SURVEYING AIR TRAFFIC CONTROL SPECIALIST PERCEPTION OF SCHEDULING REGULATIONS

By

Darrius E. Thompson

August, 2015

A Thesis Presented to the
Faculty of the College of Basic and Applied Sciences
Middle Tennessee State University in Partial Fulfillment
of the Requirements for the Degree
Master of Science in Aviation Administration

Thesis Committee:

Dr. Paul Craig, Chair

Dr. Wendy Beckman

This thesis is dedicated to my grandfather Clarence Edgar Thompson Sr. who motivated me to pursue a career in aviation. Your struggle inspired me to become the man I am today. I know you are smiling down on me right now.

ACKNOWLEDGEMENTS

I would like to take the time to acknowledge several people who helped me throughout the research process: Dr. Craig, Dr. Georgiou, and Dr. Beckman, who supported me and motivated me throughout my research process. My mother Brenda Elliott for the daily inspiration and love. My father Clarence Thompson and brother Brandon Thompson for staying on top of me and not allowing me to get discouraged. My mentor and role model Shelton Snow for the insight throughout the entire study and data collection process. The entire NBCFAE organization for their love and support. My great friend Marlon Lucas, who assisted in developing the research idea and motivated me to keep pursuing my dreams. Last but certainly not least, my girlfriend Barbara Worthy for the kind words of encouragement along the way. Without all of the love and support, this study would not have been possible.

ABSTRACT

While there have been several studies conducted on air traffic controller fatigue, there is a lack of research on the subject since the scheduling policy changes that took place in 2012. The effectiveness of these changes has yet to be measured. The goal of this study was to investigate air traffic control specialist views towards the number of hours scheduled between shifts, changes in perception since 2012 regulation changes, and external factors that impact fatigue. A total of 54 FAA air traffic control specialist completed an online questionnaire. The results from the survey showed that the majority of respondents felt the 2012 regulation changes were not sufficient to address fatigue issues, and work with some amount sleep deprivation. The factors that appeared to have the most significant effect on fatigue included facility level, age group, availability of recuperative breaks, and children under 18 in the home.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

ARTCC	Air Route Traffic Conrol Center
ATC	Air Traffic Control
ATCS	Air Traffic Control Specialist
ATCT	Air Traffic Control Tower
AT-SAFE	Air Traffic Shiftwork and Fatigue Evaluation
CAMI	Civil Aeromedical Institute
CARI	Civil Aeromedical Research Institute
CBA	Collective Bargaining Agreement
CFR	Code Federal Regulations
CPC	Certified Professional Controller
FAA	Federal Aviation Administration
FMS	Fatigue Management System
FPL	Full Performance Level
FRM	Fatigue Risk Management
FRMS	Fatigue Risk Management System
FSS	Flight Service Station
IRB	Institutional Research Board
MOU	Memorandum of Understanding
NASA	National Aeronautics and Space Administration
NATCA	National Air Traffic Control Association
NBCFAE	National Black Coalition of Federal Aviation Employees
NIOSH	National Institute for Occupational Safety and Health

NTSB	National Transportation Safety Board
OIG	Office of Inspector General
OPAS	Operational Planning and Scheduling
SSI	Standard Shiftwork Index
TLX	Task Load Index
TRACON	Terminal Approach Control
USAF	United States Air Force

CHAPTER I: INTRODUCTION

Literature Review

There have been several fatal accidents throughout history attributed to an operator in a safety-sensitive position suffering from lack of rest. The tragic incidents that occurred at Chernobyl, Exxon Valdez, and Three Mile Island were all related to operator fatigue (Smith, 2002). In 2002, Circadian Technologies Inc. conducted a survey among Operation Managers regarding workplace fatigue. The results of the study showed that Operation Managers believe that 18 percent of all accidents and injuries are directly related to employee fatigue (Smith, 2002). The Federal Aviation Administration has defined fatigue as, "a condition characterized by increased discomfort with lessened capacity for work, reduced efficiency of accomplishment, loss of power or capacity to respond to stimulation, and is usually accompanied by a feeling of weariness and tiredness" (Salazar, n.d, p. 2). According to the Mayo Clinic, most cases of fatigue typically stem from one of three areas. These areas include lifestyle factors, psychological conditions, or medical conditions (Mayo Clinic, 2013). One lifestyle factor mentioned is the lack of sleep. Lack of sleep, or sleep deprivation, is an issue that shift workers, such as Air Traffic Control Specialist (ATCS), must combat on a regular basis. With the 24/7 nature of the National Airspace System (NAS), ATCS are often required to work alternating shifts to ensure proper staffing at all times of the day. This practice of continuous shift work can have adverse effects on an individual. When an employee works hours that are after dark, these adverse effects can be compounded. Working during the night can often lead to problems with job satisfaction, health, family life, social activity, and on the job safety (Finn, 1981). To combat these issues, the FAA and several other agencies have collaborated to investigate which shift patterns would be the best for ATCS. In 1965, the FAA's Civil Aeromedical Research Institute (CARI), now known as the

Civil Aeromedical Institute (CAMI), started to do extensive research on ATCS health and stress (Haughty, Trites, & Berkley 1965).

Early Research on Shift Rotations

The first study conducted in 1965 by CARI was a survey of ATCS at six ATCTs and six ARTCC facilities. The goal of the study was to, "evaluate the differential effects upon job-related health and well-being that might be attributable to the different shift rotation schedules employed by various ATC facilities" (Haughty et al., 1965, p. 1). The researchers predicted that the facility that rotated their shifts the most frequently would have the most reported adverse symptoms. The results did not show the frequency of the shift rotation to relate directly to the frequency of symptoms being reported. However, this study did show that around 60% of the time, air traffic control specialist were reporting symptoms ranging from headaches, aching or burning of the eyes, to difficulty staying awake. ATCS reported the highest frequency of symptoms on the days they had 8 or fewer hours in between shifts (Haughty et al., 1965). This study was the first research conducted by the FAA and would lay the foundation for the research that would soon follow.

Circadian Rhythms

In 1967, operating under the new name, CAMI started to investigate the effects of the circadian rhythms during long distance flights. The circadian rhythm is essential to the research on shift patterns and schedules for ATCS. The term circadian comes from the Latin word "*circa dies*" which translates to about a day and was introduced by Dr. Franz Halberg in 1959 (Mohler, Dille, & Gibbons, 1967). The term describes a period that equals approximately 24 hours, but can range from 20-28 hours. Luna, French, and Mitcha (1997) describes the circadian rhythm in *Aviation Space and Environmental Medicine* as,

> Physiologic functions, such as body temperature and hormone release, are given their endogenous rhythmicity by a pacemaker located in the suprachiasmatic nuclei of the hypothalamus. Temporal isolation experiments on volunteer subjects have demonstrated that this clock-like timing mechanism has an intrinsic period slightly longer than 24 h. It is synchronized daily to the 24-h day by cues from the external environment. (Luna et al., 1997, p. 69)

The cues that Dr. Luna is eluding to can range from things such as daylight to daily habits like brushing one's teeth and are termed zeitgebers. The term zeitgeber originates from the combination of two German words, zeit, which means time, and Geber, which means giver (Luna et al., 1997). That is essentially what a Zeitgeber does. They act as a time-giver to the human body. There are two types of zeitgebers, the photic zeitgeber that refers to light and the non-photic or social zeitgeber that refers to cues not related to sunlight. Social zeitgebers are daily habits such as taking a shower in the morning or putting on pajamas before going to sleep and can often be stronger influences on the pacemaker than light. However, it is important to note that without photic zeitgebers, the pacemaker will not function correctly. One example of this is the visually impaired, who often deal with significant disturbances when sleeping and while awake (Klein et al., 1993). Night shift workers lack this photic zeitgeber, often disturbing their circadian rhythm if permanently assigned to a night shift.

There have been several experiments that have shown that even with forced adaptation to different sleeping schedules issues often arise. Shift workers, such as ATCS, who work a shift pattern that rotates between day and night shifts, either have an extremely hard time adjusting their circadian rhythm, or it never fully adjusts at all (Mistlberger & Skene, 2004). Many shiftwork studies measure circadian pacemaker activity through the monitoring of body

temperature during the sleep/wake cycle. The typical pattern of body temperature during the sleep/wake cycle is that of a sinusoidal nature (Luna et al., 1997). The most common pattern of this sinusoidal curve has its lowest point, or nadir, during the morning around 0400-0600 hours and the peak in the early evening around 1600-1800 hours(see Figure 1) (Luna et al., 1997). There are several other circadian rhythms that follow similar patterns. This information has been used to determine which shift patterns would be considered the most efficient for ATCS.

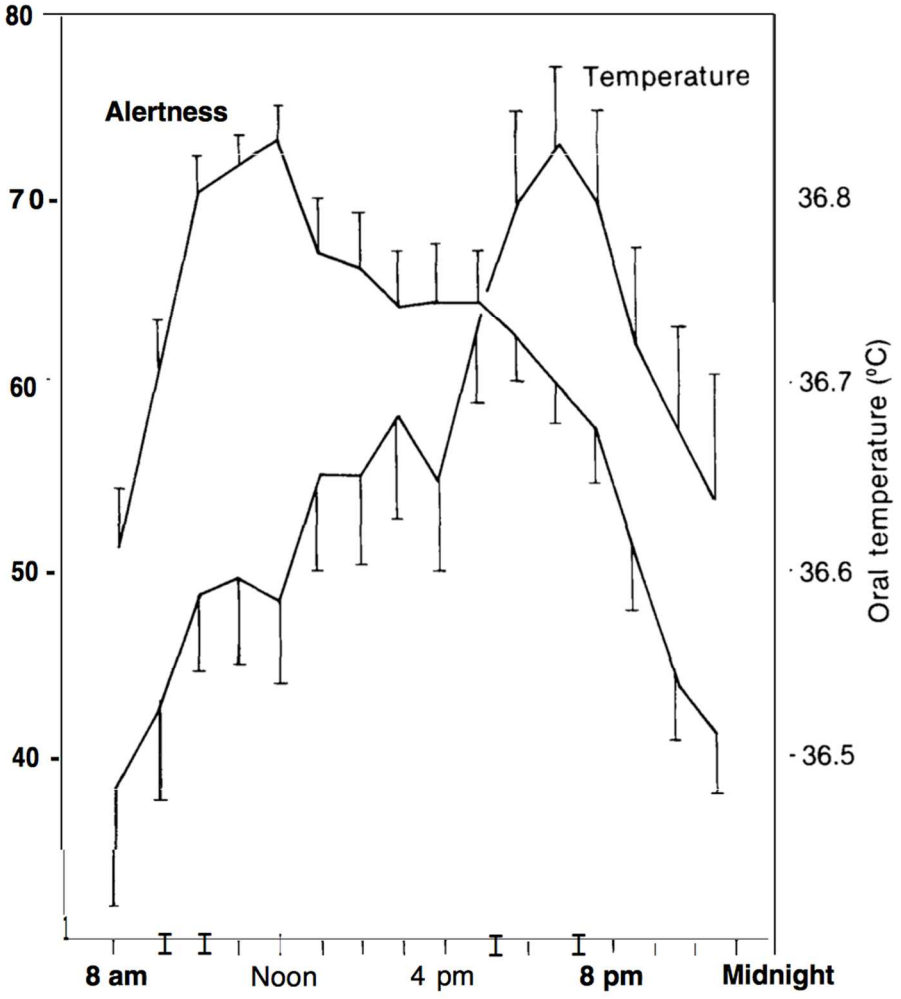


Figure 1 The Circadian Rhythms of Subjective Alertness and Body Temperature From Persons Synchronized to a 24-Hour Day note: Circadian rhythms of subjective alertness and body temperature. Reprinted from "A study of USAF air traffic controller shiftwork: Sleep, fatigue, activity, and mood analyses" by Luna et al., 1997, Aviation Space and Environmental Medicine, 68(1), 18–23.

Exploring the Effects of Different Shift Rotation Patterns

In 1993, CAMI received a request from the management of an ATC facility to evaluate the adaptation of ATCS to shiftwork. The researchers from CAMI used the General Health and Adaptation Survey that was designed by the National Institute for Occupational Safety and Health (Rocco, Ramos, Mccloy, & Burnfield, 2000). According to the NIOSH, the Survey was designed to assess "shiftwork adaptation in the areas of sleep, health, and lifestyle" (Rocco et al., 2000, p. 5). CAMI surveyed 210 ATCS, and around half of them reported symptoms of shiftwork maladaptation. These symptoms included gastrointestinal symptoms such as bloating and periods of severe fatigue or exhaustion. Also, nearly a third of the participants reported that they had fallen asleep while on the way home from work at least once in the last six months. These issues can directly linked to the patterns of the shifts being worked and the amount of sleep reported by the ATCS. The results from this study could not be directly compared to other populations of shift workers since it had not been widely administered before.

In 1992, a study was conducted on United States Air Force (USAF) ATCS that sought to analyze the effectiveness of using the forward rapid rotation 2-2-2 shift. The controllers recorded their sleep, oral temperature, and subjective fatigue levels then completed a computerized cognitive performance battery and the Profile of Mood States questionnaire. This 2-2-2 shift pattern utilized by USAF ATCS lasted for eight days and consisted of two day shifts, two swing shifts, then two night shifts, followed by 48 hours off (Luna et al., 1997). The schedule seemed ideal because it allowed the employees to remain in a diurnally oriented circadian rhythm and helped combat a large amount of the chronic health issues commonly seen in shift workers. However, there was a significant drawback to operating on this forward rapidly rotating schedule. The primary concern was that during the night shifts, the controllers were forced to work at the lowest point of their diurnally oriented circadian rhythm. Previous studies have

shown that operating in a safety sensitive position during the nadir of the circadian can be hazardous. The hazard arises due to a drop in alertness and increase in fatigue (Luna et al., 1997). The results of this study showed more reported sleep, fatigue, and confusion associated with working the night shift than any other shift in the rotation.

In 1995, Roske-Hofstrand made a presentation at the Eighth International Symposium on Aviation Psychology titled *Raising Awareness for Fatigue among ATCS*. At this presentation, the two men categorized the fatigue that was reported to them by different ATCS during their research. The four categories that were developed are end of shift /workload fatigue, emotional stress fatigue, physical fatigue, and shift/schedules fatigue (Roske-Hofstrand, 1995). Shift/Schedule related fatigue was fatigue associated with the length, frequency, and amount of time between of the shifts scheduled for the controller. Roske-Hofstrand defined physical fatigue as fatigue related to lack of sleep and sluggishness at the start of the shift. Emotional stress was the fatigue caused by sleep loss when dealing with an issue with a supervisor, co-worker, or spouse. End of shift and workload fatigue relates to the amount of workload that the controller has, whether high or low, and the time spent on duty (Roske-Hofstrand, 1995).

CAMI also conducted a study in 1995, with the goal of investigating the shift schedules in place at FAA ATC facilities and how they affect the sleep/wake cycle of the ATCS. The three shifts that they would investigate were a straight day schedule of morning shifts and both the 2-2-1, and 2-1-2 counter-clockwise rapidly rotating shifts (Cruz & Rocco, 1995). All three shift patterns were analyzed in terms of sleep and awake times, total sleep times, and subjective ratings of sleep quality and sleepiness (Cruz & Rocco, 1995). The data was collected using daily logbooks provided by the researchers to the ATCSs. The 2-2-1 consist of two afternoon shifts followed by two morning shifts and then a midnight (mid) starting on the same day as the second

morning shift. Figure 2 shows an illustration of an example of each of the three shift patterns. The results of this study showed that the 2-2-1 rotation consistently had a decline of sleep reported between shift types. Before the two afternoon shifts, ATCS averaged 7.5-8 hours of sleep. That number decreased before the two early morning shifts to an average of 5 then decreased even further to an average of just 2.4 hours before the mid shift (Cruz & Rocco, 1995). The 2-1-2 shift pattern also saw a reduction of sleep received before the midnight shift, dropping from an average of 8 hours to 6 hours.

