



12-1-2010

# Air Traffic Controllers: Flying in the Face of Danger? A Look Into the Effects of the Time of Day

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AIR TRAFFIC CONTROLLERS: FLYING IN THE FACE OF DANGER? A LOOK  
INTO THE EFFECTS OF THE TIME OF DAY

by

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An Independent Study

Submitted to the Graduate Faculty

of the

University of North Dakota

in partial fulfillment of the requirements

for the degree of

Master of Science

Grand Forks, North Dakota

December, 2010

This independent study, submitted by Jason Boergerhoff in partial fulfillment of the requirements for the Degree of Master of Science from the University of North Dakota, has been read by the Faculty Advisor under whom the work has been done and is hereby approved.

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(Advisor)

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## ABSTRACT

Since the events of September 11, this country has continued to grow and its commercial air travel along with it. As the number of passengers and planes increase, so must the skill and determination of the air traffic controllers. They must be at their peak performance levels to ensure the flying public is handled safely and expeditiously. This study looks at the possible effects of the time of day. After defining time of day effects and giving some of the consequences of these effects, a look into the task of a controller was necessary. This study broke the task down to concentration and memory as the two most important aspects. These were examined and numerous examples were found that indicated it was possible for the time of day to have a negative effect. As there is little research on this very topic in aviation, it is clear that it is necessary. An answer may be found that can neutralize these effects and improve safety overall.

CHAPTER I  
INTRODUCTION

According to the Federal Aviation Administration (FAA) (2010), on an average day, there are approximately 30,000 scheduled domestic and international flights operated by air carriers in the United States National Airspace System (NAS). In fact, there are approximately 7,000 flights in the air at any given time. These flights carry the approximately 2 million passengers that travel around the world (bts.gov, 2006). With these staggering numbers of people and equipment in the air, it is critical to have a system in place to make safety a priority. This task has fallen to the nearly 15,000 air traffic controllers who monitor and control the traffic flying through the NAS. (faa.gov, 2010)

Since the early 1940's, during the time of the Civil Aeronautics Administration (CAA), air traffic controllers have been tasked with keeping the skies safe. Their job is to provide safety alerts and traffic information to pilots and to safely and expeditiously move the aircraft through the NAS (7110.65T, 2010). To function in this capacity, controllers require specialized skills and training. Controllers are

heavily trained in procedures and phraseology to ensure they perform their jobs at the highest possible level of competency. The Bureau of Labor Statistics (BLS) describes some of the critical qualifications of controllers and what they may face in their facilities:

Air traffic controllers must be articulate to give pilots directions quickly and clearly. Intelligence and a good memory also are important because controllers constantly receive information that they must immediately grasp, interpret, and remember. Decisiveness also is required because controllers often have to make quick decisions. The ability to concentrate is crucial because controllers must make these decisions in the midst of noise and other distractions. (bls.gov, 2009)

To be clear, the BLS also described some of the more dangerous aspects of being a controller:

During busy times, controllers must work rapidly and efficiently. Total concentration is required to keep track of several planes at the same time and to make certain that all pilots receive correct instructions. The mental stress of being responsible for the safety of several aircraft and their passengers can be exhausting. (bls.gov, 2009)

To help ensure that candidates for hire have the highest level of professional training, the FAA created the Air Traffic Collegiate Training Program (AT-CTI). This program was designed to allow educational institutions to offer federally approved training and evaluation of air traffic control procedures and skills. Until recently, attending one of these AT-CTI programs or transferring from the US military were the only means of becoming a FAA Air Traffic Control Specialist. With the current hiring problems, the FAA has begun to institute off-the-street hiring practices to help fill the vacuum created by increased attrition due to retirement.

With the increased hiring of new controllers entering the workforce, it will become a difficult task to properly fill daily schedules at each facility. In many cases, these new hires will simply be placed in the first available slot on the schedule. This study will address the possible safety concerns of failing to take into account the changes in mental abilities and performance due to time of day.

#### Purpose of the Study

The purpose of the study is to discover if there is sufficient evidence in the current literature to warrant further study into the time of day effects on air traffic controllers. As there is little research on this subject in aviation, other

disciplines will be examined as well. After a thorough review of the literature, further recommendations will be made.

