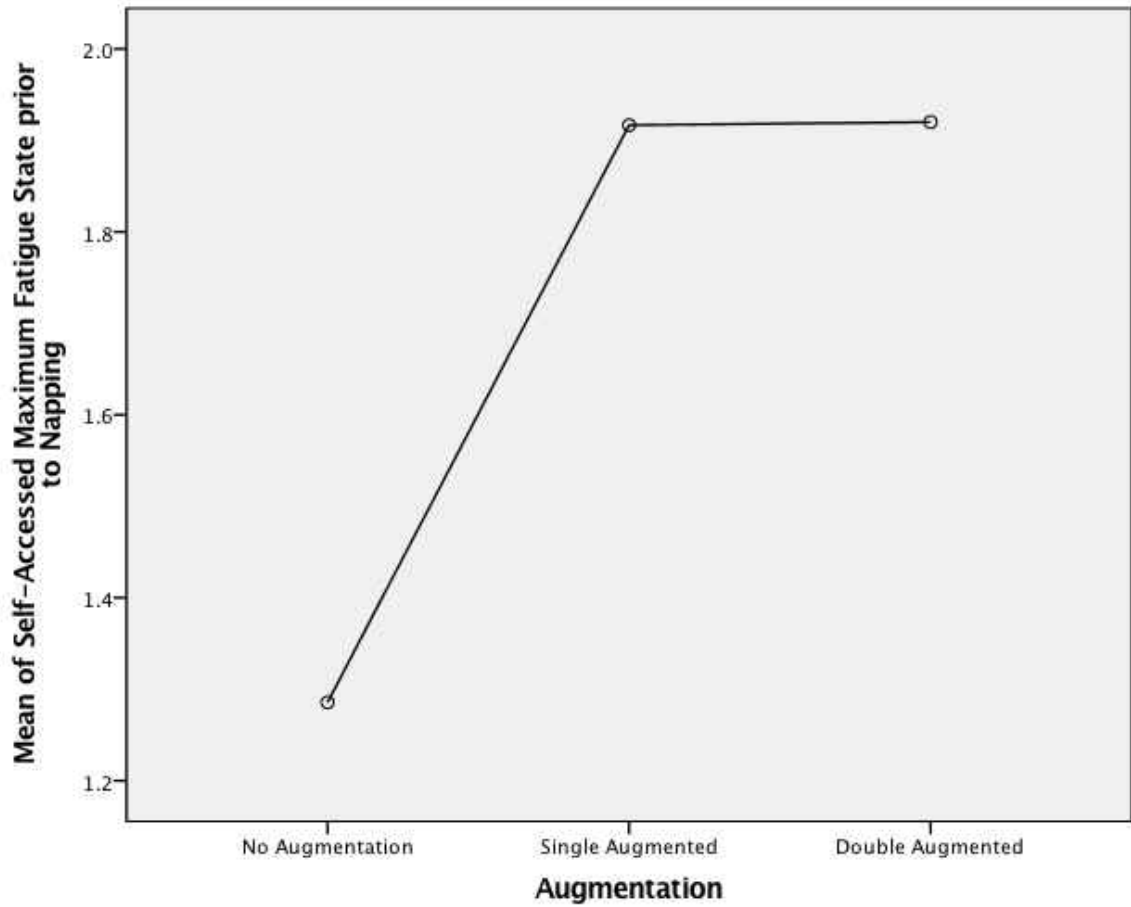


Figure 26. Means Plot FLTFT vs AUGMT.

Figure 26 depicts the relationship between FLTFT and AUGMT. The level of Self-Accessed Fatigue State prior to Napping increases with higher levels of Augmentation.