Table 1

Work Schedules

	Day 1	Day 2	Day 3	Day 4	Day 5
Straight Day Schedule					
Shift Type	E	E	E	E	E
Approximate Start Time	0730	0700	0700	0630	0630
Range of Start Times	0630-1000	0630-0900	0630-1000	0630-0700	0630-0645
Approximate Hours Off Between Shifts	16 hrs.	16 hrs.	16 hrs.	16 hrs.	
2-2-1 Schedule					
Shift Type	A	A	E	E	N
Approximate Start Time	1430	1330	0700	0600	2230
Range of Start Times	1330-1600	1000-1600	0600-0800	0600-0620	2200-2400
Approximate Hours Off Between Shifts	16 hrs.	8 hrs.	16 hrs.	8 hrs.	
2-1-2 Schedule					
Shift Type	A	A	M	E	E
Approximate Start Time	1430	1330	1030	0700	0700
Range of Start Times	1330-1500	1250-1400	0955-1100	0630-0700	0600-0745
Approximate Hours Off Between Shifts	16 hrs.	12 hrs.	12 hrs.	16 hrs.	

Figure 2 Examples of Straight Day, 2-2-1, and 2-1-2 Work Schedules. Reprinted from "Sleep patterns in air traffic controllers working rapidly rotating shifts a field study," by Cruz et al., 1995, p. 3.

8-Hour vs. 10-Hour Shifts

In December of 1995, CAMI began conducting research to determine the effects of working 8-hour versus 10-hour work days on both alertness and test performance of the ATCS (Schroeder, Rosa, & Witt, 1998). The FAA was receiving requests from its employees for more schedule flexibility. Several of these requests were to work four 10-hour days as opposed to the five 8-

hour day work week that was in place at the time. The 10-hour day schedule permitted the employee to compress the work week into four days allowing more time off between work weeks. An example of both work schedules are shown below in Figure 3, but these patterns can vary (Schroeder et al., 1998). There were several studies investigating the compressed workweek in other positions such as nurses, police officers, and workers at a nuclear reactor. The issue with these studies was that they all did a comparison of the 8-hour shift to the 12-hour shift, not the 10-hour shift that was being investigated by the FAA (Schroeder et al., 1998). The agency allowed ATCS to work the 10-hour shifts based on the previous research of the 12-hour shifts in other professions. However, the FAA noted that there was not enough scientific research exploring the differences in performance of the 10-hour vs. the 8-hour shift and wanted to further to knowledge on that subject (Schroeder et al., 1998). CAMI led a research study with the goal of providing scientific research examining the difference in performance in the two schedule patterns. The CAMI study consisted of 52 ATCS that volunteered to participate in the research. The participants were currently employed at an FAA enroute facility. Fifty percent of the participants worked the 10-hour schedule, and the other 50% worked the 8-hour 2-2-1 schedule. The researchers utilized a modified version of the National Institute of Occupational Safety and Health (NIOSH) Fatigue Test Battery. The eight items measured included sleep amount, sleep quality, current mood, physical complaints, Task Load Index(TLX) workload, reaction time, arithmetic, and grammatical reasoning (Schroeder et al., 1998). The researchers gathered this performance data at three times throughout the shift, at the beginning of the shift, two hours prior to the completion of the shift, and at the end of the shift.

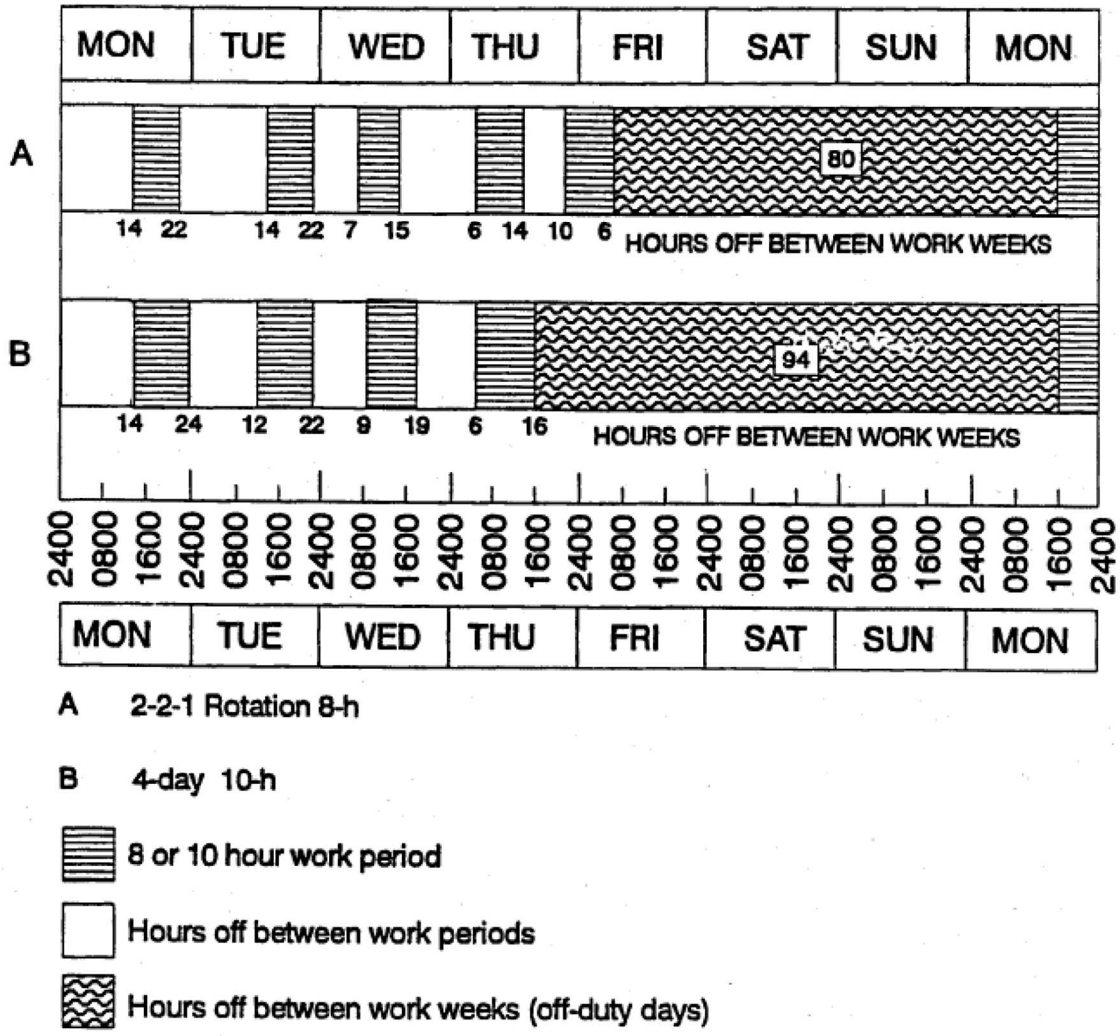


Figure 3 A Graphic Representation of a Work Week on the 2-2-1 8-Hour and 4-Day 10-Hour Shift Schedules Note. Reprinted from "Some effects of 8- vs. 10-hour work schedules on the test performance/alertness of air traffic control specialists," by D. J. Schroeder, et al., 1998, International Journal of Industrial Ergonomics, 21, p. 4.

The results of the study showed that there was not a significant difference in performance during the first four days of the 8-hour or 10-hour shift rotation while working day or afternoon shifts (Schroeder et al., 1998). However, the data did show a significant increase in reaction time for both the 8-hour and 10-hour shift patterns during the early morning shifts. Also, on the final

day of the 8-hour 2-2-1 rotation, which consisted of a midnight shift, the researchers saw a significant decrease in performance. The data also showed a relationship to the decline in the amount of self-reported sleep to changes in test performance and mood ratings (Schroeder et al., 1998). The amount of sleep reported by the ATCS were consistent with previous research studies. The amount of reported sleep decreased throughout the week. The average amount of reported sleep was the nearly identical during the first four days of both the 8-hour and 10-hour shift rotations. The highest amount of reported sleep was the night prior to the first day of the shift rotation at approximately 8.3 hours. The lowest amount of reported sleep during the first four days of the shift rotation was prior to day four at approximately 5.75 hours. The ATCS working the 8-hour 2-2-1 schedule reported their lowest amount of sleep prior to the midnight shift on the final day of the workweek with an average of 3.75 hours. This reduced amount of sleep was similar to that found in previous studies.

1999 FAA ATC Shiftwork Survey

In 1999, there was extensive research done on the topics of both shiftwork and fatigue in the ATC industry. The research was supported by congressional fund appropriations for FY 1999 and the 1998 National Air Traffic Control Association (NATCA) Collective Bargaining Agreement (CBA) (Rocco, Ramos, Mccloy, & Burnfield, 2000). A portion of the Congressional funding, $1 million, was designated to conduct a survey of all FAA ATC personnel. The survey sought to determine, "the extent of fatigue among the workforce and the effects of current shift patterns and rotation practices of health, well-being, and performance" (Rocco et al., 2000, p. 2). In the CBA agreement for 1998, NATCA declared that within the five-year agreement, the involved parties and CAMI would collaborate to conduct a comprehensive study of human factors associated with ATC (Rocco et al., 2000). The study addressed issues such as stress,

fatigue, shiftwork, and several others. To meet the needs of both the Congressional agreement and the NATCA CBA, CAMI designed a three-phase action plan. CAMI assigned Dr. Rocco and three researchers from the Human Resouces Research Organization to lead the effort. The first phase of the action plan included the comprehensive survey of ATCS personnel agency-wide and met the need of the Congressional request. The second phase included what CAMI described as "a more in-depth follow-up at selected facilities using objective measures to validate survey findings" (Rocco et al., 2000, p. 2). The final phase of CAMI's three-phase action plan included conducting a laboratory comparison of current ATC shift scheduling practices to the shift patterns recommended in the previous scientific literature. This three-phase plan presented CAMI with a unique opportunity. The earlier studies conducted by CAMI regarding shift work usually included the participation one facility as opposed to the entire agency. Also, often at the particular facility being examined, the scheduling practices had not been in place long enough to consider long-term effects of working that particular rotation pattern. This study presented CAMI with an opportunity to have an agency-wide, cross-sectional analysis of both, the long-term effects associated with working similar schedules and an assessment of the degree that fatigue is affecting the workforce.

CAMI made the decision to use a modified Standard Shiftwork Index (SSI) in this study. The SSI involves a battery of standardized questionnaires assessing several different factors. These factors include the respondents shift schedules, sleep patterns, physical and mental health, job satisfaction, social and domestic life, and fatigue (Rocco et al., 2000). Several occupational groups such as nurses, industrial and service workers, and manufacturers have used the SSI to evaluate the effects of shiftwork on their employees. Using a modified SSI allowed the researchers to compare the data collected during this study involving FAA ATCS with other

shiftworking populations. ATCs in the United Kingdom and Italy also took the SSI and would offer an excellent point of comparisons. The researchers at CAMI received recommendations from a scientific advisory group on what modifications needed to be made to the current SSI to achieve the purpose of this study. Three main factors determined the questions that would be included in the survey. The three factors listed by the researchers were: knowledge of ATC schedule characteristics, the requirement to have a survey instrument that was suitable for large-scale administration, and experience with the SSI and other similar instruments (Rocco et al., 2000). The final instrument developed for this study was named the 1999 FAA ATC shiftwork survey and would be 24 pages long with 161 items.

The 1999 FAA ATC shiftwork survey was distributed agency-wide in November of 1999. The participants included ATCS, ATC management, and Flight Service Station (FSS) employees. CAMI distributed a total of 22,958 surveys, 6,573 of which were completed and returned. At the end of data collection, the survey had a 28.7 response rate. The researchers noted that several factors might have impacted the rate of response. The factors listed by the researchers included; the length of the instrument, inconsistencies associated with the required distribution method, and the personal nature of medical and psychological items contained in the survey (Rocco et al., 2000). The amount of ATCS that participated in this study were 4,078 out of roughly 15,000 ATCS employed by the FAA. The study found that the participants in this study reported levels of cardiovascular problems, digestive disorders, chronic fatigue that were similar or lower than the normative group. Also, the participants reported lower levels of cognitive anxiety with higher levels of psychological well-being and general job satisfaction(Rocco et al., 2000). However, the study did find that ACTSs reported higher disruption in domestic and social life than the normative group. When compared to the Italian

ATC population, FAA ATCS reported higher ratings of chronic fatigue. CAMI attributed the difference to factors such as the schedule being worked and the amount of rest before the night shift. The Italian ATCS also worked the counter-clockwise rapidly rotating shift. One major difference found was the amount of sleep reported prior to the midnight shift. The Italian ATCS reported an average of eight hours prior to a night shift in comparison to the of three to four hours reported by FAA ATCS(Rocco et al., 2000). Other major differences were present in the scheduling patterns. The Italian controllers only worked three consecutive days prior to scheduled time off, and they rarely had a morning and night shift on the same day. Another practice employed by Italian ATCS that was beneficial to reducing fatigue during the night shift was the two-hour break in which the controllers were allowed to sleep in designated resting rooms. The research group recommended three things for ATCS working counterclockwise rotating shifts. The first was the education of sleep and circadian rhythm management to the ATCS workforce to help raise awareness of possible issues and coping strategies. Second, the researchers recommended the ATCSs working the midnight shift should be permitted to take one or two-hour naps to improve performance and vigilance. Lastly, the research group recommended that examination of schedules take place on a local facility level to reduce exposure to the midnight shift. The data collected from the from the Nationwide Shiftwork & Fatigue Survey would be used for several other studies.

CAMI researchers utilized the 1999 survey data in 2004 to conduct the study titled Gender and Family Responsibilities as They Relate to Sleep and Fatigue Responses on the FAA Air Traffic Control Shiftwork Survey (Seber, et al., 2010). The study utilized responses to the shiftwork survey that were from ATCS between the age of 18-50. This age range gave the researchers a total of 2,879 responses out of the total 6,712 (Seber, et al., 2010). The measures

analyzed for this project included the presence of children younger than age 13 in the home, domestic disruption, sleep quality, total sleep time, and chronic fatigue. This study examined the effects of having children younger than 13 and the difference of this effect on male ATCS compared to female ATCS. The data showed that ATCS with children under the age of 13 reported fewer hours of sleep time on days off, poorer sleep quality, higher domestic disruption, and higher chronic fatigue levels. Females with children in this age group were 2.4 times more likely to have domestic disruption and also reported higher chronic fatigue (Seber, et al., 2010). The researchers concluded from this study that when analyzing fatigue, sleep, and domestic variables, having young children is more important than gender.

In 2005, CAMI used the survey data to assess the relationship of age and shiftwork to sleep, fatigue, and coping strategies in ATCS. The 2005 study used the responses to the 1999 survey. 3,247 of the total 6,712 respondents to the survey were Certified Professional Controllers (CPCs) and included their age in their response. CAMI researchers used the items that assessed sleep disturbances, sleep duration, body mass index, the use of coping strategies, and chronic fatigue. The results showed that the younger age group tended to have poor coping strategies and that the quality of coping strategies increased with age. Also, ATCS in the 31-45 age group reported the highest chronic fatigue levels, least amount of sleep prior to a morning shift, and the poorest sleep quality (Seber, et al., 2010). However, overall fatigue, poorer sleep, and age were not consistently related. Body Mass Index did seem to increases in the ATCS respondents with age up until age 55.