#### Statement of the Problem

It is important for air traffic controllers to be at their peak performance when they are controlling traffic. Almost anyone can relate to the difficulty in balancing a decent sleep schedule and a busy work schedule. Often times, sleep will have a lower priority in the balance.

In addition to the lack of sleep, research has determined that each person has a preferred time of day. For example, a person who functions at a higher level of efficiency and competency during the evening would be categorized as an evening type. The natural opposite are those who function better during the early morning, the morning types. (Horne & Ostberg, 1976)

The main issue is that these factors are not taken into consideration when scheduling air traffic controllers to cover shifts at FAA facilities. Scheduling is normally accomplished using a seniority-based bidding system. With the addition of new employees entering the system, a seniority-based program will be little more than a lottery system. At this time, there is no program in place to account for the preferred time of day of individual controllers. This study will attempt to determine if this may be causing a reduction in service and proficiency

and therefore a decrease in safety. If there is significant evidence found in the available literature, there may be need to introduce new programs to limit the increased risk to safety.

#### Significance of the Study

If this study finds enough evidence to show there may be a significant difference in the performance of air traffic controllers due to time of day effects, there may be some safety concerns for the FAA. With the large number of new controllers entering the industry, it may be helpful to test them for their preferred time of day and try to schedule them accordingly. This could help maximize the performance for each individual controller and consequently the air traffic control system as a whole.

#### Research Questions

1. What are the effects of time of day compared to the preferred time of day for most people?
2. What are the primary skills used by an air traffic controller while working traffic?
3. Are these skills affected by the time of day compared to the controller's preferred time of day? If so, in what way?

### Limitations of the Study

As stated above, there is very little research on these types of issues within the aviation industry, let alone specifically air traffic controllers. Due to this limitation, a significant portion of the literature in this study is derived from other disciplines/industries.

## CHAPTER II

### GENERAL TIME OF DAY EFFECTS

#### What Are Time of Day Effects

As stated above, there is very little literature regarding time of day effects in the aviation industry. Compared to most industries, aviation is relatively young and therefore has not had the time to gather a vast history of research and discovery. To establish a frame of reference, this section will discuss these time of day effects on humans in general, in the hopes that parallels can be drawn within the aviation industry, specifically with air traffic controllers.

This researcher defines time of day effects to be the interaction of an individual's preferred time of day, and the time of day they are tested or told to perform. The comparisons will be addressed later, but for now, there needs to be a little background on the concept of an individual's preferred time of day.

The development of an individual's preferred time of day appears to begin at a very young age. Some researchers,

including Thoman (1999) believe that these preferences begin at the earliest of postnatal stages and some believe that it may be even earlier than that, potentially while the child is still in the womb. This may be caused by the child taking on the habits of its mother and on various environmental effects such as light exposure while still a fetus. Another study by Randler (2008) showed a simple factor like sun exposure has been proven a major factor in the development of a preferred time of day in adolescences across the world.

However these preferences develop, everyone has a time of day during which they perform at their highest levels. To establish a method of testing this preference, Horne and Ostberg (1976) created the Morningness-Eveningness Questionnaire (MEQ). This self-reporting test determines if the taker is a morning or evening type person based upon numerical values assigned to each answer. The final determination is said to show that a person is either a morning or evening person. A great deal of research has used this test to determine the time of day effects many different skills and traits.

One of the first factors to examine is the effects of age on an individual's MEQ results. May, Hasher, and Stoltzfus (1993) found in their study that most young adults, ages 18-22, tended to have a significant preference for eveningness. They also found that their older subjects, ages 66-78, tended to lean

more towards morningness. This trend is consistent throughout the research. Randler and Frech (2006) found similar results regarding young adults in their study on school exams. One important item to remember is that a large portion of the new air traffic control trainees will fall into the latter portion of the young adult range. Most of them will be recent college graduates or people exiting the military. If these new employees are mostly evening type people, where will they be placed on a schedule? Will their preferred time of day play any type of role in schedule selection? These questions will need to be addressed, as they may be very important.

