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Correlating Boredom Proneness With Automation Complacency in Modern Airline Pilots

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CORRELATING BOREDOM PRONENESS

WITH AUTOMATION COMPLACENCY

IN MODERN AIRLINE PILOTS

by

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ABSTRACT

According to the FAA's forecasts, air traffic growth will outpace infrastructure growth into the future. Thus, the solution to this discord involves increased use of technology to enable more aircraft to use the existing airspace and infrastructure more efficiently. Automation levels and sophistication in transport category aircraft will only increase in the future as evidenced by the trend toward satellite-based navigation. As automation technology has advanced, the role of the airline pilot has changed. This paradigm shift is seeing pilots move from active participants in the flying duties of the aircraft to automation managers relegated to monitoring the automated systems.

A possible consequence of this is increased levels of boredom in individual pilots due to the decreased involvement pilots have in the management of the flight. Automation technology has improved to where the aircraft's flight management systems can manage an entire flight from shortly after take-off to touchdown. As automation increases so does the risk of automation complacency, defined as the pilot abdicating responsibility to the automation or failing to supervise it adequately. The study examines whether a correlation exists between boredom and automation complacency practices. Other research variables included type of operation (international versus domestic), longevity in aircraft, and frequency of attention lapses.

The sample consisted of active professional airline pilots at a major airline as defined by revenue in the United States (N=273). Each pilot completed a survey that included general demographic data, the Boredom Proneness Scale (BPS), an automation complacency practices questionnaire, and some automation philosophy questions. The survey also probed self-assessed boredom and frequency of attention lapses. Pearson Correlation Coefficients allowed for a quantitative analysis between the variables, while the free comments section in the survey facilitated a qualitative examination of the issues and underlying causes.

The results indicated a small but statistically significant positive correlation between boredom proneness and automation complacency practices (r=.181, p=0.01). Other statistically significant positive correlations included self-assessed state boredom and frequency of attention lapses (r=.293, p=0.01). The research has implications for employee selection, training methods, and operating procedures for individuals engaged in extended vigilance and monitoring of automated systems.

CHAPTER 1

INTRODUCTION

Statement of the Problem

Airline traffic will grow at extraordinary levels in the next decade. In 2006, the airline industry flew 741 million passengers, which will increase to one billion annual passengers in 2015 (Federal Aviation Administration, 2007). All of these passengers will need to fly in new aircraft especially in the 70 to 90--seat size range meaning the industry will need a greater number of flight segments to carry these extra passengers.

Unfortunately, the infrastructure required to handle the increasing amount of airplanes will not keep pace with the rapid traffic growth. New infrastructure takes years to design, plan, and build while airlines can add capacity almost instantaneously. Clearly, the aviation industry requires solutions. If new infrastructure is politically or economically unfeasible then the solution requires using the existing infrastructure much more efficiently. This is a trend already happening with the transition away from static land based navigation aids toward satellite based GPS systems for almost all functions of a flight including the arrival and approach phase (Kvalheim & Andersen, 2007). Not only do these new types of approaches permit efficient use of airspace, they can accommodate curved paths to avoid terrain, increase traffic capacity, and reduce the impact on noise sensitive areas. The most significant feature of these new RNP (Required Navigation Performance) type approaches is lack of ground based navigation aids. Thus, management of entire flight from take-off to touchdown is self-contained within the aircraft's automation systems. The consequences of this trend is a substantial increase in the complexity and automation dependency since pilots are now relying on flight management systems (FMS) tasked with performing more functions that are critical. With the increased emphasis now on automation to manage almost every phase of a flight, the aviation industry is experiencing some unintended consequences. Perhaps the most significant consequence is the issue of automation complacency as it relates to the interface between pilots and the increasingly complex aircraft automation systems (Parasuraman, Molloy, & Singh, 1993; Prinzel, Freeman, & Prinzel, 2005; Bailey & Scerbo, 2008). Finally, this is not a transitory issue nor can the industry afford the luxury of "de-automating" aircraft in the future to remediate any complacency problems. Technologies such as RNP remain the optimum method of helping solve aviation's growing capacity and carbon emissions problems and will proliferate globally in the years to come (Kvalheim & Andersen, 2007).

Automation "…refers to systems or methods in which many of the processes of production are automatically performed or controlled by autonomous machines or electronic devices" (Billings, 1997, p. 6-7). Automation is silently prevalent in many aspects of everyday life, such as in electronic banking systems that operate transparently without any direct action from the user. Electronic banking and similar types of systems are the autonomous devices referenced by Billings (1997) that require no user interface or, more importantly, no monitoring. For example, pushing a requested floor in an elevator starts a complex process where automated systems safely deliver the elevator car to the desired floor and open the doors when appropriate – all done silently to the user. Computer programmers develop these systems to operate efficiently by accurately executing narrowly defined set preprogrammed instructions.

In aviation, aircraft automation is different in that it requires a high degree of monitoring by the user due to its dynamic nature (Billings, 1997). The literature defines eight levels of automation ranging where the human operator must do everything to where the computer does everything ignoring the human (Sheridan & Parasuraman, 2006). The intermediate levels discussed by Sheridan et al. (2006) are most applicable to modern aviation, specifically the level where the automation "…executes the suggestion automatically, then necessarily informs the human" (pg 94). This rubric tasks the human operator, in aviation's case the pilot, with evaluating the computed suggestion and either stopping the automation or allowing it to continue. In other words, the pilot is now required to provide mostly supervisory control over the automation versus manually computing functions such as vertical and lateral navigation. Thus, the nature of the work an airline pilot performs has transitioned from one where the pilot is an active participant in controlling the aircraft to one where the pilot is an overseer of the automation. As RNP and other efficiency enhancing technologies gain approval and reach, the speed and scope of the transition will accelerate.

Purpose of the Study

Prior to modern automation, the pilots were responsible for managing all aspects of the aircraft and the flight. Early jet transport aircraft such as the Boeing 727 and early versions of the 747 included a flight engineer as part of the crew. Some versions of the Boeing 707 included a flight navigator to assist the flying pilots with lateral navigation. The flight engineer responsibilities mainly comprised of managing the aircraft's various systems. In that role, he or she manually opened and closed valves along with functions such as fuel cross feeding. The flying pilots had very limited flight management (FMS) systems especially in contrast to modern jets. The automation available on these pre FMS airplanes often consisted of a rudimentary autopilot capable of only basic functions such as heading, altitude, and pitch hold along with basic navigation abilities. The net result is the nature of the pilot position in a non-FMS aircraft is very different from the position in a modern automated aircraft. The pilots who flew these aircraft were much more involved in the physical operation of the aircraft and thus not subject to the same amount of monitoring tasks a modern pilot is.