In 2006, CAMI researchers used the data from the survey to analyze the risk factors for ATCS during their commute. During the 1999 survey, the respondents also answered questions concerning their commute. The topics included things such as commuting variables (i.e., number

of miles and roadway types), driving outcomes (i.e., lapses of attention, falling asleep, accidents, and near misses), and alertness (Nesthus, Cruz, Hackworth, & Boquet, 2006). This data was separated from the rest of the survey and classified into two groups FSS and ATCS. The results showed that the highest risk for an accident was during commutes of 20 miles or greater, in the city after early morning, afternoon, or midnight shifts (Nesthus et al., 2006).

Air Traffic Shiftwork and Fatigue Evaluation (AT-SAFE)

The other method of data collection that CAMI used to fulfill the needs of the Congressional agreement and the NATCA CBA was a field study. The field study was named the Air Traffic Shiftwork and Fatigue Evaluation (AT-SAFE) and consisted of 72 Full Performance Level (FPL) ATCS with ages ranging from age 28 to age 55 (Collins & Wade, 2005). Twenty of the 72 participating ATCS were employed at an FAA TRACON facility while the other 52 worked at an ARTCC. The purpose of the AT-SAFE study was to provide empirical data on shiftwork and fatigue within the ATC workforce and to validate the results of the 1999 FAA ATC shiftwork survey (Collins & Wade, 2005). The data that would be collected from these ATCS included:

> entries into the daily logbooks by the volunteers throughout the 21-day study period (sleep duration, quality of sleep, subjective mood, and sleepiness); measures from wrist activity monitors worn by the volunteers 24 hrs a day to provide corroborative data of sleep duration; and cognitive performance (via CogScreen – Aeromedical Edition). (Collins & Wade, 2005, p. 45)

The data collected from the AT-SAFE field study would be utilized by CAMI to conduct other research on the topic of ATC shiftwork and fatigue, like that of the 1999 FAA ATC Shiftwork survey. The first study would be carried out in 2001 and was designed to assess how ATC shift start times affected quantity and quality of sleep, mood, and fatigue (Seber, et al.,

2010). The results were consistent with what CAMI has discovered in previous research. Sleep quality was consistently correlated with sleep quantity. Also, the least amount of sleep recorded throughout the week was always before the midnight shift with an average among the participants of 2.3 hours. The midnight shift for this study was defined as any shift starting between 8:00 p.m. and 1:00 a.m. The midnight shift was also the time in which ATCS rated the highest on the sleepiness scale at all points of measurement which included preshift, postshift, drive home, and after arriving home (Seber, et al., 2010). The periods that the ATCS recorded the most hours of sleep was before the midday shift with an average of 7.7 hours of sleep and regular days off with 7.8 hours (Collins & Wade, 2005). For the purposes of this study, a midday shift was defined as a shift starting between 10:00 a.m. and 12:59 p.m.

The following year another analysis of the AT-SAFE data was performed. In the 2002 CAMI study, the researchers focused on four specific schedules and assessed how each affected quantity and quality of sleep, mood, and fatigue. Of the 72 participants of the AT-SAFE study, 44 worked the schedule types that were being researched. The schedule types included the 2-2-1 (2 afternoons, 2 early mornings, 1 midnight), 2-1-2 (2 afternoons, 1 midday, 2 early mornings), 2-3 (2 afternoons, 3 early mornings), and SS-EM (5 straight early mornings) (Seber, et al., 2010). The researchers observed that sleep duration was a direct function of shift start time, which was consistent with previous studies conducted by CAMI. Sleep quality showed a trend of declining throughout the workweek and improving on the weekends. The ATCS's mood also saw a general decline throughout the work week, and the 2-1-2 pattern seemed to have the better mood when compared to the other shift patterns (Seber, et al., 2010). Sleepiness ratings across ATCS increased throughout the workweek and appeared to be directly correlated with sleep duration and sleep quality.

The last study that utilized the AT-SAFE data was conducted in 2005. The objective of this study was to observe how age affected performance and how the performance varied for shifts with less than 12 hours off and shifts with more than 16 hours off (Nesthus, Dattel, & Holcomb, 2005). The researchers took the data from the AT-SAFE study and grouped the participants based on age. The performance of the different groups on the Cognitive Screen(CogScreen) test that examined the participants accuracy, response time, and correct completions per minute were reviewed (Seber, et al., 2010). This information was then compared on the basis of hours between shifts. The researchers concluded from this study that, 8-11 hours between shifts typically lead to decreased performance when compared to shifts with more than 11 hours between them. This effect was more evident in the ATCS that were over the age of 40 (Nesthus et al., 2005).

The results of the FAA ATC Shiftwork Survey and the AT-SAFE studies conducted by CAMI and NATCA were summarized and then distributed to the FAA workforce. The feedback that was given to the controllers included coping mechanisms and better practices on fatigue management on a personal level. CAMI also compiled a CD-ROM entitled Shiftwork Coping Strategies and distributed it to all FAA ATCS. The Shiftwork Coping Strategies CD provided the controllers with material relating to working a rotating shift schedule and the effects that it has on both performance and fatigue (Colins & Wade, 2005). Also, the CD showed ATCS different ways to decrease the amount of fatigue experienced by working these type of schedules and better adaptation techniques.

NTSB Safety Recommendations

On August 27, 2006 a Comair Airlines flight was scheduled to takeoff from Blue Grass Airport in Lexington, Ky heading to Hartsfield-Jackson Atlanta International Airport. Comair Flight 5191 was a CRJ-100 carrying 47 passengers and 3 crewmembers (National Transportation

Safety Board [NTSB], 2007). Around 0607 eastern daylight savings time, the aircraft was cleared for takeoff on runway 22 by ATC. Runway 22 is 7,003 feet long and has high-intensity runway lights installed that illuminate the runway. The crew of the aircraft mistakenly taxied onto runway 26 which is only 3,500 feet and is unlighted. While attempting the takeoff, the CRJ-100 overran the short runway and crashed into an airport perimeter fence and some trees off the end of the runway. This crash claimed the lives of 49 of the 50 souls on board and caused serious injuries to the survivor.

Upon the initial investigation into the accident, the NTSB discovered that the ATCS, who was handling the aircraft, was sleep deprived. On the previous day, the ATCS worked a shift from 0630 to1430. The controller was then scheduled to come back into work 9 hours later. The ATCS worked from the shift start time of 2330 until the time of the accident at 0607 (NTSB, 2007). The ATCS revealed in his post-accident interview that the only sleep obtained in the 24 hours prior to the crash was a two-hour nap in between the two shifts. This amount of sleep was not uncommon for ATCS working the midnight shift, as shown in the previous research. However, several accidents such as the one mentioned above have made the dangers of such practices more evident. Studies have shown that sleep deprivation can diminish the vigilance, judgment, and alertness (NTSB, 2007). The NTSB issued a safety recommendation in April of 2007 following the tragic accident of Comair Flight 5191. Historically, the FAA has not taken action on the NTSB's safety recommendations. In 1983, the NTSB issued two safety recommendations regarding ATC fatigue Saftey Recommendation A-83-35 and A-83-36 (NTSB, 2007). Recommendation A-83-35 encouraged the FAA to "disseminate guidelines for controller stress and fatigue detection and management" (NTSB, 2007). Recommendation A-83-36 suggested that the FAA "expedite the development and implementation of a controller

performance assessment program" (NTSB, 2007). Both of these recommendations were closed by the NTSB in 1989 due to unacceptable action on the part of the FAA. The NTSB had issued over 80 fatigue-related safety recommendations since 1989, but none of them was on ATC fatigue. The 2007 NTSB Safety Recommendation would be the first since the two in 1983 to address ATC fatigue.

In the Safety Recommendations report, the NTSB summarized four other runway incursions that had occurred in previous years in which the ATCS was dealing with fatigue. The first incident occurred in March of 2006. The ATCS cleared an Airbus A320 to cross a runway and then 15 seconds later cleared a Boeing 737 to take-off on the same runway. The pilot of the 737 taking off spotted the A320 crossing the runway and aborted the takeoff before reaching the intersection. This could have been a tragic accident if it were not for the awareness of the flight crew of the aircraft that was taking off. The NTSB investigation revealed that the ATCS only had 9 hours between his previous shift and the shift in which the incident occurred. Of the 9 hours he was scheduled off, about 4 of the hours consisted of sleeping with the rest of the time being spent on commuting and personal activities. He stated during the interview that he felt "semi-rested but was not as sharp as he could have been" and he attributed this to the quick turnaround (NTSB, 2007, p. 3).

The second incursion occurred in August of 2004 in Los Angeles, California. The ATCS had cleared a 737 to taxi and take-off on a runway while a 747 was on final approach and had already been cleared to land. While on short final, the 747 saw the aircraft on the runway and 12 seconds prior to the impending collision and executed a go-around (NTSB, 2007). The 747 passed 200 feet over the traffic on the runway during the go-around. The ATCS worked a previous night shift from 1530 to 2330 and reported during his post-incident interview that he

received 5 to 6 hours of sleep before returning for a 0730 shift. The ATCS attributed his error, in part, to fatigue (NTSB, 2007).

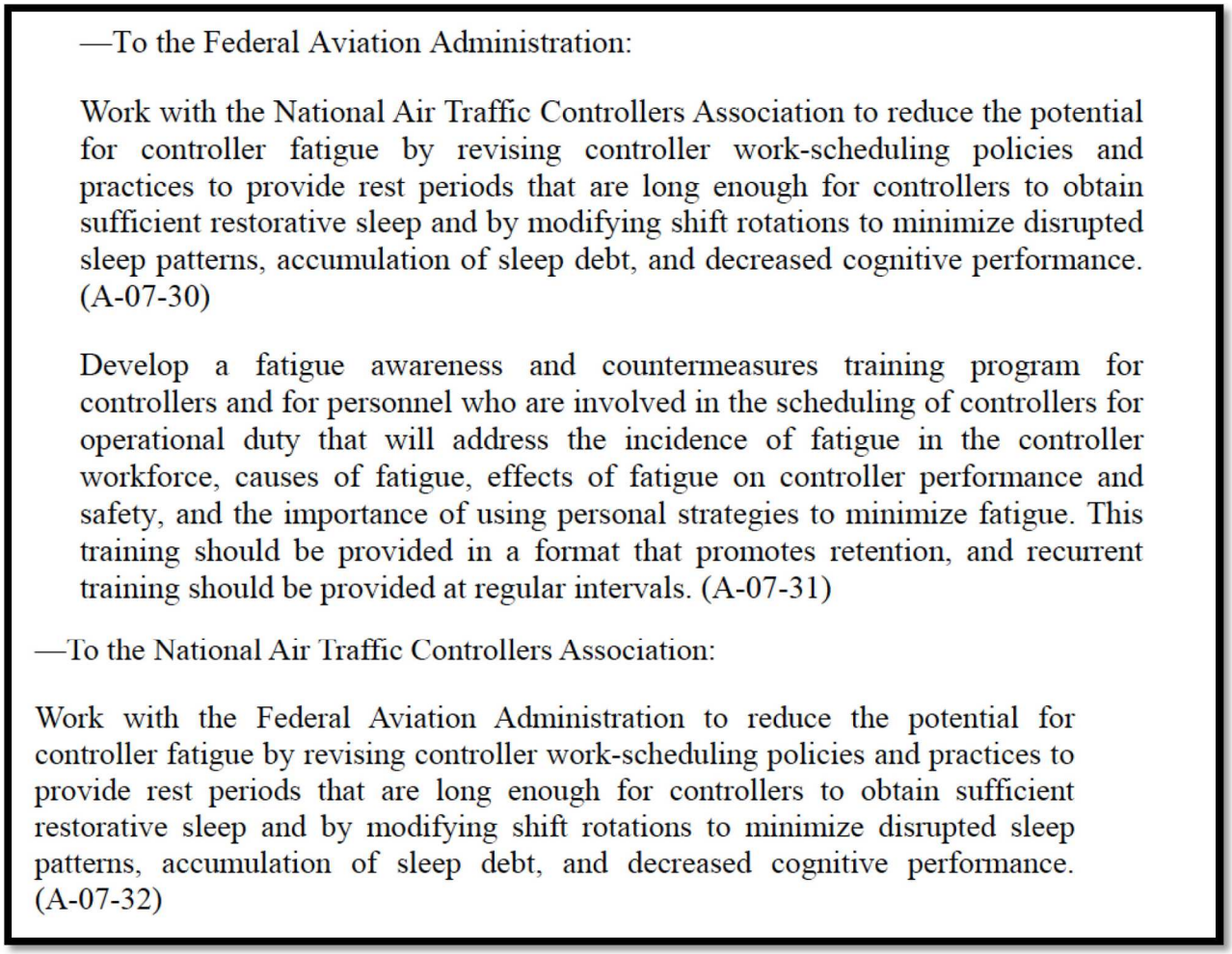
The third incident covered in the NTSB involved a 757 cargo plane taking off from Denver International Airport in September of 2001. The ATCS instructed the aircraft to taxi to depart from a runway. The crew of the aircraft requested a takeoff from a different runway, which the ATCS knew was closed. The controller agreed and cleared the aircraft to taxi and take-off on the closed runway. During the take-off, the aircraft passed within 35 feet of some work lights that were set up to illuminate the construction area (NTSB, 2007). Upon investigating this incident, the NTSB discovered that the ATCS only had a 9 hour period between her previous shift, which was from 0530 until 1330, and the shift in which the incident occurred which started at 2230 on the same day. In this 9-hour period, the ATCS reported that she only had 60-90 minutes of sleep. She stated during her interview that she was "probably tired, not alert enough".

The final incident highlighted by the NTSB occurred at Seattle/Tacoma International Airport during July of 2001. The ATCS instructed a Boeing MD-80 to taxi across a runway. At the same time, a Boeing 767 was on short final and had previously been cleared to land on the same runway that the MD-80 was crossing. When the 767 landed, the crew was forced to apply maximum braking action to avoid a collision and stopped a mere 810 feet of the crossing MD-80. The NTSB investigation determined that the ATCS forgot about the aircraft on short final and did not perform the required scan for traffic prior to issuing the crossing instructions to the MD-80. The day prior to the incident, the ATCS worked from 1400 to 2200 then slept for 4 to 5 hours before returning the following day to work a shift from 0555 to 1355. After the shift, he went home and slept for 3 hours and had to return the same day at 2245. Essentially at the time of the incident, the controller was working his third shift in two days with only 8 hours between

shifts. The incident occurred 7 minutes after the controller got on the position at 2252. He reported to the NTSB that he felt tired and tried to avoid working midnight shifts whenever possible due to fatigue.

These four incidents all highlight the issue of fatigue experienced by ATCS caused by the minimal time scheduled between shifts. The four of the ATCS involved in the runway incursions admitted that they felt tired at the time of the incident. All of the mistakes that were made are common effects of sleep deprivation, including degradation of performance when conducting cognitive tasks involving working memory and vigilance (NTSB, 2007). The shifts that the ATCS worked in these incidents fell into the legal limitations of the shift scheduling policy. At the time of the NTSB report, the regulations related to ATCS scheduling were found in Title 14 CFR 65.47, "Maximum Hours". The CFR stated that controllers may be scheduled for up to 10 hours of operational duty and requires the controller to have a rest period of at least 8 hours and be provided with one 24 hour day off per week (NTSB, 2007). FAA Order 7210.3, "Facility Operations and Administration" section 2-6-7, "Basic Watch Schedule" states that ATCS, who work a midnight shift, must have a rest period of at least 12 hours following a midnight shift (NTSB, 2007). The NTSB determined that both the FAA policies and the ATCS off-habits were contributing to the problem of controller fatigue. The FAA and several agencies had conducted a proper amount of research and had developed a scientific understanding of the causes of fatigue, how it affects the performance of ATCS, and countermeasure to minimize the adverse impact. However, the NTSB noted that the FAA has had a lack of action in regards to changing the controller scheduling practices that were in place (NTSB, 2007). The NTSB also cited the FAA Air Traffic Organization's (ATO) lack of awareness of fatigue-related issues and importance of using personal strategies for reducing fatigue when assigned to shiftwork (NTSB, 2007). These

issues were the basis of the NTSB's three safety recommendations to the FAA and NATCA regarding ATC fatigue, Recommendation A-07-30 through -32. The NTSB Recommendations are shown in Figure 4.



