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Airline Pilot Non-Flight Related Activities During Cruise Flight And Perceptions On Their Safety Effects

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AIRLINE PILOT NON-FLIGHT RELATED ACTIVITIES DURING CRUISE FLIGHT AND PERCEPTIONS ON THEIR SAFETY EFFECTS

by

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ABSTRACT

Automation complacency, boredom, and fatigue pose significant risk to aviation. There have been many incidents and accidents as a result of these challenges to human performance. In previous studies pilots have admitted to performing non-flight related activities in order to deal with these challenges. However, no research has been done on the frequency and perceived safety effects of non-flight related activities. If pilots are engaging in activities intended to counter these challenges, it is important to know the frequency and how pilots feel these non-flight activities affect safety.

This study used a survey tool to gather information regarding non-flight related activities from airline pilots in the United States. Participants provided data on frequency of non-flight related activities, perceptions of their safety effects, opinions on the activities related to automation complacency, boredom, and fatigue, and general information on the positive and negative outcomes of these activities. Results suggest that pilots routinely engage in non-flight related activities during cruise flight and perceive most of the activities to be safe. In addition, pilots believe that these activities help to prevent boredom, which then helps to prevent automation complacency and fatigue. Pilots seem to understand that these activities can have negative safety implications, but overall have more positive outcomes.

CHAPTER I

INTRODUCTION

On August 31, 1983 a Korean Airlines Boeing 747 took off from Anchorage, Alaska en route to Seoul, South Korea (International Civil Aviation Organization [ICAO], 1993). The pilots mistakenly put the autopilot into heading mode shortly after takeoff, which caused the aircraft to slowly proceed off course into North Korean airspace where it was shot down killing 269 people onboard (ICAO, 1993). What caused professionally trained pilots to fail to monitor the automation mode?

Mosier, Skitka, Heers, and Burdick (1998) describe this failure as automation complacency. Automation complacency, often referred to automation bias, relates to the interaction between humans, automation, and the errors that result (Mosier et al., 1998). The Korean Airlines accident is only one example of this kind of failure. In 1997 an Airbus 300 auto-throttle system disconnected during a descent (Dismukes, Berman, & Loukopoulos, 2007). The flight crew failed to notice the auto-throttle disconnect and the aircraft stalled and entered uncontrolled flight.

The growth of automation in the aviation industry has paralleled the stunning growth of computer technology. Some contribute the decrease in commercial aviation accidents in the United States to the increase in technology in modern commercial airplanes (Gaudry & Mayes, 1999). However the introduction of this technology has had some unintended consequences (Wiener & Curry, 1980;

Parasurman & Riley, 1997; Mosier et al., 1998; Parasurman, Molloy, & Singh, 1993; Reason, 1997; Parasurman & Manzey, 2010). It's important to point out that automating a function does not mean that the pilot is being replaced. Rather it means that the nature by which the pilot interacts with the systems has changed (Parasurman & Riley, 1997). As a result the workload of the pilot hasn't necessarily decreased (Damos, John, & Lyall, 2005).

In 1878, Nietzsche said that a machine culture would create hopeless boredom that would cause humans thirst for changeable idleness. Pilots have complained for years that automation is increasing their mental workload, making their job less enjoyable, and doesn't always eliminate safety concerns (Bhana, 2010; Damos et al., 2005). Today pilots spend most of their time monitoring systems. Monitoring an automated system may seem easier than manually controlling it, but research has shown otherwise. Vigilance has been shown to be an extremely demanding mental task and pilots are being required to do it for hours on end with little or no reprieve (Molloy & Parasurman, 1996; Bhana, 2010; Tenney, Rogers, & Pew, 1998; Warm, Parasurman, & Matthews, 2008; Grier et al., 2003).

In addition to automation, fatigue continues to play a major role in aviation safety. Since 1990 the NTSB has listed fatigue as an item on their most wanted safety improvements list (NTSB, 2010). It is only after a fatal 2009 airline accident that the Federal Aviation Administration (FAA) has begun to move on creating new fatigue regulations. These rules, which are supposed to help solve many of the fatigue problems, continue to be delayed as the FAA scrambles to satisfy all interested parties (Pasztor, 2011). As a result the aviation community continues to operate in what many consider to be an unsafe condition (Aviation Safety: Pilot Fatigue [ASPF], 2009).

Pilots have used many methods to help fight automation complacency and fatigue. Petrie and Dawson (1997) surveyed international pilots and found that to combat fatigue pilots were using a variety of factors including communicating with crew and drinking coffee. Petrilli, Roach, Dawson, and Lamond (2006) found that pilots would nap during flights to help combat fatigue. Bhana (2010) received many candid responses from pilots stating that they became bored quickly and monitoring cockpit equipment became very difficult. Pilots note that without activities such as talking to crewmembers or reading it would be extremely difficult to function at the level needed for safe operations (Bhana, 2010).

Coping strategies can be beneficial to automation complacency, boredom, and fatigue (Bhana, 2010; Mackworth, 1948; Temple et al., 2000; LeDuc, Caldwell, & Ruyak, 2000; Dalton & Behm, 2007; Davies, Lang, & Shackleton, 1973; Kishida, 1977). Many of the coping strategies pilots have admitted to using have never been studied (LaVenture, 2010; Bhana, 2010). These activities include conversation, listening to music, reading, and utilizing personal electronic devices. In addition, some coping strategies pilots have admitted to using are against their company regulations (LaVenture, 2010). It is important that we understand the nature of these countermeasures and consider whether they may be useful tools in combating safety issues today or whether they bring up new safety concerns.

Purpose of the Study

Before research can move forward we must begin to understand what pilots are doing during flight to cope with automation complacency, boredom, and fatigue, and their perceptions on how these activities affect safety. This study seeks to understand how pilots cope, what methods they use, and their perceptions of the safety implications. Those who operate airplanes on a day-to-day basis will have a unique understanding of the safety implications. It is important to note that this study does not seek to determine if a particular activity is safe, but to understand why pilots are utilizing it.

Research Questions

1. How frequently do commercial airline pilots engage in non-flight related activities during cruise flight?
2. Is there a relationship between age, average stage length, flight time, total part 121 time, and frequency of these non-flight related activities?
3. What do commercial airline pilots report as the reason for engaging in non-flight related activities during cruise flight?
4. How do commercial airline pilots feel performing non-flight related activities during cruise flight affects safety?

LITERATURE REVIEW

Automation and Vigilance

Vigilance research started when Mackworth (1948) took subjects and instructed them to monitor a clock hand. Participants were instructed to note when the clock hand moved twice the normal distance. Within 30 minutes the level of vigilance among the participants declined rapidly. This experiment proved that humans are not adept for vigilance tasks. It was significantly correlated that the longer the vigilance behavior was required, the less likely the subjects were to note a difference in the clock hand movement. In addition, the less sleep the participants had, the less likely they were to detect the change.

Frankmann and Adams (1962) published a meta-analysis of vigilance research. Every study conducted found that within 30 minutes vigilance abilities decreased among participants. In fact, the authors stated:

> When background stimuli are at a minimum and only occasional and often low key critical stimuli are present, rapid deterioration should be expect. The more unchanging are the critical stimuli, the sooner deterioration will occur. Rest periods and introduction of extraneous stimuli serve to increase the variety of stimulation needed to maintain or restore effective behavior. (Frankmann & Adams, 1962, p. 265).

Aviation itself has become a highly automated environment that requires vigilance from pilots (Wiener & Curry, 1983; Billings, 2007). There have been multiple accidents as a result of vigilance failures among flight crews (Wiener & Curry, 1983; Billings, 2007). Table 1 lists a few of these accidents.

Table 1. Incidents and Accidents in Aviation due to Vigilance Failures

Year	Aircraft	Accident Description
1973	L-1011	Flight crew failed to monitor the status of the autopilot while diagnosing a faulty landing gear light. Autopilot disconnected and the aircraft slowly descended into the Florida Everglades (NTSB, 1973).
1983	B-747	After takeoff the flight crew failed to monitor the status of the autopilot navigation select system. The aircraft slowly flew off course and entered North Korean airspace where it was shot down (ICAO, 1993).
1985	B-747	Autopilot was left on during cruise flight when an engine failure occurred. The autopilot attempted to compensate to hold its selected mode and the flight crew failed to monitor its status. When the crew disconnected the autopilot the aircraft entered an uncontrolled descent from flight level 410 and recovered at 9,500 feet (NTSB, 1985).
1995	B-757	While flying an approach in mountainous terrain the flight crew entered a fix in their Flight Management System. The fix was in the wrong direction and the aircraft descended into a valley. Not realizing the full extent of the mistake the crew flew into a mountain (NTSB, 1995).
1997	A-300	Flight crew failed to notice the auto-throttle system disconnected during a descent. As a result, while leveling, the aircraft stalled and entered uncontrolled flight. The crew performed a successful landing after the incident. (Dismukes et al., 2007)

Warm et al. (2008) published a definition of vigilance: “Vigilance refers to the ability of organisms to maintain their focus of attention and to remain alert to stimuli over prolonged periods of time” (pg. 433). Previous research and theory have always thought of vigilant activities as being easy and low-workload (Warm et al., 2008). Today it's understood that maintaining vigilance in human beings is actually a higher workload than traditional hands-on tasks. Grier et al. (2003) had participants monitor a computer screen to detect changes in the visual stimuli. Participants not only reported a higher workload during the vigilance activity, but increased stress levels. Although most studies show a vigilant decrement after 30 minutes, some have shown that in as little as five minutes there can be a decrease in vigilance (Warm et al., 2008).

Since the jet era began automation has rapidly increased in aviation (Billings, 2007). Systems have been designed to help manage flying the aircraft (autopilot), navigate (GPS, Flight Management Systems), and even see out the window (Heads Up Display). Concern began to rise regarding possible consequences to this increase in automation (Wiener & Curry, 1983). In a qualitative study of flight managers, Wiener and Currey (1983) found that pilot flying skills were degrading as a result of automation. In addition, monitoring failure accidents were beginning occurring regularly (see Table 1).

Despite these concerns, the push for automation has always been very strong. In addition to economic considerations, such as fuel savings from more efficient aircraft, automation has been introduced in an attempt to decrease a large contributor to aviation accidents: human error (Wiener & Curry, 1983). Human error is estimated to be a factor in 70 to 80% of aircraft accidents (Shappell & Weigmann, 2000). A myth that is often discussed is that by increasing automation, the human can be replaced and therefore there will be fewer accidents (Billings, 2007). Often times by increasing automation you increase the number of possible failures in a system (Billings, 2007; Reason, 1997).

Parasuraman et al. (1993) conducted a study into the theory of automation complacency which was emerging in aviation. Participants were placed in front of a computer screen with multiple aircraft systems. Over a 30 minute period, participants monitored the systems for automation failures. Even in this multi-tasking environment, where it was believed there would be enough stimuli to maintain vigilance, participants were lulled into automation complacency. The complacency took only 20 minutes to occur. Some subjects even failed to detect one error in a 10 minute block of time. This study had an automation reliability rate of 87.5%. In the real world automation has a reliability rate of greater than 99%. This lower reliability rate in the study compared to the real world may mean that pilots would be more complacent than this study indicated.

Molloy and Parasuraman (1996) conducted another study regarding automation complacency, but this time with a higher reliability rate. During a 30 minute block of time participants received only one automation failure while monitoring a series of systems on a computer monitor. Some participants were required to manually manage the systems while others just monitor. The results showed that the participants detected the automation failure more frequently during manual control. Highly automated systems were found to result in poor monitoring. Still, even with only one failure in a 30 minute window this is a lower reliability rate that found in the real world. Today, aviation automation has a 99% reliability rate (Bailey & Scerbo, 2007).

Bailey and Scerbo (2007) tested the theory of trust and automation complacency by placing participants in a 100 minute simulation of automation during which a 99.7% reliability rate was demonstrated. The results found that at this level of reliability, there was a 33.3% detection rate among participants for automation failures. The detection of single failures that are complex and subtle is very difficult when the reliability rate is so high. In addition, participants who experienced the 99.7% reliability level had a much higher trust level of the automation, which in turn made it more difficult for them to monitor for automation failures.

Unmanned aerial vehicle pilots spend their time on the ground monitoring and making changes to the flight of their craft (Cummings, Hart, Thornburg, & Mkrtchyan, 2011). Cummings et al. (2011) found that these pilots spend a majority of their time monitoring systems and have very little interaction with the control systems. Forty-five percent of their time monitoring is spent in a distracted state not monitoring their systems. During their distracted time the pilots talked to people, played on the internet, used cell phones, and ate.

Tenney et al. (1998) researched pilot perceptions about automation. Pilots responded that they wanted reliable and understandable automation as a priority over accountable, subordinate, flexible, error resistant, or error tolerant automation. Pilots preferred simple, dependable automation to the latest technology available. In addition, pilots reported that the automation has reduced physical workload more than cognitive workload. Pilots reported increased head-down time, complacency, and degradation of their piloting skills.

Damos et al. (2005) found that pilots who were using automation and as a result not flying as much, did not actually experience a decrease in the frequency of many routine tasks. Although automation aided the flight, the physical workload placed upon the pilots did not actually decrease. This study was limited in that it only studied physical workload and did not study whether mental workload had decreased as a result of automation.

Parasurman and Manzey (2010) argue that automation does not replace human operators, it changes the nature of how humans interact with it. Mosier et al. (1998) tested pilots to see their omission rates with automation systems. The overall rates of omission were 55% when pilots were presented with a variety of automation failures such as incorrect frequency, altitude input failure, and heading capture. In addition, when the automated system put in the wrong frequency, 71% of the pilots failed to detect the error. The more experience the pilots had the more likely they were to commit the automation complacency errors.

Flying airplanes is a multi-task environment that today is highly automated (Billings, 2007). This environment has been found to create the most likely scenario for automation complacency (Parasurman & Manzey, 2010). Training does not eliminate automation complacency. However, some studies, such as Parasurman and Riley (1997), have suggested that hand flying the aircraft more often helps to prevent automation complacency.

Many researchers have studied the effects of countermeasures for automation complacency. Mackie (1987) discussed how, "well over a thousand studies have been published… vigilance decrements occur as a function of time spent." (p.707).

Many suggestions from research have been discussed as a way to counteract these decrements. Suggestions include providing varied auditory stimulation or employing alerting secondary tasks (Mackie, 1987). Many pilots have already begun to find ways to combat complacency and boredom (Bhana, 2010).

Bhana (2010) did a survey of commercial airline pilots regarding boredom and automation complacency. The study positively correlated that the more bored a pilot was the more attention lapses they would experience. Pilots reported using numerous countermeasures. Some pilots manually did tasks that the automation would normally handle in order to keep themselves involved in the operations. One pilot reported, "I find it absolutely crucial to find non-aviation items to engage the mind." Some pilots read, played games and engaged in conversation. Some of these activities may be against an airline's standard operating procedures.

Fatigue

Fatigue regulations have been a subject for debate in the aviation community since 1931 when the national labor board imposed an 85 hour per month flight time limitation on airline pilots (Hopkins, 1982; ASPF, 2009). In 1938, the Civil Aeronautics Act increased this limitation to 100 hours, where it stands today. Since this time there has been huge debate regarding whether current duty time regulations are safe and if they should be revised (ASPF, 2009). During his testimony to the United States Congress in 2009, Prater, former head of the Air Line Pilot's Association, Int., noted that the NTSB had issued more than 70 fatigue-related safety recommendations since 1989. Fatigue safety improvements have been sought after by the NTSB since 1989 (NTSB, 2010).

Co, Gregory, Johnson, and Rosekind (1999) did a survey of fatigue on regional airline pilots. Sleep is vital for human beings and without it cognitive processes, vigilance, physical coordination, judgment, and decision making can suffer greatly. Co et al. (1999) found that 88% of flight crews regularly experienced fatigue, and 92% said that when fatigued occurred it was a “moderate” or “serious” safety issue. Eighty percent of pilots admitted to falling asleep during flight at least once and 56% admitted that they had arranged it so that one pilot could sleep during flight.

LaVenture (2010) analyzed continuous duty overnights at a regional airline and fatigue affects. Continuous duty overnights are defined by Co et al. (1999) as operating late at night, landing, having anywhere from zero to eight hours on the ground at destination, and then operating the first flight back in the morning. Due to the legality of keeping crews on duty for up to 16 hours they are not required to have the normal rest period because the entire continuous duty overnight does not extend past this limitation. Of the pilots studied by LaVenture (2010), 63% reported that fatigue was a common occurrence. Fifty point seven percent of pilots reported that fatigue was a moderate concern, 40.6% reported minor concern, 8% a serious concern, and 0.7% reported not at all a concern. Over half, 59.1% of the pilots, reported nodding off at some point and 88.4% of pilots admitted they had been on a flight where the other pilot had slept or nodded off.

One of the many arguments for increasing automation has been that workload should decrease, and as a result so should fatigue (Harris, Hancock, Arther, & Caird, 1995). As noted in previous studies, automation does not necessarily decrease workload. Harris et al. (1995) had participants monitor an automated system and manually control a system. Participants who were using the automated system and only monitoring for failures more efficiently utilized their resources. Although workload was reported lower when the participants only monitored, fatigue increased equally across both groups. This study illustrated that although perception of workload may decrease, fatigue may not when a system is automated.

There have been many incidents and accidents where fatigue has been cited by the NTSB as a contributing factor. Table 2 lists a few of these accidents.