The next factor to examine is whether gender has any major role in the preferred time of day of an individual. The results of this question have also been consistent in the available literature. In general, there is no significant difference in time of day preference between genders. There are some results that contradict each other, but overall there appears to be no significant claims to be made. (Díaz-Morales, Ferrari, & Cohen, 2008; Randler, 2008; Randler & Frech, 2006; Tonetti, Fabbri, & Natale, 2008)

#### Time of Day Effects on Sleep

Now that there is a general understanding of what time of day effects are, they can be examined in various different

interactions. The first factor studied was that of sleep and to what extent sleep is affected by time of day. The examination of time of day and its effect on sleep is important when shift work, or night work are involved. As air traffic control is largely a 24-hour business, this factor is very important to address.

Many studies have looked into shift work from a cautionary standpoint. One such study by Soni et al. (2008) looked into permanent night workers and the difficulties they face. They found that although most tested individuals showed signs of gaining a tolerance to the permanent night shift, they still showed a sharp decrease in their rest activity. This would indicate that these individuals would be more susceptible to health problems in the future. This determination was independent of the workers' preferred time of day, but the study did show that evening types had a more significant decline in the amplitude of circadian rhythms.

A similar interpretation was found by Chung et al. (2007) in their study of shift nurses in a hospital setting. Their study focused on sleep quality and other sleep factors effecting job performance. They found that evening types had worse quality of sleep than morning types. They also found that evening types generally required longer sleep periods. This

would lead to sleep debt during their morning shifts and would then in turn possibly affect their performance.

A third study, this one by Schwartz (2010), covered another potential threat in the form of a sleep disorder they refer to as shift work disorder (SWD):

“Shift-work disorder (SWD) is experienced by individuals whose work schedule overlaps with the normal sleep period, causing misalignment between the body’s endogenous circadian clock and the time at which the worker is able to rest”. (p. 1)

This disorder can cause the individual’s performance to suffer due to lack of effective rest and quality sleep. This study acknowledged that using the MEQ for evaluating SWD is unproven; it also mentions that morning-types generally get less sleep after a night shift, and would therefore be more susceptible to SWD.

These are all important issues to acknowledge when examining air traffic controllers and their susceptibility to time of day effects. This shows that the sleep quality and duration are critical aspects that should be taken into account when assigning shift work to new air traffic controllers.

## Time of Day Effects on Learning

This section is a brief note regarding the current training practices for air traffic controllers. While they are at the FAA Academy in Oklahoma City, the students typically begin their training at 7:00am. This early start time may have a negative impact on the students, especially if they are evening types. These evening types would not usually get enough sleep and may consequently suffer from reduced performance.

A similar situation was studied in Germany concerning US high school equivalent students and their final school leaving exams. Randler and Frech (2006) found a significant positive correlation between exam scores and morningness on the MEQ. They also agreed with previous findings that indicate children tend to shift from morning to evening types around 18-20 years of age. That age corresponds to the students in their final years of school, and these students are required to take final school leaving exams. The researchers believed that these evening type students were at a disadvantage when school and exams remain at an earlier time.

It may prove beneficial for the FAA to examine these findings and perhaps produce a study of their own to determine if this is a factor in air traffic control training. If so, modifications could be made to ensure that their trainees are in the best position to learn the skills they need.

## The Dangers of Time of Day Effects

Thus far this study has looked at some of the general effects of time of day on people in different jobs and activities. It is important to highlight some additional research that has uncovered more serious consequences of time of day, particularly for those who are evening types.

Díaz-Morales, Ferrari, and Cohen (2008) found that evening types are more likely to delay working on tasks until later in the day, likely to let them coincide with their preferred time. This would likely be viewed externally as avoidant procrastination and these individuals would be looked down upon for this delay. These evening types would have a low perceived level of conscientiousness, and would therefore not be considered as reliable when given critical and time-sensitive tasks. This may have a direct parallel in air traffic control, simply on a smaller time frame. Most ATC job tasks are time sensitive as the situations rapidly change during a normal working session. If an evening type controller is more likely to try and delay making a decision regarding a traffic issue, there may be an increased safety risk.

Similar results were found in another study involving college students and their tendencies towards procrastination and lower levels of self-regulation. Digdon and Howell (2008)

found a significant correlation between MEQ scores and self-regulation and procrastination scores. They admit that a causal relationship cannot be drawn due to the type of study they performed, but it is still important to note the specificity of their findings. One of the most impressive finding is that, "the relationship between eveningness and poorer self-regulation remained significant after controlling for age," (p. 1040). This discounts the argument that younger people tended to have lower levels of self-regulation. Again, these findings relate directly to air traffic control, as there is little room for procrastination and even less for poor self-regulation, as job tasks need to be accomplished quickly and efficiently.