Means Plot

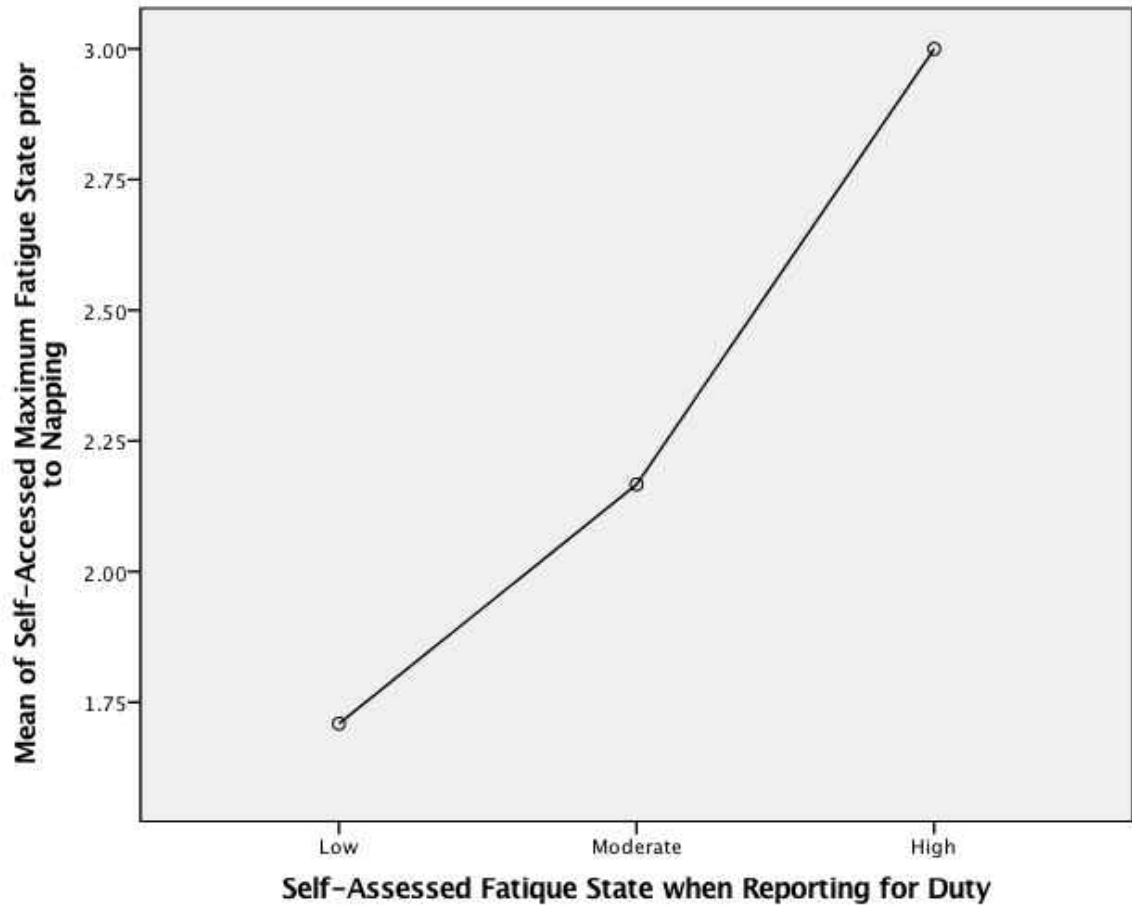


Figure 27. Means Plot FLTFT vs REST.

Figure 27 depicts the relationship between FLTFT and REST. The level of Self-Accessed Fatigue State prior to Napping increases with higher levels of Self-Accessed Fatigue State when Reporting for Duty.

Means Plot

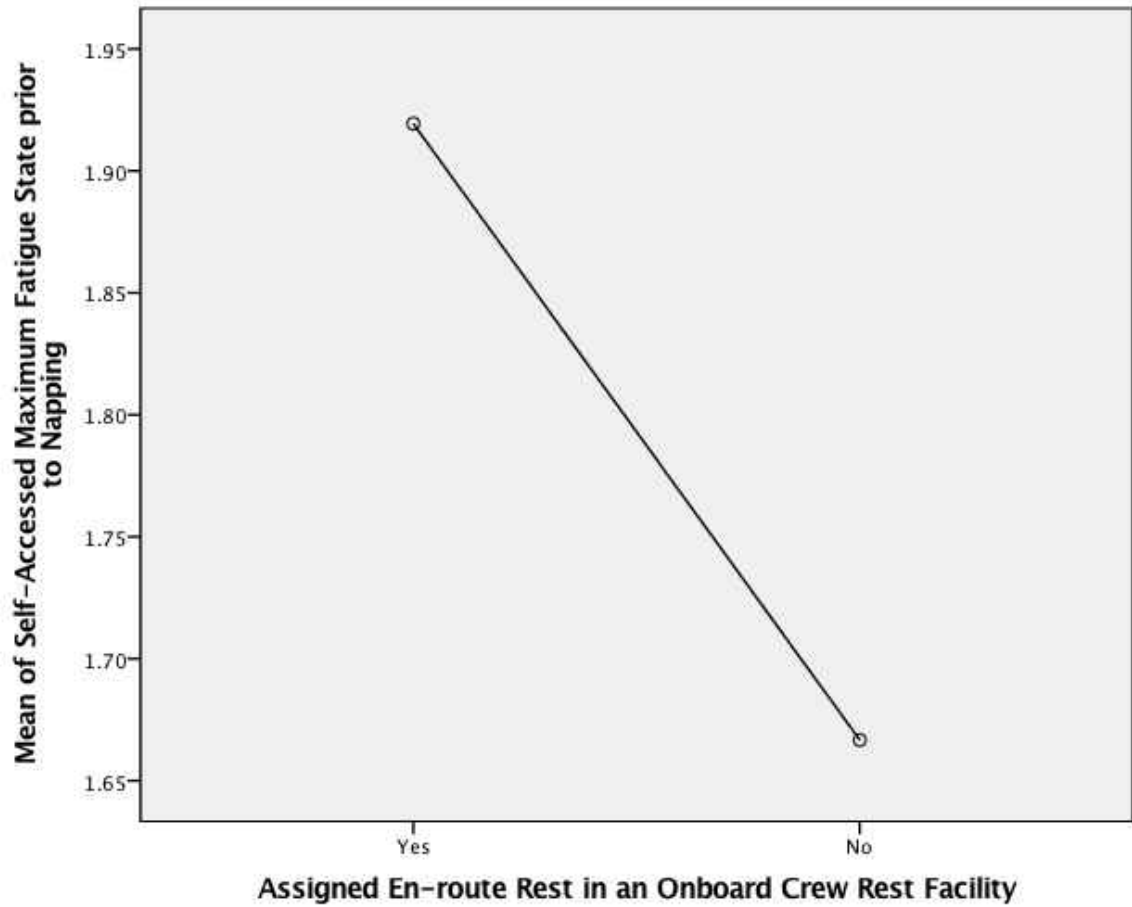


Figure 28. Means Plot FLTFT vs FACLT.

Figure 28 depicts the relationship between FLTFT and FACLT. The level of Self-Accessed Fatigue State prior to Napping increases if Assigned En-Route Rest in an Onboard Crew Rest Facility.