For example, calculating a "top of descent" point involved manual math using a prescribed formula along with any experience derived "rules of thumb" by the pilot. Once the pilot calculated this point, at the appropriate time he or she manually adjusted the aircraft's flight trajectory to meet any altitude crossing restrictions. Contrast this to a modern jet where the FMS calculates the "top of descent" point very accurately and accounts for environmental variables such as winds and aircraft weight. At the appropriate time, if the pilot has correctly programmed the automation, the airplane will start a descent to meet any altitude restrictions often without input from the pilot.

Once again, there are unintended consequences with advanced automation. With their role increasingly becoming monitors of the flight instead of active participants, pilots may experience higher rates of boredom. Boredom is commonly defined by psychologists as "…a state of relatively low arousal and dissatisfaction, which is attributed to an inadequately stimulating situation" (Mikulas & Vodanovich, 1993). Recent evidence suggests there are correlations between workload, complacency potential and boredom proneness (Stark & Scerbo, 1998 as cited in Prinzel, DeVries, Freeman, & Milulka, 2001). Further, research shows a considerable link between boredom and the vigilance tasks necessary to perform the duties of supervising automation (Sawin & Scerbo, 1995; Warm, Parasuraman, & Matthews, 2008). Research also suggests boredom may affect the propensity for attention lapses (Cheyne, Carriere, & Smilek, 2006). The authors of many of these studies linking boredom to the complacency, vigilance tasks, and attention issues inherent in automation complacency examined individuals in laboratory settings using psychometric tests or a form of desktop simulator. Thus, the purpose of the study is to determine whether modern airlines pilots who are more prone to boredom, and thus more likely to experience the state of boredom, are more likely to perform automation complacency related actions or have attention lapses in a setting representative of the daily challenges pilots face in the course of a workday.

Significance of the Study

There are increasing numbers of NASA Aviation Safety Reporting System (ASRS) reports that demonstrate the increasing nature of pilot overconfidence incidents (Research Integrations, 2007). The data compiled by Research Integrations (2007) indicate that of the 890 incident reports they analyzed, 22% were attributable to automation complacency. This issue tied "unexpected automation behavior" for first place as the greatest systemic problem facing pilots. Therefore, if there is a correlation between boredom proneness and automation complacency, it will indicate that boredom is another factor that influences automation behavior. Persons with increased boredom proneness are also more likely to experience attention lapses (Cheyne, Carriere, & Smilek, 2006). If the data shows a correlation between boredom proneness and the issues of automation complacency and attention lapses, the industry can devise new procedures and training emphasis areas that can help mitigate these two issues.

Hypothesis and Research Questions

The advent of modern avionics and sophisticated Flight Management Computers has removed pilots from the direct actions of controlling the aircraft in certain phases of flight. Instead, the automation relegates pilots to systems monitors, a task that requires vigilance, trust, and supervision of the automation. This in turn may increase the amount of boredom a pilot experiences, which may subsequently increase the rate of automation complacency related errors and attention lapses. The null hypothesis is that pilots who fly modern automated aircraft and are more prone to boredom commit the same amount of automation complacency related practices and experience the same attention lapses as a pilot not prone to boredom.

Research Questions

1. Are pilots who are more prone to boredom more or less likely to commit an automation complacency related behavior?
2. Are pilots who have flown their current airplane for greater than four years more or less likely to commit an automation complacency related behavior than a pilot with less than four years experience?
3. Are pilots who are more prone to boredom more or less likely to have a self-reported attention lapse?
4. Do pilots who fly wide-body aircraft in international operations self-report higher rates of boredom? If so, does this cause them to make increased amounts of automation complacency mistakes?

Conceptual Framework

The fieldwork comprised of a four-part quantitative and qualitative survey. The first section in the survey asked for basic demographic data such as age group, type of flying, gender, and longevity on the current airplane. The second section administered the Experience of Activities test, commonly known as the Boredom Proneness Scale, or BPS (Farmer & Sundberg, 1986). The third section administered the automation complacency questionnaire based on data derived from the NASA ASRS program. The final section at the end of the complacency questionnaire probed the frequency of attention lapses along with automation philosophy. The Boredom Proneness Scale utilized a 7-point Likert scale while the complacency test employed a 6-point scale. Several questions provided participants to enter qualitative comments regarding their individual practices. Survey participants were all experienced airline pilots from a major airline in the United States who have undergone an initial and recurrent training regimen that is representative of the American airline industry as a whole.

Existing research positively associates length of job tenure with boredom due to repeated exposure to monotonous tasks (Drory, 1982; Kass, Vodanovich, & Callender, 2001). If the first hypothesis is correct then pilots who are more prone to boredom will commit a greater number of automation complacency related mistakes. Therefore, pilots who have been flying their respective airplane continuously for over 4 years should experience higher states of boredom and thus commit greater complacency related automation behaviors. The study will test this hypothesis.

Two studies associate boredom with lapses in attention suggesting individuals who are prone to boredom will experience an absent-minded event (Cheyne, Carriere, & Smilek, 2006; Carriere, Cheyne, & Smilek, 2008). In aviation, lapses in attention or absent-mindedness could have adverse consequences regarding flight safety. Therefore, the study will determine if pilots who are more prone to boredom and thus more likely to be bored experience a greater number of attention lapses or absent minded behavior than is expected by controls or those who are less likely to become bored.

Finally, the pilots' surveyed self delineated the majority of their flying as either "narrow-body domestic (including Canada and Mexico)" or "wide-body international (including Hawaii)" primarily based on the predominant length of their trips. The difference is significant, since narrow-body pilots (Airbus A320, Boeing 737 and 757) fly shorter segments with frequently more take-offs and landings, which are high workload actions and thus more stimulating. Wide-body pilots (Boeing 747, 767, and 777) perform fewer take-off and landings instead spending a greater amount of time in the cruise phase with relatively lower levels of arousal and stimulation. According to the definition of boredom posited by Mikulas et al. (1993), wide-body pilots are more likely to experience the state of boredom. The study will test this hypothesis.

Assumptions

1. Participants are current 14 CFR Part 121 pilots employed by a major airline in the United States.
2. Participants are graduates from the airline's training curriculum and are current and qualified in their respective airplane.
3. Each participant has at least one year of experience in a highly automated transport category aircraft, specifically the Airbus A320/A319, Boeing 737-300/500, 747-400, 757-200, 767-300, or the 777-200 series aircraft.
4. Participants honestly answered the automation section based on their aggregate flight experiences.
5. Participants honestly assessed themselves in the Experience of Activities test.