The most disturbing find when conducting this research was a study that looked at the relationship between eveningness and psychological symptoms. Varder et al. (2008) found that after removing individuals with existing psychiatric and psychological conditions from their sample there was still a difference in the presence of psychological symptoms between what they refer to as chronotypes. In their discussion they highlight these findings:

With respect to the psychological features, the present study demonstrated that evening types have more anxiety, obsessive-compulsiveness, hostility and phobia symptoms than the other chronotypes. These symptoms are related to clinical anxiety disorders

such as generalized anxiety disorder and adjustment disorders with anxiety. (Varder et al., 2008, p. 498)

The study does not indicate the presence of any anxiety or mood disorders, but the increased psychological symptoms could cause additional problems for the individuals. It is important to note that all air traffic controllers must pass both physical and psychological testing before they are allowed to begin training at the academy. With this barrier in place, the controller workforce shares similar traits with the sample from this study. If the individual or organization they work for are aware of these symptoms they can attempt to correct them, or at least control for them. The FAA could produce additional programs and training for their evening type employees in an effort to minimize any effect these symptoms may create.

## CHAPTER III

### AIR TRAFFIC CONTROL

#### What Is Necessary To Control Traffic

This study has looked into the general effects of time of day and its interaction with an individual's life. These factors obviously influence air traffic controllers as well, but there may be additional factors in play due to type of work they must perform. To look further into these other factors, it is important to have an understanding of the fundamental skills and traits necessary for air traffic controllers to work safely and efficiently.

Fisher and Kulick (1998) examined this same question in their work on creating a new training model for the FAA. They used a cognitive task analysis to determine the skills critical for air traffic controllers. It was their hope that if these skills could be identified, they could be worked into the new training model.

The cognitive task analysis they used came from a study performed by the FAA to determine key cognitive components for en route controllers (Redding et al., 1992). From this study

came a list of 12 main tasks requiring cognitive skills, and of these 2 were identified as primary tasks supported by the other 10. Below is the cognitive task model they created:

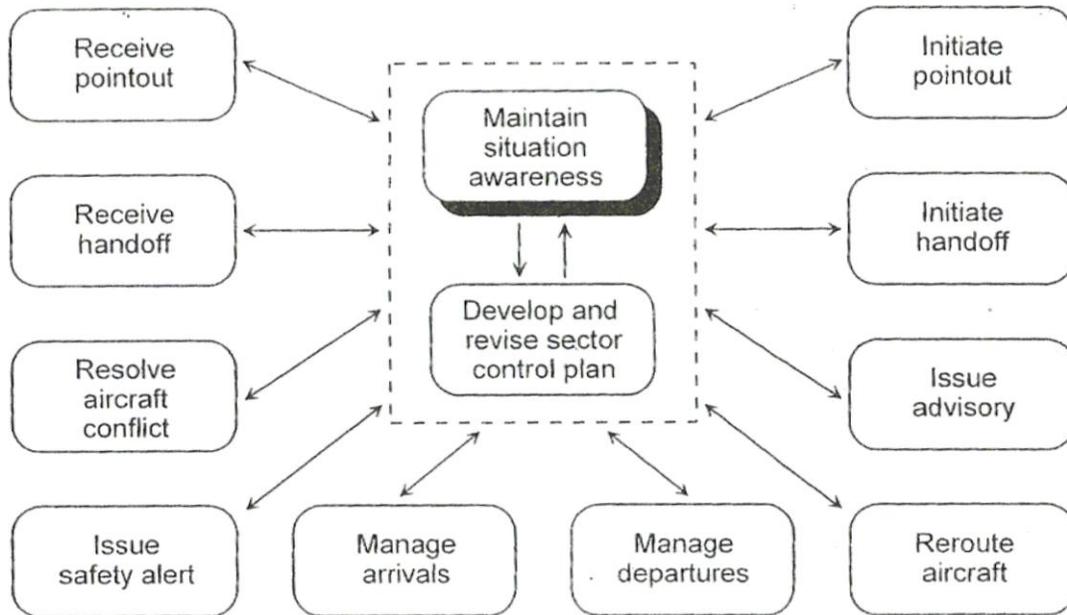


Figure 1: Cognitive Task Model (Fisher & Kulick, 1998)

Redding et al. (1998) expanded upon this model by developing another model, a mental model for an air traffic controller's ability to receive, process, and apply information. This mental model broke the tasks down into components dealing with what ATC knowledge was required for decision-making. After examining the cognitive task model, the mental model, and an additional look into perceptual processing and expert strategies, Fisher and Kulick (1998) concluded that two critical dimensions of an air traffic controller's job are planning and maintaining situational awareness.