Means Plot

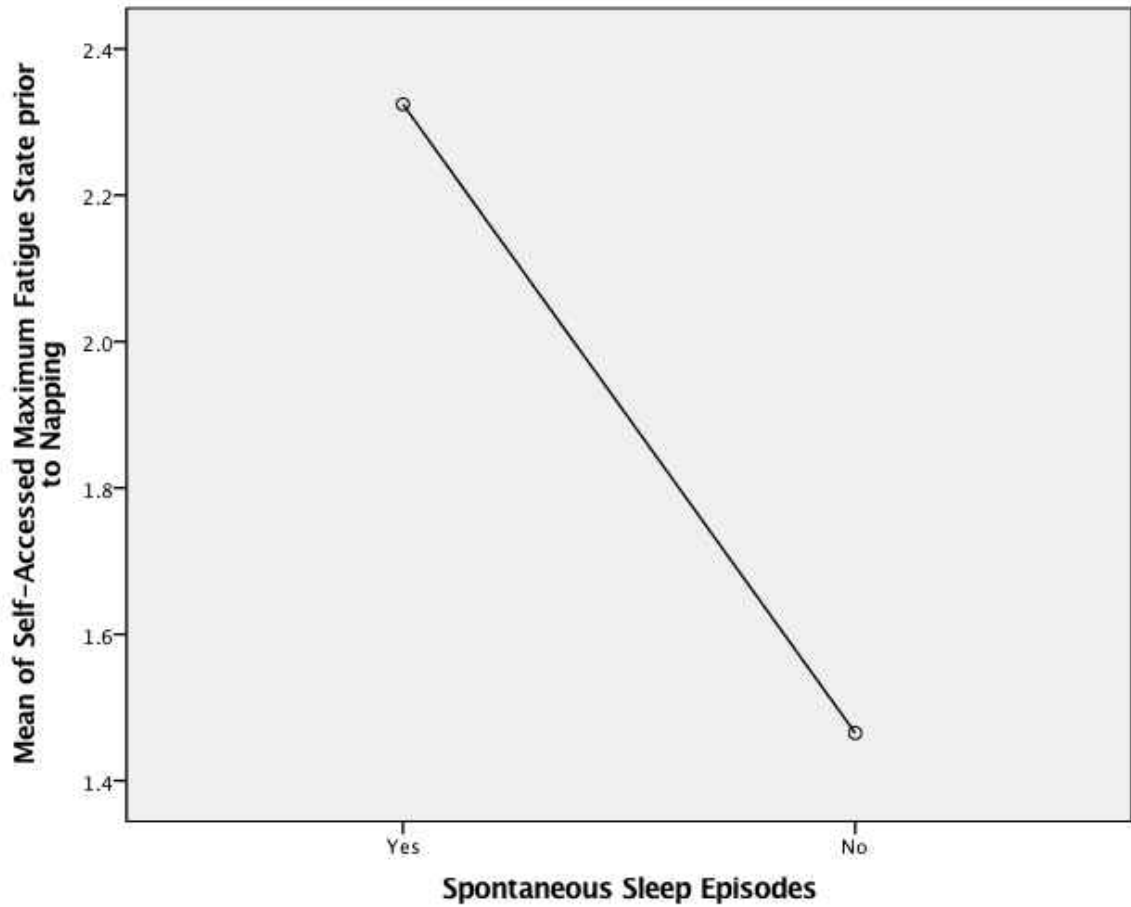


Figure 29. Means Plot FLTFT vs SPONT.

Figure 29 depicts the relationship between FLTFT and SPONT. The level of Self-Accessed Fatigue State prior to Napping increases with having experienced Spontaneous Sleep Episodes.

Research Question (2) Analysis

Research Question two (2) asked: Does the availability of scheduled en-route rest opportunities, in an onboard crew rest facility, affect the usage of en-route napping, as a

fatigue mitigation strategy, as self-assessed by commercial airline pilots flying international route segments?

Table 17 depicts the results of an independent samples T-test performed utilizing the Modified Data Set. This test looks at the relationship between Pilot Reported some Naptime (NAPPY) and Assigned En-Route Rest in an Onboard Crew Rest Facility (FACLT).

Test results from the T-Test indicated that there was not a significant relationship ($p < .05$) between NAPPY and FACLT.

Table 17. Independent Samples T-Test for Research Question #2.

Dependent Variable: NAPPY

Independent Variable	FACLT	<i>n</i>	Mean	<i>SD</i>	<i>t</i>	<i>p</i>
FACLT	Yes	102	1.74	.242	.117	.907
	No	29	1.72	.254		

* $p < .05$

Research Question (3) Analysis

Research Question three (3) asked: Does the duration of en-route napping affect the fatigue mitigation benefits of en-route napping, as self-assessed by commercial airline pilots flying international route segments?

Table 18 depicts the results of a Linear Regression Test with ANOVA performed utilizing the Modified Data Set. These tests looked at the relationship between Self-Assessed Maximum Fatigue State after Napping (NAPBN) and Minutes spent Napping during the Flight (NAPTM).

Test results from the Linear Regression Test indicated that there was not a significant relationship ($p < .05$) between NAPBN and NAPTM.

Test results from the ANOVA Test indicated that there was not a significant relationship ($p < .05$) between NAPBN and NAPTM.

Table 18. Linear Regression with Analysis of Variance Test for Research Question #3.

Dependent Variable: NAPBN

Coefficients

Independent Variables	<i>B</i>	<i>SE</i>	<i>N</i>	<i>t</i>	<i>p</i>
NAPTM	.012	.008	131	1.474	.150

* $p < .05$

ANOVA

Independent Variables	<i>df</i>	<i>F</i>	<i>N</i>	<i>p</i>
NAPTM	1	2.172	131	.150

* $p < .05$

Table 19 depicts the results of a Pearson's R Correlation Test performed utilizing the Modified Data Set. This test looked at the relationships between NAPTM, NAPBN, FLTFT, and Self-Assessed Maximum Fatigue State after Napping (NAPFT). Test results from the Pearson's R Correlation Test also indicated that there was no significant Correlation ($p < .05$) between NAPBN and NAPTM. There were significant correlations between FLTFT and NAPFT, $r(35) = .518, p < .01$, and between FLTFT and NAPBN, $r(35) = .754, p < .01$.

Table 19. Pearson's R Correlation Test for Research Question #3.