Limitations

1. The study relied on the honesty of each survey participant when answering questions. Although the survey instructions emphasized anonymity and the need for truthfulness, there is no way to gage how honestly each participant answered a question.
2. The survey did not delineate aircraft type or automation behaviors specific to a particular aircraft.
3. The study used participants of only one particular major airline.
4. The study used participants who have graduated from the same airline training facility meaning consistency in exposure to the same automation philosophies and training emphasis points.
5. Some of the automation complacency behaviors surveyed are training or operation emphasis items. Therefore, pilots may be aware of the behavior and their consequences prior to the survey.

Definitions

- ATC – Air Traffic Control. The government agency that directs and controls air traffic.
- Automation Mode – The state of the automation, or what action the autopilot is currently performing.
- Auto-thrust – The aircraft system that automatically manages the engine thrust to maintain a desired speed.
- "Behind the airplane" – A colloquialism used by pilots to indicate events are proceeding faster than the pilot can keep up.

- Flight Director – A visual tool present on the primary attitude indicator that provides guidance regarding control inputs to maintain a desired state.
- FMC/FMS – Flight Management Computer or System. The primary interface computer that manages all aspects of the aircraft's performance, lateral and vertical navigation, and fuel calculations.
- "Navable" – A colloquialism used by pilots to indicate that a departure utilizing land-based navigation aids can be navigated exclusively within the aircraft using the FMS.
- Raw-data – Information presented to the pilot in its raw or non-automated form.
- SID – Standard Instrument Departure. A routing assigned to pilots to facilitate the flow of traffic away from an airport.
- STAR – Standard Terminal Arrival Route. A routing assigned to pilots to facilitate the flow of traffic into an airport.
- Waypoint – A navigational fix that the aircraft uses to fly toward as part of the course.
- ILS – Instrument Landing System. A system that provides lateral and vertical guidance toward the runway threshold in poor visibility situations. It is comprised of two systems:
    - Localizer, or LOC – The ILS system that provides lateral guidance.
    - Glide-slope, or GS – The ILS system that provides vertical guidance.
- VNAV – Vertical Navigation. The automated mode that manages a descent to meet any required altitude-crossing restrictions.

LITERATURE REVIEW

Complacency

Because of the increasingly supervisory role of a modern airline pilot, that pilot's main task is the passive act of monitoring the automation – a role that can lead to complacency (Billings, 1997). Automation complacency results when the operator over relies or excessively trusts the automation and fails to exercise his or her vigilance or supervisory duties (Parasuraman & Riley, 1997). In other words, "Pilots may become complacent because they are overconfident in and uncritical of automation, and fail to exercise appropriate vigilance, sometimes to the extent of abdicating responsibility to it [which can] lead to unsafe conditions" (Research Integrations. Inc, 2007). The NASA Aviation Safety Reporting System (ASRS) publication Callback defines complacency throughout multiple issues as "…the state of self-satisfaction that is often coupled with unawareness of impending trouble" (Aviation Safety Reporting System, 2009). The definitions quoted clearly imply that complacency occurs when the automation supervisor is unaware of the current or impending actions of the machine, which can have tragic results. Automation complacency has led to several crashes with fatal results most notably in 1995 when an American Airlines crew flying a Boeing 757 into Colombia did not notice the aircraft's automation activity resulting in tragedy (Aeronautica Civil of the Republic of Colombia, 1996). The autopilot began to navigate toward the incorrect navigation fix, and subsequently commanded a left turn that went unnoticed by both pilots.

One of the first studies on complacency involved simulated Air Traffic Control tasks both with and without an automated aid (Thackray & Touchstone, 1989). The researchers set up a head-on collision scenario and offered half the participants the benefit of an automated aid that gave erroneous information at predetermined points. The authors reasoned complacency should be evident due to the reliable nature of the automated aid, and that participants using the automation would become dependent upon it and therefore make more mistakes when given incorrect guidance. However, in their analysis they found that both the non-automated and the automated group performed equally well in the task. They explained the result was due to the short duration of the experiment and its single task nature that did not allow the operator to gain the necessary dependence and trust in the automation required for complacency.

The next step involved a study that tested subjects in multi-task environment very similar to a modern aircraft flight deck (Parasuraman, Molloy, & Singh, 1993). The authors examined the nature of complacency related ASRS reports and hypothesized that complacency is most evident when pilots are performing concurrent tasks such as simultaneously managing and monitoring the automation. They argued that the two most important elements of an automated system, its reliability and consistency, most directly influences how the operator is able to detect and respond to failures. Reliability refers to how often the automation works correctly, whereas consistency refers to the exact and predictable point where the automation fails. The increased workload nature of the experiment is significant, since some cognitive scientists have argued complacency is a method of coping with the increase in workload (Elin Bahner, Huper, & Manzey, 2008). If the operator perceives the automation to be consistent and reliable, then he or she needs to allocate fewer cognitive resources to the monitoring aspect. In other words, the user "assumes" the automation will work just as it has in the past and subsequently focuses on other tasks in the multi-task environment. Important to note is the workload threshold required for complacency is subjective, and varies between operators. How each operator perceives his or her individual cognitive load determines both the response strategy and how they allocate mental resources to cope with the situation (Prinzel, DeVries, Freeman, & Milulka, 2001).

In their study, Parasuraman et al. (1993) focused on the two variables of reliability and consistency in the complacency equation. The research assigned participants into one of three groups all of whom performed an automation-monitoring task on a desktop simulator. The first group had a low automation reliability level, the second group a high reliability level, and the third a variable level that alternated between high and low and specific points in the task. Subjects in the variable reliability group performed significantly poorer that the other two, leading the authors to conclude that machine performance consistency was the major factor in determining complacency levels over operating reliability. Stated differently, automation users who are accustomed to the automation in abnormal ways at known times can increase their monitoring at those points. However, when the automation behaves inconsistently detection performance drops leading to a complacency event. The authors reasoned this characteristic was caused by the study subjects trusting the automation to perform in a particular way based on their assumptions regarding its reliability. Thus, a key element to the issue of complacency is operator trust. This construct allows the user to reallocate attentional resources away from close monitoring duties toward other activities thus decreasing the chances of detecting an automation abnormality.