## Hierarchy of Cognitive Skills

The findings above broke the primary mental tasks of air traffic controllers into planning and situational awareness. This researcher believes there is a hierarchical relationship between those two components. Looking at them logically it seems clear that without situational awareness, or the awareness of where the traffic is, where they are going, and what procedures will be used, a controller would be unable to properly plan their traffic flow. This interpretation can also be found in a study on decision making and planning in ATC, in which they state that situational awareness, "is the principal input to decision making and planning," (D'Arcy & Della Rocca, 2000, p. 4).

This relationship is analogous to that of a navigator aboard a ship. If that navigator was not familiar with the performance characteristics of the vessel, the supplies available, the current and forecasted weather, and known dangers along their path, how could they plot a safe course to their destination? Even pilots have to follow this same path as they prepare flight plan, looking at the weather, the weight and balance of the aircraft, and the fuel requirements of the journey.

The training of air traffic controllers seems to proceed along the same lines. When a controller first enters the FAA Academy, they are given classroom-based instruction on regulations and procedures, airspace familiarization, aircraft recognition, and scanning techniques. These skills, in addition to numerous others, will help the trainee build the situational awareness they will need when they first get to the training simulators. Once the trainee is able to reach this level of awareness and maintain it, they will be able to move on to planning what they want to do with the traffic they have and the traffic they will have in the future. Therefore, it is important to understand how the controller will reach this level of situational awareness, only then can the effects of time of day be truly examined.

#### Situational Awareness

The best definition found for situational awareness states that it is, "the perception of the elements in the environment within a volume of time and space, the comprehension of their meaning, and the projection of their status in the near future," (Endsley, 1988). This definition is further broken down into its components in a study by Endsley and Garland (2000), who took the three components from the definition and placed them into hierarchical levels. The following is a table illustrating

this point:

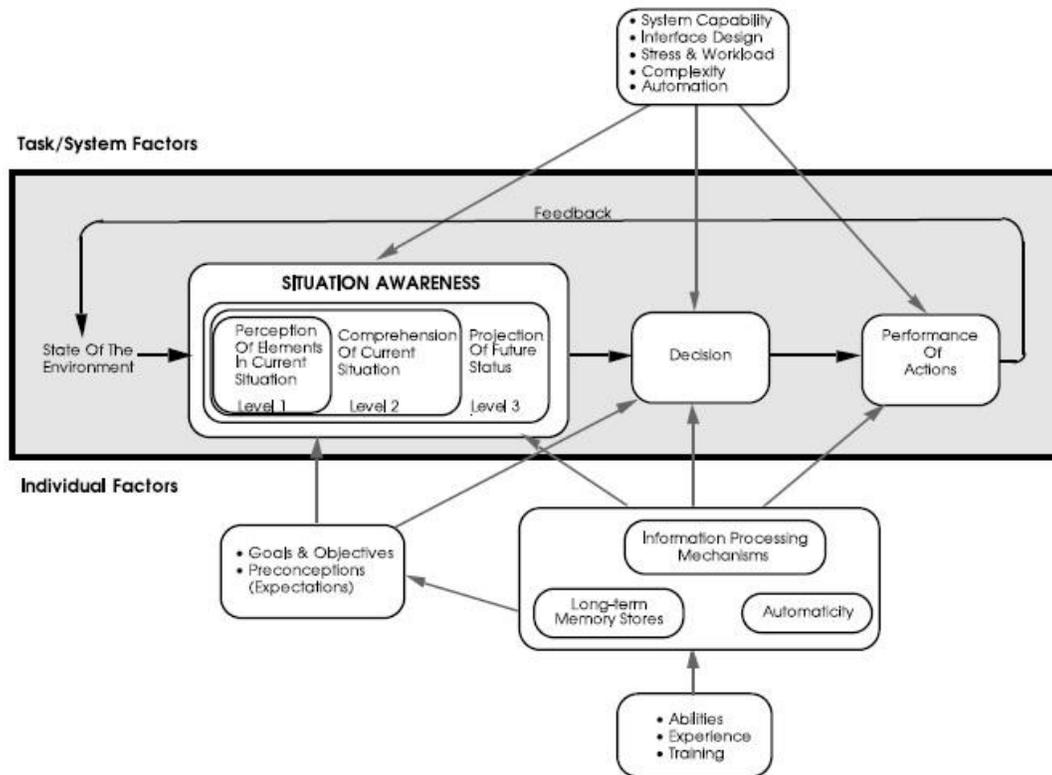


Figure 2: Model of SA in Dynamic Decision Making (from Endsley, 1995)

The first level created by Endsley and Garland (2000) includes the perception of the aircraft in the airspace, the conditions within the airspace (weather, military activity, etc.), and other information that could be found with a mental snapshot of the situation. This level does not include any interpretations of the data, simply the knowledge of their existence. This follows the training at the academy, as one of

the first things trainees learn is how their airspace is defined and how to scan that airspace for traffic.

The second level Endsley and Garland (2000) found was that of, comprehension of the current situation). Now the controller not only has to be aware of the existence of the traffic, but also know where they are in relation to the other traffic, ground obstacles, and any adjacent airspace. In essence, this level requires the controller to take all of the individual pieces of data from the first level and put them all together into a cohesive picture. Only with this picture built in their mind, can the controller move up to the final level of situational awareness.

The highest level of situational awareness defined by Endsley and Garland (2000) is that of projecting where the traffic will be. This is the most difficult level as not only does the controller need to have a highly detailed picture of what is happening within their airspace, but they must also be able to estimate how that picture will change over time. A simple example would be two aircraft at the same altitude are observed on a converging course to the same point. The controller must perceive each aircraft individually, find their relation to each other within the airspace, and now they must realize that if the situation is not corrected the aircraft may be in unsafe proximity with each other as they reach the common

point. Only when all these levels are achieved, can a controller move on to planning how they will manage their traffic and provide the best service possible.

## CHAPTER IV

### TIME OF DAY EFFECTS ON SITUATIONAL AWARENESS

To understand how time of day effects situational awareness and consequently planning, the specific skills and traits required in attaining that level of awareness must be examined. This study looks at two of these characteristics and their interaction with the time of day: concentration and memory. This is not designed to be an all-encompassing review of situational awareness, as there are too many characteristics to examine in this one study. Further research is recommended to look into other characteristics for their susceptibility to time of day effects.

#### Time of Day Effects on Concentration

The first, and likely the most obvious skill is that of concentration. As already quoted, "total concentration is required to keep track of several planes at the same time and to make certain that all pilots receive correct instructions," (bls.gov, 2009). With so much going on outside the windows or on the radar screen, a controller must be able to focus their

mind to the job at hand. Not only will there be a great deal of information to assimilate, but there will be plenty of distractions as well. The ability to screen the various stimuli and only take in what is necessary to perform their job is critical for a controller, regardless of the type of traffic they work.

In 2006, Nesthus, Cruz, Hackworth, and Boquet researched whether or not driving was affected by time of day. They found that terminal and en route controllers were affected differently depending upon their commute, the type of road they went over, and the time of day at which they went over it. They found that "low mental sharpness was generally found to be associated with an elevated risk for lapses in attention and falling asleep," (p. 7)

A similar result was found by Jankowski and Ciarkowska (2008) when they looked at the levels of arousal in people throughout the day. They found that morning-types increased their effectiveness throughout the morning peaking at about 11 AM to 12:30 PM and reached a low point at 8 PM. On the other hand, this that evening-type people reached at their low point at 8 AM and increased throughout the day to peak at 8 PM. This stark contrast shows that the time of day can be significant when talking about arousal and levels of concentration throughout the day. If a person is scheduled to work traffic

during their off-peak time, they will be able to concentrate far less on their task of separating aircraft.

This result is further backed up by a different study that looked at comparing the wakefulness of a person and their ability to evaluate errors as they see them. Murphy, Richard, Masaki, and Segalowitz (2006) found that, "although awareness (they notice) and motivation (take care) remained relatively intact, error evaluation (Pe) is impaired after extended wakefulness," (p. 19). This could make a significant difference when controlling traffic, especially during busy times. Not knowing whether two aircraft coming together at a specific point at the same altitude is dangerous could lead to greater accidents within the NAS.