Table 2. Incidents and Accidents in Aviation Due to Fatigue

Year	Aircraft	Accident Description
1993	DC-8	Flight crew crashed in Guantanamo Bay during final approach. Having been awake for 19-23 hours, the captain publically testified, "…I felt very lethargic or indifferent." (NTSB, 1993).
1999	MD-80	Flight crew continued approach and landing into thunderstorms. Contributing factors to the accident were impaired performance relating to fatigue (Dismukes et al., 2007).
2007	ERJ-700	While landing the aircraft overran a snowy runway and impacted an instrument landing system. The captain was fatigued at the time of the accident (NTSB, 2007).
2008	CRJ-200	The flight crew fell asleep during cruise and overflew their destination by 27 nautical miles before waking up (NTSB, 2009b).
2009	DHC-8	On final approach the flight crew stalled the aircraft. The NTSB concluded that performance was most likely impaired due to fatigue (NTSB, 2010a).

Napping has long been cited as an effective countermeasure to fatigue (ASPF, 2009, Co et al., 1999). Singal, Gander, Anderson, and Brash (2009) studied napping as a countermeasure in air traffic controllers. Twenty-eight participants were monitored on late night shifts. The participants were allowed to have a scheduled nap. The results indicated that although performance did increase for air traffic controllers following the nap, the performance increase did not extend for the duration of the evening. The authors concluded that although an effective countermeasure, napping is not fail-safe nor should be utilized as a sole method to help prevent fatigue.

Multiple studies have cited the usage of caffeine by pilots as a countermeasure to fatigue while flying (Petrie & Dawson, 1997; Petrilli et al., 2006; LaVenture, 2010). In fact, some airlines today train that the usage of caffeine at carefully selected times is warranted, and some carriers even go as far as providing crews with specific caffeine rich beverages to consume at recommended times. Temple et al. (2000) did an experiment in which caffeine was utilized to see if performance was affected on a vigilance task. The vigilance experiment only lasted 12 minutes, but even in this short duration it was found that participants were unable to remain fully vigilant during that period. The addition of caffeine did help performance and vigilance, however it did not decrease workload or stress.

Tying caffeine to aviation, Depperschmidt, Bliss, and Woolsey (2010) studied the effects of caffeine on collegiate flight students. Students either consumed an energy drink with caffeine or a placebo. They were then placed into a flight simulator and graded on their performance. Students who consumed the placebo performed better at flying straight and level but took longer to complete complex turns. In addition, there was no significant effect of dealing with an in-flight engine failure between the groups. Although a relatively small study, Depperschmidt et al. (2010) argue that caffeine, though it may help in some regards, does not assist the pilot in routine flight maneuvers.

LeDuc et al. (2000) studied the effects of exercise as a countermeasure to fatigue in aviators. Twelve army aviators participated, staying in a laboratory for seven days. Throughout the experiment aviators were sleep deprived at different points and then subjected to exercise, followed by cognitive tests. It was determined that exercise significantly helped pilots get over short bouts of fatigue. In addition, the exercise decreased the amount of anxiety normally associated with being awake over a long period of time.

In order to connect these theoretical studies regarding caffeine, exercise, and other countermeasures to real world aviation, Petrie and Dawson (1997) did a study of international pilots, fatigue, and coping strategies. One hundred and eighty-eight pilots participated, all flying the Boeing 767, 747-200, or 747-400. The survey responses indicated that the top four fatigue symptoms pilots noted were feeling sleepy, low in energy, mentally slow, and loss of concentration. Pilots reported that they had multiple strategies to cope with fatigue. Some included taking things one step at a time, conversing with the crew, having a cold drink, moving around, being organized, keeping busy, and keeping their mind active. Petrie and Dawson (1997) divided all of the coping strategies into five coping categories: planning energy use, active coping, mental withdrawal, communicating with other crew, and coffee drinking.

Petrilli et al. (2006) did another study regarding fatigue and international airline pilots. Pilots tracked their sleep cycles and completed a questionnaire before and after each flight they conducted. Results indicated that pilots had reduced sustained attention after flights which can lead to errors. In addition, this indicates that the final stages of flight, such as approach, are more susceptible to fatigue risk. Petrilli et al. (2006) note that the actual sleep attained by the pilot will better predict fatigue levels than any duty history the pilot may have.

To determine what fatigue countermeasures the average person uses, Anund, Kecklund, Peters, and Åkerstedt (2008) surveyed Swedish car owners. Responses indicated that when feeling sleepy, 54% would go for a walk, 52% would turn on the radio/stereo, 45% would drink coffee, and 35% would engage in conversation. One of the most effective methods to combat fatigue, sleeping, was utilized in the form of pulling over to get some sleep by only 18% of drivers.

LaVenture (2010) performed a study regarding fatigue in aviation. Pilots at a regional airline in the United States were surveyed regarding their fatigue countermeasures during continuous duty overnights. The study found that 73.7% of pilots reported engaging in conversation, 62.8% drank coffee, and 48.9% stretched. Some of the participants wrote in responses, which included "Doing puzzles in newspapers," "reading," "do usa today puzzles," "listen to ADF," and "music." Many of these write in responses are considered against the applicable airline's policies. LaVenture (2010) questions whether these write-in responses are increasing alertness or causing a distraction.

In-Flight Countermeasures

Music

In the LaVenture (2009) study, pilots admitted to combat fatigue they "listen to ADF" or "music" in order to help stay awake. Listening to an ADF would imply listening to an AM radio station, which can be picked up in flight using the aircraft's automatic direction finder (ADF) receiver. The participants did not indicate how they would listen to other music.

Much of the research done on auditory stimulation while operating machinery has been done in automobiles. Konz and McDougal (1968) did a study on whether the tempo of music had an effect on the amount of inputs by drivers. Participants drove an 11.5 mile circuit between two Midwestern towns. The automobile was equipped with recorders that determined the amount of steering wheel inputs, accelerator applications, brake applications, speed changes, and total time. Music that was utilized included no music, slow music, and Tijuana brass music. The results indicated that drivers were more active during the Tijuana brass music, but there was no significant difference between the no music and slow music condition. The increased tempo music may have led the participants to more alert behavior. Although seemingly important, Konz and McDougal (1968) caution that these results cannot necessarily be deemed "good" or "bad," but simply "are."

Davies et al. (1973) did a study on the effects of music on a vigilance task. Participants were told to note when a light changed brightness levels. The participants completed the task in silence or with music playing. The music selected was instrumental in nature and set to approximately 75 dbA. The results indicated that when the vigilance task was simple, music had no effect. However, when the vigilance task was more difficult, a significant increase in the detection rate was noted. Therefore, when a vigilance task is difficult music will improve performance levels.

Backing up both of these studies, Beh and Hirst (1999) took participants and placed them in front of a computer screen with a joystick and foot pedal. Depending on the display on the screen participants were required to manipulate either the foot pedal or joystick. Participants either completed the task in quiet, with low-intensity music, or with high-intensity music. Participants were tested twice, under a low demand, single-task presentation and high demand, multiple-task presentation. The results showed that both the low-intensity music and high-intensity music increased vigilance performance. Ben and Hirst (1999) believe that participants who are listening to music are more likely to focus on the external environment rather than on internal thoughts, thereby increasing vigilance abilities.

There are many factors that could possibly change the nature of how music might affect human performance. Tempo is one of them. Brodsky (2002) did an experiment to test the effect of tempo on a simulated driving environment. A fast tempo has previously been found to make supermarket shoppers move more quickly around the store, eat more quickly, and drink in pubs faster. Time judgments are also affected by the tempo of music such that when shoppers hear familiar music they are more likely to perceive they spent more time shopping. In Brodsky’s (2002) experiment, participants utilized a computer and drove a simulated driving course. Music tracks were selected with slow-tempo, medium-tempo, or fast-tempo. The results indicated that the faster the tempo of the music, the faster the simulated driving speed.

Music can naturally be hazardous to health if played at a high enough volume level (Dalton, Behm, & Kibele, 2007). At some point, music volume becomes so great any possible performance increase in vigilant activities does decrease. While driving in a simulated environment, participants were exposed to either a loud set of music, 95 dbA, or quiet music, 53 dbA. The results indicated that the loud music significantly decreased performance abilities in the participants. Previous studies cited have shown that between 50 dbA and 80 dbA performance usually increases, but as you approach 90 dbA performance decreases.

Dalton and Behm (2007) made several determinations about music and task performance. First, that music may or may not help mental performance. During situations where concentration and attention are required, music can improve performance. However, when comprehension is required music is detrimental to performance. A faster tempo of music speeds the rate to which a task is carried out. Again, however, the faster tempo increases the rate of mistakes made. When a task requires high levels of attention and concentration, a moderate level of music is optimal. The definition of moderate level is subjective to the listener. Regardless of the type of music, loud volume is detrimental to performance.

Conversation

No research has been done on conversation during cruise flight in aviation. Most conversation research has been conducted in either a workplace or automobile setting (Kishida, 1977; Atchley & Dressel, 2004; Atchley & Chan, 2011). Some studies have cited the usage of conversation in the cockpit (LaVenture, 2010; Bhana, 2010). For example, to help stay awake on a continuous duty overnight, 74% of pilots reported that they engaged in conversation (LaVenture, 2010). In Bhana's (2010) study regarding boredom, 97.8% of pilots reported they engaged in conversation in order to prevent boredom.

Commercial aviation can become routine and monotonous in nature. Pilots in the Bhana (2011) study reported that, "…boredom is a very large part of my flying time." Kishida (1977) did a study regarding the subsidiary activities that result from monotonous work. Boredom and poor performance often results from repetition in simple, routine tasks (Kishida, 1977). Kishida (1977) studied two bottling plants where they observed workers and their activities under different inspection speed rates. Subsidiary behaviors, activities not related to their primary work tasks, that were noted included napping and sleepy state, conversing, looking around, and hand-moving. The results indicated that conversing increased the performance level of workers. These compensatory subsidiary activities are a result of workers attempting to increase their interest in the monotonous work they perform.

Utilizing students at a university, Atchley and Dressel (2004) attempted to determine what effect conversation had on the field of view of participants. Participants monitored a computer screen, which displayed vehicles at different points in different locations on the screen, and were required to make a determination of how much the vehicle moved around the screen. The conversation tasks consisted of the researcher reading a word to the participant, who then was required to think of another word that started with the same letter as the word the researcher had read.

Results significantly indicated that by adding the conversational task, the field of vision was decreased

Atchly and Chan (2011) did a study that indicated adding a secondary task at the right time significantly increased vigilance levels in drivers. Forty-five students drove a 25 minute simulated drive. The drivers were randomly assigned to three different groups: no verbal task, continuous verbal task, and late verbal task. Billboards were placed along the route driven and at one point a vehicle pulled out into the lane the participant was driving into. This was done in order to determine if the participant was paying attention. In addition, a computer randomly played words and the participant was instructed to free respond to the words however they saw fit. Results showed that the late verbal tasks significantly increased driving performance of the participants, which indicates that by applying a concurrent task at the right moment performance can be increased and it is possible to mitigate the decrements of performance over time.

Reading

As with conversation, no research regarding reading in aviation has been conducted. However, the write-in responses in LaVenture's (2010) study regarding continuous duty overnights, one person stated that a fatigue countermeasure they used was "reading" while another said, "Doing puzzles in newspaper." In the Bhana (2010) study regarding boredom and automation complacency, one pilot wrote, "If it were not possible to read during cruise my boredom level would be significantly higher." It is clear that some pilots engage in reading activities during cruise flight, however the effects of this practice are unknown.

Lin, Robertson, and Lee (2009) looked at how college students handle multitasking. Specifically Lin et al. (2009) was looking for differences in multitasking abilities between novices, averages, intermediates, and experts. Generally speaking, as knowledge, experience, and expertise increases then the level of focus required decreases. As humans increase their abilities the activity becomes routine, which lowers the overall workload. The study broke the participants into several groups and had them read an article while a background video was played. The video was not played, played with no audio, or played with video and audio. Participants did best with the video playing in the background, but no audio. The exception to this was the experts, who performed almost equally between silence and video, but no audio conditions. All participants performed worst with the background video and audio condition.

Bowman, Levine, Waite, and Gendron (2010) did a study regarding whether participants could multitask between reading information on a computer screen while receiving instant messages. While reading, participants either received an instant message before they started, during, or no instant message. The results indicated that those who received the instant message during reading took longer to complete the reading assignment. However, no group significantly differed in their understanding of the reading assignment based upon when they received the instant message. Bowman et al. (2010) determined that participants could successfully multitask between the two tasks, but it would take longer to complete the task.

The LaVenture (2010) study stated that although crewmembers did admit to reading during flight, the airline did have a specific policy against the practice. As an example of airline policies that prohibit reading, Delta Airlines' flight operations manual stated "Crew members will not read material or engage in activity not directly related to aircraft operation while at their duty stations" (NTSB, 2009). Not all companies prohibit reading while in flight, however, Federal Aviation Regulations (FAR) 121.542 (2011) states that below 10,000 feet crewmembers will not engage in any non-operational related activity.

Personal Electronic Devices

In 2008 the Department of Transportation Federal Railroad Administration (FRA) did an initial study into the impact of distracting electronic devices. The FRA (2008) report discusses how in the past years personal electronic devices have become prevalent in society and those devices have become more versatile in their abilities. Cell phones were initially utilized to help promote more effective communication for railroad employees, however, as these devices have become more multi-functional they allow workers to utilize them for personal activities.

Railroad safety reviews have noted several accidents in which the NTSB found employees have been distracted with personal electronic devices. During the investigation of one railroad accident, the NTSB found that workers had placed 25 calls during the trip leading to the accident, and 22 of those calls were of a personal nature (FRA, 2008). A Metrolink accident in California was found to be partially the result of the train engineer distracted due to texting on his cell phone (FRA, 2008). FRA inspectors have witnessed many employees utilizing electronic devices for personal reasons. Multiple times the FRA has found employees using cell phones, DVD players, and computers while on duty (FRA, 2008).

On October 21, 2009 an Airbus 320 overflew its destination airport, Minneapolis – St. Paul International/World-Chamberlain Airport (MSP), Minneapolis, Minnesota (NTSB, 2009a). During the flight the aircrew was without air traffic control communication for one hour and seventeen minutes. The flight crew stated they were distracted while working on their laptops discussing a new bidding system the airline had implemented. The Captain did state that the laptop he had out did not block the view of any instrumentation, but that the distraction had caused them to get into a conversation that made them not realize they had missed their destination.

FAR 121.542 (2011) prohibits the use of any non-operational activities below 10,000 feet for flight crews. In addition, many companies also prohibit the usage of personal electronic devices in flight. The 2009 Delta Airlines flight operations manual stated that:

> Crew Members are prohibited from using any device not certified for use in the aircraft. Certain devices that are certified are further restricted to prohibit their use on the flight deck. These items include, but are not limited to, personal computers, hand-held GPS units, CD players, MP3 players, DVD players, etc. (NTSB, 2009).

This FAR regulation has created what is commonly called the "sterile cockpit" (Sumwalt, 1993). Sterile cockpit means that below 10,000 feet airline pilots will only perform duties, including conversation, on topics that specifically relate to the operation of that flight. Prior incidents and accidents had occurred as a result of pilots performing non-flight related activities and the FAA felt that by implementing this system they would cut down on the safety issues. As a result, any non-flight related activity would be prohibited by regulation below 10,000 feet.

CHAPTER II

METHODOLOGY

Commercial airline pilots today face the issues of automation complacency, boredom, and fatigue. As aircraft become more automated the nature of how pilots interact with the aircraft is changing, and as a result how pilots combat these human factor issues is critically important to keep commercial aviation safe. There are many countermeasures already utilized to help fight these issues, but no studies have been done on activities pilots already utilize in flight and how those activities may affect safety. This study will examine how frequently activities are performed, why pilots do them, and their perceived safety effects. This chapter discusses the study population, sample, and design in detail.

Population

The population group examined by this study is commercial airline pilots flying two, three, or four-person crews under Federal Aviation Regulations part 121, often referred to as airlines or air carrier operations. This group of pilots was selected because of the nature of their flying. Part 121 flying is scheduled and routine. Flight crews frequently fly scheduled routes many times. Procedures and policies are highly uniform and do not vary. The automation utilized is very uniform and advanced, including autopilots, flight management systems, moving display maps, and ground proximity warning systems.

General aviation pilots were excluded. These pilots fly a large variety of type of aircraft with a large range in the amount of automation onboard. Procedures widely vary. Routes may not be frequently flown. Corporate pilots were also excluded from this study. Corporate pilots, although flying often technologically advanced aircraft with automation, do not always fly with two person crews. In addition routes may vary and change frequently depending the nature of their mission. Procedures and policies also may vary greatly from company to company. Lastly, single pilot part 121 pilots were excluded given that they do not have a second pilot in the aircraft to rely on, therefore the activities being researched may not be possible given their need for greater vigilance due to lack of pilot redundancy. In addition, many single pilot part 121 carriers often have no separator, such as a door, from the passengers being carried. Therefore it is unlikely that the activities being researched would be possible given the greater visibility to passengers the activities would have during flight.

Sample

The study surveyed pilots employed at part 121 air carriers in the United States. None of the participants were compensated for their time and all responses were voluntary. The survey was available from any computer with Internet and there were no time constraints. Responses that were excluded were those that failed to answer any question beyond the demographics, participants who reported zero part 121 time, participants who failed to answer any question, or participants who answered no demographic questions which does not allow for verification of part 121 time.

Study Design

Sample subjects were recruited in several ways. First, a *blast* e-mail, defined as an e-mail sent to a large mailing list, was sent out through a mailing list provided by a national pilot organization (see Appendix A). Second, a web posting was placed on the union forum for one airline (see Appendix B). Both methods included a description of the study and the Internet hyperlink. The survey was administered online to allow for simplicity of delivery and anonymity for the participants. In addition, this online method of delivery allows participants to complete the survey at their leisure when time allotted.

The survey was administered through an online survey tool. Once the participant loaded the survey, the first page included a description of the research and instructions on how to complete the survey. The survey was open for responses for four weeks.