Trust

A good definition of trust is "…the attitude that…will help achieve an individual's goals in a situation characterized by uncertainty and vulnerability" (Lee & See, 2004, p. 54). According to this definition, the amount of trust guides the level of automation usage when the complexity or uncertainties of the situation make a complete understanding of the nuances of automation impractical. In other words, trust allows users to make inferences regarding how the automation will perform when neither time nor a complete understanding of the event is present. The amount of trust an operator has in the automated system depends heavily on the perceived reliability of the system in question (Prinzel, DeVries, Freeman, & Milulka, 2001; Lee & See, 2004; Bailey & Scerbo, 2008).

High levels of automation reliability and consistency tend to impart greater levels of trust in the operator, which he or she can then use as a coping mechanism. Rather than continue with the task of monitoring the automation, automation users can make assumptions on what the automation will do and concentrate on other duties. This technique allows automation operators to allocate cognitive resources to other places or tasks that the user deems less trustworthy or requiring more attention. To prove this concept, Bailey et al. (2008) gave their subjects a flight task on a desktop simulator while simultaneously monitoring several displays for a single failure. The researchers repeated their experiment several times with the failure occurring in different places. Their results suggested that as the subjects gained experienced with the overall system, their monitoring performance decreased directly related to the level of familiarity and trust they had in the automation. The researchers manipulated the system reliability thus altering the amount of trust each operator had in the predictability of the machine. From this data, they could prove a direct relationship between the levels of trust and degraded monitoring performance. Their subjects also had difficulty detecting minute changes, further suggesting that recognizing complex or subtle patterns are difficult. The level of trust the operator places in the machine particularly in multiple task environments, however, is most directly responsible for the level of monitoring or oversight the user places on it (Lee & See, 2004).

Along with perceived reliability, one of the major factors in determining the level of trust an operator places in the machinery is the risk involved with a particular action (Riley, 1996; Lee & See, 2004). The consequence of an action or inaction directly influences how the much emphasis the operator places on the vigilance task associated with proper automation monitoring. The concept of risk tends to negate the influence of perceived reliability in the automated system. Operators conducting a task with a greater risk will monitor the automation with greater accuracy regardless of how much confidence or trust they have in the system. Riley (1996) identified this construct as a shortcoming of research on automation complacency. Previous research on complacency involved subjects performing automation monitoring tasks on static simulators where the consequences of a complacency error are extremely low. Riley (1996) argued that this research may not be indicative of "real world" applications since errors of omission and commission are often related to the seriousness of the potential outcomes. The introduction of risk may generate a new set of biases and emphasis points that directly affect a monitoring task. Therefore, perceived risk of an automated action does have an effect on whether a user will commit a complacency related action.

Another determinate of the trust level involves the perceived robustness of a system (Sheridan 1988, as cited in Sheridan & Parasuraman, 2006). The operator determines this perceived robustness by how well he or she views the automation as a tool that can perform under various circumstances. There needs to be a sense of familiarity of the machine in the user where the automation utilizes a set of predicable and familiar actions, terms, and displays. All of these traits directly affect the mental model the operator creates of the automated system especially regarding its future actions. Further, the operator needs to have a level of dependence on the automated system and view it as a useful tool necessary to complete the mission.

When operators violate these concepts and do not use or monitor the automation properly, the result is often the misuse, disuse, and abuse of the automation (Parasuraman & Riley, 1997). The misuse and disuse constructs are consequences resulting from the general theme of automation complacency. Misuse results from the overreliance of the operator in the automation system and thus do not notice failures or exercise proper vigilance. Automation disuse refers to an operator rejecting the capabilities of the automation commonly caused by items such as false alarms. This results in errors of omission where the operator abdicates vigilance of the automation in favor of some other technique that may not be as effective in accomplishing the goal of automation supervision. In both of these cases, the user neglects the concept of vigilance, which is a key component to the monitoring task associated with automation.

Vigilance

The term vigilance commonly refers to the ability of an individual to maintain his or her attention for long and interrupted periods (Sawin & Scerbo, 1995). This ability is particularly important given the "monitoring" aspect to a pilot's job. Since automation now manages an increasing number of functions during a flight, vigilance becomes important at detecting subtle mode changes. Bailey et al. (2008) determined that vigilance performance varied directly with the complexity of the task. The more complex the task is, the greater the amount of monitoring errors they found in their sample once again suggesting that the trust and reliance constructs is a coping mechanism. The more cognitively demanding a task is, the more the user is likely to "load shed" and assume the correct action of the automation rather than use resources to monitor it. More importantly, the vigilance performance decreased even more if the inflection or change is subtle. Noticing changes to an automation mode or recognizing any improper programming is more difficult if there are no highlighting or warning systems. Bailey et al. (2008) concluded, "…the impact of highly reliable automation on monitoring performance suggests that operator detection of complex or subtle patterns is incredibly difficult" (pg 345).

Conventional theories by psychologists regarding reasons why vigilance performance decreases have centered on the monotonous nature of the activity. The monotony supposedly lulled the operator into a decreased state of vigilance through a lack of stimulation. However, new research has offered alternate theories for the performance decrement, instead arguing that vigilance is a demanding task associated with high levels of stress and concentration and not related to monotony (Sawin & Scerbo, 1995; Warm, Parasuraman, & Matthews, 2008). The reasons for this are complex. Typically, the research has found that the need to maintain high levels of vigilance for extended periods substantially increases the operator's workload increasing the amount of stress (Hancock & Warm, 1989). In addition, a perceived lack of control over future events magnifies the stress factor in vigilance tasks. As the vigilance task extends, the stress and perceived lack of control tend to deplete cognitive resources and contribute to a feeling of dissatisfaction (Warm, Dember, & Hancock, 1996). Thus, the stress of vigilance may be a cognitive reaction to a lack of control and to the perceived pressure to maintain high levels of accurate monitoring. The stress results in what cognitive scientists call the *performance decrement*, where vigilance performance in high workload situations can decrease rapidly from around 5 minutes of the onset of the task and stabilizes at a significantly lower level within 25 to 30 minutes (see Warm, Parasuraman, & Matthews, 2008, for a complete review). One of the factors that directly affect vigilance performance is boredom (Sawin & Scerbo, 1995; Kass, Vodanovich, Stanny, & Taylor, 2001). In addition, Prinzel et al. (2001) found boredom a contributing factor in the general issue of automation complacency, of which vigilance is a major element. Kass et al. (2001) found that subjects with high scores on the Boredom Proneness Scale (discussed later in the review) experienced a performance decrement much sooner than less boredom prone subjects. They attributed this finding to the monotonous and under stimulating nature involved in vigilance tasks – concepts that directly contribute to boredom (Sawin & Scerbo, 1995). In summary, the performance decrement found in vigilance tasks is attributable to the stressful nature of the task itself, while the speed of onset depends on how prone to boredom a person is.