—To the Federal Aviation Administration:

Work with the National Air Traffic Controllers Association to reduce the potential for controller fatigue by revising controller work-scheduling policies and practices to provide rest periods that are long enough for controllers to obtain sufficient restorative sleep and by modifying shift rotations to minimize disrupted sleep patterns, accumulation of sleep debt, and decreased cognitive performance. (A-07-30)

Develop a fatigue awareness and countermeasures training program for controllers and for personnel who are involved in the scheduling of controllers for operational duty that will address the incidence of fatigue in the controller workforce, causes of fatigue, effects of fatigue on controller performance and safety, and the importance of using personal strategies to minimize fatigue. This training should be provided in a format that promotes retention, and recurrent training should be provided at regular intervals. (A-07-31)

—To the National Air Traffic Controllers Association:

Work with the Federal Aviation Administration to reduce the potential for controller fatigue by revising controller work-scheduling policies and practices to provide rest periods that are long enough for controllers to obtain sufficient restorative sleep and by modifying shift rotations to minimize disrupted sleep patterns, accumulation of sleep debt, and decreased cognitive performance. (A-07-32)

Figure 4 NTSB Recommendations A-07-30 Through 32. Note. "Reprinted from National Transportation Safety Board. A-07-30 through -32," by National Transportation Safety Board, 2007, p. 10-11.

In a statement made by the FAA to the NTSB in August of 2007 regarding Recommendations A-07-30 and -31, the FAA planned to,

> Develop, within 12 months, and implement a fatigue awareness and countermeasures training program to be used by all FAA Air Traffic Organization operational service units. Pending (1) the development of guidance for controller work scheduling policies and practices to provide rest periods that are long enough for controllers to obtain sufficient restorative sleep and (2) the modification of shift rotations to minimize disrupted sleep patterns, accumulation of sleep debt, and decreased cognitive performance (Federal Aviation Administration & National Transportation Safety Board [FAA & NTSB], 2010, paragraph 5)

This 12-month deadline was not met, but the ATO did establish the Fatigue Risk Management (FRM) Program Office within the Office of Safety. This FRM program office would be tasked with the goal of, "directly and aggressively addressing the management and mitigation of fatigue risk in both the Air Traffic Controller and Air Transportation Safety Specialist operating environments (FAA & NTSB, 2013 para. 9)."

Article 55 Fatigue Risk Management Workgroup Recommendations

NATCA would help do its part to help address the issues of controller fatigue through its 2009 CBA. Article 55 of the 2009 NATCA FAA CBA titled Human Factors, had a three part section that would outline the efforts that the FAA and NATCA would agree upon to help mitigate the risks posed by human factors such as fatigue (FAA & NTSB, 2007). Section 1 of Article 55 stated the parties agreed that operational errors resulting from human factors could be avoided and that both entities would reinforce the importance of human factor considerations. The second section gave CAMI permission to collect any and all data concerning human factors and causal factors associated with operational errors as long as participation was voluntary and confidential. The third section of Article 55 established the Article 55 Fatigue Risk Management Workgroup. The overall goal of the group would be to develop a fatigue management system

(FMS). The workgroup would be tasked with identifying and mitigating workplace fatigue concerns. Recommendations would be reached by the members of the group to be presented to both the FAA and NATCA. The Article 55 workgroup would be co-chaired by NATCA Northeast Region Vice President and the FAA FRM Program Office Manager (FAA & NTSB, 2007). The workgroup would collaborate to develop scheduling and shift rotation guidelines for ATCS. The FRM program office would sponsor a controller fatigue study that would be conducted by the National Aeronautics and Space Administration (NASA) Ames with the collaboration of both the FAA and NATCA on reviewing and providing design consultation (FAA & NTSB, 2007). The NASA study would have two parts, an online survey and on-sight objective study at selected facilities.The study would begin in April of 2010.

In March and April of 2011, there was a series of incidents involving ATCS that drew a good amount of negative media attention. These nine incidents involved supervisors and controllers who allegedly fell asleep while on position during the midnight shift, a controller who was watching a DVD while on duty, and an incident in which a plane carrying the first lady lost separation (National Air Traffic Controllers Association [NATCA], 2011). In a few of the incidents, planes were forced to land with no instruction or clearance from ATC. These incidents were not related, but all posed risked to safety and hurt the reputation of the nation's ATC system as a whole. These incidents forced both the FAA and NATCA to be more proactive on improving the scheduling policies in place at ATC facilities. Soon after these mishaps, the FAA changed the policy of having a single ATCS working on the midnight shift. Also, the FAA increased the minimum amount of hours scheduled between shifts from eight to nine hours (NATCA, 2011).

In July of 2011, the NATCA and FAA Fatigue workgroup would present it's recommendations. There were a total of 12 recommendations, 8 of directly address issues of controller scheduling, recuperative breaks, and fatigue management (NATCA, 2011). The first recommendation made by the workgroup was that the scheduling policy be modified to permit recuperative breaks during relief periods. The second recommendation addressed recuperative breaks on the midnight shift, suggesting that controllers be allowed a recuperative break of up to 2 ½ hours. Recommendation three encouraged the minimum time scheduled between evening and day shifts be increased from 8 hours to nine hours (NATCA, 2011). The fourth workgroup recommendation addressed the amount of time between a day shift and midnight shift on the same day. The workgroup encouraged reducing the day shift from eight to seven hours and beginning the midnight shift an hour later. Recommendations five through seven discussed issues of sleep apnea and does not relate to this research. The eighth recommendation covered education of employees on fatigue minimization responsibilities and what action should be taken if an employee considers themselves too fatigued to safely perform their operational duties. The ninth recommendation was directed towards managers (NATCA, 2011). The workgroup recommended that a non-punitive system be put into place to allow employees to self-declare as too fatigued to safely perform their operational duties without fear of repercussions. Recommendation ten suggested that the FAA and NATCA update existing fatigue awareness training to reflect current science and personalize the application of the training. Recommendation eleven and twelve discussed the design and implementation of a Fatigue Risk Management System (FRMS) within the FAA ATC environment. The workgroup recommended that a post-Article 55 workgroup be formed with the same members until the FRMS is established.

The recommendations by the article 55 workgroup were agree upon by the FAA and NATCA. The two parties signed a Memorandum of Understanding (MOU) in 2012 that reiterated the recommendations made by the workgroup (Federal Aviation Administration & National Air Traffic Control Association [FAA & NATCA], 2012). This MOU introduced recuperative breaks, a nine-hour minimum between shifts, and introduced a system where ATCS could self-declare as too fatigued to safely work an operational position (FAA & NATCA, 2012).

OIG Audit Report and Current Regulations

On February 14, 2012, President Barack Obama signed the FAA modernization and reform act of 2012 (FAA, 2012). One of the objectives of the act was for the Office Inspector General to "review the considerations of safety, controller performance, and cost effectiveness when controllers schedules are developed (Office Inspector General [OIG], 2013)". This objective was to be achieved by an audit of the ATC scheduling system. According to the OIG report (2013), the audit would have three goals. The first goal was to "determine the impact that controller scheduling practices have on safety and air traffic controller performance". The second goal was to, "evaluate the cost effectiveness of controller scheduling practices (OIG, 2013)". The final goal of the audit was to, "assess the air traffic control facility compliance with FAA scheduling policies (OIG, 2013)". The FAA made changes to its scheduling policies after the Article 55 Workgroup made its reccomendations in 2012 through a MOU. However, facility managers began to raise the question of if these scheduling policy changes were sufficient enough to reduce fatigue.

The OIG could not complete first goal of the audit because the FAA had no metrics which measured the effectiveness of scheduling practices (OIG, 2013). The OIG was able to address the audit's second goal of evaluating cost effectiveness of scheduling. Although the new

scheduling policy which reqiured an additional controller to work on overnight shifts cost the agency 1.9 million per year, there were measures availible to cut cost (OIG, 2013). These included implementing the Operational Planning and Scheduling (OPAS) tool which would help managers design shift schedules that were more efficient. Also the audit found 72 facilities that do not meet the minimum traffic guidelines set by the agency for continous overnight operation (OIG, 2013). The agency could reduce cost by possibly reducing services offered at these facilities. The last goal of assessing compliance of scheduling policies was achieved by examining a sample of 32,814 shifts for 403 controllers over a 16-week period at 20 facilities (OIG, 2013). The audit found that controllers are often working shifts that do not comply with the minimum amount of time between shifts that have been set by the FAA. 279 cases were discovered by the audit that was not in compliance with the 9 hours off duty time between an evening shift and a day shift. One hundred and two cases were found in which the minimum of 8 hours off between all shifts was not given (OIG, 2013). While majority of the cases were within 15 minutes, this is still an issue that needs to be addressed by the agency. The agency did agree to take some steps such as conducting regular audits and implementing an alert in the timekeeping system that will notify controllers of potential violation. The OIG stated in its audit that the notification can be bypassed without approval from a supervisor and that does not fully address the issue. As stated in the OIG report, the current scheduling policies for ATCS are as follows:

- Controllers cannot have more than 10 operational hours in a shift.
- There must be at least an 8-hour break from the time work ends to the start of any subsequent shift and a minimum 9-hour break preceding the beginning of a day shift.
- Controllers must have an off-duty period of at least 12 hours following a midnight shift.
- Controllers cannot work more than 6 consecutive days without a day off. (2013, p. 3-4)

Research Questions

The issue of fatigue for the ATCS has been a topic of concern since the 1960's. Extensive research has been conducted on the subject. The majority of research that has been conducted reveals that ATCS have been working with some form of sleep deprivation. Causes of this sleep deprivation vary by the individual, but scheduling policies have consistently been an issue. The FAA made a step towards addressing the problem of fatigue by amending the scheduling policy in 2012. Since these regulation changes, there has not been public research regarding the effectiveness of the policy changes. This research will seek to investigate the effectiveness of these changes from an ATCS perspective. Specifically, this research will focus on four things: ATCS views towards the amount of hours allocated between shifts, personal sleeping habits, changes in perception since the 2012 regulation changes, and which external factors impact the perception of fatigue in the ATC community.

The research will seek to answer the following questions:

1. Do ATCS feel that there is currently enough time between shifts to receive adequate rest?
2. Has the perception of fatigue among ATCS changed since the implementation of the new scheduling rules in 2012?
3. What factors have the most significant impact on ATCS perception of fatigue in regards to shift schedules?
4. Has the perception of health among ATCS changed since the implementation of the new scheduling process in 2012?

CHAPTER II: METHODOLOGY

The goal of this research is to evaluate the effectiveness of the recent changes made to scheduling regulations. The quantitative research approach was the most suitable research method to get the information needed for the study. According to Educational Research Competencies, for Analysis and Applications, "Quantitative research approaches are applied to describe current conditions, investigate relations and study cause-effect phenomena. Survey research is often designed to describe current conditions", (Gay et al., 2009, p. 8). This study looks to describe the current conditions and effects of recent changes to the scheduling practices within the FAA. The study will utilize a survey to analyze the perception of ATCS currently employed by the FAA. A survey was determined to be the most appropriate method to collect the data required for this research. The use of an online survey allowed respondents to remain completely anonymous, decreasing the possibility of bias due to fear of possible repercussions. Also, use of a survey enables the collection of a larger amount of data than other methods such as interviews and is less expensive than other methods (Gay, 2009). The survey assessed the effectiveness of current scheduling practices. Also, the survey analyzeed the effectiveness of recent regulation changes and examine external factors that could impact the amount of rest received by ATCS. The survey was hosted on Surveymokey.com due to their reputation within the academic field and the ability to encrypt IP addresses to ensure anonymity. This study was designated as exempt by Middle Tennessee State Universities Institutional Review Board via 45 CFR 46.101(b)(2) Educational Tests, Surveys, Interviews, or Observations. The Protocol Number for the exemption is #15-319, and the exemption form is available in Appendix A.

Participants

The participants of the study needed to meet two criteria. They had to hold the position of ATCS and had to be currently employed by the FAA. The survey was disseminated through

three different modes: Aviation blogs, LinkedIn, and an organization weekly newsletter. A post was made on several aviation blog sites including a message explaining the purpose of the research and a link to take the survey. The message informed the reader that participation was not required and that there was no identifying information collected during the survey. Those who chose to participate clicked on the link and was taken to SurveyMonkey.com to complete the survey. The survey link could be accessed either on a computer or mobile device. The message was posted on both LiveATC.net and stuckmic.com. The message used for survey dissemination can be found in Appendix B. The same message was then posted on the LinkedIn professional networking site. There was one general post in which the researcher requested the help of any personal connections that were ATCS currently employed by the FAA. A second post was made to the discussion board of several professional aviation groups on LinkedIn. Members of the group were invited to participate in the study using the same message that was posted to the online aviation blogs. The post was made on eight discussion boards for groups relating to air traffic control. These groups include Air Traffic Complexity, National Alliance to Advance NextGen, Human Factors in ATC, NBCFAE (National Black Coalition of Federal Aviation Employees), Air Traffic Control Network, Air Traffic Flow and Capacity Management, FAA Managers Association, and Air Traffic Control @ TRS Resource Group.

Design of Instruments

The questionnaire utilized several different question types. These included Likert-scale, multiple choice, and open-ended questions. The majority of the data needed for the study was collected via Likert-scale questions. Likert-scale is an attitude scale question that is used to measure what an individual perceives or believes about activities, situations, or institutions (Gay et al., 2009). Since the study was seeking the perception of ATCS, Likert-scale questions were

selected to be the primary source of data collection. The survey consisted of 28 questions. All questions were put into five different categories based on the overall subject of the question. The categories included:

- Demographics
- Education
- Availability of Recuperative Breaks
- Perception of Facility Scheduling Trends
- Perception of Fatigue and Scheduling Regulations

The demographics category included questions 1-10. These questions sought to collect information about the participant's facility level, facility type (Enroute, Tower, and TRACON), years as an ATCS, amount of years at specific facility, age group, gender, and age of children. Questions 11-13 were in the education category. The education category included questions regarding the participant's highest level of education and whether the participant has taken a course on human factors or fatigue management. Question 14 was a yes or no question and placed into the category titled availability of recuperative breaks. The questions asked if the participant's facility allowed recuperative breaks. The fourth category was titled perception of facility scheduling trends and included questions 15-17. The questions in this category asked the respondent about the amount of time that is typically scheduled between shifts on day four and five in their standard work week, how many hours they believed should be scheduled between any two shifts, and if they felt the hours scheduled between day four and five of their shift was enough to get adequate rest. Questions 18-27 where all Likert-scale questions and were placed in the perception of fatigue and scheduling regulations category. The questions in this category sought to get the perception of the respondent regarding fatigue, sleep patterns, and current scheduling regulations.

Question 28 was an open-ended question giving the participant the opportunity to recommend changes they would like to see to current scheduling policies.

The survey was made available from May 6, 2015- May 19, 2015. The survey yielded a total of 65 total attempts, and 57 complete attempts. There were four of the fifty-seven participants that provided great insight on questions 1-17 but seemed to not be aware of the last part of the survey. The responses for those 17 questions that were completed will be used for data analysis, but the data for questions 18-28 will only include 57 the completed attempts. The number of responses is not completely representative of the over 15,000 ATCS currently employed by the FAA. However, due to the diversity of the respondents, the data can still provide useful insight for future studies if trends are evident.