The survey included both quantitative and qualitative questions (see Appendix C). The survey was created to allow participants to have plenty of opportunity to provide more information if they wished to do so and many questions were open ended specifically to explore the nature of these activities. There were 26 questions broken into the following sections: demographics, personal activities, witnessed activities, perceived safety effects, and specific positive and negative events.

Methods and Data Collection

Subject's responses were received via the online survey tool and saved when the participants completed the survey. When the survey collection period ended, the responses were exported into Microsoft Excel and securely given to the researcher for analysis.

Data Analysis

Quantitative question data was imported into SPSS and analyzed. Significant values were set at the 0.05 alpha level (2-tailed). The researcher read through all qualitative data to obtain a general sense of the information, coded the data, formulated themes, and then classified the data into categories for reporting. Results are displayed both by listing categorical themes and through narrative passages from participants. All data was reviewed to ensure reliability.

Validity and Limitations

The survey was designed by the researcher for this topic. Questions were derived from previous research studies and researcher experience. A panel of experts validated the survey. In addition, members of the subject population reviewed it before being administered to ensure that the survey was comprehensible for the target population.

To ensure validity of qualitative data analysis the researcher ensured that themes were built from multiple participants. In addition, specific information that runs against the primary theme was be reported. This ensured a more balanced report of data.

Several limitations are present within the study. Since the survey is anonymous there is no way for the researcher to follow up in case of questions regarding responses. In addition, due to this anonymity there was no way to ensure that individuals only took the survey one time. This anonymity may also permit those not in the population group from taking the survey. Given the sensitive nature of some of the questions asked it is possible some participants will begin the survey and chose not to complete it. Also, due to the need for anonymity some demographic questions, such as participant's flight time, are asked in estimated values, such that it is possible a participant could answer with more or less flight time than they actually have.

Protection of Human Subjects

Participants volunteered their time and responses for this survey. Every effort was made to protect participants from harm. The survey received approval from the Institutional Review Board of the University of North Dakota. In addition, the survey received approval from the national pilot organization that e-mailed the survey and the pilot union that posted the survey on their web forum. Although none of the activities discussed in the survey are considered illegal by current Federal Aviation Regulations, some activities are considered against regulations based upon the operating manual of some airlines. As a result, no personally identifiable information such as an IP address was collected. All subjects were informed that participation was voluntary and that they need only answer the questions they felt comfortable answering. Any response received in the open-ended questions that could identify any specific person was de-identified by the researcher. The online survey tool collected no data that could link any specific survey to a participant.

CHAPTER III

RESULTS

Demographics

One hundred and forty-six (*N* = 146) pilots completed the survey. Nineteen (*n* = 19) surveys were removed from analysis. Table 3 outlines reasons for removal.

Table 3. Number of Participants Removed and Reason

Number Removed	Reason Removed
15	Participants only provided demographic information and failed to answer any other question
2	Participants reported zero part 121 flight time, which implies they have never flown at a part 121 carrier
1	Participant answered no questions in the survey
1	Participant answered no demographic questions, which does not allow for verification of part 121 requirement
19	Total Removed

After removal of surveys that did not meet criteria one hundred twenty-seven (*N* = 127) surveys remained. The age range of participants was 22 to 59 years. Mean age was 36.89 years. Total time at part 121 carriers ranged from 0.8 to 31 years with a mean length of 9.37 years. Figures 1 and 2 provide graphical representation of this information.

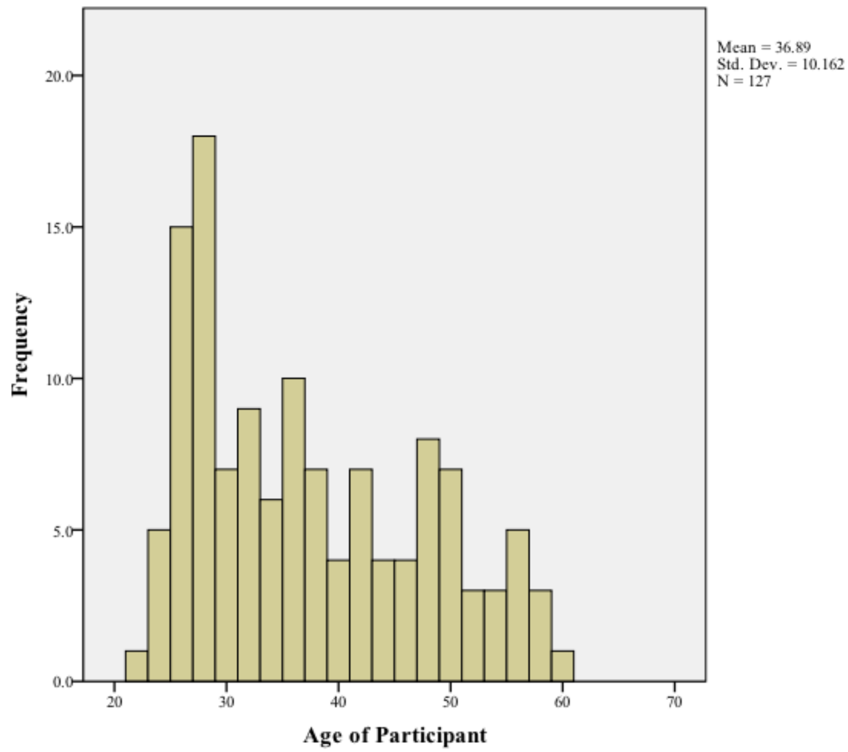

Figure 1. Histogram of Participant Age.

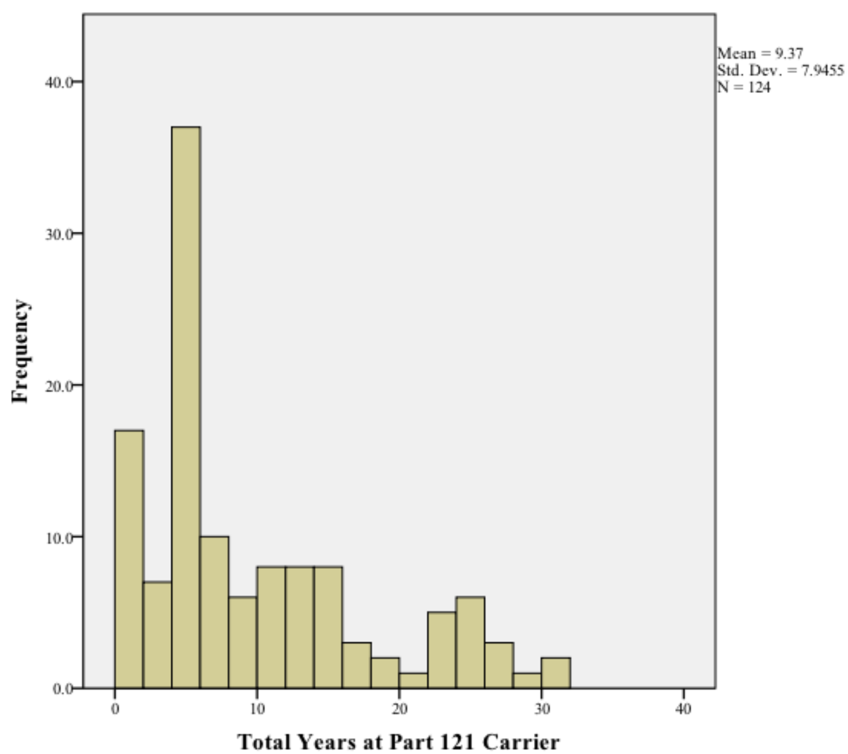

Figure 2. Histogram of Participant Total Time at Part 121 Carrier.

Flight time reported is listed in Table 4.

Table 4. Flight time reported by participants in hours

Variable	Minimum Value	Maximum Value	Mean
Total Time*	1,000	25,000	7,678.40
Part 121	26	22,000	5,603.67

**Note:* One participant's total time was removed due to a believed impossible time estimation of 57,000 hours. Total time numbers therefore included only one hundred twenty-six (*n* = 126) participants.

Figures 3 and 4 provide a graphical representation of total flight time. Average stage length was reported with a minimum of 00 hours and 45 minutes, a maximum of 11 hours and 00 minutes, and an average of 2 hours and 46 minutes. Figure 5 provides a graphical representation of average stage length.

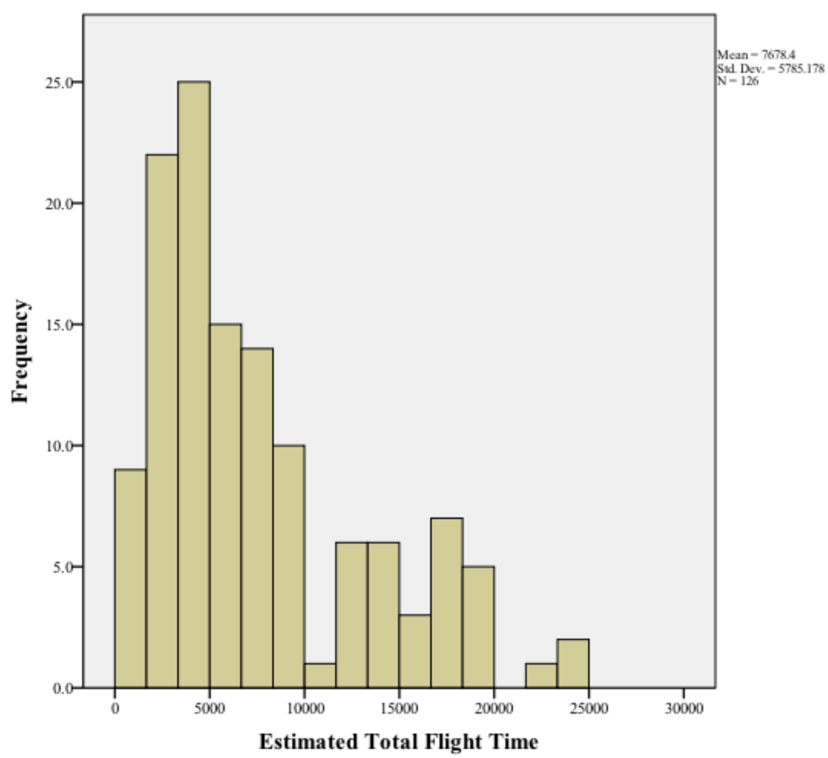

Figure 3. Histogram of Participant Estimated Total Flight Time.

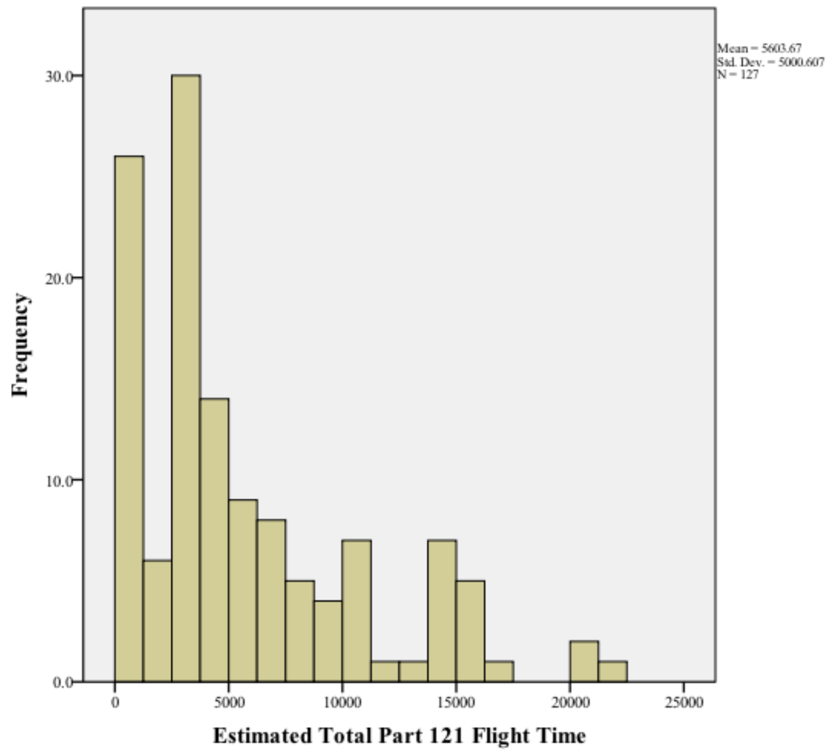

Figure 4. Histogram of Participant Estimated Total Part 121 Flight Time.

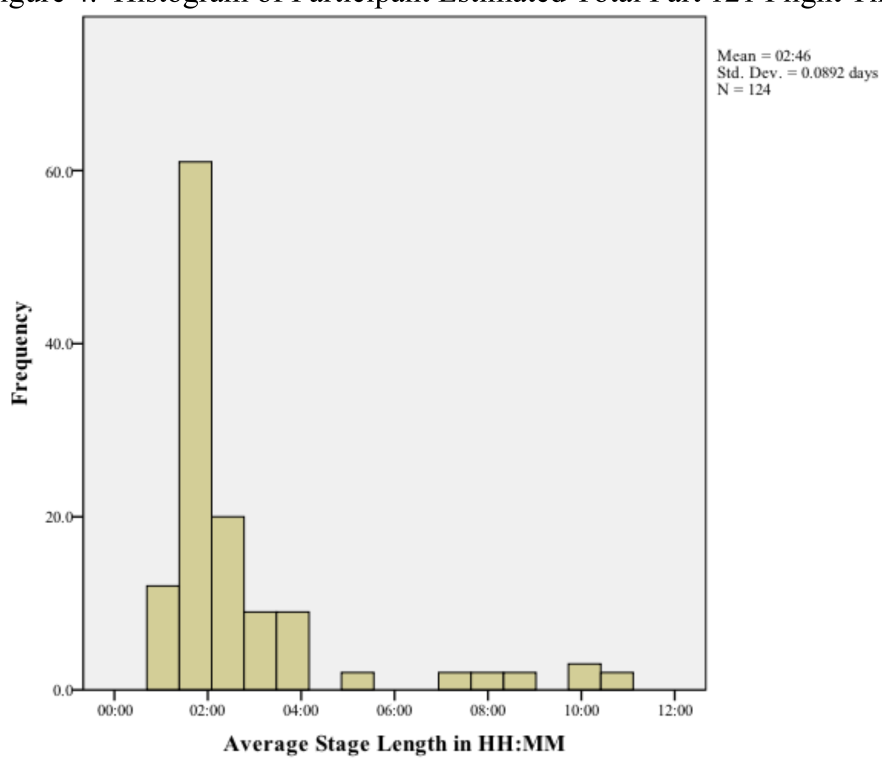

Figure 5. Histogram of Average Stage Length.

Frequency of Activities

The first research question asked the frequency of non-flight related activities during cruise flight. Table 5 represents a comparison of the frequency of activities participants performed. Table 6 represents a comparison of the frequency of activities participants witnessed.

Table 5. Frequency of Activities Performed

Category	Non-Flight Related Conversation	Reading	Listening to Music	Utilizing a Personal Electronic Device
Every Flight	88	16	1	9
Most Flights	33	32	5	27
Some Flights	3	50	13	32
Few Flights	2	24	21	26
No Flights	1	5	87	33
n	127	127	127	127

Table 6. Frequency of Activities Witnessed

Category	Non-Flight Related Conversation	Reading	Listening to Music	Utilizing a Personal Electronic Device
Every Flight	80	12	0	9
Most Flights	36	51	3	31
Some Flights	5	51	25	56
Few Flights	2	9	67	24
No Flights	1	1	29	4
n	124	124	124	124

Non-flight related conversation

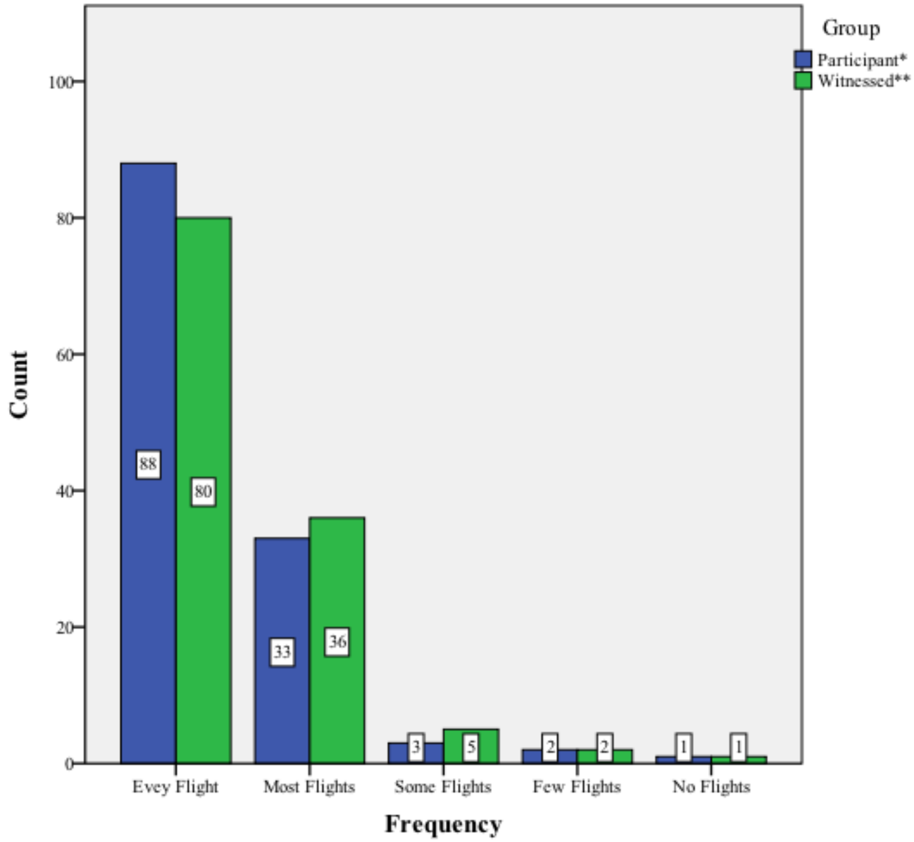

Figure 6. Comparison of Engaged in and Witnessed Non-Flight Related Conversation
Note. *n = 127, **n=124

Participants reported greater frequency of participating in conversation (M = 1.39, SE = .061) than witnessing conversation (M = 1.45, SE = .065). This difference was not significant $t(252) = .46$, $p > .05$.