Boredom

As previously stated, boredom is commonly defined "…as a state of low arousal and dissatisfaction attributed to an inadequately stimulating situation" (Mikulas & Vodanovich, 1993). Another definition adds the concepts of interest and attention. Fisher (1993) defined boredom as "…an unpleasant, transient affective state in which the individual feels a pervasive lack of interest in and difficulty concentrating on the current activity" (pg 396). The term "state" refers to a transitory period of consciousness that affects how a person views the world around them. For example, a person in a situation that meets the requirements posited by Mikulas et al. (1993) and Fisher (1993) of low arousal, dissatisfaction, inadequate stimulation, lack of interest, and difficulty concentrating may experience boredom. Due to its transitory nature, the "state" of boredom is temporary meaning when one or more of the conditions are resolved the person is, by definition, no longer bored. Boredom proneness by contrast, is a *trait* referring the propensity of an individual to become bored (Farmer & Sundberg, 1986). Individuals who are more prone to boredom may need lower arousal, dissatisfaction, and stimulation thresholds to experience the *state* of boredom than a person who is not as prone to boredom. This review examines the connection between state and trait boredom later.

Recent theories on how people respond to arousal suggest individuals will seek out ways to cope with various stimulation levels in order to maintain the optimum arousal level (Mikulas & Vodanovich, 1993). The associated cognitive performance required to sustain a task closely correlates to arousal and performance chart according to the Yerkes-Dodson principle (in Staal, 2004). This principle states that performance increases with arousal until it reaches a peak and then drops quickly. If a person is in a situation with low arousal resulting in boredom, he or she is likely to seek ways to increase the arousal and avoid the boredom suggesting people will develop coping mechanisms to counter the low arousal (Fisher, 1993). Conversely, if the arousal is too high, a person may seek ways to reduce the level before the corresponding performance level drops substantially. The perceived complexity of a particular situation is an important concept since people respond to stress and arousal according to their abilities. What may be an uncomplicated situation for one person may be extremely complex for another. Thus, boredom in individuals results in part from situations whose complexity is too low *for that specific individual* resulting in below optimum arousal levels (Mikulas & Vodanovich, 1993).

The second element of the definition, dissatisfaction, refers to an individual's perception of the action. For a person to be in a state of boredom he or she must not enjoy the particular situation they are in (O'Hanlon, 1981). A person who is meditating may be in a low state of arousal but may not be bored if they are satisfied with the activity. O'Hanlon (1981) reasoned the cause of this dissatisfaction is a person's "…aversion to monotonous elements of the situation [that are]…the source of the feeling" (pg 54). Thus, people have a natural aversion to monotony, which causes a person to feel dissatisfied with his or her current situation. O'Hanlon (1981) found boredom and job dissatisfaction strongly related.

The final component of the definition deals with inadequately stimulating situations. This concept is unique to each individual and depends on the individual's perception of the task. A person's assessment of how stimulating a task is depends heavily on any prior experiences with performing that task. O'Hanlon (1981) posited that monotony might be a driving factor in a person being bored. His work described the onset of boredom arriving within minutes especially if the person is engaged in a repetitive activity that he or she has done extensively in the past. Repetitive activities lose their complexity after continuous practice and fail to provide the level of arousal necessary to be stimulating. Research on job tenure found employees with longer tenure experienced greater boredom suggesting people exposed to the same job stimuli over time experienced higher boredom levels (Drory, 1982; Kass, Vodanovich, & Callender, 2001). Drory (1982) experimented on long haul truck drivers, and found significantly increased levels of boredom in drivers who had driven the same route repetitively. Kass et al. (2001) summed up the concept when they wrote "…repeated exposure to the same stimuli (e.g. , job tasks) leads to lower levels of arousal, which results in less satisfaction and greater boredom" (p 324). Therefore, for a person to stave off boredom there needs to be a source of stimulation either from the current environment or from somewhere else.

The etiology of boredom can be isolated into five factors (discussed later in the review). In work environments, the most common factors are the need for stimulation from external sources and stimulation through internal methods (Vodanovich & Kass, 1990; Vodanovich, Craig, & Kass, 2005). External stimulation refers to the perceived need for novelty, excitement, and variety from external sources and may explain why men and extroverts are more prone to boredom (Vodanovich & Kass, 1990; Vodanovich, Weddle, & Piotrowski, 1997; Gosline, 2007). These population groups tend to require more external stimulation than internal. The other major factor, internal stimulation, deals with methods to keep oneself interested and entertained through internal mediums. Subjects who are dependent on internal stimulation need to be proficient at concentrating on and maintaining self-created tasks and often possess better absorption and self-awareness levels (Seib & Vodanovich, 1998). These elements are often associated with introverted people who require fewer outside stimuli to stave off boredom (Gosline, 2007). Research on working conditions suggest extroverted individuals who are more prone to boredom are best suited for opportunities that offer external and tangible rewards, while introverted people who are less prone to boredom are better suited to positions that offer intrinsic rewards (Vodanovich, Weddle, & Piotrowski, 1997).

Important to note is that all three elements of the definition, low arousal, dissatisfaction, and inadequate stimulation, depend heavily on the individual's perception of the situation regardless of the actual events taking place (Mikulas & Vodanovich, 1993). An individual's propensity to experience the *state* of boredom varies depending on their individual environmental situation and may be transitory. Thus getting an accurate measure of boredom is difficult given the variety of perceptional differences between people and the transitory nature of the construct. What is boring to one person may not be to another, and what is not boring today may be tomorrow. However, the best method of quantifying boredom for research purposes is by measuring an individual's proneness to boredom that in turn can help predict a number of personality constructs a person is likely to experience (Farmer & Sundberg, 1986; Vodanovich, 2003). The most widely used tool is the Boredom Proneness Scale by Farmer and Sundberg (1986), and is a full-scale measure of the boredom construct. Other boredom indicators tend to analyze only specific aspects to boredom such as job boredom or are subscales of larger boredom scales (Vodanovich, 2003).

Measuring Boredom

In 1986, Farmer and Sundberg developed the Experience of Activities scale, commonly known as the Boredom Proneness Scale or BPS. The original test included 28 true/false questions that asked subjects to self-assess their general attitudes toward situations and constructs commonly associated with boredom. Farmer and Sundberg (1986) determined the internal consistency to be satisfactory (α=.79) using 233 college undergraduates as their sample. In addition, they found the test has shown good test-retest reliability (r=.83) after one week with greater stability demonstrated by females (r=.88) than by males (r=.74). Using another sample Farmer et al. (1986) found a strong correlation between the BPS and a boredom self-assessment questionnaire (r=.67, p<.001) suggesting that the BPS bears a close association with people willing to label themselves as bored, uninterested, or unsatisfied in their personal activities. Their other validating study using college students in a pseudo-lecture found the BPS correlated closely with attention (r=-.29, p<.05) and lack of interest (r=.25, p<.05).