CHAPTER III: ANALYSIS OF RESULTS

The first question of the survey was used to determine if the respondent met the minimum qualifications for participation. This question ensured they were currently an active ATCS working for the FAA. If the respondent answered no to this question, their data was not used for the study. Of the 64 total responses collected, 57 were completed. Fifty-four of the 57 were able to be used, because three respondents answered no to the first qualification question.

Demographics

The next nine questions in the survey were categorized as demographic questions. The demographic questions were used to see the diversity of the participants. The questions asked about facility information, age, gender, children at home, experience, and length of time acclimated to current scheduling rules at the current facility. This information was also used in analyze the data in different demographic groups.

The first two of the demographic questions were regarding the facility that the participant currently worked. Question two of the survey asked about facility level. The majority of responses were from level 12 facilities. The responses to the facility level question are shown in the chart below in Figure 5. The third question asked about facility type (Enroute, Tower, TRACON, Up-down tower and TRACON). Enroute had the most respondents out of all facility types with 30. The responses to question three are shown below in Figure 6.

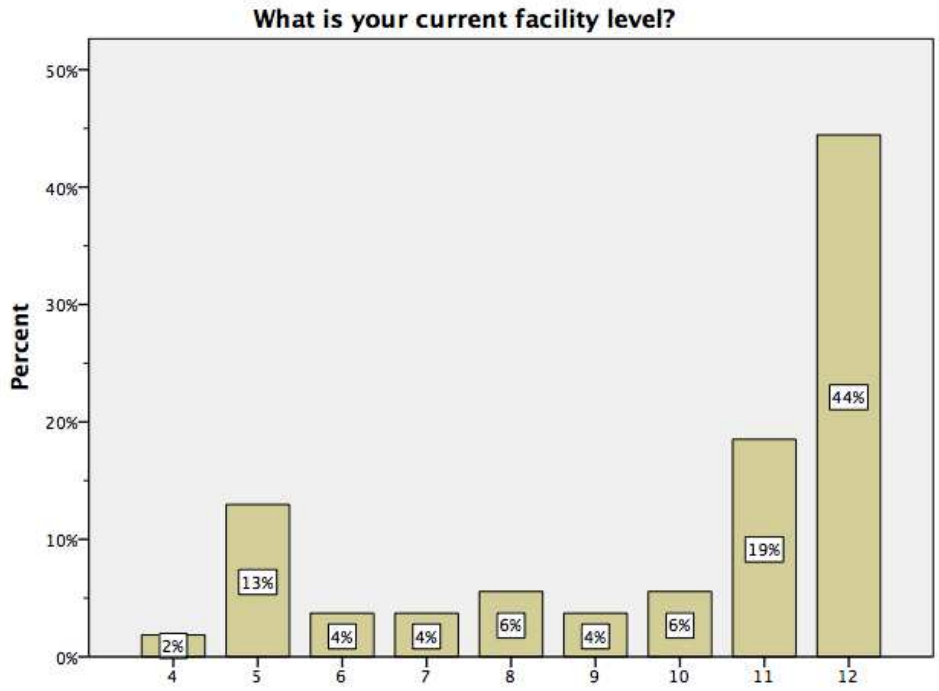


Figure 5 Facility Level Reported by Respondents

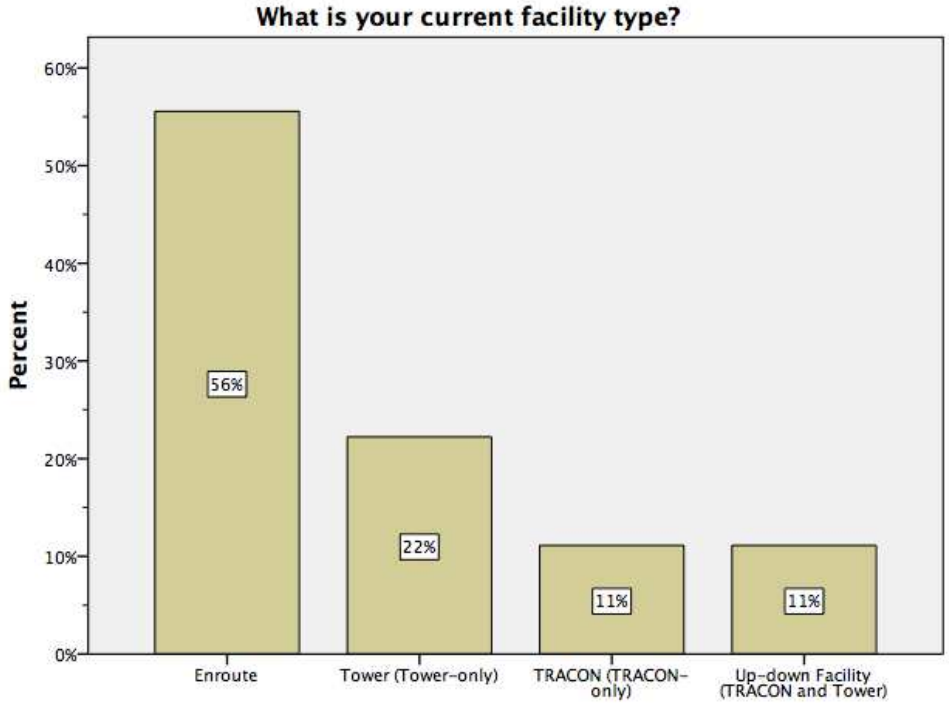


Figure 6 Facility Type Reported by Respondents

The third demographic question asked if the ATCS was a Certified Professional Controller (CPC). Fifty-three of the possible 54 respondents indicated that they are CPC. The fourth and fifth demographic questions were used to collect information about the respondents work experience as an ATCS. The first of these two questions related to experience and asked the respondent how long they had been an ATCS. There was diversity in experience among the sample with reported experience ranging from one year to thirty-four years. The average experience of the participants was 14 years and 5 months at the position of ATCS. The second question about experience asked the respondent how long they had been at their current facility. This information was used to see if the longer a respondent was at a facility affected the perception of the scheduling regulations and fatigue. The respondents were allowed to select one of five categories: less than 1 year, 1-3 years, 3-5 years, 5-10 years, or more than 10 years. The responses to this question are shown below in Figure 7.

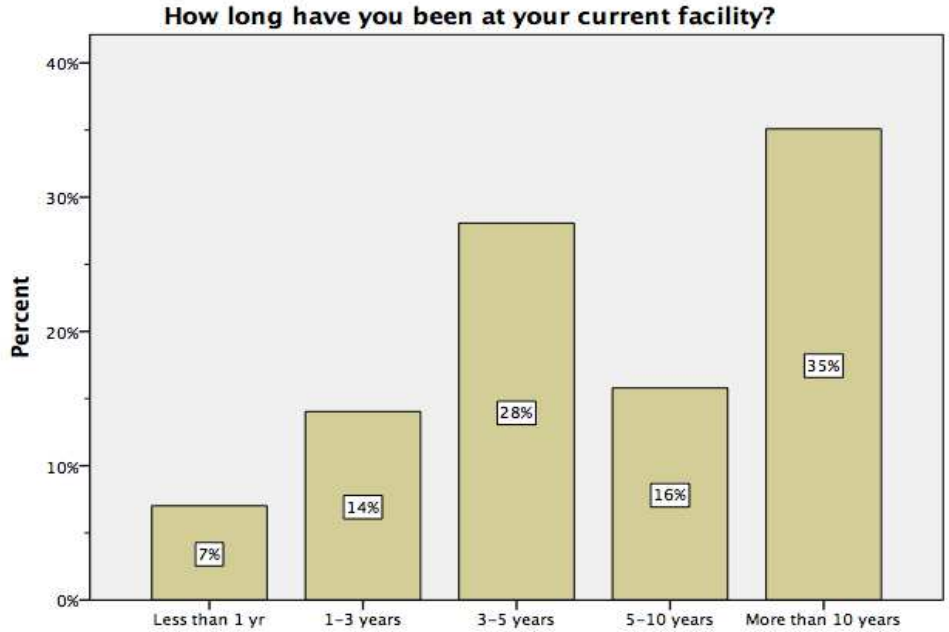


Figure 7 Length at Current Facility

Demographic question six asked participants to select their age group from one of the five age groups displayed. The age groups listed included below 30, 30-40, 41-50, 51-60, and above 60. The most frequent response was the age group 30-40 with 42 % of responses. The results of this question are shown in the graph below labeled Figure 8.

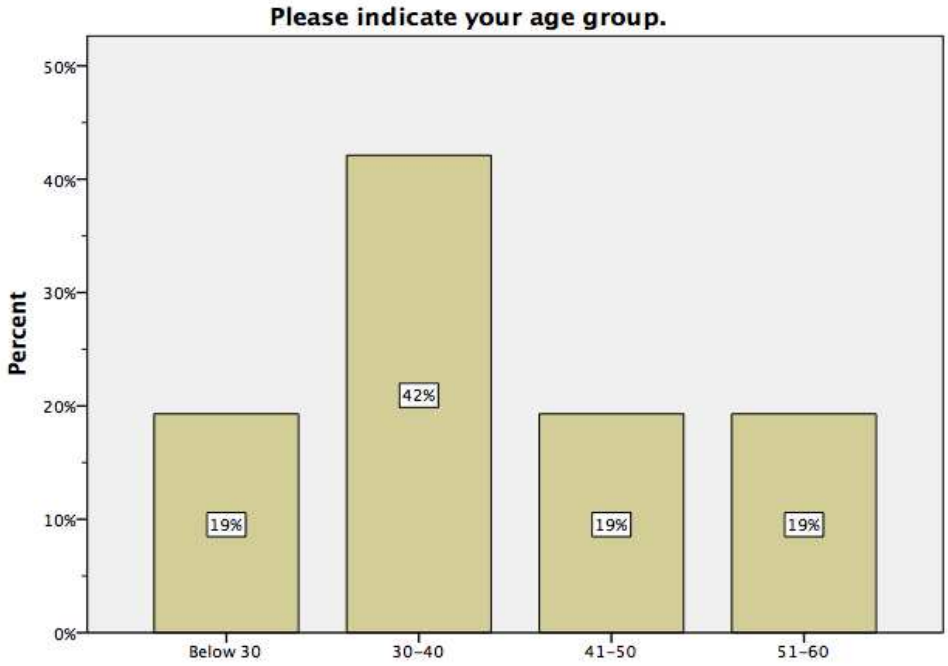


Figure 8 Age Group of Participants

The next demographic question asked the respondent to select their gender, male or female. This information was used to ensure the sample collected was diverse and included the perception of both male and female ATCS. Seventy-two percent of the respondents were male, and 28% were female. This was expected since males make up the majority of the ATCS workforce at the FAA.

The last two demographic questions were related to the children of the respondent. Question 9 asked the participants to indicate if they had any children under the age of 18. This question was used to examine if the presence of children affected the amount of sleep of the

participant or the perception of the current scheduling regulations. Fifty-two percent of the respondents indicated they had children under the age of 18 while 48% stated they did not. If the respondent answered yes to the question 9, they were routed to question 10 that asked the age group of their youngest child. This question was skipped if the respondent answered that they did not have any children. The age groups of the ATCS's youngest child are shown in Figure 9.

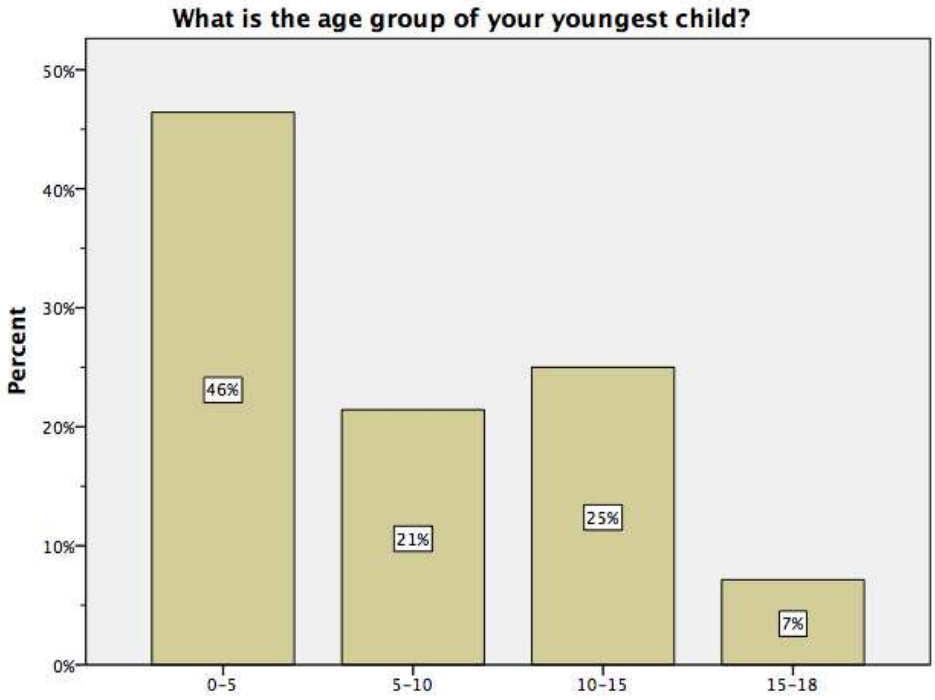


Figure 9 Age Group of Children of Participants

Education

The next category of questions was related to the education of the participants. The first question in this category was question 11 which asked the ACTS to indicate their highest level of education. The responses to this question showed that the participants came from diverse education backgrounds. Fifty-five percent of respondents indicated they had either a 4-year or graduate degree. The results to question 11 are shown in their entirety in Figure 10.

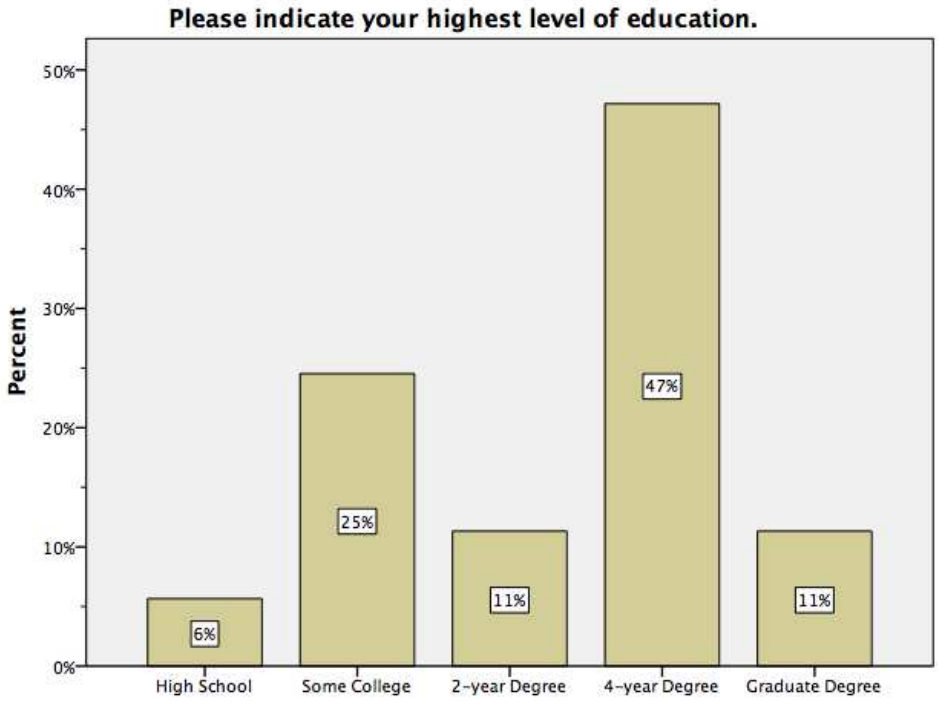


Figure 10 Highest Level of Education as Indicated by Respondent

Questions 12 and 13 of the survey were the last two questions in the education category. Question 12 asked the respondents if they have ever taken a course on human factors. Since sleep deprivation and fatigue are commonly covered in human factors courses, this information could show the effectiveness of said courses. Seventy-four percent of the participants stated that they had taken a human factors course, while remaining 26% indicated they did not. Question 13 asked if the participants had ever taken a college or FAA course on fatigue management. The reasoning behind this question was similar to that of question 12. The information could also be used to see if there were a trend behind the responses of those who took fatigue management courses versus those who did not. Twenty-one percent of respondents indicated that they had never taken a course on fatigue management, while 79% indicated that they did take a course.