Participants were asked if they answered “Few Flights” or greater to please elaborate on what they might talk about. One hundred twenty-one participants (n = 121) chose to respond. Primary categories included work, family, personal life, news, and general conversation topics. One participant best summarized the range of responses with “Pretty much any subject you could think about.” Another reported “Anything and everything.” Lastly, another said, “Just normal conversation.”

When asked what types of conversations participants had witnessed if they answered “Few Flights” or more, one hundred and seven participants (n = 107) responded. As with conversational topics participants performed during flight, witnessed conversational topics included “Anything and everything, Everyday conversation,” as reported by a participant. Topic categories included work, family, personal life, current events, and general conversation. Many participants reported the same things they talked about they witnessed other people talk about. One participant reported they witnessed “Normal conversation” and another said, “Just normal social conversation.”

Reading

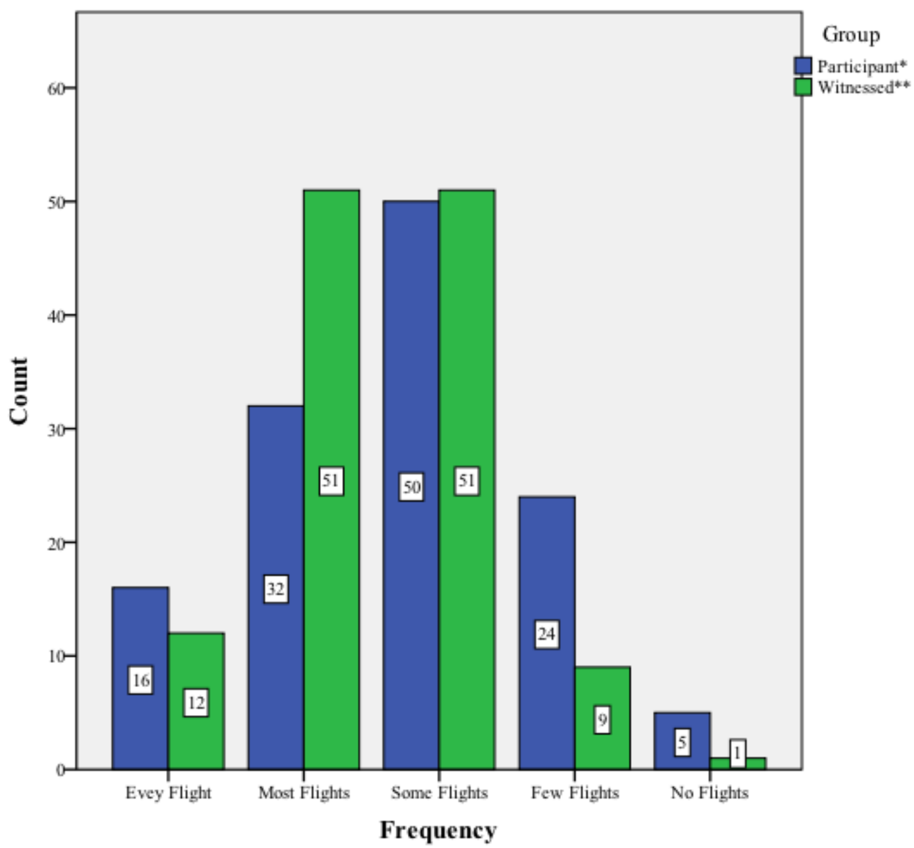

Figure 7. Comparison of Engaging in and Witnessing Reading
Note. *n = 127, **n = 124

Participants reported lower frequency of reading ($M = 2.76$, $SE = .091$) than witnessing reading ($M = 2.48$, $SE = .072$). This difference was significant $t(237.51) = .017$, $p < .05$.

As with conversational activities, participants were asked if they answered "Few Flights" or more to reading to please elaborate on what they might read. One hundred seventeen participants ($n = 117$) chose to respond. Almost every participant that responded reported reading the newspaper, with the USA Today© receiving specific mention in ten ($n = 10$) responses. One participant reported "USA Today most prevalent due to it being often given at hotels for free." Magazine and book categories were also reported with high frequency. Many participants also reported reading company manuals or material. Eight participants specifically reported reading material on an electronic device such as a Kindle®, eReader, or iPad®. A few participants reported doing crossword puzzles.

When asked what kind of reading participants had witnessed if they answered "Few Flights" or more, one hundred and thirteen ($n = 113$) responded. As with items participant read, almost everyone reported witnessing pilots reading the newspaper. The USA Today© was reported three times. Magazines and books were reported with high frequency. Company, training, and union material were also reported by many participants. Electronic methods to read were reported by six participants and included ebooks, iBooks®, Kindles®, and eReaders.

Listening to music

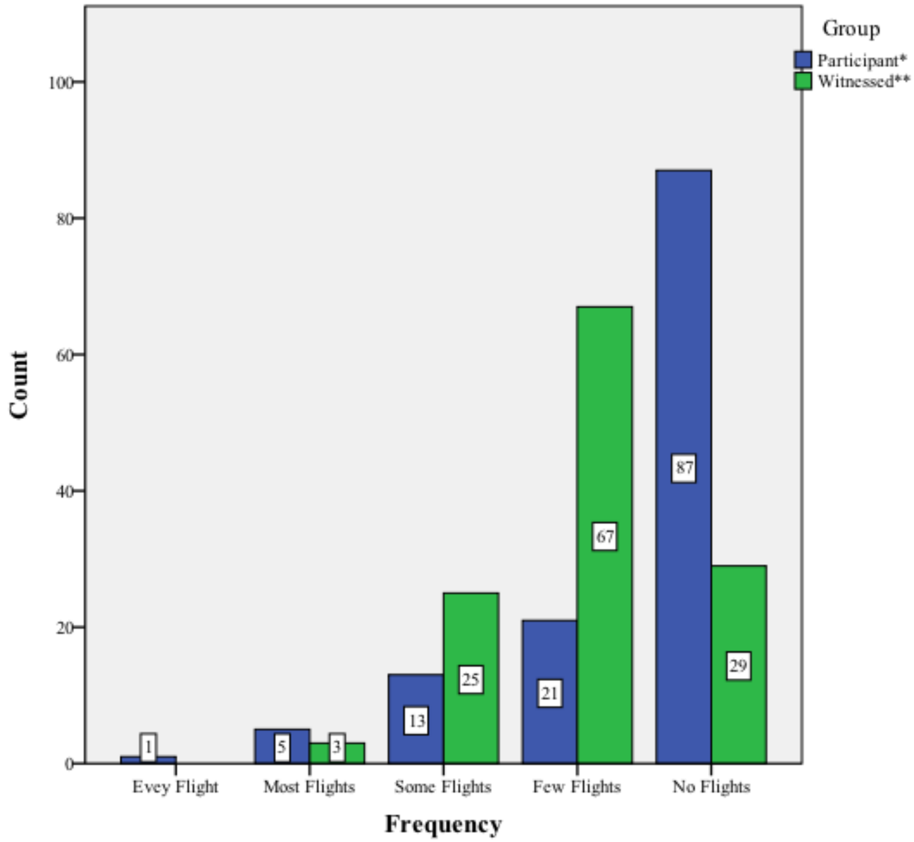

Figure 8. Comparison of Engaging in and Witnessing Listening to Music
Note. *n = 127, **n = 124

Participants reported lower frequency of listening to music (M = 4.48, SE = .079) than witnessing pilots listening to music (M = 3.98, SE = .066). This difference was significant $t(242.13) = .00$, $p < .05$.

When asked if they listened to music, what they listen to and how they listen to it, sixty-nine (n = 69) responded. Thirty (n = 30) respondents indicated the question was not applicable or that they did not listen to music which left thirty-nine (n = 39) for qualitative analysis. Types of music indicated by participants included many genres, including rock and roll, techno, dance, pop, country, top 40, club, gospel, and classical. Primary methods for listening to music were personal music players. The iPod® and iPhone® were the primary tools utilized. A non-descript mp3 player and DROID® were also listed. There were three primary means by which pilots listened to the music. Many respondents indicated they were able to play the music through their aviation pilot headset from their personal music player. A few participants indicated they put an earphone directly into their ear. Several participants said they used the aircraft's automatic direction finder (ADF) to listen to AM radio stations through their headset.

Participants were asked if they witnessed music being listened to what they were listening to and how they were listening to it. Ninety-two (n = 92) participants responded with eleven (n = 11) indicating that the question was not applicable or no music was seen being listened to. That left eighty-one (n = 81) responses for analysis. Most participants indicated they did not know what the other pilot was listening to. However, primary means of listening to music were the iPod®, followed closely by the iPhone®. Also indicated were mp3 players, cell phones, DROID®, and iPad®. Several participants indicated they witnessed pilots utilizing the ADF receiver to listen to AM radio through their headset. Most participants indicated pilots listened to the music through their headset, however many also reported witnessing pilots placing an earphone bud directly into their ear either only on one side or underneath their headset. Two participants reported that pilots utilized Bluetooth to listen to music. One participant stated, "One pilot would plug his ipod into the observer's jack so we were both hearing music."

Utilizing personal electronic devices

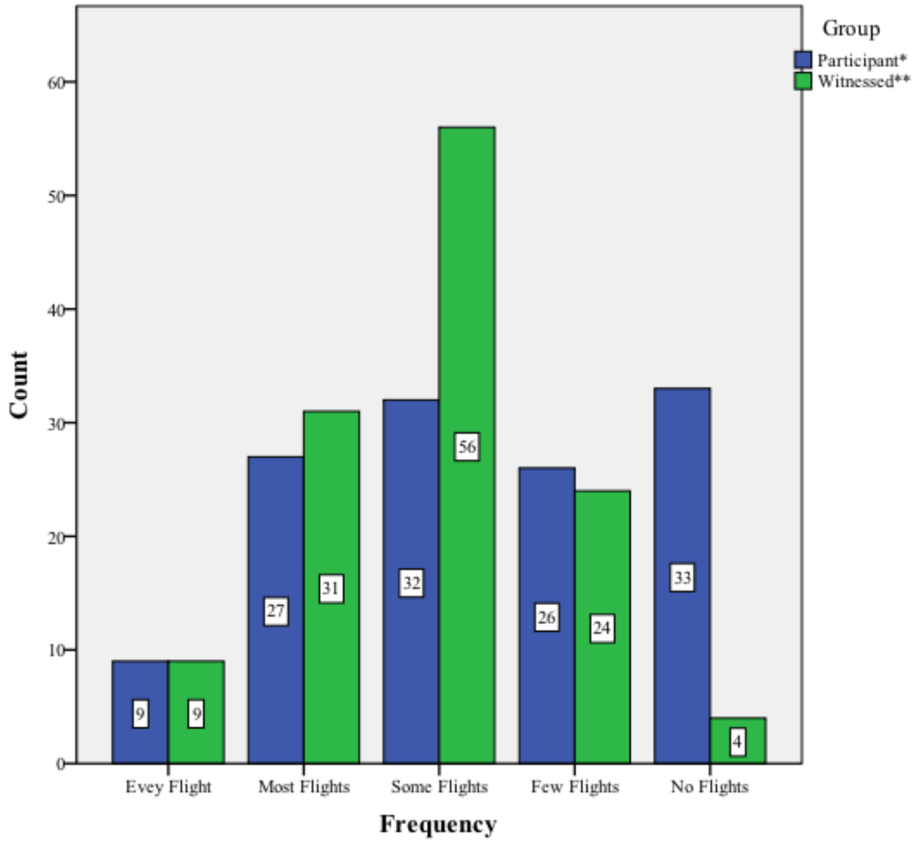

Figure 9. Comparison of Engaging in and Witnessing Using Personal Electronic Devices
Note. *n = 127, **n = 124

Participants reported lower frequency of utilizing personal electronic devices ($M = 3.37$, $SE = .113$) than witnessing the utilization of personal electronic devices ($M = 2.86$, $SE = .083$). This difference was significant $t(230.02) = .00$, $p < .05$.

When asked if they utilized a personal electronic device, what they used and what they used it for, one hundred and one ($n = 101$) responded with eleven ($n = 11$) indicating the question was not applicable. This left ninety ($n = 90$) for analysis. Most participants indicated they utilized their phone, primarily an iPhone®. Many participants reported using an iPad®. Kindles®, eReaders, and iPods® were also reported. Nine participants reported using a laptop. There was a wide range of responses for what the devices were used for. Many reported work related issues such as referencing company materials, work issues, pay sheets, flight schedules, bidding, and performance calculations. Also highly reported were playing games. There were many other responses, including checking weather, reading, listening to music, looking at or taking photos, personal stuff, finances, and organizing files. Four participants indicated they watched movies, one participant said they were learning another language, and one other participant said they used their phone to check out the constellations at night.

Participants were asked if they had seen other pilots utilize personal electronic devices what they saw used and what it was used for. One hundred and nine (n = 109) participants responded with one participant (n = 1) indicating the question was not applicable. This left one hundred and eight (n = 108) responses for analysis. Most participants indicated that a smart phone was the primary device utilized and this was followed closely by laptop computers. Tablet computers, primarily the iPad®, were also very frequently reported. A few participants reported witnessing eReaders and cameras being used. Most common usage of these devices was playing games, followed closely by reading, updating logbooks, and reading e-mails. Some participants reported work related functions, such as checking weather, updating manuals, and bidding for their schedule. Two participants reported utilizing the wireless internet provided on their aircraft. A few other participants reported witnessing pilots watching movies.

Other Activities During Flight

Participants were asked what other activities they have engaged in during flight. One hundred and one ($n = 101$) responded with eighteen ($n = 18$) indicating no activities or not applicable, leaving eighty three ($n = 83$) for analysis. Most participants indicated that they had eaten during cruise flight. Some participants said they had slept during flight. Photography, bidding for their schedule, and manual revisions were listed by a few participants. A few participants also reported personal tasks, such as sorting mail from home, working on their checkbook, and other general work from their home life. Three participants said they had studied work related material during flight.

When asked what other activities participants had witnessed, seventy seven ($n = 77$) responded with ten ($n = 10$) indicating none or not applicable, leaving sixty seven ($n = 67$) for analysis. Almost equal, eating and sleeping were the most common responses from participants and were reported by just under half of respondents. Some participants reported witnessing pilots bidding and updating their manuals. A few participants reported activities of a personal nature, such as learning another language, doing work for another job, and financial tasks such as balancing a checkbook.

Relationships Between Demographics and Activities

A Pearson's r was utilized to analyze the relationship between demographics, frequency of activities performed, and frequency of activities witnessed. Tables 7, 8, and 9 outline the relationships. Because the data was collected in a Likert scale, a negative r indicates an increase in frequency and a positive r indicates a decrease.

Table 7. Relationships Between Demographics and Frequency of Activities

	Non-Flight Related Conversation	Reading	Listening to Music	Utilizing a Personal Electronic Device
Age	-.064	-.168	.243**	.101
Total Time	-.144	-.328**	.250**	.063
Total Part 121 Time	-.150	-.372**	.228**	.025
Years Employed	-.177*	-.281**	.257**	.053
Average Stage Length	-.211*	-.246**	.116	-.126

Note. n varies based upon each individual correlation with a range of 124 to 127.
$*p < .05$. $**p < .01$

Table 8. Relationships Between Demographics and Witnessed Frequency of Activities

	Non-Flight Related Witnessed Conversation	Witnessed Reading	Witnessed Listening to Music	Witnessed Utilizing a Personal Electronic Device
Age	-.008	-.122	.184	.190
Total Time	-.112	-.236**	.164	.175
Total Part 121 Time	-.131	-.281**	.107	.137
Years Employed	-.097	-.204*	.158	.173
Average Stage Length	-.190*	-.302**	-.018	-.055

Note. n varies based upon each individual correlation with a range of 122 to 124.
$*p < .05$, $**p < .01$

Table 9. Relationships Between Performing Activities and Witnessing Activities

	Witnessed Activities			
	Non-Flight Related Conversation	Reading	Listening to Music	Utilizing a Personal Electronic Device
Non-Flight Related Conversation	.747**	.230*	.044	.236**
Reading	.196*	.627**	.241**	.349**
Listening to Music	-.077	.000	.537**	.171
Utilizing a Personal Electronic Device	.178*	.413**	.347**	.667**

Note. $n = 124$.
*$p < .05$, **$p < .01$

Perceptions on Activities and Safety Levels

Pilots were asked their perception on the level of safety these activities. Table 10 outlines the frequency of responses. Figures 10 through 14 provide a graphical representation of results.

Table 10. Frequency of Reported Perceived Safety Level of Activities

	Non-Flight Related Conversation	Reading	Listening to Music	Utilizing a Personal Electronic Device
Very Safe (1)	72	33	12	20
Safe (2)	48	70	41	60
Unsure (3)	1	15	28	32
Unsafe (4)	0	2	29	7
Very Unsafe (5)	1	1	12	3
No Opinion	0	1	0	0
Mean (SD)*	1.44 (.604)	1.91 (.730)	2.90 (.816)	2.29 (1.167)

Note. $n = 122$
*Mean and standard deviation are calculated without “No Opinion” category.