Giannot, Cortesi, Sebastiani, and Ottaviano (2002) provide a link between the last two studies. According to their results, by looking at adolescent behavior, they found that evening preference as well as many other factors was significantly related to daytime sleepiness. "This insufficient sleep may interfere negatively on daytime functions with increasing risk of accidents, injuries, and poor school attendance," (p. 197). Therefore, if an evening-type were scheduled for a morning shift they would likely not be at their peak proficiency in till later in the day. Until that time the

traffic, that that person controls is at a higher risk than if it were controlled by a morning-type person.

These studies show that time of day can have a significant impact upon the controller's effectiveness throughout the day. If the controller gets tired, there is a higher risk of them losing concentration and becoming unable to separate traffic properly.

#### Time of Day Effects on Memory

There seems to be a much larger focus on memory in the previous research as this study was able to find quite a few examples of memory and recall. None of the studies focused on air traffic controllers specifically, but there is enough research to be found in other disciplines. Though it seems clear that further research is necessary in ATC, looking at these other disciplines will help determine the direction from which to start.

In addition to looking at how memory changes throughout the day, Hogan et al. (2007) found that the performance of older adults was poorer in the evening. Some people might not consider this a time of day effect, but this is still a result that needs further testing. This is directly related to controlling, as the workforce will change significantly over the next few years as older controllers are replaced with younger

ones. If the poor performance of the older adults was more a function of their age, rather than time of day, it is still important to know.

The view that this is not a time of day effect may be a bit unfounded as another study had a similar discovery. In 2007, a study by Martin, Buffington, Walsh-Bohmer, and Brandt revealed that the performance of older adults during different times of day could be a factor when trying to diagnose Alzheimer's disease. They found that, "two of the three clinical tests of episodic memory were found to be sensitive to the time of day at which they were administered," (p. 156). They determined that older adults might show altered performance when tested at different times of day. This trend towards morning preference as a person gets older may be important to look into as controller shifts are handed out.

While looking back, further proof of this possibility was already found in the second study performed by May, Hasher, and Stoltzfus (1993). When looking in whether the time of day had any impact on memory they found some substantial results. They found that,

Each age group's optimal performance is seen at that group's peak period, create an overall pattern in which older and younger adults are equivalent in the morning and

in which older adults are substantially disadvantaged in the afternoon. (p. 329)

To bring this further together, a study by Schmidt, Collette, Cajochen, and Peigneux (2007) looked at trying to summarize some of the available literature on these effects and draw some conclusions. They saw that most of the existing research, "suggests that higher order cognitive functions, mainly executive control or working-memory load, are processes that appear intrinsically sensitive to time-of-day modulations," (p. 781).

It is important to look at the two different studies which have been performed locally as they may also shed some light on this topic. Petros, Beckwith, and Anderson (1990) looked at the possibility that the time of day may have an impact on memory, specifically prose memory recall. They found that the time of day did have an effect on a person's ability to recall no matter the difficulty. This idea was looked into further in a study by Anderson et al. (1991), where they also found this affect on long-term memory access. One interesting fact that they found in this study was that, "the present results for evening-subjects are consistent with previous research suggesting that memory access speed groups across time of day for evening types," (p. 251).

It seems clear that the time of day can influence an employee and make a difference when looking at the potential memory problems that can occur. Further study is necessary to see if this effect is still a factor to consider when dealing with air traffic controllers.

## CHAPTER V

### CONCLUSIONS AND RECOMMENDATIONS

The purpose of the study was to discover if there is sufficient evidence in the current literature to warrant further study into the time of day effects on air traffic controllers. It seems clear that there is plenty of research on this topic in other disciplines, but not specifically aimed at aviation, more specifically air traffic control. However, there does not appear to be a vast body of knowledge concerning the time of day and its effects upon controllers. This gap in the literature should necessitate to the need to have that information available for anyone who might need it, specifically air traffic managers and supervisors when scheduling their controllers.

With the constant increase in numbers of the traveling public, it is more and more important to look into all available factors that may play a part in safety. It is crucial that those passengers reach their destinations quickly and safely. To help ensure this the nation's air traffic controllers must be at their highest level of proficiency so they can detect any errors and correct them before they become a danger.