Dependent Variables: NAPTM, NAPFT, FLTFT, and NAPBN

Independent Variables		NAPTM	NAPFT	FLTFT	NAPBN
NAPTM	Pearson Correlation	1	.104	.325	.249
	Sig. (2-tailed)	–	.553	.057	.150
	<i>N</i>	35	35	35	35
NAPFT	Pearson Correlation	.104	1	.518**	-.172
	Sig. (2-tailed)	.553	–	.000	.136
	<i>N</i>	35	78	77	77
FLTFT	Pearson Correlation	.325	.518**	1	.754**
	Sig. (2-tailed)	.057	.000	–	.000
	<i>N</i>	35	77	80	77
NAPBN	Pearson Correlation	.249	-.172	.754**	1
	Sig. (2-tailed)	.150	.136	.000	–
	<i>N</i>	131	131	77	77

* $p < .05$, ** $p < .01$

Means Plot

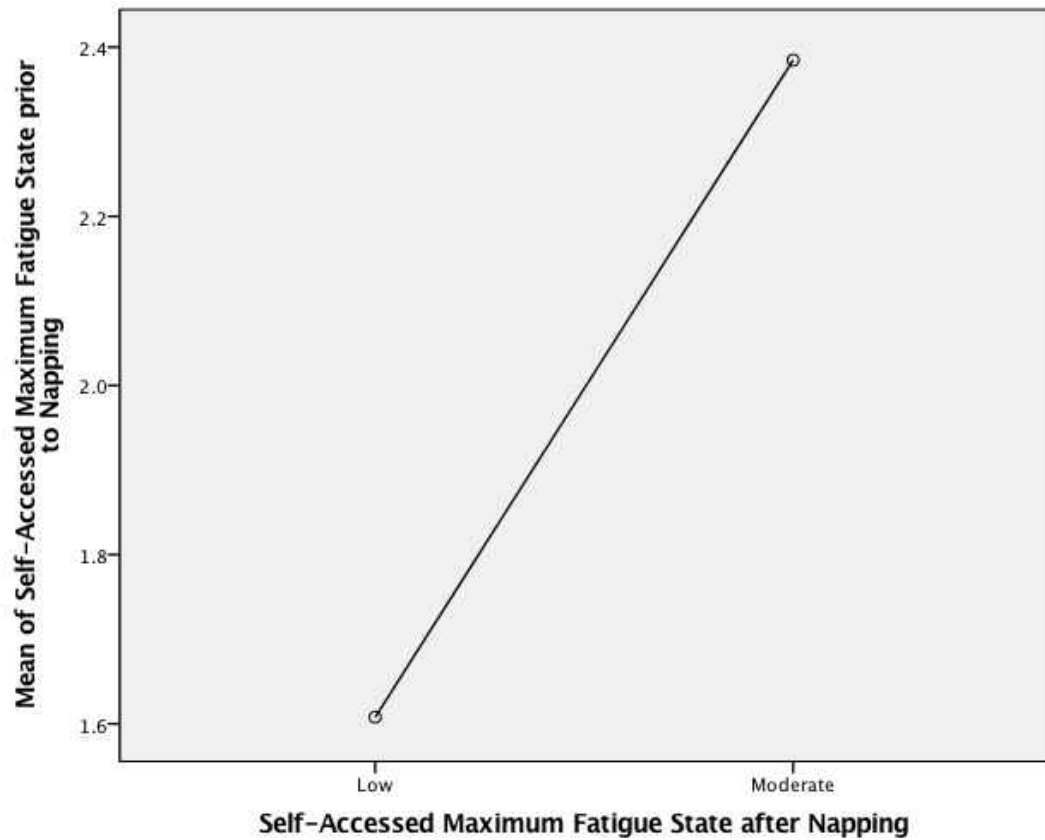


Figure 30. Means Plot FLTFT vs NAPFT.

Figure 30 depicts the relationship between FLTFT and NAPFT. The level of Self-Accessed Fatigue State after Napping increases with higher levels of Self-Accessed Fatigue State prior to Napping.

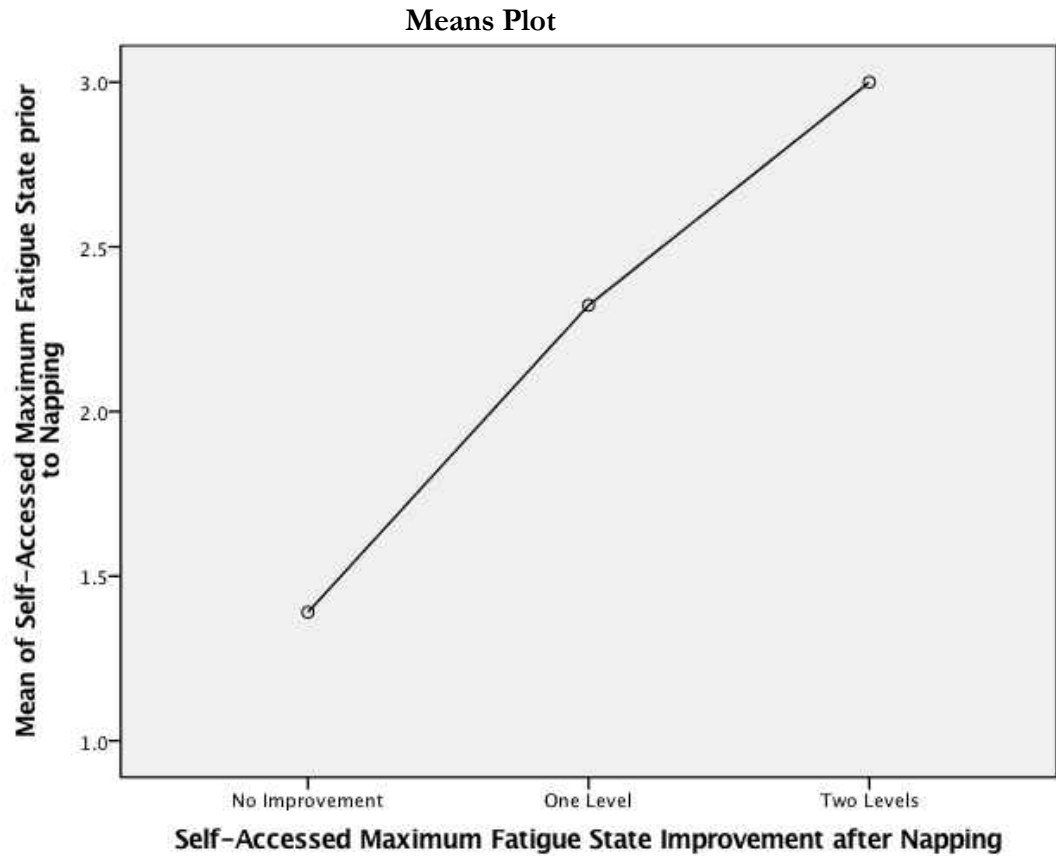


Figure 31. Means Plot FLTFT vs NAPBN.