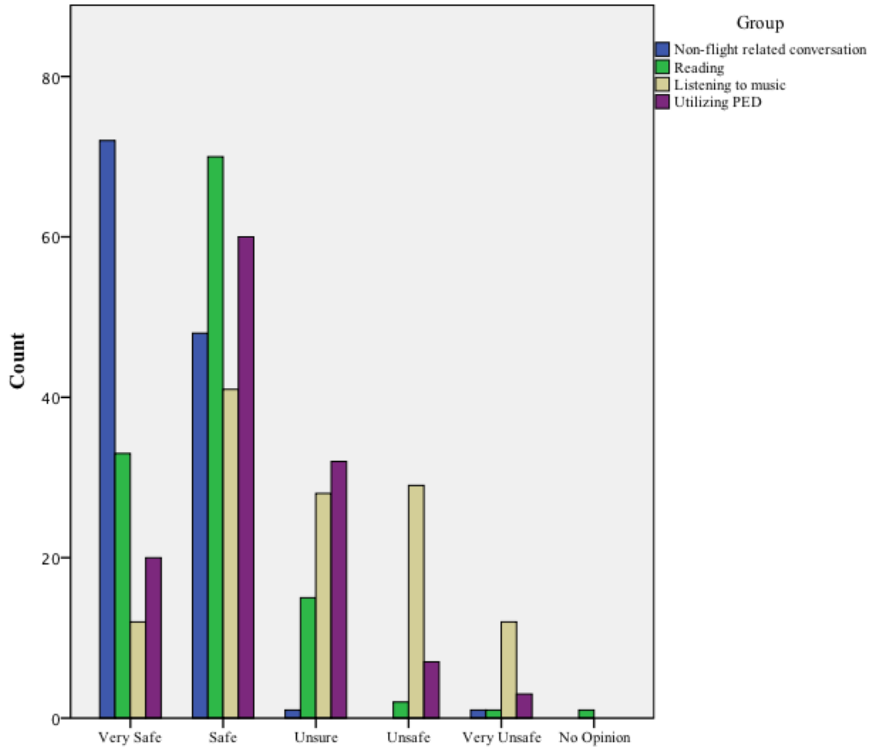

Figure 10. Comparison of Perceived Safety Levels Across Activities.
Note. n = 122

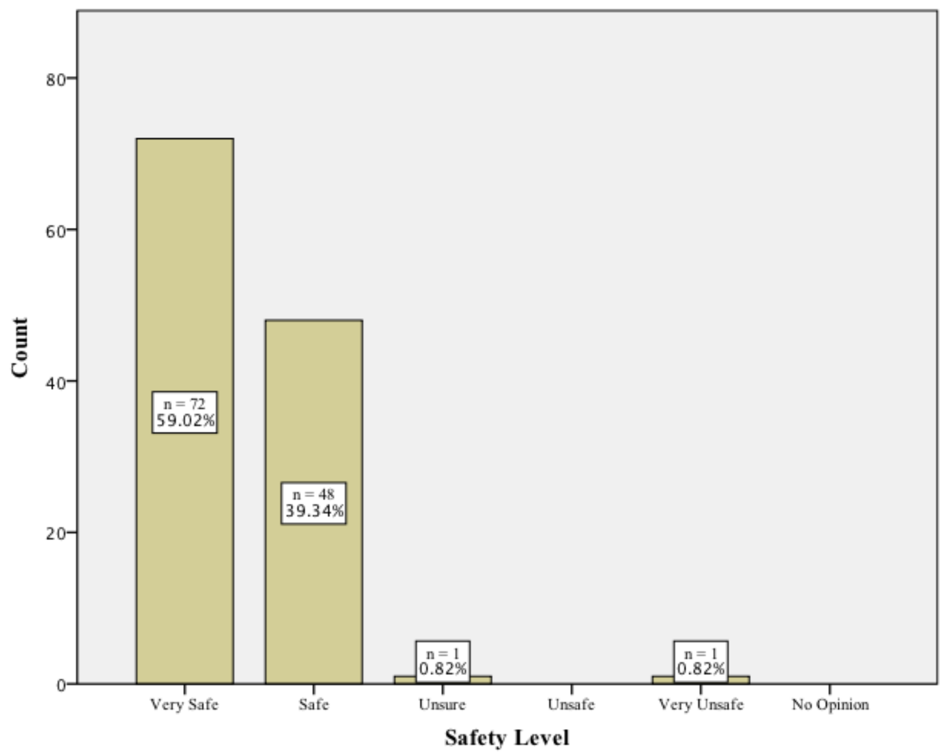

Figure 11. Perceived Safety Level of Non-Flight Related Conversation.
Note. n = 122

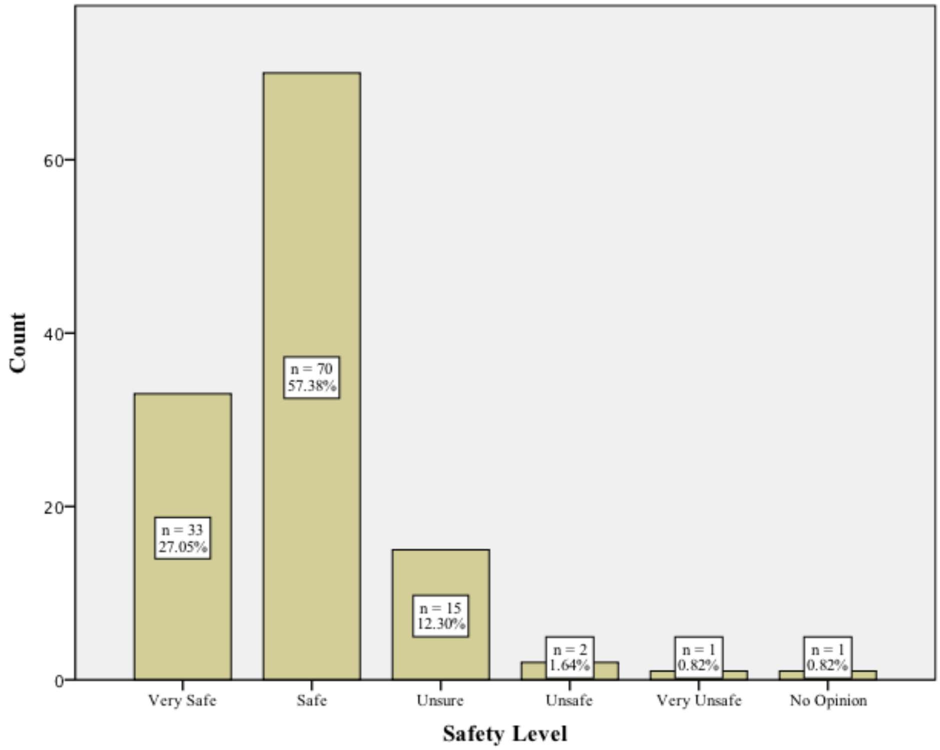

Figure 12. Perceived Safety Level of Reading.
Note. n = 122

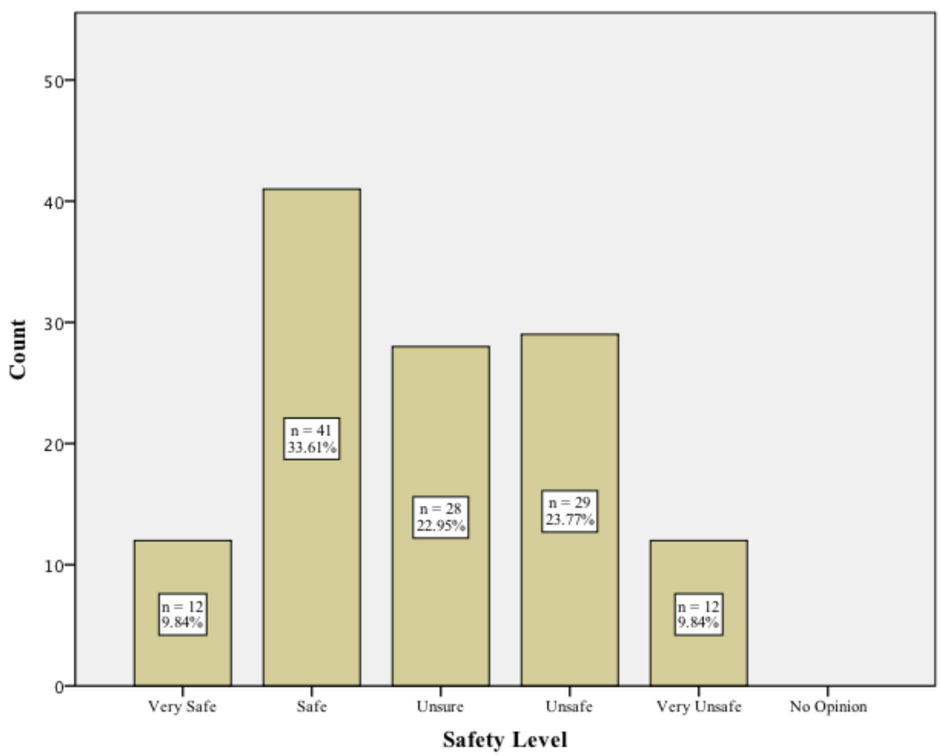

Figure 13. Perceived Safety Level of Listening to Music.
Note. n = 122

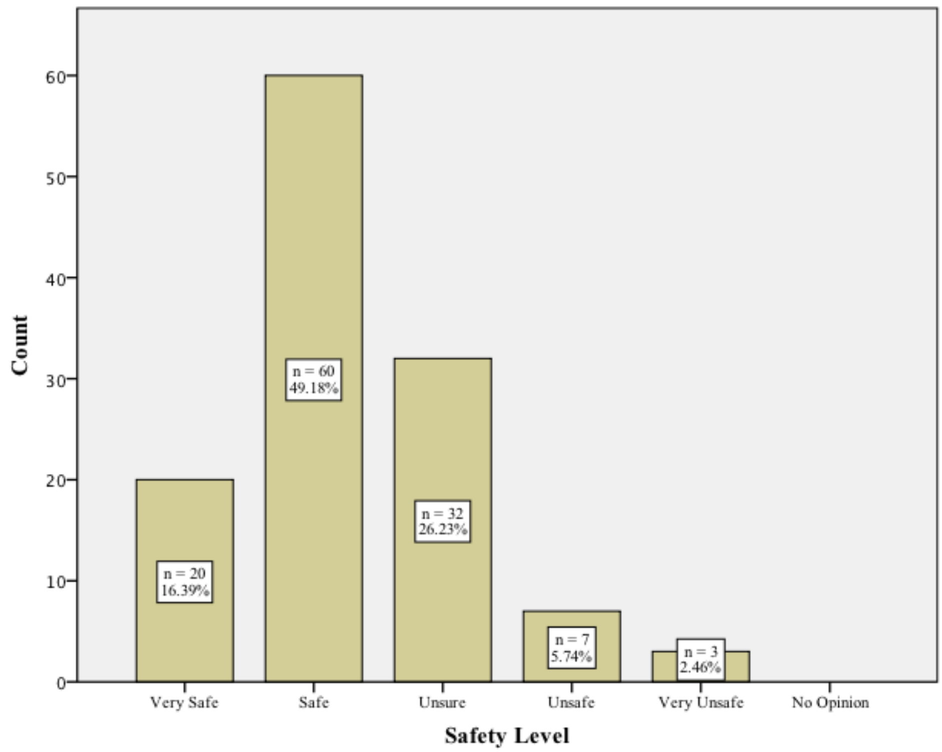

Figure 14. Perceived Safety Level of Utilizing a Personal Electronic Device
Note. n = 122

Perceptions on Activities and Automation Complacency, Boredom and Fatigue

Participants were asked whether they believed these activities help to prevent automation complacency. Figure 15 displays the results.

Participants were asked to comment on their choice. Seventy-nine participants (n = 79) chose to respond. The overall response from this question indicated that pilots are aware that these activities can be a distraction, the distraction level depends on the individual, and overall the activities help to prevent boredom and fatigue.

Of the responses that discussed the activities being a distraction, one pilot said, "I feel that SOME activities do alter the pilots from monitoring the aircraft status and automation." Another said, "Distractions can be bad." Some pilots

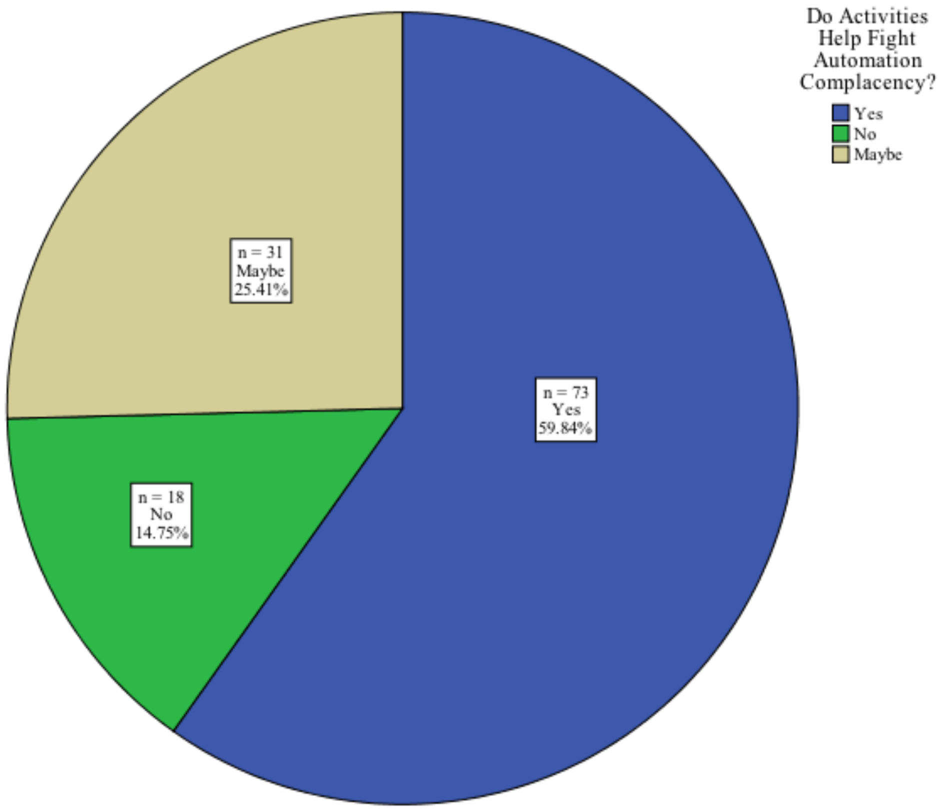

Figure 15. Perception on Whether Activities Help Fight Automation Complacency.
Note. n = 122

commented on specific items such as "Music I think can be just too distracting and cause missed radio calls." One pilot said, "Automation complacency is pilot error and should not happen."

Despite a few responses against the activities, most pilots noted that they understood that non-flight related activities could be a distraction, but that not performing the activities can have other consequences. One pilot stated:

> In cruise flight if you aren't allowed to do anything except sit there and "monitor" the instruments it is extremely monotonous and boring. Especially because the two or more crew members up front don't always have things to talk about.

Another participant said that "They can help break up boredom that can make you tired and cause you to be less ready should something come up." Yet another wrote "Keeps pilots from zoning out." One pilot said:

> It keep pilots awake and alert during long flights (longer than 3 hours) Boredom is a major issue for flights longer than that. Imagine sitting in a office in front of a PC and just staring at the monitor for 3 hours… you'll go crazy and probably get sleepy and very bored.

This notion of staring out the window also came up several times. "What elese [*sic*] are you supposed to do—stare out the window?" was a comment. Another said "What's the alternative, staring blankly out the window?"

Some pilots noted that the level of distraction and its effect on safety varied based upon the person. For example:

> Depending on the individual, those activities may increase complacency as to distract the pilot if the pilot is not a good multi tasker. Vice versa if you give a pilot something to do a cruise vigilance lasts longer and fatigue may take longer to set in.

Another pilot said that "Some pilots can be engaged in one or all of the above activities and still be alert to what's going on. Other's lose all attentiveness." Lastly responded with, "In some cases… it depends on the individual. It helps some stay alert, and it can distract some."

Participants were asked whether they felt these activities helped to prevent boredom. Figure 16 shows the results of this question.

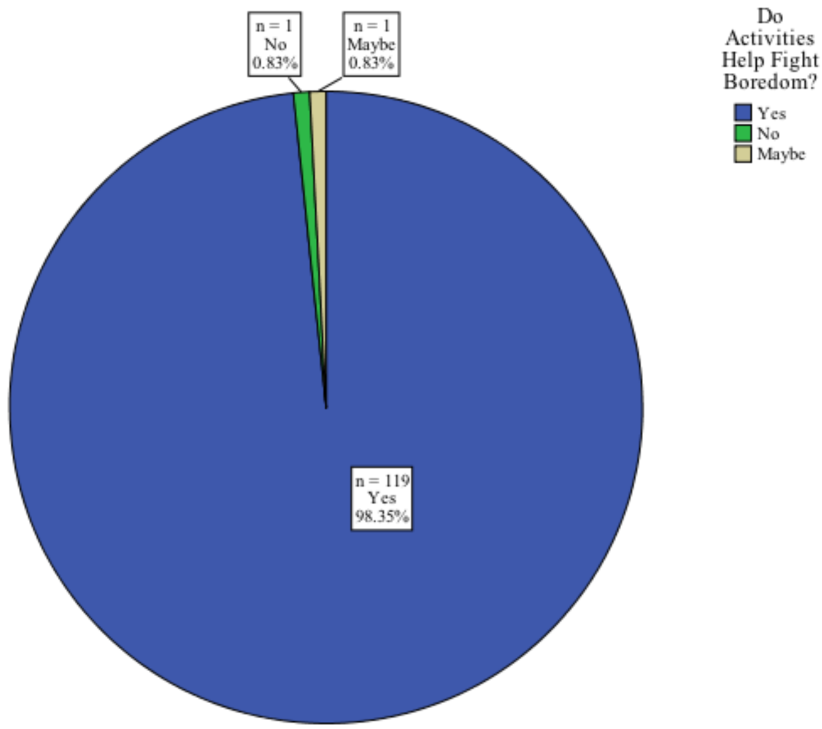

Figure 16. Perceptions on Whether Activities Help Fight Boredom.
Note. n = 122

Participants were asked to comment about their choice. Sixty-one participants chose to respond (n = 61). One pilot did comment against these activities by saying, "No. If you are bored being a pilot, than do something else." Otherwise the overwhelming response was that these activities help to keep the mind engaged which helps to prevent boredom, which can lead to fatigue. In addition, several participants commented on how modern aircraft make it easy to become bored.