Their original test used a true/false format that some researchers began changing to a 7-point Likert scale to increase the measurement sensitivity (Vodanovich & Kass, 1990). The work by Vodanovich et al. (1990) is particularly significant since it established a factor structure within the BPS scale allowing researchers to isolate what dimension is causing the boredom. For instance, if two people have the same total score on the BPS, the factorial approach will allow researchers to isolate what specific deficiency is causing the boredom. In addition to the two major factors listed earlier, External and Internal Stimulation, Vodanovich et al. (1990) found evidence of three more factors: Affective Responses, which deal with emotional reactions to boredom, Perception of Time dealing with issues associated with the coping and conceptualizing of time, and finally Constraint, which addressed individual reactions to waiting such as restlessness or patience. As an example, a high score on the following BPS question, "I find it easy to entertain myself," indicates the subject responds better to internal stimulation. A high score on the "Many things I have to do are repetitive and monotonous" question indicates an Affective Response, or an emotional reaction to boredom. Other researchers have found similar factors incorporated in the BPS (see Vodanovich, 2003, for a review). However, the consensus amongst the literature finds the two most common and dominant factors are the need for External Stimulation and Internal Stimulation (Vodanovich & Kass, 1990; Vodanovich, Weddle, & Piotrowski, 1997; Gordon, Wilkinson, McGown, & Javanoska, 1997; Vodanovich, Craig, & Kass, 2005).

State versus Trait Boredom

Research examining a correlation between trait and state boredom has centered on measuring job satisfaction metrics (Kass, Vodanovich, & Callender, 2001) and by correlating the BPS with other job boredom scales that measure state boredom (Farmer & Sundberg, 1986). In their original work, Farmer et al. (1986) found the BPS closely tracked Lee's Job Boredom Scale ($r=.49$, $p<.001$) that evaluated a person's satisfaction, interest, and connectedness to his or her job suggesting that if a person is prone to boredom, he or she is more likely to experience the state of boredom when environmental conditions dictate. Recall also the validation study done by Farmer et al. (1986) that found a strong correlation between the BPS and a boredom self-assessment questionnaire. In addition, research on automation complacency by Prinzell et al. (2001) found a strong relationship between boredom proneness as measured by the BPS and a task-related boredom scale. Some of the strongest evidence for the trait versus state link in boredom comes from the research on boredom and vigilance by Sawin et al. (1995). In their study, the researchers administered the BPS and another psychometric test measuring state boredom to their subjects about to undergo a vigilance test on a desktop simulator. Their results suggest the BPS is a good indicator of vigilance performance. The test also significantly correlated with the state boredom measure providing "…evidence for the long-sought, elusive link between trait boredom and performance in vigilance" (pg 763). Clearly, research examining a link between state and trait boredom has involved correlating boredom proneness (trait boredom) in individuals with job boredom at work (state boredom). The results by Sawin et al. (1995) are significant in that they permit the BPS, which measures trait boredom, to be utilized in measures that examine how state boredom affects automation complacency issues. Recall that vigilance is an important component to preventing complacency. Highly boredom prone individuals reported significantly more boredom than subjects did with low boredom proneness. The BPS scores "…reflect the propensity to become bored as a result of completing a monotonous and under stimulating task (Sawin & Scerbo, 1995, p. 763).

The research by Kass et al. (2001) hypothesized those individuals who perceived their work as repetitive, monotonous, and boring will score high on the BPS indicating a high proneness to boredom. Their job assessment metrics were satisfaction, absenteeism, and tenure, and they expected absenteeism and tenure to be associated with both trait and state boredom measures.

Consistent with Farmer et al. (1986), the researchers in the study found a correlation between state and trait boredom measures (r=.50). The results also found that high levels of both job boredom (state) and boredom proneness (trait) contributed to lower job satisfaction scores. Finally, the results indicated individuals with greater job tenure perceive their work as more boring consistent with the result found by Drory (1982). This enhances the theory that repeated exposure to monotonous tasks results in lower arousal, less satisfaction, and greater boredom. Finding both measures of boredom indicative of the same job problems support the idea that quantifying boredom proneness is an accurate measure of the problems associated with state boredom.

Characteristics of Boredom Prone Individuals

There is a wealth of studies on the psychopathology of boredom. In their original work, Farmer and Sundberg (1986) found boredom to be associated with depression, hopelessness, and loneliness. Other studies have positively linked boredom, as measured by the BPS, to procrastination (Vodanovich & Rupp, 1999; Ferrari, 2000), paranoia and self-consciousness (von Gemmingen, Sullivan, & Pomerantz, 2003), cognitive failure (Wallace, Vodanovich, & Restino, 2003), and automation complacency (Prinzel, DeVries, Freeman, & Milulka, 2001). Other studies have examined how boredom affects psychological and physical health symptoms (Sommers & Vodanovich, 2000), and vigilance performance (Sawin & Scerbo, 1995; Kass, Vodanovich, Stanny, & Taylor, 2001). One of the constructs most applicable to this study and to aviation is the examination of boredom and attention lapses along with cognitive failure (Wallace, Vodanovich, & Restino, 2003; Cheyne, Carriere, & Smilek, 2006; Carriere, Cheyne, & Smilek, 2008).

Boredom and Attention Lapses, Cognitive Failure, and Flow

In aviation, lapses of attention can lead to potentially tragic consequences. For example, in the NASA ASRS database, ACN number 754217 recounts the story of a pilot who accidentally shut down one of the engines on his aircraft during the approach to landing sequence instead of moving the flap selector. Fortunately, the crew caught the mistake in time and landed the aircraft safely. However, the incident illustrates the nature and importance of attention and cognitive deficits. Recall the factor structure of the BPS where Internal and External stimulation are the two main sources of alleviating boredom (Vodanovich & Kass, 1990; Vodanovich, Craig, & Kass, 2005). Research done by Kass, Wallace, & Vodanovich (2003) found a significant correlation between scores on the Boredom Proneness Scale and the Adult Behavior Checklist (ABC), a scale intended to assess symptoms associated with attention deficit and hyperactivity disorder (ADHD). The ABC has two sub-scales, one for attention and one for hyperactivity. Using the factor approach to the BPS, the researchers found subjects who required more internal stimulation or the need to concentrate on tasks and both create and maintain self-interests, scored high on the ABC attention subscale. This provided "…empirical support for various conceptualizations of boredom as consisting of cognitive/attentional shortcomings" (Kass, Wallace, & Vodanovich, 2003, p. 86).