Figure 31 depicts the relationship between FLTFT and NAPBN. The level of Self-Accessed Fatigue State Improvement after Napping increases with higher levels of Self-Accessed Fatigue State prior to Napping

CHAPTER IV

DISCUSSION

Introduction

The current state of the aviation regulatory process is a living, breathing example of the difficulties involved in modernizing pilot flight and duty time regulations so that they fully incorporate and take advantage of the latest advancements in our understanding of human factors, especially in important areas of knowledge such as the role that fatigue plays in the safe operation of aircraft. While it is widely recognized that fatigue, and the deleterious effects it can have on human performance, represents a serious threat to the safe operation of aircraft, proper training to recognize fatigue states and deployment of effective countermeasures to combat fatigue are areas where there is room for further improvements. A permissive regulatory environment that supports and promotes the best science based practices available to combat fatigue is an essential element if real progress is to be made in this area. FAR 117 has opened a window of opportunity for air-carriers to develop and obtain FAA approval for FRMS programs that can incorporate what we have learned about effective fatigue countermeasures in an aviation environment. Studies like this one, and others that hopefully will follow, can provide valuable insights into how such FRMS programs should be designed and implemented. These programs should incorporate best practices that are designed to achieve a higher level of safety, not only for aviation professionals who operate and work in the national aerospace system, but also for the traveling public that relies on these professionals to maintain and insure the highest levels of aviation safety.

Primary Research Findings

The Survey Tool used to solicit responses from the target population of commercial airline pilot flying international flight segments provided a wealth of data to work with for this research project. Both IBS SPSS version 24 software and the statistics and graphic engine built into the Qualtrics Survey Tool website were used to produce the graphics and statistical analysis used in the report. Two (2) datasets were utilized in producing the charts, graphs, and tables contained herein. The Raw Dataset ($N=132$) contained every survey question response from every survey participant exactly as those responses were entered into the Survey Tool and was used to generate Tables (3) through (15) and Figures (2) through (25). The Modified Dataset, with the data conventions outlined in Table (2) applied, was used to perform the statistical analysis for Research Questions (1) through (3) utilizing IBM SPSS analysis software to perform the required statistical tests and to generate the output contained in Tables (16) through (19)

Research Question (1) sought to investigate to what extent the self-accessed maximum fatigue state prior to napping of commercial airline pilots flying international route segments is affected by a number of operational metrics and conditions that these commercial airline pilots are commonly exposed to or coping with in the normal conduct of their profession. Results were reported as significant where $p < .05$. A univariate analysis of variance test was used to investigate these relationships.

A significant relationship was reported between FLTFT and AUGMT $F(2, 55) = 4.651, p = .014$. Pilots working single or double augmented flights reported being more fatigued prior to napping than pilots working flights with no augmentation did.

A significant relationship was reported between FLTFT and REST $F(2, 55) = 4.563, p = .015$. Pilots that reported lower fatigue states when reporting for duty tended to report lower maximum fatigue states prior to napping as well.

A significant relationship was reported between FLTFT and FACLT $F(1, 55) = 4.538, p = .038$. Pilots that reported being assigned en-route rest in an onboard crew rest facility tended to report higher maximum fatigue states prior to napping than pilots who were not assigned en-route rest in an onboard crew rest facility.

A significant relationship was reported between FLTFT and SPONT $F(1, 55) = 23.968, p = .000$. Pilots that reported experiencing spontaneous sleep episodes reported higher maximum fatigue states prior to napping than pilots who did not report experiencing spontaneous sleep episodes.

Research Question (2) sought to investigate to what extent the availability of scheduled en-route rest opportunities, in an onboard crew rest facility, affect the usage of en-route napping, as a fatigue mitigation strategy, as self-assessed by commercial airline pilots flying international route segments? Results were reported as significant where $p < .05$. An independent samples T-Test was used to investigate this relationship. No significant relationship was reported between NAPPY and FLTFT.

Research Question (3) sought to investigate to what extent does the duration of en-route napping affect the fatigue mitigation benefits of en-route napping, as self-assessed by commercial airline pilots flying international route segments? Results were reported as significant where $p < .05$. A linear regression test with ANOVA and a Pearson's R correlation test was used to investigate these relationships.

No significant relationship was reported between self-accessed fatigue state improvement after napping (NAPBN) and minutes spent napping during the flight (NAPTM).

A significant relationship was reported between self-accessed maximum fatigue state after napping (NAPFT) and FLTFT $r(35) = .518, p < .01$. Pilots that reported higher fatigue state levels prior to napping also reported higher fatigue state levels after napping.

A significant relationship was also reported between NAPBN and FLTFT $r(35) = .754, p < .01$. Pilots that reported higher fatigue state levels prior to napping also reported higher fatigue state improvement after napping.

Secondary Research Findings

The primary goal of this study was to answer the research questions that were posed and the data presented herein accomplishes that goal. Beyond that, the data provides a window into the operational lives of commercial airline pilots flying international routes and provides valuable insights into how they are coping with a variety of common factors that can affect how well they feel and how well they perform their duties in the complex and physiologically challenging environment that they work in.