Recuperative Breaks

The 14th question of the survey did not fit into any of the other categories for questions. Therefore, it was put into a category by itself named availability of recuperative breaks. The yes or no question asked if the respondent's facility allowed recuperative breaks. The results for this question were used to compare the perceptions of those who are allowed recuperative breaks to those that are not. Eighty percent of the respondents indicated that their facility allowed recuperative breaks. The remaining 20% indicated that recuperative breaks were not allowed at their facility.

Perception of Facility Scheduling Trends

The next category in the survey was Perception of Facility Scheduling Trends and consisted of survey questions 15-17. The responses to this category of questions directly answered the first research question. Question 15 asked the participant the following question, "On an average, how many hours are you scheduled off between day 4 and day 5 of your standard workweek?" In previous studies, the time between day 4 and day 5 was the time in which the least amount of sleep was reported (Salazar, n.d.). The respondent was able to select from multiple options the amount of hours that was typically scheduled between shifts 4 and 5. The results from this question were used to see how this affected the answers to later questions regarding fatigue and sleeping habits. Figure 11 shows the responses collected from question 15. The next question in the Perception of Facility Scheduling Trends category asked participants, "How many hours do you feel you should be scheduled off between any two shifts in order to receive adequate rest?" The most prevalent responses to question 17 were ten and twelve hours. The results are shown in full in Figure 12.

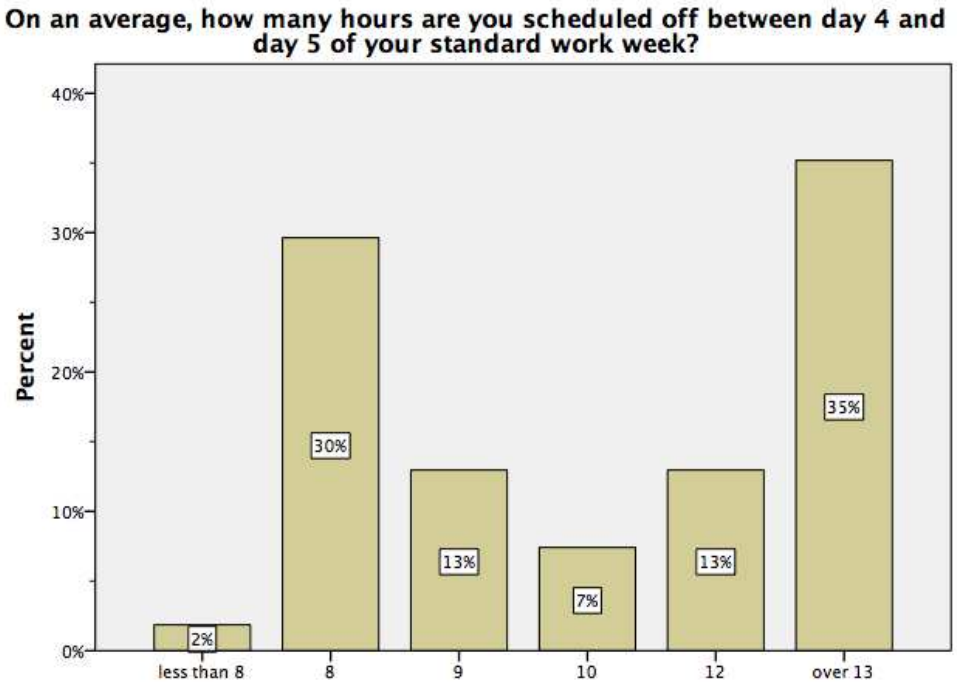


Figure 11 Amount of Hours Off Scheduled Between Day 4 and Day 5 Of Standard Workweek

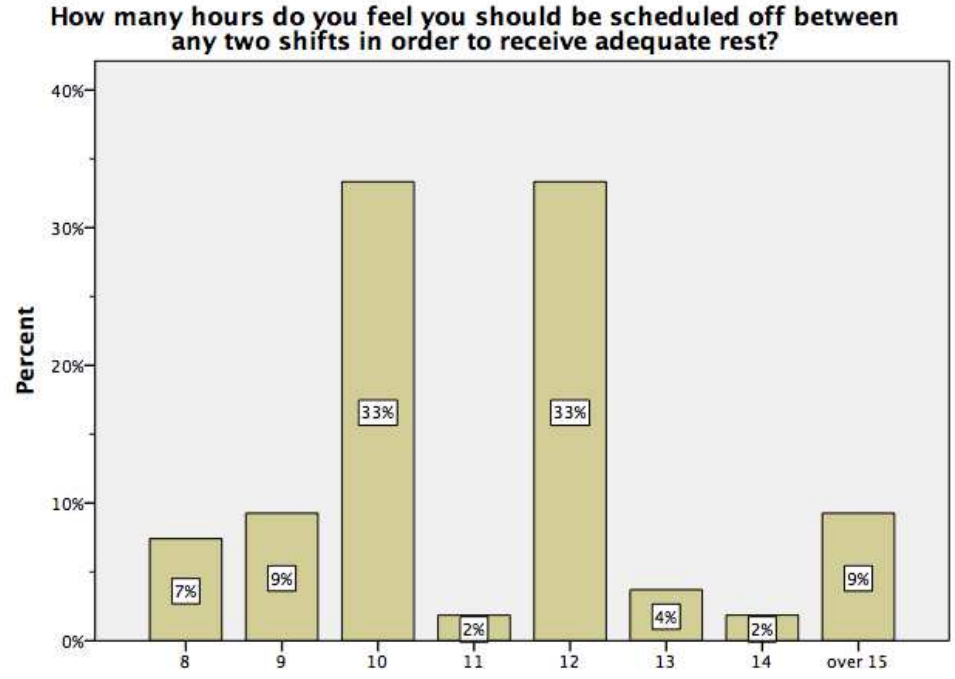


Figure 12 Hours Respondent Feels Should be Scheduled Between Two Shifts to Receive Adequate Rest

Question 17 was the first of a series of Likert-item style questions and the last question of the Perception of Facility Scheduling Trends category. The participants were asked "Regarding your answer selected for question #15, please read the sentence below and select the appropriate response. I feel that this amount of time permits me enough rest to not feel fatigued on the following shift." Respondents could select Strongly Agree, Agree, Neither Agree or Disagree, Disagree, or Strongly Disagree to the previous statement. An overwhelming amount of respondents either agreed or strongly agreed with the statement in question 17. The data collected from the question was analyzed and was shown to be extremely statistically significant through a chi-squared test. The responses and chi-square results are shown below in Table 1.

Table 1

Frequency of Responses to Question 17

Survey Answers	Likert Answer Value	Frequency of Responses	% Surveyed		
Strongly Disagree	1	7	13%		
Disagree	2	2	4%		
Neither Agree or Disagree	3	2	4%		
Agree	4	28	52%		
Strongly Agree	5	15	28%	Chi Square	P-Value
Average Value	3.78			44.704	<0.0001

Perception of Fatigue and Scheduling Regulations

The last category of questions was titled Perception of Fatigue and Scheduling Regulations and included questions 18-27. All of the questions in this category were Likert-type questions that allowed respondents select Strongly Agree, Agree, Neither Agree or Disagree, Disagree, or Strongly Disagree to a statement. Question 18 stated "Human fatigue can be avoided." The majority of the ATCS (65%) surveyed either agreed or strongly agreed with this statement. The responses to this question were found to be extremely statistically significant. The frequency of the answers and chi-square results are shown below in Table 2.

Table 2

Frequency of Responses to Question 18

Survey Answers	Likert Answer Value	Frequency of Responses	% Surveyed		
Strongly Disagree	1	2	4%		
Disagree	2	9	17%		
Neither Agree or Disagree	3	6	11%		
Agree	4	28	52%		
Strongly Agree	5	7	13%	Chi Square	P-Value
Average Value	3.43			39.731	<0.0001

The next question, question 19, dealt specifically with current scheduling minimums and the loss of situational awareness. The statement that the participant was to respond to stated, "Because of the current scheduling minimums while on duty, I've lost situational awareness due to insufficient rest between shifts." The overall responses for this question varied widely among participants as shown in Table 3. Based on the Chi-square analysis, the results were shown to not be statistically significant.

Table 3

Frequency of Responses to Question 19

Survey Answers	Likert Answer Value	Frequency of Responses	% Surveyed		
Strongly Disagree	1	9	17%		
Disagree	2	14	26%		
Neither Agree or Disagree	3	10	19%		
Agree	4	15	28%		
Strongly Agree	5	6	11%	Chi Square	P-Value
Average Value	2.91			5.074	0.2798

Question 20 was used to assess the current sleeping habits of controllers. The controller was asked their level of agreement with the following statement, "I get an average of 8 hours of sleep per night." Since the majority of available literature suggest between 7.5 and 8.5 hours of sleep per night, the average of 8 was used in this question. An overwhelming majority (76%) of ATCS surveyed disagree with this statement. This disparity suggests that there is a culture of sleep deprivation among FAA ATCS. Based on the statistical analysis this was found to be extremely statistically significant. The results to question 20 are shown in full in Table 4 below.

Table 4

Frequency of Responses to Question 20

Survey Answers	Likert Answer Value	Frequency of Responses	% Surveyed		
Strongly Disagree	1	18	33%		
Disagree	2	23	43%		
Neither Agree or Disagree	3	3	6%		
Agree	4	8	15%		
Strongly Agree	5	0	0%	Chi Square	P-Value
Average Value	1.94			37.038	<0.0001

Questions 21 and 22 dealt with answering the second research question related to the perception of fatigue since the implementation of the new scheduling policies. Question 21 asked the respondent their level of agreement with the following statement, "Because the new scheduling requires 12 hours between midnight shifts after a mid, I feel more rested while on my assigned shift". The majority of respondents (55%) neither agree or disagree with the statement. Only 25% agreed with the statement. The statistical analysis showed the results to be extremely statistically significant based on the chi-squared test. Table 5 below displays the responses in full.

Table 5

Frequency of Responses to Question 21

Survey Answers	Likert Answer Value	Frequency of Responses	% Surveyed		
Strongly Disagree	1	4	7%		
Disagree	2	5	9%		
Neither Agree or Disagree	3	30	56%		
Agree	4	14	26%		
Strongly Agree	5	0	0%	Chi Square	P-Value
Average Value	2.96			54.264	<0.0001

Question 22 asked the respondents their level of agreement with the following statement, "Because of the 9-hour rule between shifts, I feel less likely to have an operational error due to fatigue." Nearly half (48%) of participants had some level of disagreement with this statement. Based on the Chi-square statistical analysis these results were found to be extremely statistically significant. The frequency of responses is shown in Table 6 below.

Table 6

Frequency of Responses to Question 22

Survey Answers	Likert Answer Value	Frequency of Responses	% Surveyed		
Strongly Disagree	1	6	11%		
Disagree	2	20	37%		
Neither Agree or Disagree	3	15	28%		
Agree	4	11	20%		
Strongly Agree	5	1	2%	Chi Square	P-Value
Average Value	2.59			20.868	0.0003

Question 23 was used to answer research question 4 regarding the perception of health among ATCS. The question asked the participants level of agreement to the following statement, "Because of the 9-hour rule between shifts, I feel that my overall health has improved." Almost half of the ATCS surveyed (48%) disagreed with this statement, and only 13% agreed. The chi-square statistical analysis proved the results of this question to be extremely statistically significant. The results certainly suggest that the 9-hour rule between shifts has not had an impact on the overall health of FAA ATCS. The frequency of each response is shown in full below in Table 7.

Table 7

Frequency of Responses to Question 23

Survey Answers	Likert Answer Value	Frequency of Responses	% Surveyed		
Strongly Disagree	1	6	11%		
Disagree	2	20	37%		
Neither Agree or Disagree	3	20	37%		
Agree	4	7	13%		
Strongly Agree	5	0	0%	Chi Square	P-Value
Average Value	2.48			30.491	<0.0001

Question 24 was used to investigate the culture of reporting fatigue while on duty at the facilities of the participants. The question asked the subject to rate their level of agreement with the following statement, "There is currently a non-punitive system in place to report fatigue while on position." 46% of respondents had a level of agreement with this statement. 33% neither agree or disagree with the statement, possibly suggesting that there is a reporting system but it is punitive. The chi-square statistical analysis showed the results to be extremely statistically significant and not by chance. Table 8 displays the frequency of all responses to question 24.

Table 8

Frequency of Responses to Question 24

Survey Answers	Likert Answer Value	Frequency of Responses	% Surveyed		
Strongly Disagree	1	5	9%		
Disagree	2	6	11%		
Neither Agree or Disagree	3	18	33%		
Agree	4	24	44%		
Strongly Agree	5	1	2%	Chi Square	P-Value
Average Value	3.19			35.074	<0.0001

Question 25 was used to investigate research question three which asked about the external factors that have the most significant impact on ATCS perception of fatigue. The respondent was asked to rate their level of agreement with the following statement, "My home responsibilities make it hard for me to get adequate rest between shifts with the scheduling regulations that are in place." 65% of responses agreed with this statement. The chi-squared analysis showed these results to be extremely significant. Frequency of answers is shown below in Table 9.

Table 9

Frequency of Responses to Question 25

Survey Answers	Likert Answer Value	Frequency of Responses	% Surveyed		
Strongly Disagree	1	3	6%		
Disagree	2	10	19%		
Neither Agree or Disagree	3	6	11%		
Agree	4	26	48%		
Strongly Agree	5	9	17%	Chi Square	P-Value
Average Value	3.52			25.519	<0.0001

Question 26 asked the respondent about the use of sick days to get adequate rest. The participant was asked to rate their level of agreement with the following statement, "The scheduling regulations that are in place have caused me to take a sick day in order to get adequate rest." The responses to this question varied greatly among participants. The chi-squared test showed the results to not be statistically significant. The frequency of each answer is provided in table 10 below.

Table 10

Frequency of Responses to Question 26

Survey Answers	Likert Answer Value	Frequency of Responses	% Surveyed		
Strongly Disagree	1	8	15%		
Disagree	2	14	26%		
Neither Agree or Disagree	3	6	11%		
Agree	4	18	33%		
Strongly Agree	5	8	15%	Chi Square	P-Value
Average Value	3.07			9.333	0.0533

The last Likert-type question was Question 27. This question asked respondents about the extent that the scheduling regulations have affected their lives and career choice. The participant was asked to rate their level of agreement to the following statement, "The scheduling regulations that are currently in place have caused me to consider changing careers." The majority of responses were in disagreement with this statement. The Chi-square test showed the frequency of the responses to be extremely statistically significant. The frequencies of each survey answer are shown below in Table 11.