These findings parallel the work by Wallace et al. (2003) who examined a possible association with boredom proneness as measured by the BPS to cognitive failure. Their sample used a combination of military personnel and undergraduate students whom the researchers administered the BPS and the Cognitive Failures Questionnaire (CFQ). The CFQ is also subject to a factor approach similar to the BPS. The variables causing any cognitive failures can be memory issues (memory failures and forgetfulness), distractibility (perceptions on divided attention tasks), blunders (physical mishaps resulting from inattention), and names (remembrances of associated names). The overall results demonstrated that "…boredom proneness scores were found to be significant predictors of cognitive failures" (pg 641). However, examining the results in detail found the factor most applicable to aviation in the CFQ questionnaire is arguably distractibility, since pilots often deal with multiple tasks when monitoring and supervising the automation (Parasuraman, Molloy, & Singh, 1993). Wallace et al. (2003) found that subjects scoring the high on the affective and time subscales of the BPS correlated the highest to the distractibility subscale of the CFQ ($r=0.52$ and 0.53 respectively, $p<0.001$). This finding suggests that subjects who have an emotional reaction to boredom and who cannot properly cope with extended time passing will experience greater cognitive failures during multiple tasks.

Work on boredom and attention continued with Cheyne et al. (2006). In this study, the researchers postulated that the inability to engage in and sustain attention is boredom. This argument parallels the definition of boredom by Fisher (1993), when she proposed that part of the effect of boredom is a lack of interest and a difficulty in concentrating. Cheyne et al. (2006) found that their subjects who were more prone to memory failures and attention lapses also scored high on the BPS. Further, they determined that these two underlying causes of the elevated BPS scores also contributed to depression, an illness that shares similarities with boredom including a negative mood and loss of meaning in life (Carriere, Cheyne, & Smilek, 2008). The results of Carriere et al. (2008) found that attention is the common link between depression, lack of meaning, and boredom. Their conceptual model showed statistically significant and positive correlations between attention disorders and boredom proneness ($r=.33$, $p<0.01$) and depression ($r=.18$, $p<0.01$).

Finally, boredom is counterproductive to a concept known as flow, or the "…holistic sensation that people feel when they act with total involvement" (Csikszentmihalyi, 1975, p. 36). Psychologists describe flow as intrinsic motivation, where constructs such as attention, focus, and absorption are effortless and come without much conscious thought. It is very similar to the practice of Zen, where the meditation goal is the elevation of thought into the subconscious akin to what professional athletes call being "in the zone." An important concept regarding flow is the matching of skills and abilities to the immediate task (Shernoff, Csikszentmihalyi, Schneider, & Shernoff, 2003). If a person is assigned a task that is too demanding and outside of his or her abilities, anxiety often ensues disrupting the state of flow. Conversely, tasks that are not challenging enough lead to boredom that also disrupts flow. Shernoff et al. (2003) found that subjects in environments that insufficiently tasked them often developed coping strategies to bring their level of challenge to an optimal level in order to achieve flow. This concept is important, as it highlights the tendencies of people to develop coping strategies if their workload is insufficient and boredom inducing.

Coping with Boredom

Coping with boredom, particularly in workplace settings, involves two general strategies (Fisher, 1993). The first requires refocusing attention on the task and the second involves seeking additional stimulation. Refocusing attention on a task may involve subjects forcing themselves to pay attention regardless of how they feel about it. This is particularly true if the task carries an element of risk similar to the way risk effects monitoring and vigilance performance. Another coping strategy for task refocusing involves goal setting and working toward the final result by emphasizing specific steps. This technique is congruent with the findings by Shernoff et al. (2003), who posited that achieving flow best occurs when the goals and tasks are within a person's skills and abilities.

The other method for coping with boredom is to seek out additional stimulation either from the current task or by changing activities. Seeking additional stimulation from the current task particularly during monotonous tasks often involves "subsidiary behaviors," or actions in addition to the requisite tasks to increase the level of stimulation (Kishida, 1977). These behaviors included actions daydreaming, talking to colleagues, playing mental games, fidgeting, and looking around among others. While some of these behaviors reduced the monitoring performance slightly, they proved effective in reducing boredom slightly (Kishida, 1977). Finally, another coping mechanism involves changing activities by engaging in things such as reading and other non-work related activities. Surveys of employee activities when people are bored indicated subjects tended to read novels or write letters during low workload periods (Fisher, 1987, as cited in Fisher 1993). Other tasks involved talking to co-workers about various subjects and reading training manuals. Again, these results parallel the concept of flow, where individuals will undertake additional activities to bring the workload to an optimum level consistent with their abilities (Shernoff, Csikszentmihalyi, Schneider, & Shernoff, 2003).

CHAPTER 2

METHODS

Introduction

Since automation has become so prevalent, pilots have increasingly become monitors and supervisors of the automation instead of active controllers of the aircraft. Thus, the nature of the work a modern pilot performs has changed. This paradigm shift now subjects pilots to longer periods of low arousal and monotonous situations resulting from monitoring the automation to ensure it is performing correctly. This can lead to boredom, and the purpose of this study is to examine what the effects of boredom are on automation practices. This chapter discusses the study population, sample, and design in detail.

Population

The population group the study generalizes is glass flight deck pilots. This is not isolated to just airline pilots, but rather any pilot who flies a large aircraft that relies heavily on advanced automation including autopilots and auto-thrust systems to successfully complete a flight. The population group is not limited to pilot certificate, since a glass flight deck corporate aircraft does not require an Airline Transport Pilot license. However, there is a basic minimum standard of pilot requirements necessary to operate such aircraft. The study has the most applicability to aircraft certified as transport category. These aircraft typically feature the most advanced automation, and the pilots who fly them undergo annual recurrent training that includes automation awareness. Even though the study's population group is independent of license, the study assumes a high degree of piloting ability and experience as its population.

Sample

The study utilized pilots employed by a major airline (as measured by revenue) in the United States. Each pilot was either a Captain or First Officer, and was an experienced pilot in a highly automated aircraft due to the nature of the airline's hiring practices and fleet make-up. Three hundred and one (301) subjects started the survey with 273 completing it. This represents slightly fewer than 4% of the total pilot population at this specific airline (not identified in this study). All participants voluntarily donated their time and expertise and were uncompensated for their efforts. Participants were under no time limits to complete the survey and could access the survey related internet pages at a location of their choice.