Napping is being used as an effective tool in the pilot's fatigue mitigation strategy tool kit. Thirty-five ($n=35$) reported valid naptimes in accordance with the data conventions utilized for the Modified Dataset as outlined in Table (2). While thirty-five survey participants out of the study population of one hundred and thirty-one ($N=131$) is a substantial minority of the survey participants, this number does not tell the entire story. A review of the Raw Dataset reveals that a total of Ninety-seven ($n=97$) survey participants gave an answer to survey question 11 which asked how many minutes did you nap during the flight. A large number of these survey participants ($n=53$) gave an answer of zero (0) minutes to this question. What makes this even more interesting is looking at this in the context of answers provided to some of the other survey questions. For example, eighty-one ($n=81$) survey participants rated their fatigue state prior to napping and seventy-eight ($n=78$) survey

participants rated their fatigue state after napping. This would seem to suggest that at least some of the survey participants who did not report valid naptimes for the Modified Dataset may have taken naps during the reported flight segments. It is also interesting to note that thirty-eight ($n=38$) survey participants answered yes to the survey question asking if they had experienced any unplanned spontaneous sleep episodes during the flight. This too tends to support the notion that more than thirty-five (35) survey participants actually took naps.

Also of note, there was another smaller subgroup of survey participants ($n=9$) that reported naptimes that were considered invalid. For this subgroup, reported naptimes of (60 – 180 minutes) exceeded the valid naptime range of the Modified Dataset (1 - 59 minutes). A closer examination of the Raw Dataset reveals that one hundred and two ($n=102$) of the survey participants answered yes to a question that asked if they had been assigned a scheduled rest period in a private crew rest facility (bunks) on board their flight while one hundred and fourteen ($n=114$) of the survey participants reported that their flight was augmented, a difference of eight (12) cases. Since all augmented flights have scheduled rest periods in an onboard crew rest facility, it is plausible that some or all of the survey participants of this subgroup were actually reporting time slept during their scheduled rest break in a designated onboard crew rest facility, a cabin seat in this instance (not a bunk), as not all aircraft are equipped with crew rest bunks. This would corroborate real world experience which suggests that it is unlikely naps in this duration range are taking place. Accordingly, these nine (9) responses were categorized as SLEPTM as reported in the Modified Dataset.

Another interesting way of looking at the data was to generate fatigue mitigation strategies themes from comments reported by the survey participants in their answers to survey question #14 and then compare those themes to survey participant answers to some of the other survey questions. Figure 16 shows the eight (8) fatigue mitigation strategy themes

that were derived from survey participant comments. Napping came in ranked fifth out eighth overall. Figures 17 through 25 graphically illustrate the relationships of fatigue mitigation strategy themes with other reported study metrics.

Captains and First Officers both ranked napping higher than Relief Pilots. This may be due to the fact that in a typical long range flight operation, the Captain and First Officer start out flying and continue at their duty stations for an extended period of time while the Relief Pilot or Pilots begin their scheduled crew rest period shortly after takeoff.

Napping was also ranked higher on single augmentation flights vs double augmentation flights. This may be due to the fact that the rest breaks on single augmentation flights tend to be shorter since you are dividing the available rest time three ways instead of dividing it two ways when there is double augmentation.

Commuting pilots ranked napping higher than non-commuting pilots. This may be due to the fact that often commuting pilots must start their work day earlier than non-commuting pilots so they can travel by air to the departure point of their duty assignment. This time spent commuting is not counted towards duty time and rest requirements, nonetheless, it can and does contribute to higher levels of fatigue.

Pilots reporting a higher level of fatigue when reporting for duty also ranked napping higher than pilots reporting a lower level of fatigue at report time. Along these same lines, pilots reporting a higher fatigue state prior to napping also ranked napping higher than pilots who reported a lower fatigue state prior to napping.

Not surprisingly Pilots experiencing spontaneous sleep episodes, which were reported by 28.79% of the survey participants, ranked napping as their #1 fatigue mitigation strategy. At least for this subset of pilots, once one starts nodding off, after having employed a number

of other fatigue countermeasures no doubt, a brief restorative nap may become the only fatigue countermeasure that is effective.

It is notable that strategic napping, in an aviation setting, is not currently sanctioned by some regulatory authorities and this fact alone may contribute to the underreporting of its use as part of an effective fatigue mitigation strategy. That so many pilots have reported napping while operating international flight segments, which were the subject of this research study, makes for a compelling narrative that strategic napping, as a fatigue countermeasure, is considered by some long haul commercial airline pilots to be an essential part of their fatigue mitigation tool kit. No doubt this finding speaks to the physiologically challenging operating environment that these pilots work in and the limitations of human physiology in coping with this environment without the use of restorative rest in the form of a strategic nap when deemed prudent and necessary.

Further Study

The data collected in this research study opens a window into the operating world of commercial airline pilots operating international route segments. While the focus of this research has been to look at fatigue mitigation strategies in use by these pilots and in particular, the use of en-route strategic napping as an effective fatigue countermeasure, the data offers a number of entry points for follow on research to expand on and further explore how best to define, develop, test, and implement fatigue mitigation strategies that can be employed effectively by individual pilots to suit their individual needs and circumstances. Every pilot is different and every flight operation is different. A one size fits all approach simple won't do and further studies can focus on additional conditions and variations of circumstances and how these variables interact to affect the fatigue states pilots experience. There clearly is a

need to qualify and quantify what fatigue mitigation strategy or strategies work best under a variety of conditions and how individual pilots can best self-assess what works best for them.