Table 11

Frequency of Responses to Question 27

Survey Answers	Likert Answer Value	Frequency of Responses	% Surveyed		
Strongly Disagree	1	30	56%		
Disagree	2	12	22%		
Neither Agree or Disagree	3	2	4%		
Agree	4	4	7%		
Strongly Agree	5	5	9%	Chi Square	P-Value
Average Value	1.87			49.736	<0.0001

Question 28 was the last question of the survey. It was an open-ended question asking respondents to do the following; "If granted the power to amend the policy that identifies ATC time between shifts, briefly explain what changes you would make." Thirty-four of 54 respondents answered this question. The responses were very informative of changes that ATCS would make to the current scheduling policy if given the opportunity to do so. The responses were sorted into 13 categories based on the overall topic of the comment. Some comments fell in more than one category. The most frequently mentioned suggestion was more time off between shifts. Several responses also mentioned traffic as an issue that is not taken into account with

current scheduling practices. The categories and frequency of responses are shown below in Table 12. The comments from question 28 can be seen in full in Appendix D.

Table 12

Categories and Frequency of Responses to Question 28

Response Category	Frequency	Percentage
2-2-1 shift rotation	1	3%
10 hour days	3	9%
Fewer hours per week	1	3%
More time off between shifts(Unspecified amount of hours)	6	18%
8 hours between	1	3%
10 hours between	8	24%
12 hours between	3	9%
More staffing	2	6%
No more than two mids per week	1	3%
Shorter mids	1	3%
No Changes	5	15%
Permanent shifts	4	12%
Straight 5's	4	12%

CHAPTER IV: DISCUSSION

Analysis of Research Question I

The main goal of this research was to investigate the four research questions that were posed at the end of chapter one. The objective of the first research question was to determine if ATCS felt that there is currently enough time between shifts to receive adequate rest. Several questions on the survey were used to gather the information needed to fufill this objective. Four questions were chosen to gather the overall perception of the survey population in regards to time scheduled between shifts. The first question selected from the survey to answer research question one was question 15. Question 15 asked participants, "On an average how many hours are you scheduled off between day 4 and day 5 of your standard workweek." Based on the avalible literature, in a typical workweek day 4 and day 5 is usually the quickest turnaround and has the least amount of time scheduled between the two shifts. The results to this question showed that 45% of ATCS report being scheduled less than 10 hours between this two days. Question 16 then asked the ATCS how many hours they felt should be scheduled between any two shifts to receive adequate rest. Eighty-four percent of respondents felt that 10 hours or more were needed between two shifts to receive adequate rest. The relationship between these two answers shows that close to half of the ATCS surveyed feel that they are not being scheduled enough time between day 4 and 5 of the workweek to receive adequate rest. The next question that was used to investigate the first research question was survey question 20. Question 20 asked the participant to rate their level of agreement to the statement "I get an average of 8 hours of sleep per night." Only 15% of participants surveyed indicated they agreed with this statement. This shows that the majority of ATCS are dealing with some level of sleep deprivation due to current scheduling regulations.

The last question that was analyzed in regards to research question one was survey question 26. Question 26 asked the participant to rate their level of agreement to the statement, "The scheduling regulations that are in place have caused me to take a sick day in order to get adequate rest." Only 41% disagreed with this statement. This shows that the current scheduling regulations are causing the majority of ATCS to take a sick day to receive adequate rest. The analysis of these results has shown that the answer to research question one is that the majority of FAA ATCS do not feel there is enough time scheduled between shifts to receive adequate rest. This is especially true for lower level facilities and facilities that do not allow recuperative breaks.

Analysis of Research Question II

The second research question that was investigated was, "Has the perception of fatigue among ATCS changed since the implementation of the new scheduling rules?" This question was to be answered by three survey questions related to new scheduling rules. The first survey question related to the second research question was survey question 21. Question 21 asked respondents to rate their level agreement to the statement, "Because the new scheduling requires 12 hours between midnight shifts after a mid, I feel more rested while on my assigned shift." Only 26% of respondents agreed with this statement. The low agreement rate on this question suggests that the regulation changes have not been an effective method to reduce fatigue on the midnight shift.

Question 22 was similar in nature to 21 but asked about the rule regarding the amount of time scheduled between any two shifts where question 21 was specific to midnight shifts. Question 22 asked respondents to rate their level of agreement to the statement, "Because of the 9-hour rule between shifts, I feel less likely to have an operational error due to fatigue." Almost half of respondents (48%) disagreed and only 22% agreed that the new 9-hours between shifts

regulation makes them less likely to have an operational error. This data suggest that the changes made were not sufficient and more than 9 hours is needed between shifts. This conclusion is supported by the responses on question 28 that asked respondents "If granted the power to amend the policy that identifies ATC time between shifts, briefly explain what changes you would make." The largest percentage of responses were in the category related to having at least 10 hours between shifts. Several of the respondents specifically mentioned the fact that the current scheduling regulations do not take into account the time it takes for commuting to and from work and other mitigating factors. Based on this information, the answer to research question two is that the majority of ATCS do not feel that the recent changes made to scheduling regulations have been sufficient to address fatigue issues that are prevalent in the ATC workforce.

Analysis of Research Question III

The goal of the third research question was to investigate the factors that impact ATCS's perception of fatigue in regards to shift schedules. This questiQon was answered by doing a cross-examination of several research questions with different variables. The first survey question analyzed with research question three was question 19. Question 19 asked participants to rate their agreement with the statement, "Because of the current scheduling minimums while on duty, I've lost situational awareness due to insufficient rest between shifts." One interesting trend was seen with question 19 when cross-examined with two variables. The first variable taken for a cross section analysis was the responses to question 19 broken down into the facility level of respondents. The majority of the participants that either agreed (73%) or strongly agreed (100%) with the statement were in facility levels 9-12. This suggests that the higher level facilities may be at higher risk for experiencing a loss of situational awareness due to the current scheduling regulations than the lower level facilities. It is also worth noting that all respondents

that strongly agreed with the statement came from level 12 facilities. The second variable taken for cross-sectional analysis for this question was the availability of recuperative breaks. 60% of the respondents that are not allowed recuperative breaks at their respective facility agree with the statement compared to 33% of those that are allowed recuperative breaks. This suggests that the use of recuperative breaks could be a successful mitigation strategy to avoid the loss of situational awareness due to scheduling minimums.

Question 20 was the second survey question that a cross analysis of other available variables was conducted to investigate research question three. There were four variables that when cross-examined with question 20 stood out and showed possible trends among ATCS. Theses variables include facility level, age group, and availability of recuperative breaks. When analyzed based on facility level of the respondent, one thing that was concerning was the responses of ATCS level 10 through level 4. Out of 19 responses for those facility levels, there was only one respondent who reported receiving an average of 8 hours of sleep per night. This suggest that the lower level facilities may be at a higher risk for sleep deprivation than higher level facilities. However, levels 11 and 12 give a reason for concern with 7 out of 33 respondents agreeing that they receive 8 hours of sleep per night. When analyzed by age group, none of the 18 participants in the 41-50 and 51-60 age group reports receiving an average of 8 hours of sleep per night. The eight participants who agreed to the statement that they receive 8 hours of sleep per night were in the below 30 and 30-40 age group with 3 and 5 responses respectively. This information suggested that ATCS over the age of 40 may be suffering from sleep deprivation at a higher rate than the rest of the ATC workforce. The last variable analyzed was the availability of recuperative breaks. The results showed that 0 of the 10 respondents that were not permitted to take recuperative breaks reported receiving an average of 8 hours of sleep per night. This

certainly strengthens the argument for recuperative breaks agency-wide. It is also worth mentioning just 20% of ATCS that do receive recuperative breaks report receiving an average of 8 hours of sleep. This is concerning and suggest that the majority of the ATC workforce is suffering from sleep deprivation to some extent. Also, this suggests that recuperative breaks are a step in the right direction, but not a solution to the sleep deprivation issue in the ATC community.

The last cross-examination for research question three was done on survey question 9 which asked respondents if they had children under the age of 18 and survey question 25. Survey question 25 asked respondents to rate their level of agreement with the statement, "My home responsibilities make it hard for me to get adequate rest between shifts with the scheduling regulations that are in place." Responses to survey question 25 were grouped into two categories, respondents with children and respondents without children. The results showed that 75% of respondents with children under age 18 agreed with the statement from survey question 25 versus 53% of respondents that indicated they did not have children under age 18. This disparity shows that children under 18 are one of the factors that impacts ATCSs perception of fatigue in regards to shift schedules. Based on the information gathered, the factors that have the most significant impact on ATCS perception of fatigue in regards to shift schedules include facility level, children under 18 in the home, age group, and availability of recuperative breaks.

Analysis of Research Question IV

Research question four was exclusively addressed with survey question 23. Question 23 asked respondents to rate their level of agreement with the statement, "Because of the 9-hour rule between shifts, I feel that my overall health has improved." The results showed that the majority of ATCSs surveyed, 48%, indicated that they disagreed with this statement, and only 13% agreed. It is worth noting that zero of the ATCSs surveyed indicated that they strongly agreed

with this statement. The 9-hour rule has not improved the overall health of ATCS and most likely was not sufficient. Sleep deprivation can be extremely detrimental to one's health, and it is clearly evident that the majority of the ATC population is sleep deprived.

Limitations of Research

This study was not conducted agency-wide, like previous CAMI studies. Therefore, the population surveyed was much smaller. Also, the survey was limited to just ATCS currently working for the FAA. Therefore, retired ATCS, who possibly could have provided valuable insight, were not surveyed. Also, ATCS that work for contract facilities were not surveyed and could have provided a different perspective. Another limitation was the possibility of those that were most concerned about fatigue issues responded, while those that were not did not bother to participate in the study.

Recommendations

This research project was one of the first to examine the effectiveness of recent changes that have been made to the scheduling regulations for ATCSs. The results show that the regulation changes are a start but do not fully address the pressing issue of fatigue seen throughout the ATC industry. The information gathered here could lay the foundation for studies in the future. Future studies should incorporate the time of commute into the study since that was an issue mentioned several times in the open-ended survey question that does not seem to be factored into the minimum time between shifts. Also, a field test is recommended to gather more information about sleeping habits, controller alertness, and other relevant subjects. There has not been an agency-wide shiftwork survey since the Article 55 workgroup. Since regulation changes have been made, it is necessary to evaluate the effectiveness of those changes through some follow-up study. The majority of the participants in this study seemed to feel 9 hours was not enough time between shifts. In these nine hours, the ATCS is expected to commute home, deal

with any home responsibilities, get 8 hours of sleep, get ready for work, and commute back to their facility. When put into this perspective, it is understandable that 76% of ATCS surveyed indicated that they do not receive an average of 8 hours of sleep per night. These issues must be addressed by comprehensive changes to scheduling practices and a proactive Fatigue Management System in place agency-wide. The fact that there has not been a comprehensive fatigue study since the AT-SAFE study is very concerning. Until changes are made, one can only expected incidents to take place with ATCSs falling asleep while working or having health problems due to sleep deprivation. The FAA has been able to achieve a record of the safest airspace in the world, but it is hard to imagine that remaining the case if majority of ATCS are consistently working while fatigued.

REFERENCES

Collins, W. E., & Wade, K. (2005). A milestone of aeromedical research contributions to civil aviation safety: the 1000th report in the CARI/OAM series (No. DOT/FAA/AM-05/3). FEDERAL AVIATION ADMINISTRATION OKLAHOMA CITY OK CIVIL AEROMEDICAL INST.

Cruz, C., Rocco, P. S. Della, United States. Office of Aviation Medicine & Civil Aeromedical Institute. (1995). Sleep patterns in air traffic controllers working rapidly rotating shifts a field study. Retrieved from http://purl.access.gpo.gov/GPO/LPS84772

Federal Aviation Administration. (2012, February 14). FAA Modernization and Reform Act (P.L. 112-095) reports and plans. Retrieved June 19, 2015, from https://www.faa.gov/about/plans_reports/modernization/

Federal Aviation Administration, & National Air Traffic Controllers Association. (2012). Memorandum of understanding between the National Air Traffic Controllers Association and the Federal Aviation Administration. Retrieved June 18, 2015, from http://www.faa.gov/pilots/safety/media/Fatigue_MOA.pdf

Federal Aviation Administration, & National Transportation Safety Board. (2010, November 15). Safety recommendation history. Retrieved June 18, 2015, from http://www.ntsb.gov/_layouts/ntsb.recsearch/Recommendation.aspx?Rec=A-07-031

Federal Aviation Administration, & National Transportation Safety Board. (2013, April 23). Safety recommendation history. Retrieved June 18, 2015, from http://www.ntsb.gov/investigations/data/_layouts/ntsb.recsearch/Recommendation.aspx?Rec=A-07-030

Finn, P. (1981). The effects of shift work on the lives of employees. *Monthly Labor Review*, *104(10)*, 31-35. Retrieved June 18, 2015, from

http://www.companiongroup.com/UserFiles/compgroup/Documents/Safety Risk Management/Effects of Shift Work.pdf

Gay, L., & Mills, G. (2009). *Survey research in educational research: Competencies for analysis and applications* (9th ed., pp. 175-186). Upper Saddle River, N.J.: Merrill/Pearson.

Hauty, G.T., Trites, D.K., & Berkley, W.J. (1965a). *Biomedical survey of ATC facilities I: Incidence of self-report symptoms*. (DOT/FAA/AM-65/5). Washington, DC: Federal Aviation Administration Office of Aviation Medicine.1

Klien, T., Martens, H., Dijk, D., Kronauer, R., Seely, E., & Czeisler, C. (1993). *Circadian sleep regulation in the absence of light perception: Chronic non-24-hour circadian rhythm sleep disorder in a blind man with a regular 24-hour sleep-wake schedule. Sleep, 4*, 333-343. Retrieved May 16, 2015, from http://www.ncbi.nlm.nih.gov/pubmed/8341894

Luna, T. D., French, J., & Mitcha, J. L. (1997). A study of USAF air traffic controller shiftwork: Sleep, fatigue, activity, and mood analyses. *Aviation Space and Environmental Medicine, 68(1)*, 18–23. Retrieved from https://ezproxy.mtsu.edu/login?url=http://search.ebscohost.com/login.aspx?direct=true&db=psyh&AN=1997-02282-003&site=ehost-live&scope=site&scope=cite

Mayo Clinic. (2013, February 27). Fatigue causes. Retrieved March 27, 2015, from http://www.mayoclinic.org/symptoms/fatigue/basics/causes/sym-20050894

Mistlberger, R. E., & Skene, D. J. (2004). Social influences on mammalian circadian rhythms: animal and human studies. *Biological Reviews of the Cambridge Philosophical Society, 79(3)*, 533–556. http://doi.org/10.1017/S1464793103006353

Mohler, S. R., Dille, J. R., & Gibbons, H. L. (1968). Circadian rhythms and the effects of long-distance flights. Department of Transportation, Federal Aviation Administration, Office of Aviation Medicine.

National Air Traffic Controllers Association. (2011, May 24). Congressional testimony. Retrieved June 18, 2015, from http://natca.org/legislative_congressional_testimony.aspx?zone=Congressional Testimony&nID=2873#

Nesthus, T. E., Dattel, A. R., & Holcomb, K. (2005, May). Test-battery performance associated with age, shift schedule and quick-turn rotations for a sample of air traffic controllers. *In Poster presented at the 76th scientific meeting of the Aerospace Medical Association, Kansas City, MO.*

Nesthus, T., Cruz, C., Hackworth, C., & Boquet, A. (2006). An assessment of commuting risk factors for air traffic control specialists (No. DOT/FAA/AM-06/13). FEDERAL AVIATION ADMINISTRATION OKLAHOMA CITY OK CIVIL AEROMEDICAL INST.

National Transportation Safety Board. (2007, April). National Transportation Safety Board. A-07-30 through -32. Retrieved September 5, 2009, from http://www.ntsb.gov/Recs/letters/2007/A07_30_32.pdf

Office of Inspector General. (2013). FAA's controller scheduling practices can impact human fatigue, controller performance, & agency costs (Rep. No. AV-2013-120). Washington, DC: Author.