One pilot said "Boredom leads to momotony [*sic*] and complacency, so I think any other side-activities are important to maintaining an alert pilot." Another stated, "Extra activities keep the mind stimulated." "Engaging in conversation will keep you alert. Being too quiet makes me bored" was another response.

Many pilots commented about how by preventing boredom these activities also prevent fatigue. "Boredom leads to sleepiness or 'zoning out' which is when things are most missed" was a response. Another said, "Keeps you from nodding off." Lastly one participant said, "Not being able to talk, read, or access electronic devices would lead to COMPLETE boredom and zoning out. Daydreaming would set in, and focus would be lost."

Several participants commented on how modern aircraft are so automated that boredom occurs frequently. One stated:

> Long flights on highly automated airlines can leave the crew little to do. A lot of the long haul flights are also on the back side of the clock. No one can stare at the course line disappearing from the NAV Display for that long and not be bored or sleepy. These activities can keep your mind active and I think to some degree more alert.

Another pilot said:

> In today's automated cockpits, the airplane is going to tell you is something is wrong, so there is not as much need to be monitoring the aircraft. If a task need to get done we either remind each other, or I'll set an alarm to do so.

Lastly one pilot stated that, "In cruise there is little required of the pilot, even in a low automation aircraft."

Participants were asked whether they felt these activities helped to prevent fatigue. Chart 17 shows the results of this question.

Pilots were asked to comment on their choice and sixty-two (n = 62) responded. A few participants indicated that they believed none of the activities could help fight fatigue rather that fatigue could only be dealt with by adequate sleep.

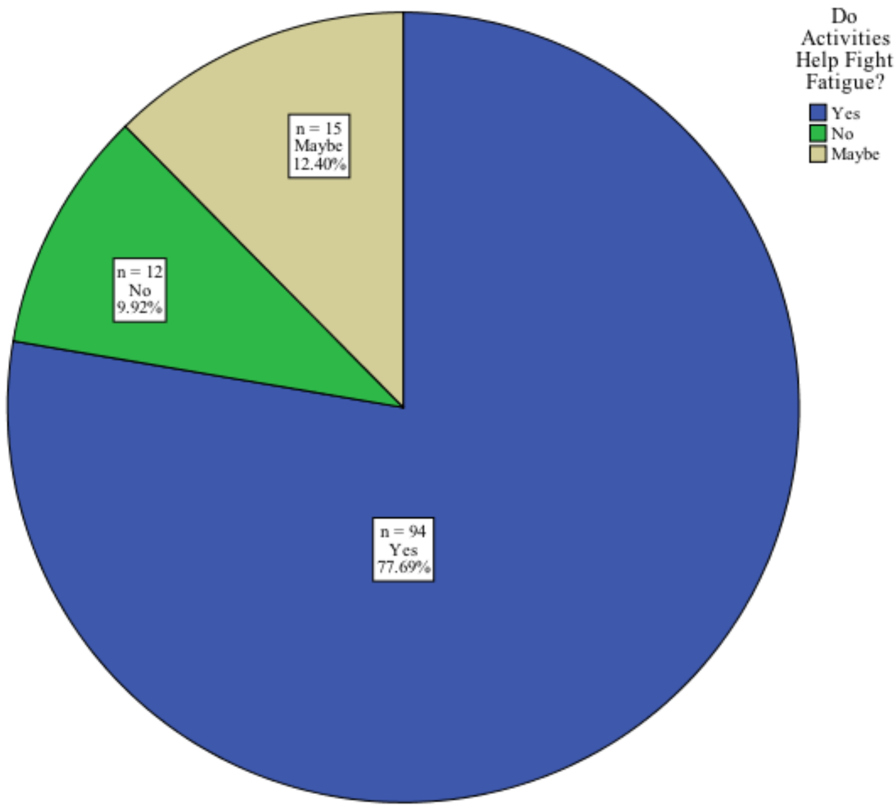

Figure 17. Perception on Whether Activities Help Fight Fatigue.
Note. n = 122

One participant stated, “If you are fatigued, nothing but time down will help.” Some participants weren’t sure if the activities helped fatigue, but did indicate they helped to remain alert. For example one participant said, “The napping helps combat fatigue but the other activities just keep us awake.” Another said, “Depends on how the individual responds to their non flying related activity.”

Most respondents indicated that the activities help to keep the mind engaged which prevents boredom and therefore keeps them awake. A common response was “Keeping the brain and body more active helps to keep one awake.” Participants indicated that boredom is common and engaging in the activities helps to keep them from falling asleep. One participant said, “Cruise flight is boring and engaging in something prevents dosing off.” Another stated:

> Staring at instrumentation is boring, especially on long flights since there is little to do at cruise altitude, but if I engage in another mental or physical activity while flying I think it helps me combat sleep deprivation and remain alert.

Lastly, one participant noted that, "By keeping the mind active instead of looking at things which 99.9% of the time look absolutely the same."

Some participants commented on individual activities and how they specifically help them. One participant said, "For me talking prevents fatigue. It is also a great way to judge the other guys alertness based on what you are talking about. When I read or play video games it tends to make me sleepy." Another stated, "Listening to some 140 beat per minute techno via an mp3 player on a flight after 10pm is better than a venti coffee!" A few participants commented on how the activity helps to keep them awake and they need to do it regardless of the rules, for example:

> I believe boredom is one of the first factors leading to pilot fatigue. If the mind is not engaged in some sort of stimulating activity for an extended period of time, I can see how it would be easy for fatigue to develop as a result. Certain types of music can stimulate the brain as well, which is why I think it's ridiculous that our company manual states the use of personal music devices is prohibited at all times during flight. I've already broken this rule and I'll continue to break it if means keeping me awake and alert in the air.

Positive and Negative Results of Activities

All participants were asked what positive and negative things or events had occurred as the result of non-flight related activities. Ninety-four participants (n = 94) chose to respond to the positive question, ninety-three participants (n = 93) responded to the negative.

For the positive question, most participants indicated that the activities had helped them to stay alert and awake. Some participants indicated that being at work was more enjoyable when performing the activities and that conversation in particular helped to build a relationship between them and other crewmembers. A few participants indicated that it allowed them to have a better communication flow with their fellow pilot, which could help in the event of an emergency. Lastly a few pilots indicated that the activities helped to decrease boredom and make the flight go by faster.

When asked about the negative effects of the activities, most participants indicated that missing radio calls from air traffic control (ATC) were the most frequent negative consequence of the activities. Some participants indicated that routine procedures, such as plotting a position on a chart, monitoring fuel cross feeding, making a position call, and turning off fuel pumps when required, can be missed. Several participants indicated that they were aware that the activities could be a distraction and sometimes have resulted in a loss of situational awareness. A few participants indicated that often conversation had caused problems as the result of a lively debate or conflict that arises in the flight deck as a result of difference of opinions. Lastly a few participants noted that altitude crossing restrictions issued by

ATC had been missed before. One participant did note that the activities go against company policy.

Comments Regarding Safety and Activities

The final two questions of the survey asked what comments regarding safety and other general comments had regarding the activities. Eighty-two participants (n = 82) chose to respond to the first question and sixty-seven participants (n = 67) responded to the second.

In regards to safety and the activities, the overwhelming response was that the activities help to promote safety under the assumption that the pilot understands their primary responsibility and their personal limitations. Most responses indicated that the activities helped them to remain vigilant, stay alert, and help to prevent fatigue. However, most indicated that the activities should be use at appropriate times, judgment is key, and that pilots should find a limit to the activities that works for them. Some participants indicated that some of the activities are helpful, while some are not. Other participants would indicate the contrary activates were helpful and the others not. The theme was that each individual pilot is unique and may react differently to performing any non-flight related activities. Participants stated that each pilot should know their limitations and respect them.

The general comment section had a wide variety of general comments, but the overwhelming response was that if used appropriately these activities are fine to partake in. One participant said "If done properly, they are all fine and safe and been done for years." In addition, most participants indicated that regardless of what activities are being done, pilots should never place them above their responsibility to ensure the safe completion of the flight. Most pilots also indicated that it was the pilot's responsibility to police the activities and to ensure they are not done inappropriately. For example one participant said, "Mandating use or non use is not the answer, yet ensuring pilots understand their duties and responsibilities as pilots." Another participant noted that:

> ANYTHING can be a distraction to safety. Professionalism must prevail to know one's limitations when it comes to engaging in non-flight related activities at cruise. But there are not enough non-flight duties at cruise to prevent fatigue from setting in. Pilots must still remain vigilant during cruise, but talking, reading, or using electronics do not prohibit this.

A few participants stated they believed that the activities had been over analyzed by governmental agencies, such as the FAA, NTSB, and Congress in terms of their safety hazard.

CHAPTER IV

DISCUSSION

This data indicates that not only do pilots perform many non-flight related activities during cruise flight, they believe that many of those activities are not only safe, but actually help to fight the safety issues of boredom, complacency, and fatigue faced on a daily basis.

Frequency of Activities

Conversation

Non-flight related conversation was reported by a cumulative 99.2% of participants as something they engage in "Few Flights" or more and 99.2% witness conversation. This parallels Bhana's (2010) study where 97.8% of participants said they engage in conversation during flight. LaVenture (2007) found that 74% of pilots reported conversing to help fight fatigue. It is not surprising that there was no significant difference between performing and witnessing conversation, as it is likely the pilots would be conversing with each other. On a day-to-day basis the only other person that is close enough to talk to during flight regularly is the other pilot. Also not surprising is the wide range of topics that pilots discussed, such as "Anything and everything, everyday conversation," as reported by one participant. Pilots routinely fly with the same person for several days in a row and sometimes a whole month. Conversation would be normal social conversation that people experience in most workplace environments.

Reading

Pilots reported that they read at least "few Flights" or more with a cumulative 96.1% and witnessed reading cumulatively 99.2%. These numbers parallel Bhana's (2010) study, which reported 85.3% of pilots read during flight, and confirms that the majority of pilots read during flight. That data found that pilots are significantly more likely to witness reading than read themselves. Reading is against some company's regulations, therefore some participants may have been reluctant to admit to reading during flight but were more likely to report others reading.

The newspaper was the most frequently read item, with the USA Today® being highly prevalent because it is given away for free at hotels pilots spend the night at. Other entertaining reading material seems routine, such as magazines and books that crewmembers may bring from home with them to read during down time in flight. The company material that participants reported reading is likely so that pilots can keep up with policies and perhaps study for a recurrent training event that may be coming up.

Listening to Music

Listening to music was the lowest frequently reported activity with a cumulative 31.5% reporting "Few Flights" or more. However, 76.6% of participants reported witnessing listening to music "Few Flights" or more, a significant result. This difference may result from a variety of factors. As discussed later, listening to music was the least safe activity reported, therefore pilots may be reluctant to admit to doing it. In addition, it may be against company regulations and therefore pilots are unwilling report it. Reporting that others listen to music poses no risk, which may explain the difference. Listening to music is definitely something that is occurring during cruise flight.

Pilots reported they listen to all types of music, which isn't surprising because each individual would have a type of music they prefer. As headset technology has advanced it has given pilots the ability to listen to music through their aviation headset, therefore possibly having increased the frequency of listening to music over previous years. It would be interesting to know how often pilots listened to music before this attachment was readily available. Most participants did not specify whether their aviation headset had a "cut out" feature, which is a setting that causes the music to silence when ATC broadcasts. This may have implications on the perceived safety level of listening to music, which is discussed later. Some participants did report listening to AM radio stations through the aircraft's ADF transmitter. One pilot said, "I have only seen this when we had ADFs. We no longer have them." It is very possible that pilots have been listening to music for years, even before personal music players were available, through their ADF receiver with AM radio stations.

Utilizing a Personal Electronic Device

A cumulative 74% of participants reported using a PED "Few Flights" or more and witnessed the use of PEDs with a cumulative 96.8%. There was a high frequency of using the PED for work related functions. Some companies have begun to use tablet computers to perform work related functions (Allied Pilots Association, 2011). One participant reported "Company Paperwork and Jeep [*sic*] Charts." "Jeep charts" would refer to Jeppensen Airway Charts, sometimes referred to as "Jepp charts" or "Approach plates" (Jepp Direct, 2012). These airway charts are used by most airlines and have recently gone digital for some carriers through the use of PEDs. This would mean that PED usage is becoming more frequent for many pilots as their usage is required by the carrier to perform work. Using PEDs for games was also highly reported, which would help to alleviate boredom.

There was a notable difference in the open ended responses in regards to laptop computers. Few participants reported using laptop computers while a very high frequency of participants reported witnessing pilots use laptops. Two weeks after the closing of this study, Congress passed the FAA Modernization and Reform Act of 2012 (H.R. 658, 2012). In that legislation, under section 307, it read that:

> It will be unlawful for a flight crew-member of an aircraft used to provide air transportation under part 121 of title 14, Code of Federal Regulations, to use a personal wireless communications device or *laptop computer* [emphasis added] while at the flight crewmember's duty station on the flight deck of such an aircraft while the aircraft is being operated. (H.R. 658, 2012, p.51)

Although some PEDs, such as laptops, are prohibited by certain airlines, until this time it was not against Federal Aviation Regulations (FAR) for flight crewmembers to use a laptop while at their duty station. This means that this has been the only study ever conducted where crewmembers could admit to using or witnessing the use of a laptop without admitting to breaking a FAR.

In addition, as technology advances, the use of PEDs is likely to increase in the future. Tablet computers, such as the iPad®, are increasing in popularity. Many of their functions are a repeat of what a laptop can do, therefore the banning of laptops may do little to quell pilots from doing the same activities that they previously may have performed on a laptop. Given how rapidly technology advances, banning one device today that will have been replaced by the next advancement tomorrow seems ineffective. Rather the allowance or prohibition of PEDs in the cockpit should be based upon when the activity may be performed, not what the device is.

Other Activities

In regards to other activities during flight, eating was the most common and was expected. Eating is not known to be prohibited by any company. Although only some participants reported sleeping during flight, witnessing other pilots sleep was reported frequently. This parallels Co et al. (1999) and LaVenture (2007) who found that 57% and 88.4% respectively had another pilot sleep on them during flight. Co et al. (1999) found that 80% of regional pilots had fallen asleep at some point. In this study fewer participants indicated they had slept than had witnessing sleeping. This represents a much lower frequency that Co et al. (1999) found in regards to individual pilots sleeping. However, given that the question was open ended, participants may not have thought about sleeping while responding. It is quite possible a specific question that had targeted sleeping might have elicited a higher response rate similar to Co et al. (1999) and LaVenture (2007).

Relationship Between Demographics and Frequency of Activities

Conversation increased in frequency as pilots were employed longer and as their average stage length increases. As pilots are more familiar with the operation, they seem more likely to engage in non-flight related conversation because they are likely more comfortable. Lin et al. (2009) had determined that as experience increased, the ability to multitask became easier because the required activity was now routine. In addition, the longer the stage length the more time there is in cruise to talk when the workload is lower.

As total flight time, total part 121 flight time, years employed, and average stage length increased, so did reading. As discussed by Lin et al. (2009), as experience increases the level of focus required decreases as the activity becomes routine. As pilots become more accustomed to flying and have more experience, they may have the ability to divide their attention better. As with conversation, the longer the stage length the more opportunity there is for reading to occur.

While other activities were mostly noted to be “Very Safe” or “Safe” by a large majority of participants, music received a 33.6% “Unsafe” and “Very Unsafe” combined. Music may pose a larger safety risk and therefore as pilots become more experienced they are less likely to engage in the activity having seen negative safety events as a result. It is also possible that as pilots age their multitasking abilities in regard to hearing may degrade, therefore they are less able to listen to music while hearing air traffic control messages.

For those pilots who engage in conversation, reading, listening to music, and using a PED, there was a significant relationship between engaging in and witnessing the same activity. For example, the more likely a participant is to have a conversation the more likely they are to witnessing someone having a conversation. The same goes for reading and witnessing reading, listening to music and witnessing someone listing to music, and using a PED and witnessing someone use a PED. As pilots note the other is engaging in the activity they may be themselves more likely to engage in the activity, as it is now a normal behavior on the flight deck. One participant said that music was witnessed by “Typically a clandestine wire out of the side where the CA cannot see them.” Another said that “Music is very distracting, and I have seen missed radio calls because of it. Therefore I don’t engage in it and I won’t tolerate it.”

In a dual-crew environment where the captain is typically in charge these comments may indicate that if the captain does not want an activity performed the other crewmembers are less likely to perform them. First officers have often been described as “chameleons,” in the sense that they are required to adjust the way they do things based upon the captain they are flying with. If a captain chooses to ban a certain activity, thereby forcing a first officer to not participant in a tool they use to battle fatigue, it may have a factor in the vigilance abilities of the first officer. It is important therefore that if activities are allowed, the cockpit environment should not be such that one crewmember may prohibit another from engaging in an activity. It is the personal responsibility of each pilot to ensure they are not in an overly distracted state that impedes on their primary task of flying the airplane.