Conclusion

Effective fatigue mitigation in aviation is a subject that should matter to everyone who utilizes our national aerospace system. Regulatory bodies are beginning to take steps to overcome old taboos and to bring what has been learned in the area of fatigue science into the regulatory framework. Rather than taking a one size fits all approach to combating fatigue, the International Civil Aeronautics Organization (ICAO 2011) and the FAA (FAA 2010-2) have both shown interest in allowing air carriers to develop their own fatigue management strategies with the hope of achieving benefits in both safety and organizational efficiency. To fully realize potential benefits from this apparent shift in regulatory philosophy, better tools and strategies for defining, measuring, and coping with pilot fatigue need to be developed. Such tools and strategies may incorporate innovative and individualized fatigue mitigation techniques such as variable rest breaks, supervised naps while on duty, innovative fatigue self-assessment tools, and a full range of effective fatigue countermeasures. This change in regulatory philosophy provides a framework within which all major stakeholders in the aviation safety debate may achieve benefits such as lowered operating costs, lower accident and incident rates, and higher dispatch reliability. Insuring, on an individual basis, that pilots are at their cognitive best during all phases of flight, especially the high workload departure and arrival phases, has been proven to be essential as these phases of flight have been shown to have the greatest accident risks (NTSB 1999-2008). Providing pilots flying long-range international flight segments with the effective fatigue management tools they need is essential if progress is to be made in this arena.

The FAA has taken an important first step with the implementation of FAR Part 117 and its more science based approach to scheduling practices and required rest requirements for air-carrier pilots operating under FAR Part 121. Air-carriers now have a mechanism through which they can devise, seek approval, and then implement their own FRMS programs within the framework of FAR 117. Such FRMS programs may contain features and fatigue mitigation strategies that go well beyond the current scope of FAR 117 regulations provided it can be demonstrated that these features can provide an equivalent (or improved) level of safety.

While it is true that some aviation regulatory officials have continued resist incorporating science based fatigue mitigation strategies into regulatory reforms that can promote and enhance the safety of flight operations, especially where such regulatory reforms involve issues that have been seen as taboo or politically incorrect in the past (Thompson, Dennis 2011), there is movement towards taking a more enlightened approach to insuring that we are doing all that we can to incorporate the current state of scientific knowledge and understanding of human physiology into the aviation regulatory framework in a way that can result in an increase in safety and benefits the traveling public.

We live in an era where our scientific knowledge, engineering prowess, and technical expertise have allowed us to imagine, create, and produce magnificent flying machines that demonstrate high levels of passenger comfort, mission capability, and operational reliability. These advancements have allowed air-carriers to operate these aircraft over ever increasing distances across many time zones. As the capability and reliability of modern aircraft has continued to improve, the human element and related human factors have taken on an increasingly important role in our ongoing effort to maintain and improve the safety of air-carrier flight operations. The relationships of man and machine and our understanding of how

we can best manage the limitations of human physiology, especially as it relates to preserving alertness and cognitive abilities while conducting long range and ultra-long range international flight operations, have taken on increasing importance and urgency. Research projects like this one, and those that will hopefully follow, can help provide policy makers, air-carrier managements, labor leaders, and other industry stake holders with the knowledge and the wisdom they need to better understand the current state of fatigue mitigation strategies that pilots are employing and how best to deploy these, and other new strategies yet to be developed, to enhance the safety of commercial air travel of the future. Well designed and implemented FAA approved FRMS programs have the potential of providing pilots with a more enlightened, comprehensive, and expanded set of fatigue mitigation tools and strategies they can utilize based upon their individual needs. With proper training, and a permissive rather a punitive regulatory and operational environment that encourages and permits air-carrier pilots to effectively employ these new tools and strategies, the traveling public stands to benefit from an improved level of safety in this era of ultra-long range air-carrier flight operations.

Flying long haul international flights, that often exceed 12 hours in duration, across many time zones and often during normal bedtime hours presents huge challenges for individual pilots as they seek to preserve and maintain their cognitive skills while at their duty stations. The question now is not whether or not strategic napping is being employed successfully by commercial airline pilots flying international route segments, the question is whether or not the professional aviation community, including commercial air-carriers, professional aviation associations, labor leaders, aviation regulators, and their legislative and executive oversight bodies, are ready to move forward and sanction this ongoing activity by providing pilots with the regulatory authority, training, self-assessment tools, and operational

concepts they need for its proper use. Effective fatigue mitigation strategies are essential for the safe operation of aircraft. Strategic napping, as one tool of many in a pilot's fatigue mitigation tool kit, can and should be made available for use under carefully controlled and appropriate circumstances. As is the case in many other aspects of commercial aviation operations, discretion in these matters is best left to the pilot in command, who is ultimately responsible for the safety of his or her passengers and crew, and who is in the best position to judge if, and under what circumstances, this effective fatigue mitigation tool should be deployed.

APPENDICES

Appendix A

Survey Tool Questions

Q1 Was this flight an international flight segment?

Yes (1)

No (2)

Q2 What was your crew position on this flight?

Captain (1)

First Officer (2)

Relief Pilot (3)

Q3 Prior to this flight, how many flight segments did you fly today?

None (1)

One (2)

Two (3)

More than two (4)

Q4 Was this flight augmented?

No Augmentation (1)

Single Augmented (2)

Double Augmented (3)

Q5 Did you commute to this flight assignment?

- Yes (1)
- No (2)

Q6 During the 24-hour period prior to reporting for duty, how many hours did you sleep?
Example: 10:00pm - 6:30am = 8.5

Q7 Rate your level of fatigue when you reported for this flight segment.

- | | Low (1) | Moderate (2) | High (3) |
|----------------------------------|-----------------------|-----------------------|-----------------------|
| Fatigue State at Report Time (1) | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |

Q8 Did this flight segment overlap your normal bedtime hours?

- Yes (1)
- No (2)

Q9 Were you assigned a scheduled rest period in a private crew rest facility (bunks) onboard this flight?

- Yes (1)
- No (2)

Q10 During this flight, did you experience any unplanned spontaneous sleep episodes (nodding off)?

Yes (1)

No (2)

Q11 Approximately how many minutes did you nap during this flight? (Do not include time spent sleeping during scheduled rest periods in a crew rest facility)

Q12 Rate your maximum level of fatigue prior to napping during this flight.