Rocco, P. Della, Ramos, R., Mccloy, R. a, & Burnfield, J. L. (2000, September). Shiftwork and fatigue factors in air traffic control work: Results of a survey.

Roske-Hofstrand, R. (1995). Raising awareness for fatigue among air traffic controllers. *In Proceedings of the Eighth International Symposium on Aviation Psychology, 2*, 985-991, Ohio State University, Columbus, OH, April 24-27, 1995.

Salazar, MD, G. J. (n.d.). Fatigue in aviation (Publication No. OK-07-193). Retrieved June 18, 2015, from Federal Aviation Association website: http://www.faa.gov/pilots/safety/pilotsafetybrochures/media/Fatigue_Aviation.pdf

Schroeder, D. J., Rosa, R. R., & Witt, L. A. (1998). Some effects of 8- vs. 10-hour work schedules on the test performance/alertness of air traffic control specialists. *International Journal of Industrial Ergonomics, 21*, 307–321. http://doi.org/10.1016/S0169-8141(97)00044-9

Serber, M. L., Kaminski, M. A., Payton, G. M., Moreland, K. L., Hadjimichael, M., Jarrott, W. M., ... & Neal II, T. A. (2010). Human performance and fatigue research for controllers—Revised (Tech. Rep. No. MTR100316). McLean, VA: The MITRE Corporation. Retrieved from http://www.faama.org/wp-content/uploads/2013/04/Human-Performance-and-Fatigue-Research-for-Controllers.pdf

Smith, S. (2002, April 3). Severe impact of fatigue in the workplace examined. Retrieved June 7, 2015, from http://ehstoday.com/news/ehs_imp_35340

APPENDICES

APPENDIX A IRB Exemption Letter

MIDDLE TENNESSEE STATE UNIVERSITY

5/5/2015

Investigator(s): Darrius Thompson, Paul Craig, Andrea Georgiou
Department: Aerospace
Investigator(s) Email Address: det2m@mtmail.mtsu.edu; PCraig@mtsu.edu

Protocol Title: Surveying Air Traffic Control Specialist Perception of scheduling regulations

Protocol Number: #15-319

Dear Investigator(s),

Your study has been designated to be exempt. The exemption is pursuant to 45 CFR 46.101(b)(2) Educational Tests, Surveys, Interviews, or Observations.

We will contact you annually on the status of your project. If it is completed, we will close it out of our system. You do not need to complete a progress report and you will not need to complete a final report. It is important to note that your study is approved for the life of the project and does not have an expiration date.

The following changes must be reported to the Office of Compliance before they are initiated:

- Adding new subject population
- Adding a new investigator
- Adding new procedures (e.g., new survey; new questions to your survey)
- A change in funding source
- Any change that makes the study no longer eligible for exemption.

The following changes do not need to be reported to the Office of Compliance:

- Editorial or administrative revisions to the consent or other study documents
- Increasing or decreasing the number of subjects from your proposed population

If you encounter any serious unanticipated problems to participants, or if you have any questions as you conduct your research, please do not hesitate to contact us.

Sincerely,

Lauren K. Qualls, Graduate Assistant
Office of Compliance
615-494-8918

MTSU Compliance Office
010A Sam Ingram Bldg.
1301 E. Main St.
Murfreesboro, TN 37129

APPENDIX B Message for Survey Dissemination

My name is Darrius Thompson. I am a Master's Degree candidate at Middle Tennessee State University in the Aviation Administration program. I am conducting my thesis research under the direction of Dr. Paul Craig and Dr. Andrea Georgiou. The goal of my research is to investigate the perception of current scheduling regulations for Air Traffic Control Specialists (ATCS) that are employed by the Federal Aviation Administration.

The research will consist of a completely anonymous short 27-question survey that should take around 10-15 minutes to complete. The survey has been approved by the University's Aerospace faculty and is both Android and iPhone friendly. I am seeking ATCS currently working at Air Traffic Facilities in the U.S. that are staffed by the FAA. This survey will assess the effectiveness of current scheduling rules. Also, the survey will analyze the effectiveness of recent changes and examine external factors that could impact the amount of rest received by ATCS. I am interested in the attitudes and opinions of ATCS across our nation regarding these issues and invite you to participate in this study. Again, the survey is completely anonymous and no identifying information will be collected in order to minimize the risk of participation. If you would like to participate, please click on the link below to go to the survey.

https://www.surveymonkey.com/s/ATCSScheduling

APPENDIX C Survey Instrument

Hello! Thank you for choosing to participate in this research survey concerning scheduling regulations of Air Traffic Controllers. I appreciate you taking your time to help me complete this study. Your participation in this survey is completely voluntary and failure to participate will not result in penalty of any type. The responses you provide will not be used for any purpose outside of the research being performed. All responses are completely anonymous and no personally identifiable information, including your computer's IP address, will be collected. You may discontinue this survey at any time by exiting the window before submission. You may leave any question you do not wish to answer blank, and it will not affect your participation in the survey.

If you should have any questions about this research study, please feel free to contact me, Darrius Thompson, at det2m@mtmail.mtsu.edu or my Thesis Committee Chair, Dr. Paul Craig, at Paul.Craig@mtsu.edu. Also, if there are any questions regarding the Institutional Review Board (IRB) approval process should be directed to the Middle Tennessee State University Compliance Officer at compliance@mtsu.edu.

By clicking the "NEXT" button, you agree to the above terms and agree to participant in this study. Again thank you for taking time out of your day to assist me with this research!

1. Are you currently an active Air Traffic Control Specialist (ATCS) working for the FAA?

2. What is your current facility level?

Other (please specify)

3. What is your current facility type?

- Enroute
- Tower (Tower-only)
- TRACON (TRACON-only)
- Up-down Facility (TRACON and Tower)

4. Are you a Certified Professional Controller (CPC)?

- Yes
- No

5. How long have you been an Air Traffic Controller?

Years

Months

6. How long have you been at your current facility?

7. Please indicate your age group.

- Below 30
- 30-40
- 41-50
- 51-60
- Above 60

8. Please select your gender.

- Male
- Female

9. Do you have children under the age of 18?

- Yes
- No

10. What is the age group of your youngest child?

- 0-5
- 5-10
- 10-15
- 15-18
- N/A

11. Please indicate your highest level of education.

- High School
- Some College
- 2-year Degree
- 4-year Degree
- Graduate Degree

12. Have you ever taken a course on Human Factors?

- Yes
- No

13. Have you ever taken a college or FAA course on Fatigue Management?

- Yes
- No

14. Does your facility allow recuperative breaks?

- Yes
- No

15. On an average, how many hours are you scheduled off between day 4 and day 5 of your standard work week?

- ○ less than 8
- ○ 8
- ○ 9
- ○ 10
- ○ 11
- ○ 12
- ○ over 13

16. How many hours do you feel you should be scheduled off between any two shifts in order to receive adequate rest?

- ○ less than 8
- ○ 8
- ○ 9
- ○ 10
- ○ 11
- ○ 12
- ○ 13
- ○ 14
- ○ over 15

17. Regarding your answer selected for Question #15, please read the sentence below and select the appropriate response.

I feel that this amount of time off permits me enough rest to not feel fatigued on the following shift. .

Strongly Disagree	Disagree	Neither Agree or Disagree	Agree	Strongly Agree
○	○	○	○	○

18. Human fatigue can be avoided.

Strongly Disagree	Disagree	Neither Agree or Disagree	Agree	Strongly Agree
○	○	○	○	○

19. Because of the current scheduling minimums, while on duty, I've lost situational awareness due to insufficient rest between shifts.

Strongly Disagree	Disagree	Neither Agree or Disagree	Agree	Strongly Agree
○	○	○	○	○

20. I get an average of 8 hours of sleep per night.

Strongly Disagree	Disagree	Neither Agree or Disagree	Agree	Strongly Agree
○	○	○	○	○

21. Because the new scheduling requires 12 hours between midnight shifts, after a mid, I feel more rested while on my next assigned shift.

Strongly Disagree	Disagree	Neither Agree or Disagree	Agree	Strongly Agree
○	○	○	○	○

22. Because of the 9-hour rule between shifts, I feel less likely to have an operational error due to fatigue.

Strongly Disagree	Disagree	Neither Agree or Disagree	Agree	Strongly Agree
○	○	○	○	○

23. Because of the 9-hour rule between shifts, I feel that my overall health has improved.

Strongly Disagree	Disagree	Neither Agree or Disagree	Agree	Strongly Agree
○	○	○	○	○

24. There is currently a non-punitive system in place to report feeling fatigued while on position.

Strongly Disagree	Disagree	Neither Agree or Disagree	Agree	Strongly Agree
○	○	○	○	○

25. My home responsibilities make it hard for me to get adequate rest between shifts with the scheduling regulations that are currently in place.

Strongly Disagree	Disagree	Neither Agree or Disagree	Agree	Strongly Agree
○	○	○	○	○

26. The scheduling regulations that are currently in place have caused me to take a sick day in order to get adequate rest.

Strongly Disagree	Disagree	Neither Agree or Disagree	Agree	Strongly Agree
○	○	○	○	○

27. The scheduling regulations that are currently in place have caused me to consider changing careers .

Strongly Disagree	Disagree	Neither Agree or Disagree	Agree	Strongly Agree
○	○	○	○	○

28. If granted the power to amend the policy that identifies ATC time between shifts, briefly explain what changes you would make.

APPENDIX D Responses to Question 28

ATC perception to new scheduling practices

Q28 If granted the power to amend the policy that identifies ATC time between shifts, briefly explain what changes you would make.

#	Responses
1	12 hours between At least 12 hours between shifts
2	At least 10 hours between We don't work the traditional 2-2-1 shifts and instead do a 2-3 or 3-2 schedule, whereby we have 2 evening shifts followed by 3 morning shifts or 3 evening shifts followed by 2 morning shifts. We have three ATCS that are assigned permanent midnight shifts so we don't have to work them individually. However, the "quick turn" on the second or third night is similar to the morning-to-midnight rest period in that we come off an evening shift and have to be back within 9 hours. Due to the time it takes just to get home, shower, sleep, and eat, I never get more than 7 hours of sleep on those nights, and I only live 4 miles from the facility. We've had some controllers that never even leave the facility on their quick turn nights and sleep in a quiet room in the tower. I'd rather do a "slow turn" and have at least 10 hours between the end of one shift and the start of another.
3	No changes After more than 26 years in the ATC business the current schedule works the best for a family life. The controllers need to take charge of their life and get the rest they need. If you want someone else to take charge of your life and rest, you may not like the result of the rules. Controllers are adults, start making them to be responsible for their actions.
4	More time off between More time off between shifts - since current times still do not address on the commute time involved.
5	Straight 5's 5 days of evenings, followed by 5 days of 12:00 to 8:00s, followed by 5 days of mornings(7:00 to 3:00), and 5 mids
6	Permanent shifts It's not always the time off between shifts. It's the constant rotation of week of days/week of nights/week of days. Throw in the occasional week of mids. Can't get accustomed to one schedule.
7	Straight 5's Permanent shifts for at least a few weeks before changing.
8	At least 10 hours between Provide at least 10 hours. There are not too many people who are able to go to sleep immediately after getting home from work. Many people have to drive an hour or more to or from work. That takes away 2 hours a day immediately, plus at least an hour to spool down. 3 hours before going to sleep. If you increase time between shifts to 10 hours, many controllers will be able to obtain at least 7 hours of sleep per night,
9	10 hour days At least 10 hours between I would propose 10-hr work days, (10 hours between shifts, 4 days a week.
10	More time off between I feel that we need to increase the time of rest periods between shifts. Swing shifts are detrimental to the already stressful career of air traffic.
11	10 hour days 4 day work weeks, 10 hour days
12	No changes n/a
13	Straight 5's I personally believe that working a week of close to the same shift would facilitate better fatigue avoidance. However, the many ATCS' I have known in my two facilities (the previous 23 yrs at a level 7) prefer the flexibility of a compressed schedule and/or the ability to swap to whatever shift facilitates their home life needs. More generous rest periods would probably be protested most loudly by the ATCS' themselves.
14	More time off between Biggest would be 9 hours after day shift before a mid shift
15	12 hours between My current facility does not have this issue as we have at least 12 hours inbetween our latest and earliest shift, however the past facilities I have been at should allow this minimum at least.

ATC perception to new scheduling practices

16	More staffing It is very hard to make any changes to the times between shifts currently as staffing lavels have dropped so much over the last few years that many facilities are on 6 day work weeks and mandatory overtime, especially at the lower level facilities.
17	At least 10 hours between No more than 2 mids per w Minimum of 10 hr between a night shift and a day shift starting the next morning. No more than 2 midnight shifts in a row per week, but not more than 2 weeks of double mid shifts in a row.
18	Straight 5's we worked "week of"s a few years back & it went well; people that liked day shifts bid straight days, people that liked eves bid straight eves; had a few staggered shifts to catch the coverage shifts
19	More time off between The worst quick change day for me and most of my coworkers is the 3 day. Most seem to need coffee more on that day than any other. A lot of ATC facilities have team briefing to combat this problem. Also, that 3rd day shift is a flex shift allowing for a somewhat liberal show time. Good luck either your paper.
20	Permanent shifts No more shift work. Schedule would be straight days or nights based on seniority.
21	2-2-1 I would take the Night, Night (quick-turn) Day, Day (8 hours) Midnight format and change it to all similar shifts so the body isn't thrown all over the place. A person works 1.) All Day Shifts 2.) All Night Shifts 3.) All Midnight Shifts. Body tries to adapt to a sleeping pattern but it keeps getting thrown off, so there are a lot of times where I know I need sleep so I go to bed but can't fall asleep for a very long time. People like to say that the schedule doesn't affect them and it gives them a longer weekend, but I see too any people at work who are "exhausted" and "tired" all day long and I can see after doing it for 5+ years where your body starts showing signs of the effects. It needs to change for aviation safety and quality of life of the controllers. They give us CBI computer lessons on fatigue awareness, so they know it's an issue that needs to change! Best of luck and hope you can make some changes for us!!
22	12 hours between At least 10 hours between Have between 10-12 hours off between day 4 and the overnight day 5 shift.
23	Permanent shifts If controllers worked set schedules, i.e. Controller A works a set schedule from 7:00am-3:00pm 5 days per week, Controller B worked a set schedule 3:00pm-11:00pm 5 days per week and so on, controllers would have a minimum of 16 hours between shifts daily and this will decrease fatigue because the controller will have the opportunity to have a regular sleep schedule.
24	No changes No Changes
25	More time off between There is not enough consideration given for commuting through traffic for employees living it over 40 miles. Traffic, construction, SINGLE parenting are not mitigating factors.
26	At least 10 hours between Shorter mids 10 hours rest for quick turns and 9 hours rest for mids Or even possible a 9,9,8,8,6 schedule shortening mids
27	At least 10 hours between I would require a minimum of 10 hours off between all regularly scheduled shifts and minimum 9 hours between controller requested shift swaps.
28	8 between not 9 8 hours between shifts instead of 9
29	No changes None
30	Permanent shifts Working all nights, or all mornings.
31	At least 10 hours between 10 hrs. I have an hour compute each way. 7-6 hrs of sleep would be better the the 4-5 I now get
32	No changes None, it's worth enduring the "quick turns" and midnight shifts to lengthen your weekend. For controllers not wishing to work these shifts, it is very easy to swap into another shift.
33	10 hour days I believe it would be best for my facility to go to four 10 hour shifts instead of five 8 hour shifts compressed into what is essentially a 4 day period.
34	Less hours per week More staffing More time off between We need to work less than 40 a week like other countries. More time between shift eliminating quick turns ex evening followed by early dayshift. We also need to hire more staffing to eliminate the use of mandatory overtime. More leniency on use of sick leave.