Perceived Safety Levels of Activities

The majority of pilots believe that conversation is a very safe activity. Fifty-nine percent indicated that it was “Very Safe” and 39.3% indicated “Safe.” Only 0.8% of participants said the activity was “Very Unsafe.” Conversation seems to be an activity that is routine in nature, performed frequently, and has generally perceived positive outcomes. When asked what positive outcomes come from these activities, one pilot cited conversation with, “Stay engaged, work with each other better when you know each other.” Another said that:

> Particularly to conversation, you find you have much in common with most people and it makes the trip much more enjoyable; Thereby, increasing the likelihood of good CRM in the event of an emergency.

Some pilots discussed how conversation “Builds a bond between flight crews,” and how “Inadvertent teaching and learning can occur through normal conversation. It also allows a crew to bond therefore creating a greater sense of teamwork.” By getting to know other crewmembers it may be possible to have better teamwork, which can allow for a safer cockpit because pilots are more relaxed and can work together more efficiently. Many pilots commented that conversation allows for happier pilots, better morale, and creates a positive work environment. When asked if any specific events had occurred as a result of conversation one pilot said, “No specific events but I feel that conversation in general creates a more enjoyable and appealing (and safer) work environment.”

Of course, conversation can bring up topics that may cause problems. For example, one pilot said that it “Inspires combative conversation on the cockpit.” Another said that there can be a problem of, “Religious fundamentalists, bigotry, homophobia, political disagreements.” Topics that might cause a distraction is best summed up with the response from one participant who said, “If there are differences of opinion, discussions can distract from the flight.” Often times, people can become very passionate about issues and as a result a deep conversation could become a safety concern as it may distract from the crew’s primary responsibility of flying the aircraft. Another pilot said that, "I personally feel that if two pilots end up in a good conversation, then that can end up become more distracting than skimming through a newspaper or magazine." Of course, banning conversation no matter how distracting it may be would likely be impossible unless crews were to be monitored at every moment, which is unlikely to happen. Emphasis should instead be made on sterile cockpit rules and appropriate times for conversation.

Reading was perceived by pilots to be "Very Safe" by 27% and "Safe" by 57.4%. Given how frequently reading occurs, it seems to be a very common and routine activity performed by flight crews. There were a few specifically mentioned positive events as a result of reading that indicate pilots feel that it is a beneficial activity. One pilot said that "If we're reading or engaged in other activities we're not napping or zoning out." Another said "I've actually been more attentive to listening to ATC on the radios because I especially want to make sure I don't miss a call while readin [sic]." Lastly one said, "I think that as professional pilots we are able to do many things at once. I do not think that reading a book at altitude causes any safety issue."

Given that some pilots read to stay up to date on company materials this may be a perfect opportunity to allow pilots to ensure they keep refreshed of policies and procedures. One pilot said, "Learning something new when reviewing a company manual" is something that comes out of reading. These were very common responses, which in combination with the perceived safety levels, tells us that pilots think that reading is not only safe, but also beneficial.

A few participants did note that, "Reading can be a distraction." One participant said that, "Reading and missed turning off the center fuel pumps after center tank fuel was depleted which can cause a safety hazard." Comments like this indicate that pilots are aware that reading can be a distraction, but combined with the overwhelming perception that reading is safe it seems that reading has more perceived benefits than downfalls.

Listening to music was perceived to be the least safe of the four activities discussed. A full 33.5% of pilots believe that music is either "Unsafe" or "Very Unsafe" while a total of 43.4% perceive music as "Very Safe" or "Safe." In addition, listening to music received a 23% response of "Unsure" from participants. Pilots seem to be highly divided on whether listening to music during cruise is a safe activity. There are few comments that favor listening to music. Although many comments did state that the activities helped them to remain awake and alert, there is no specific way to link those comments with the activity of listening to music.

There were several comments that were listed as to how music can have negative consequences. One participant said, "If you listen to music without an ATC delay function, you miss radio calls and miss rural [*sic*] warnings." Another said, "Having a pilot miss a radio call because he is listening to music." The most frequent reported negative outcome of any of these non-flight related activities was a missed radio call. Although listening to music does have some benefits, many pilots may feel that the missed radio call is a severe enough possible consequence that music should never be listened to in the cockpit. However, some pilots feel it is safe, beneficial, and use it to stay alert and awake.

PED usage ranked with a 65.6% of respondents listing either “Very Safe” or “Safe” regarding their perceived safety effects. PED perceived safety was listed with a 26% “Unsure” response, the highest of all four non-flight related activities. This may have to do with the very wide range of PED usage. Depending on the activity, using a PED may be perceived to be very safe or very unsafe. A PED could be used for reading, listening to music, or other activity. This is one of the issues with PED usage. PEDs could fall into several different categories of use; therefore determining the safety implications is very difficult.

Some companies use PEDs for work related tasks, such as weight and balance, en route charts, or company manuals. In this case the PED is sanctioned by the FAA and company as being not only safe, but also required. However, some companies may “lock down” their PED so that the crewmember can only use it for the flight related task. A personal PED would not be locked down and a crewmember would be free to do anything they want on it. This can range from listening to music, watching a movie, or playing games. PED safety levels would be determinate on the activity being performed. If a pilot is using a PED to read then most pilots would consider that to be safe. However, if the pilot is using it to listen to music then there would be a greater divide on the perceived safety implication. If a PED is being used for work related tasks then the PED would be considered safe. If the PED was being used to play games then that might keep the pilot alert.

Pilot Opinions on Activities and Automation Complacency, Boredom, and Fatigue

The data on automation complacency, boredom, and fatigue shows that these activities help to prevent boredom, which in turn helps to prevent automation complacency and fatigue. One pilot stated that, "Boredom leads to momotony [*sic*] and complacency, so I think any other side-activities are important to maintaining an alert pilot." Another said, "Not being able to talk, read, or access electronic devices would lead to COMPLETE boredom and zoning out. Daydreaming would set in, and focus would be lost."

Boredom

Boredom is clearly a common occurrence for flight crews on airline flights. This study verifies Bhana (2010) who found that boredom was routine for airline pilots. Automated aircraft are not going away. Aircraft will continue to become more automated as technology advances. As this occurs the issue of boredom during flight will continue to come up. Pilots clearly feel that they need to perform these activities or it will lead to other safety issues. Since vigilance is extremely difficult for human beings it is not surprising that pilots feel this way. In addition, participants noted that vigilance abilities and distraction levels can differ depending on crewmember. Another pilot said, "Depends on the pilot. A more experienced pilot can most likely multi-task better than a less experienced pilot while maintaining proper situational awareness." Yet another said, "In some cases… it depends on the individual. It helps some stay alert, and it can distract some."

In addition to ensuring that boredom doesn't lead to decreased vigilance, ensuring pilots are enjoying work can help to create better morale. Better morale can make employees happier, which in turn can increase productivity. It is always important that employees enjoy work, and if pilots are bored all the time it is likely that their job satisfaction will decrease. It is this author's opinion that although most pilots enjoy flying, no matter how much a person enjoys it over time it will become repetitious. These activities help pilots combat that boredom, and as a result want to continue flying.

Fatigue

Sleeping has repeatedly been found to be common during cruise flight (Co et al., 1999; LaVenture, 2007). Many pilots reported that sleeping was another activity that was engaged in during cruise flight in this study. Most of the responses indicate that pilots clearly feel that these activities help to deal with fatigue. Although the only scientific way to alleviate fatigue is through sleep, these appear to be common coping mechanisms that pilots utilize to deal with fatigue on a day-to-day basis. In addition this was backed up by many other pilots who said that these activities help to keep their mind active and alert. One pilot said, “Sitting there and staring at computer screens will only make you more tired. Staying engaged in other activities keeps your mind working.” Another said, “Without some sort of interaction pilots would surely fall asleep more.”

The FAA passed new fatigue rules on December 21, 2011 that will go into affect on December 21, 2013 (FAA, 2011). These new rules change the way flight crews are assigned rest periods. For example, instead of being able to reduce a crews’ rest to eight hours, they will now have a minimum rest requirement of ten hours. The idea is that rest rules should be based upon science. Realistically though, although these new rules will help, there will never be a way to completely eliminate fatigue. Pilots will chose to come to work when tired sometimes because it suits their needs and they have likely done it many times before. Although it is important that rest requirements are based in science and pilots should not come to work fatigued, it is also important that when tired pilots have coping mechanisms they feel help them to stay alert. If pilots feel that these non-flight related activities help them to stay awake, then they should partake in them.

Positive and Negative Outcomes of Non-Flight Related Activities

As discussed, the overwhelming response by participants was that these activities help to keep them alert and awake. One pilot said, "I have yet to fall asleep in a cockpit due to a combination of music and reading materials." Others said, "Happier pilots," "Better morale," and "Keeps you awake." Morale is important in an industry that frequently has ups and downs, where one day a pilot can be gainfully employed and the next need to start over due to a bankruptcy that has put him or her out of a job. In addition, burnout has been routinely reported, especially among regional airline pilots (Fanjoy, Harriman, & DeMik, 2010). This burnout, if not counteracted, could lead to problems at work.

It seems that pilots are distinctly aware that these activities can have negative outcomes as well. The most frequent response to a negative outcome was missed radio calls. There was no question that could establish if certain activities were more likely to cause a missed radio call, but it would seem that all the activities can be a distraction and could cause this. One pilot said, "Occasionally missing a radio call, but that happens occasionally even if I'm not engaging in other activities." Although possibly critical, the majority radio calls from ATC are routine in nature and an immediate non-response from the pilot would not constitute an immediate safety hazard. Loss of situational awareness was also a common response by pilots which is of greater concern depending on the time it takes for the pilot to sort out what's going on.

An example of the combination of both failure to communicate with ATC and loss of situational awareness as a result of non-flight related activities can be found from an Airbus 320 that overflew its destination airport (NTSB, 2009a). It had been without communication from ATC for one hour and seventeen minutes. At the same time, the pilots did not realize where their aircraft was in relation to their destination airport. The pilots reported they had been having a lively conversation and using their laptop computers. Much has been made of this incident, including being cited in multiple governmental reports and the mass media (NTSB, 2009; Wald, 2009; Associated Press, 2009). One pilot specifically mentioned this incident, noting that:

> Please DO NOT use this to advocate rule changes against these types of activities. Already too much has been made over the NWA MSP overflight issue. I believe that Senator Al Franken has attached some legislation to prohibit pilots from using personal electronic devices and that is BAD.

Given the high frequency reported of using PEDs and the high level of perceived safety effects, it seems that pilots highly favor using these devices and believe that their positive effects outweigh any possible distraction. Given that no serious incidents were listed in the examples of negative events or things question from participants, it would seem that pilots do not believe that these activities can have frequent, dire consequences. Pilots do clearly realize though that they can be a distraction, but not such that they perceive an accident will occur as a result.

General Comments Regarding Activities and Safety

Pilots seem to feel that these activities are safe, but with a caveat. Many pilots indicated that they are safe assuming you remain vigilant. For example, “They are safe as long as you stay vigilant.” In addition, most pilots seem to realize that although some activities are safe for them, they may not be safe for everyone. One pilot said, “Use common sense.” Another, “It all comes down to judgment. If the activities distract form [*sic*] monitoring the flight most pilots won’t do them.” It would seem that pilots realize that distraction levels depend on the person performing the activity and the situation. If the pilot is engaging in a critical function, such as dealing with a system failure, they are not likely to be reading the newspaper. However, during cruise flight when pilots are bored and nothing is going on besides monitoring automated flight systems it is likely these activities are considered acceptable.

There were quite a few comments regarding pilots’ belief that these activities are over analyzed. One pilot said, “The public would be surprise because they expect you to be sitting there hand on controls… It’s not the case nor is it safe…” This comment is very true. There is no data to show what incidents or accidents didn’t occur as a result of these activities. Given the high frequent reported of many of them, it is likely that the activities either have no large impact on safety or have prevented some incidents and accidents. If they were a serious threat to safety there would be far more incidents as a result of them and more data to support banning them. The incident where the pilots overflew their airport received wide media attention (Wald, 2009; Associated Press, 2009). Aviation has typically been subject to heavy media scrutiny. One pilot said that, "Mandating use or non use is not the answer, yet ensuring pilots understand their duties and responsibilities as pilots."

In addition, several pilots reported that these activities are against company policy but they will still be engaged in. It is unknown how many pilots reported engaging in activities that might have been against company policy. Given that several did report that it was against their company's policy and they still engage in it, it seems likely that other pilots are doing so as well. It seems unlikely that any attempt by a company to limit many of these activities would be effective unless policed heavily. Even so, it seems unrealistic that an airline could effectively control the activity of every single pilot, especially given the high frequency of many of these activities.

General Discussion

Simply telling a pilot that they are not allowed to partake in an activity that they see having little or no safety hazard is unlikely to be effective. Especially given how pilots feel these activities have a very positive impact on safety. Professional pilots, whose primary interest is safety, will likely do what they feel is necessary to ensure they remain awake and alert. If reading the newspaper, listening to music, or playing a game on a PED helps to do that, pilots will continue to do it. Simply saying they cannot engage in them will not work as pilots have explicitly stated that they do many of these activities despite them being against company regulations.

From this data, it would seem that pilots believe there should not be an attempt to limit the frequency of any of these activities. Instead pilots should be educated to ensure they understand possible consequences from these activities. They should be aware radio calls can be missed, situational awareness lost, or other issues can come up. Most pilots already seem to have a good grasp on when an activity should be done and when it shouldn't, however ensuring every pilot has that understanding would be more effective than never discussing it at all. Airlines should understand that their pilots will likely engage in these activities, therefore rules and regulations should be written so that pilots can do so safely when it is appropriate to do so.

In addition, in the future these activities should be defined as coping mechanisms, not distractions. The term 'distractions' has a negative connotation, indicating that pilots are doing something that they shouldn't, which pilots perceive they are not. However, given that these activities are commonly used by pilots to cope with human performance issues they face on a daily issue, the term 'coping mechanism' is more appropriate.

Limitations

This study was conducted with pilots from multiple carriers in the United States. Since no carriers' names were collected, there is no way to determine if the policies of a particular carrier may have influenced the results. Also, there was no statistical method used to determine if a responded had taken the survey more than one time. In addition, the category of PED was very vague. Perceptions on PED safety levels could be skewed depending on what PED the participant thought of during the survey. The survey did list several items, such as smart phones, tablet computers, and laptop computers, but pilots may feel that each of these has a different safety level. This may account for this category having the highest rating of

“Unsure” responses. Lastly, the open-ended questions often asked questions that could not be specifically tied to one activity unless the participant stated something specifically about an activity.

Future Studies

This was the first study specifically regarding these non-flight related activities and their perceived safety effects. It will not be the last. The FAA Modernization and Reform Act of 2012, section 307, requires the FAA to conduct a study regarding distractions and safety effects on airline pilots within twelve months of the February 2012 enactment date (H.R. 658, 2012). At this time it is unknown what the FAA intends to make that study look like.

Due to anonymity requirements of this survey, it will be important in the future for studies to collect more information to determine if there are other relationships that should be considered. Much demographic information was excluded to protect participants’ identity in this survey, such as aircraft type, captain or first officer, crew base, primary time of day the pilot operates, and more. In addition, it will be important to ensure that no respondent has the opportunity to take the survey more than once.

Given the high frequency of many of these activities, experimental studies should be conducted in simulators to determine what the actual safety effects are. Current airline pilots should be placed in the simulator for an extended period of time and allowed to conduct one of the activities while they monitor instruments. From this it could hopefully be determined what the safety consequences of the activities are.

In addition, a study should be conducted solely on PEDs. More and more today pilots carry technology with them, from devices to read books, listening to music, or play games. Many airlines are putting PEDs in the cockpit for pilots to use in flight for work related functions. Given that this study looked at PEDs as one group, a future study should look at individual PEDs, such as smart phones, tablets, and laptops, to determine the frequency of use for each of them and their safety effects.

Conclusions

Pilots have been engaging in non-flight related activities for many years and will likely continue to do so. From this research it is clear that pilots perceive there to be few major safety concerns that can arise from these non-flight related activities, assuming a pilot maintains professional personal responsibility for ensuring they do not become too distracted. In addition, pilots believe that without many of these activities there may be an increase in safety issues, such as more pilots sleeping while at the flight controls.

As aircraft become more automated and a pilots role transitions more to monitoring systems than flying, it will be critical to ensure that vigilance can be maintained while at the controls. If these activities assist pilots in maintaining that vigilance, then they should be permitted under certain conditions rather than restricted. These non-flight related activities should be labeled as coping mechanisms, not distractions, and used appropriately to help pilots remain alert. Automation complacency, boredom, and fatigue aren't going away. If these activates help pilots to battle them, then they should be used as a tool. Pilots need to maintain professional attitudes, understand their own personal limitations, and do what is necessary to ensure the safe completion of every flight.

APPENDICES

Appendix A

Blast E-mail to National Pilot Organization's Members

Fellow pilots!

My name is Spencer Conklin, XXXXX. I'm completing my masters' degree by conducting a research study regarding fatigue, boredom, and automation complacency in commercial aviation. I was hoping you would all do me a favor to help me out!

I'm looking for pilots working in two, three, or four-person crews, operating under FAR part 121 to take my survey.

The survey is completely anonymous; participation is voluntary. It should take approximately 10 minutes to complete. If you could help me out by completing my survey I would really appreciate it!

To take the survey please go to the following website:

XXXXX

Spencer Conklin

XXXXX

Appendix B

Union Online Forum Recruitment Message

Fellow pilots!