Low (1)

Moderate (2)

High (3)

Fatigue State prior to napping. (1)

Q13 Rate your maximum level of fatigue after napping during this flight?

Low (1)

Moderate (2)

High (3)

Fatigue State after napping. (1)

Q14 Please comment on your en-route fatigue mitigation strategies.

Note: Link to survey questions:

https://und.qualtrics.com/SE/?SID=SV_3qiXlp2MSp6215r&Preview=Survey&BrandID=und

Appendix B

Online Solicitation to Study Participants

Fatigue Mitigation Effects of En-route Napping on Commercial Airline Pilots Flying International Routes

Captain Thomas Bunting, ATP - Principal Investigator
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Warren Jensen, M.D. - Advisor
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(701)-777-3284

Purpose of the Study:

This Fatigue Mitigation Survey is being conducted as part of an educational research project in partial fulfillment of the requirements of the Aviation Masters Degree Program at the John D. Odegard School of Aerospace Sciences at the University of North Dakota. This Survey is designed to further assess the current state of operational cultures and fatigue mitigation strategies currently in use in organizations that conduct international flight operations. Recently, ICAO amended Annex 6 to allow regulatory authorities to authorize Fatigue Risk Management Systems (FRMS) to supplement existing prescriptive flight time limitations schemes (FTLs). The FAA has since issued revised Pilot Flight and Duty Time Regulations that provide a pathway for organizations to implement FRMS programs. A well designed scientifically based FRMS should provide flight crews with a variety of flexible procedures and options that they can choose from as a means to manage fatigue. For a FRMS to be effective, it must be data driven. A variety of organizations are now conducting research to collect additional data on this subject.

Procedures to be followed:

This Survey consists of 14 mostly multiple choice questions. You may participate in this research study as many times as you like, however, complete only one survey per

international flight segment. We do solicit your frank and unbiased responses to all survey questions.

Risks:

There are no known risks of psychological or emotional distress associated with participation in this research study.

Benefits:

The results will be presented at UND where a panel will have the opportunity to review and discuss the results as well as question the survey's principal researcher. It is expected that the results will be made available for educational purposes and to expand the body of knowledge of this subject for the benefit of aviation and aviators.

Duration:

This Survey can be typically be completed in 10 minutes or less.

Statement of Confidentiality:

This survey is anonymous.

The record kept of your survey responses will be treated confidentially and will not contain any identifying information about you unless you provide such information as part of your response to a specific question. Any identifying information so submitted will not be published or disseminated. Since this survey may be completed on a variety of Internet connected devices, we are unable to guarantee the security of the device you choose to use to enter your responses. You should be aware that certain "key-logging" malware exists that can be used to track and / or capture data as you enter it and / or websites that you visit.

Right to Ask Questions:

The Principal Investigator conducting this research study is Captain Thomas Bunting, ATP - captom@optonline.net. You may ask any questions about this research study now. Should

you have any questions, complaints, or concerns about this research study in the future, you may contact the Principal Investigator's Advisor, Warren Jensen, M.D.

- wjensen@aero.und.edu, (701)-777-3284.

If you have any questions regarding your rights as a research subject, you may contact the University of North Dakota Institutional Review Board at (701) 777-4279. You may also call this number with problems, complaints, or concerns about the research. Please call this number if you cannot reach the research staff, or you wish to talk with someone who is an informed individual who is independent of the research team. General information about being a research subject can be found on the Institutional Review Board website, "Information for Research Participants" at the link below:

<http://und.edu/research/resources/human-subjects/research-participants.cfm>

Compensation:

You will not be compensated for your participation in this research study.

Voluntary Participation:

You do not have to participate in this research. You can stop your participation at any time. You may refuse to participate or choose to discontinue participation at any time without losing any benefits to which you are otherwise entitled.

You do not have to answer any questions you do not want to answer.

You must be 18 years of age or older to participate.

If you would like to proceed, please begin the survey by clicking the "Continue" button below.

After completing all questions, please click "Continue" again to submit your answers.

Thank you in advance for your participation!

INTERNATIONAL PILOT FLIGHT SEGMENT FRMS STUDY



Pilot Participants Wanted

ICAO and the FAA have taken regulatory action to provide a framework for the introduction of FRMS. This Pilot Survey is being conducted by a fellow ALPA member in good standing in conjunction with Thesis Research at the University of North Dakota Graduate School. Click on the link below to take the Survey.

https://und.qualtrics.com/SE/?SID=SV_3giXlp2MSp6215r

Survey Link
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GLOSSARY

Actigraph. A device used to measure gross motor activity of an individual wearing it.

Actigraphy. A non-invasive method of monitoring human rest/activity cycles.

Augmentation. Assignment of one or more relief pilots on long haul flights.

FAA. Federal Aviation Administration

FAR. Federal Aviation Regulations

ICAO. International Civil Aeronautics Organization

Long Haul Flight. Typically refers to flights of greater than 6¹/₂ hours in duration flown by wide body aircraft.

Polysomnography. The engaged process of making a comprehensive recording of the biophysiological changes that occur during sleep.

Polysomnogram. A recording of many body functions including brain EEG, eye movements EOG, muscle activity EMG and heart rhythm ECG during sleep.

PVT. The Psychomotor Vigilance Task is a sustained-attention, reaction-timed task that measures the speed with which subjects respond to a visual stimulus.

SPSS. A statistical analysis software package developed by IBM.

Ultra-Long Range Flights. Commercial Flights in excess of 16 hours duration.

Wide Body Aircraft. Refers to large aircraft which, in passenger configuration, feature twin aisle seating arrangements with fuselage diameters typically in the 16' – 20' range such as the Boeing 767, 777 and 747 aircraft families as well as the Airbus 330, 350, and 380 aircraft families.

Wrist Activity Monitor. A wristwatch-shaped device that contains a piezoceramic sensor to measure and record limb movement over a pre-set time interval

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