## Conclusions

This study has revealed numerous examples of previous research conducted into the time of day and the preferences of individual. After briefly describing what time of day effects are, the present study found a test that can be used to find the preferred time of day of a specific person. Horne and Ostberg (1976) created the Morningness-Eveningness Questionnaire (MEQ) to make of that very determination. Once it is clear that a person has a preferred time of day the effectiveness of that person can be tested at different times during the day. With age and gender controlled for, this makes it possible to construct a person's preferred time of day. Knowing this, tests can be performed to determine how big of a factor time of day really is.

Several tests have been done looking at the time of day's effect on sleep and the quality thereof. Chung et al. (2007) found that evening workers and need more sleep, and what sleep they did get was at a lower quality level. This was especially true of evening type people, overall they scored lower than their morning type coworkers. Soni et al. (2008) found a similar such result, though they didn't base their findings off a person's preferred time of day. Studies are conducted today about the possible effects of time of day on sleep. It should

be clear that nobody performs at their top efficiency if they have got inadequate sleep or received poor quality sleep, at least not for long.

Time of day also has an effect upon learning, a key component of the ATC position. Randler and Frech (2006) found a direct significant correlation between test scores and morningness. As learning is such a large part of ATC, it is important to look at any possible effect time of day may have.

A possible negative consequence of time of day was also looked at when trying to gauge if these effects were possibly significant. Several studies showed that there were some possible consequences ranging from a lower level of consciousness to possible risks of psychological disorders. This makes it clear that the possible outcomes cannot be ignored and need to be addressed to try to minimize their impact.

This study has attempted to define ATC and its critical components. The aspects were found to be those of situational awareness and planning. The hierarchical relationship between these two components was established in order to identify the possible effects of time of day. If a controller was not able to maintain an adequate level of situational awareness, how could they plan what was their next few moves? To look into the possible effects of time of day on these components, this study examined concentration and memory.

Concentration was specifically addressed when it comes to what impact time of day has. The general conclusion here was that concentration was effected by the time the test was taken, the amount and quality of the sleep the individual received, and even what type of road surface the individual encountered on their way. In order for a controller to be at their peak performance, these variables need to be known and controlled for.

Similar to that of concentration, memory was also looked at in the current literature for its susceptibility to the effects of time of day. Several examples were found to indicate that there was an effect and that it should be a factor to be taken into account. One study in particular by Schmidt, Collette, Cajochen, and Peigneux (2007) saw that memory, among other factors, was highly susceptible to the effects of time of day. The idea has been looked at locally and similar results have been found. They determined that memory is susceptible to the effects of time of day, especially evening people.

It is clear that the time of day preference of an individual can play a major role in their performance, especially when they are responsible of numerous lives. When each individual component of the air traffic controller's task is looked at, it appears that they all point towards safety above all else. When looking at situational awareness,

specifically concentration and memory it also becomes clear that there is an impact of the time of day. This effect could be no factor, but it is critical that this determined, not simply inferred.

### Recommendations

The body of literature on air traffic control is limited, even non-existent when it comes to these factors. It seems clear that studies need to be performed to determine what impact time of day has upon controllers. This study has had to compile all of the various studies performed in other areas and attempt to apply them here. If a study were created that asked controllers themselves it would address this possibility.

If this study were authorized, individual controllers could be studied. Their age, gender, schedule, sleep quality, and their family history could be compiled. Along with this, the Horne and Ostberg (1976) Morningness-Eveningness Questionnaire could be used to determine the controllers' preferred time of day. Statistical analyses could be performed on these findings to determine whether this is a significant problem.

If the findings turn out to be significant, these studies could spark a change in the hiring and scheduling practices for controllers. The evening people could be assigned evening shifts and vice versa. Obviously, exceptions will need to be

made for children, events, etc., but each controller should work when they can perform at their highest level. There could still be a bid system in place, but since safety is a major concern, the bidding could be within these morning/evening groups. For those facilities that operate 24 hours, schedules can include these times as later for evening people and earlier for morning people. It is almost certain that this type of scheduling might ruffle a few feathers so it is critical to have all the necessary data and proof on hand. If all of the correct steps are taken, there could be a significant improvement in safety for the controllers and the flying public.

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