My name is Spencer Conklin, XXXXX. I'm also conducting a research study using a survey to complete my masters' degree through the University of North Dakota.

This survey is designed to study automation complacency, boredom, and fatigue. The union has approved the posting of this survey. It is completely anonymous; participation is voluntary. The survey will be going out to multiple pilot groups, not just this carrier. Given that, your experiences are definitely wanted to help provide comprehensive results!

If you could take the 10 minutes to complete it I would greatly appreciate it!

To take the survey, please go to the following website:
XXXXX

Spencer Conklin
XXXXX

Appendix C

Survey

Page 1 - Introduction

Welcome pilots!

This survey is being administered for completion of a graduate student's master's thesis at the University of North Dakota. It is designed to research safety issues that commercial airline pilots face. The information gathered will help to understand real-world safety issues dealt with on a daily basis.

Participation is voluntary, you may answer all questions or only those you feel comfortable answering. You will not be asked to identify yourself and your identity will not be linked to your survey in any way; this is a completely anonymous survey. At any point you wish to discontinue taking the survey you may do so. If you chose not to take or complete the survey there will be no change in relationship with any organization involved.

This survey is only for two, three, or four-person crews, operating under Federal Aviation Regulations part 121. All questions pertain to when you are sitting at your duty station. It should take approximately 10 minutes to complete.

If there are any questions please feel free to contact Spencer Conklin via e-mail at XXXXX or contact the University of North Dakota Institutional Research Board at 701-777-4279. Thank you!

To begin this survey, please select the “Next” button.

Page 2 - Demographics

1. How old are you?
2. What is your estimated flight time?
3. What is the estimated flight time you have accrued flying at part 121 air carriers?
4. How many years have you been employed at part 121 carriers? Please exclude any years you were furloughed.
5. What is your current average flight length? (HH:MM) For example, 02:30 for 2 hours, 30 minutes

Page 3 – Activities During Flight

6. How frequently do you engage in the below activities during cruise flight? Cruise flight means normal operations, no abnormal situations, above 10,000' MSL, during routine flight, and in normal weather.

	Every flight	Most flights	Some flights	Few flights	No flights
Non-flight related conversation					
Reading					
Listening to music					
Utilizing a personal electronic device (smartphone, tablet, laptop, ect.)					

7. If you said you engage in non-flight related conversation, could you elaborate on what you might talk about?
8. If you said you read, could you elaborate on what you might read? For example: newspapers, books, magazines.
9. If you said you listen to music, could you elaborate on what you might listen to and how you listen to it?
10. If you said you use personal electronic devices, could you elaborate on what you might use and what you'd use it for?
11. What other non-flying related activities have you done during cruise?

Page 4 – Witnessed Activities During Flight

12. How frequently do you WITNESS other pilots engage in the below activities during cruise flight? Cruise flight means normal operations, no abnormal situations, above 10,000' MSL, during routine flight, and in normal weather.

	Every flight	Most flights	Some flights	Few flights	No flights
Non-flight related conversation					
Reading					
Listening to music					
Utilizing a personal electronic device (smartphone, tablet, laptop, ect.)					

13. If you said you've witnessed_engaging in non-flight related conversation, could you elaborate on what you've heard pilots talk about?
14. If you said you've seen pilots read, could you elaborate on what you've seen them read? For example: newspapers, books, magazines.
15. If you said you've seen pilots listen to music, could you elaborate on what you've seen them listen to and how they'd listen to it?
16. If you said you've seen use personal electronic devices, could you elaborate on what you've seen them use and what they'd use it for?
17. What other non-flying related activities have you witnessed pilots doing during cruise?

Page 5 – Perceived Safety Implications

18. How do you feel pilots engaging in the following activities during cruise flight affects safety of flight? Cruise flight means normal operations, no abnormal situations, above 10,000' MSL, during routine flight, and in normal weather.

	Very safe	Safe	Unsure	Unsafe	Very unsafe	No opinion
Non-flight related conversation						
Reading						
Listening to music						
Utilizing a personal electronic device (smartphone, tablet, laptop, ect.)						

19. Do you feel these activities help to combat automation complacency? For example, helping to keep pilots alert and vigilant in monitoring aircraft status.
    a. Yes
    b. No
    c. Maybe
        i. Comment box
20. Do you feel these activities help to combat pilot boredom?
    d. Yes
    e. No
    f. Maybe
        i. Comment box
21. Do you feel these activities help to combat pilot fatigue?
    g. Yes
    h. No
    i. Maybe
        i. Comment box

Page 6 – Events as a Result of Activities

"These activities" refers to conversation, reading, listening to music, and utilizing personal electronic devices.

22. What examples of positive things or events have occurred due to these activities do you have?
23. What examples of negative things or events have occurred due to these activities do you have?
24. What comments regarding safety and these activities during cruise flight do you have?
25. What comments in general regarding these activities do you have?

Page 7 - Conclusion

Thank you for completing the survey!

By selecting “Done” below your responses will be submitted.

If there are any questions please feel free to contact Spencer Conklin via e-mail at XXXXX or the University of North Dakota Institutional Research Board at 701-777-4279.

Thank you for your time.

REFERENCES

Anund, A., Kecklund, G., Peters, B., & Åkerstedt, T. (2008). Driver sleepiness and individual differences in preferences for countermeasures. *Journal of Sleep Reserach*, *17*, 16-22.

Associated Press. (2009, November 27). FAA transcripts show efforts to reach flight 188. *Msnbc*. Retrieved March 22, 2012, from http://www.msnbc.msn.com/id/34175212/ns/39258985#.T2tVa-xy3R4

Atchley, P., & Chan, M. (2011). Potential benefits and costs of concurrent task engagement to maintain vigilance: A driving simulator investigation. *Human Factors: The Journal of the Human Factors and Ergonomics Society*, *53*(1), 3-12.

Atchley, P., & Dressel, J. (2004). Conversation limits the functional field of view. *Human Factors*, *46*(4), 664-673.

Aviation safety: pilot fatigue: hearing before the Subcommittee on Aviation Operations, Safety, and Security of the Committee on Commerce, Science, and Transportation United States Senate, (Serial 111-515), 111th Cong. 1 (2009)

Bailey, N. R., & Scerbo, M. W. (2007). Automation-induced complacency for monitoring highly reliable systems: The role of task complexity, system experience, and operator trust. *Theoretical Issues in Ergonomics Science*, *8*(4), 321-348.

Beh, H. C., & Hirst, R. (1999). Performance on driving-related tasks during music. *Ergonomics*, *42*(8), 1087-1098.

Bhana, H. (2010). Correlating boredom proneness with automation complacency in modern airline pilots (Master's thesis, University of North Dakota, 2009). *Collegiate Aviation Review*, *28*(1), 9-24.

Billings, C. E. (1997). *Aviation automation, the search for a human-centered approach*. Mahwah, NJ: Lawrence Erlabaum Associates.

Bowman, L. L., Levine, L. E., Waite, B. M., & Gendron, M. (2010). Can students really multitask? An experimental study of instant messaging while reading. *Computers & Education*, *54*, 927-931.

Brodsky, W. (2002). The effects of music tempo on simulated driving performance and vehicular control. *Transportation Research*, *F*(4), 219-241.

Co, E. L., Gregory, K. B., Johnson, J. M., & Rosekind, M. R. (1999). *Crew factors in flight operations XI: A survey of fatigue factors in regional airline operations* (United States, NASA). Hanover, MD: NASA Center for AeroSpace Information.

Cummings, M.L., Hart, C., Thornburg, & Mkrtchyan, A. (2011). *Boredom and distraction in multiple unmanned vehicle supervisory control.* Manuscript submitted for publication.

Dalton, B. H., & Behm, D. G. (2007). Effects of noise and music on human and task performance. *Occupational Ergonomics*, *7*, 143-152.

Dalton, B. H., Behm, D. G., & Kibele, A. (2007). Effects of sound types and volumes on simulated driving, vigilance tasks and heart rate. *Occupational Ergonomics*, *7*, 153-168.

Damos, D. L., John, R. S., & Lyall, E. A. (2005). Pilot activities and the level of cockpit automation. *The International Journal of Aviation Psychology*, *15*(3), 251-268.

Davies, D. R., Lang, L., & Shackleton, V. J. (1973). The effects of music and task difficulty on performance at a visual vigilance task. *British Journal of Psychology*, *64*(3), 383-389.

Depperschmidt, C. L., Bliss, T. J., & Woolsey, C. L. (2010). The effect of energy drink consumption on collegiate flight students' pilot skills in a simulated flight enviornment. *Collegiate Aviation Review*, *28*(2), 1-15.

Dismukes, R. K., Berman, B. A., & Loukopoulos, L. D. (2007). *The limits of expertise, rethinking pilot error and the causes of airline accidents*. Burlington, VT: Ashgate Publishing Company.

Fanjoy, R. O., Harriman, S. L., & DeMik, R. J. (2010). Individual and environmental predictors of burnout among regional airline pilots. *International Journal of Applied Aviation Studies*, *10*(1), 15-30.

Federal Aviation Regulations. (2011). §121.524 Flight crewmember duties. In *2011 federal aviation regulations for flight crew* (p. 243). Newcastle, WA: Aviation Supplies & Academies.

Federal Railroad Administration. (2008). *The impact of distracting electronic devices on the safe performance of duties by railroad operating employees* (United States, Department of Transportation, Federal Railroad Administration). Washington, DC.

Frankmann, J. P., & Adams, J. A. (1962). Theories of vigilance. *Psychological Bulletin*, *59*(4), 257-272.

Gaudry, M., & Mayes, R. R. (Eds.). (1999). Aviation deregulation and safety in the United States: The evidence after twenty years. In I. Savage (Author), *Taking Stock of Air Liberalization* (pp. 93-114). Boston, MA: Kluwer Academic.

Grier, R. A., Warm, J. S., Dember, W. N., Matthews, G., Galinksky, T. L., Szalma, J. L., & Parasuraman, R. (2003). The vigilance decrement reflects limitations in effortful attention, not mindlessness. *Human Factors*, *45*(3), 349-359.

Harris, W. C., Hancock, P. A., Arther, E. J., & Caird, J. K. (1995). Performance, workload, and fatigue changes associated with automation. *The International Journal of Aviation Psychology*, *5*(2), 169-185.

Hopkins, G. E. (1982). *Flying the line, the first half century of the Air Line Pilots Association*. Washington, DC: Air Line Pilots Association.

H.R. 658, 112th Cong. (2012) (enacted).

International Civil Aviation Organization. (1993). *ICAO completes fact-finding investigation* [Press release]. Montreal, P.Q.: ICAO: Author.

Jepp Direct. (2009). IFR charts overview. *Jeppesen's Online Store*. Retrieved March 22, 2012, from http://jeppdirect.jeppesen.com/legal/charts/ifr_overview.jsp

Kishida, K. (1977). A study on subsidiary behaviour in monotonous work. *International Journal of Production Research*, *15*(6), 609-621.

Konz, S., & McDougal, D. (1968). The effect of background music on the control activity of an automobile driver. *Human Factors*, *10*(3), 233-244.

LaVenture, A. M. (2010). *Effects of fatigue and self-reported countermeasures used by regional airline pilots conducting continuous duty overnights* (Unpublished master's thesis). University of North Dakota.

LeDuc, P. A., Caldwell, Jr., J. A., & Ruyak, P. S. (2000). The effects of exercise as a countermeasure for fatigue in sleep-deprived aviators. *Military Psychology*, *12*(4), 249-266.

Lin, L., Robertson, T., & Lee, J. (2009). Reading performances between novices and experts in different media multitasking environments. *Computers in the Schools*, *26*, 169-186.

Mackie, R. R. (1987). Vigilance research - are we ready for countermeasures? *Human Factors*, *29*(6), 707-723.

Mackworth, N. M. (1948). The breakdown of vigilance during prolonged visual search. *Quarterly Journal of Experimental Psychology*, *1*(1), 6-21.

Molloy, R., & Parasuraman, R. (1996). Monitoring an automated system for a single failure: Vigilance and task complexity effects. *Human Factors*, *38*(2), 311-322.

Mosier, K. L., Skitka, L. J., Heers, S., & Burdick, M. (1998). Automation bias: Decision making and performance in high-tech cockpits. *The International Journal of Aviation Psychology*, *8*(1), 47-63.

National Transportation Safety Board. (1973). *Aircraft accident report, Eastern Air Lines, Inc., L-1011, N310EA, Miami, Florida, December 29, 1972.* (Rep. No. NTSB-AAR-73-14). Washington, DC: National Transportation Safety Board.

National Transportation Safety Board. (1985). *Brief of accident, adopted, DCA85AA015, 02/19/1985, San Francisco, CA, aircraft registration no. N4522V.* Washington, DC: National Transportation Safety Board.

National Transportation Safety Board. (1993). *Aircraft accident report, uncontrolled collision with terrain, American International Airways flight 808, Doublas DC-8-61, N814CK, U.S. naval air station, Guantanamo Bay, Cuba, August 18, 1993.* (Rep. No. NTSB-AAR-94/04). Washington, DC: National Transportation Safety Board.

National Transportation Safety Board. (1995). *Factual report aviation, NTSBID: DCA96RA020, 12/20/1995.* Washington, DC: National Transportation Safety Board.

National Transportation Safety Board. (2007). *Runway overrun during landing, Shuttler America, Inc., doing business as Delta Connection flight 6448, Embraer ERJ-170, N862RW, Cleveland, Ohio, February 18, 2007.* (Rep. No. AAR-08-01). Washington, DC: National Transportation Safety Board. (NTIS No. PB2008-910401).

National Transportation Safety Board. (2009). *Attachment 18 to operations/human performance group chairman's factual report, flight operations manual, (flight deck decorum and PED references), DCA10IA001.* Washington, DC: National Transportation Safety Board.

National Transportation Safety Boarda. (2009). *Operational factors / human performance, group chairman's factual report, DCA10IA001* Washington, DC: National Transportation Safety Board.

National Transportation Safety Boardb. (2009). *Brief of accident, adopted 08/03/2009, SEA08IA080, 02/13/2008, Hilo, HI, aircraft registration no. N651BR.* Washington, DC: National Transportation Safety Board.

National Transportation Safety Board. (2010, February). *Most wanted transportation safety improvements*. Retrieved November 22, 2010, from http://www.ntsb.gov/recs/mostwanted/aviation_reduce_acc_inc_humanfatig.htm

National Transportation Safety Boarda. (2010). *Loss of control on approach, Colgan Air, Inc. operating as Continental Connection Flight 3407, Bombardier DHC-8-400, N200WQ Clarence Center, New York, February 12, 2009.* (Rep. No. AAR-10-01). Washington, DC: National Transportation Safety Board. (NTIS No. PB2010-910401).

Parasuraman, R., & Manzey, D. H. (2010). Complacency and bias in human use of automation: An attentional integration. *Human Factors: The Journal of the Human Factors and Ergonomics Society*, *52*(3), 381-410.

Parasuraman, R., & Riley, V. (1997). Humans and automation: Use, misuse, disuse, abuse. *Human Factors*, *39*(2), 230-253.

Parsuraman, R., Molloy, R., & Singh, I. L. (1993). Performance consequences of automation-induced "complacency" *The International Journal of Aviation Psychology*, *3*(1), 1-23.

Pasztor, A. (2011, August 3). Regulators delay pilot-fatigue rules. *Wall Street Journal*. Retrieved December 4, 2011, from http://online.wsj.com/article/SB10001424053111903341404576484391587046076.html

Petrie, K. J., & Dawson, A. G. (1997). Symptoms of fatigue and coping strategies on internaitonal pilots. *The International Journal of Aviation Psychology*, *7*(2), 251-258.

Petrilli, R. M., Roach, G. D., Dawson, D., & Lamond, N. (2006). The sleep, subjective fatigue, and sustained attention of commercial airline pilots during an international pattern. *Chronobiology International*, *26*(3), 1347-1362.

Reason, J. (1997). *Managing the risks of organizational accidents*. Burlington, VT: Ashgate Publishing Company.

Shappell, S. A., & Wiegmann, D. A. (2000). *The human factors analysis and classification system - HFACS* (United States, Department of Transportation, Federal Aviation Administration). Springfield, VA: National Technical Information Service.

Singal, T. L., Gander, P. H., Anderson, H., & Brash, S. (2009). Scheduled napping as a countermeasure to sleepiness in air traffic controllers. *Journal of Sleep Reserach*, *18*, 11-19.

Sumwalt, R. L. (1993, June). The sterile cockpit. *ASRS Directline*. Retrieved March 22, 2012, from http://asrs.arc.nasa.gov/publications/directline/dl4_sterile.htm

Temple, J. G., Warm, J. S., Dember, W. N., Jones, K. S., LaGrange, C. M., & Matthews, G. (2000). The effects of signal salience and caffeine on performance, workload, and stress in an abbreviated vigilance task. *Human Factors*, *42*(2), 183-194.

Tenney, Y. J., Rogers, W. H., & Pew, R. W. (1998). Pilot opinions on cockpit automation issues. *The International Journal of Aviation Psychology*, *8*(2), 103-120.

Wald, M. L. (2009, October 25). Officials query pilots who missed airport. *The New York Times*. Retrieved March 22, 2012, from http://www.nytimes.com/2009/10/26/us/26pilots.html?_r=1

Warm, J. S., Parasuraman, R., & Matthews, G. (2008). Vigilance requires hard mental work and is stressful. *Human Factors: The Journal of the Human Factors and Ergonomics Society*, *50*(3), 433-441.

Wiener, E. L., & Curry, R. E. (1980). Flight-deck automation: Promises and problems. *Ergonomics*, *23*(10), 995-1011.