Study Design

The study recruited the sample subjects through posters placed on bulletin boards in common areas of each pilot domicile and through a recruitment message inserted in a "blast" e-mail sent to all pilots from the union representing them. Both the poster and e-mail message directed participants to a web site containing generalized information about the study along with a hyperlink to the survey. The actual survey was administered on-line allowing confidentiality, anonymity, and accuracy.

The study utilized a 4-part survey consisting of 55 questions to measure both quantitatively and qualitatively the dependent variables. The first portion of the survey requested general demographic information such as age and experience information from the survey participants. The second portion administered the Boredom Proneness Scale (BPS) by Farmer and Sundberg (1986) which was used with permission. The third portion of the survey administered the Pilot Automation Complacency Practices Scale (PACPS) that the author created and discussed in detail next. Finally, the survey ended by measuring some general attitudes toward automation. Survey respondents had several opportunities to insert free text regarding their individual practices or feelings toward automation.

Pilot Automation Complacency Practices Scale (PACPS)

The Pilot Automation Complacency Practices Scale derived its information from an examination of NASA Aviation Safety Reporting System (ASRS) data from a ten-year period between January 1999 and January 2009. The search criteria focused only on anomaly reports from Part 121 operations where the causal factor was flight crew human performance. The search also looked for any narrative or synopsis containing variations of the terms FMC/FMS, automation, and complacency. These search criteria revealed 562 records (see Appendix C). An important consideration to remember is the nature of the ASRS program. Since the program is voluntary and done primarily for immunization against certificate enforcement action, the numbers of reports are under-representative of the actual number of events. A pilot may have an automation complacency event, but may not report it if no infraction occurred. Of the 562 records, the analysis discarded 69 due to non-relevance with the subject.

Recall the complete definition of automation complacency. Automation complacency is a term interchangeable with automation overconfidence, and is broadly described as pilots "…becom[ing] complacent because they are overconfident in and uncritical of automation, and fail to exercise appropriate vigilance, sometimes to the extent of abdicating responsibility to it. This can lead to unsafe conditions" (Research Integrations. Inc, 2007). Examining the evidence derived from the ASRS reports allows a factorial approach to the issue and reveals four subcategories pertaining to the causes of the broad issue of pilot automation complacency. They are:

1. Pilots fail to notice the automation mode or autopilot state after an FMS reprogram or other distracting event (Complacency Distraction). The ASRS analysis indicates 137 reports of this nature. Common behaviors include:
    a. Air Traffic Control issues a late runway change causing pilots to reprogram the FMS. The pilots do not notice the descent mode has changed or do not notice the altitude crossing restrictions have dropped out. In both cases an altitude crossing deviation occurs.
    b. The pilots reprogram the FMS with new information during a mode change (for example, the aircraft leveling after a descent of climb). The pilots do not notice the ensuing mode reversion resulting in an altitude deviation.
    c. Pilots reprogram the FMS with a new lateral route and fail to notice the disruption in navigation information has caused the automation to revert to

HDG mode. This causes the automation to follow heading information instead of programmed track guidance possibly resulting in a track deviation.

   d. The pilots experience an event that causes their workload to spike such as a system failure or a procedure interruption caused by non-essential issues. The pilots fail to recognize any improper automation modes.

2. Pilots do not crosscheck the automation for the correct restrictions, route, or information (Complacency Crosscheck). The ASRS analysis indicates 108 reports of this nature. Common behaviors include:

   a. A pilot failing to ensure the FMS has the correct departure, en-route, or arrival route programmed resulting in a track deviation.

   b. Pilots receive a new routing from ATC, and subsequently fail to ensure the FMS has activated the correct waypoint.

   c. Pilots fail to program the correct altitude and speed crossing restrictions in the FMS.

   d. Pilots enter a direct-to routing, and fail to ensure the aircraft is proceeding to the correct waypoint.

   e. Pilots fail to check the selected arrival or departure procedure waypoints and/or restrictions match the charted procedure.

   f. Pilots set the automation guidance (FMS, ILS, etc.) to the incorrect parallel runway resulting in inbound tracking of the incorrect runway.

   g. Pilots fail to notice incorrect performance information resulting in improper altitudes, speeds and weight and balance information.

3. Pilots fail to monitor the automation to ensure it is behaving as expected or required (Complacency Monitoring). ASRS analysis indicates 169 reports regarding this conduct. Common behaviors include:
   a. Pilots failing to monitor vertical automation with raw data information to ensure the aircraft will adhere to the altitude crossing restriction.
   b. Pilots fail to ensure the aircraft automation is performing as expected in the following ways:
      i. Failing to notice the aircraft has not acquired the TOD (top of descent) point.
      ii. Failing to notice the aircraft is not in the appropriate automation mode.
      iii. Failing to ensure proper navigation or speed capture and hold.
   c. Pilots' failing to monitor lateral automation with raw data information to ensure the aircraft is on the correct navigation track.
   d. Pilots fail to notice the automation has either overshot or undershot the assigned altitude.
4. Pilots are using the automation, or relying on automation flight guidance, instead of exercising manual pilot skills or abilities (Complacency Automation Over-reliance). ASRS analysis indicates 72 reports of this nature. Common behaviors include:

a. Pilots attempt to use the automation to salvage a poor approach or an illegal situation (such as exceeding the 250 KIAS speed limit below 10,000 feet).
b. Pilots utilize the autopilot to capture the localizer and glide-slope on the instrument landing system, and do not manually take over when the aircraft does not capture the landing guidance or behaves unexpectedly.
c. Pilots fixate on programming the FMS during high workload situations to the exclusion of monitoring the aircraft's state.
d. Pilots exhibit poor flying skills when the automation is forcibly disengaged.
e. On an ILS, the pilots continue to follow erroneous flight director guidance despite LOC and/or GS deviations.

One of the final questions queried respondents regarding attention lapses. Participants rated the approximate frequency in terms of the number of flights they experienced an attention lapse or loss of situational awareness that resulted in a missed or inappropriate action. This question will allow the study to examine a possible link between boredom proneness and the attention and cognitive issues identified by Fisher (1993), Kass et al. (2003), Wallace et al. (2003), Cheyne et al. (2006), and Carriere et al (2008) as they relate to modern airline pilots. The survey included questions assessing the participant's self-assessment of their boredom level during the majority of their flights (state boredom) along with a questionnaire regarding boredom coping mechanisms. Additional questions queried individual automation practices and philosophies. Finally, the survey ended with a qualitative open-ended question asking about general attitudes toward the overall topic.

Data Collection and Methods

The analysis scored the BPS conventionally utilizing the 7-point Likert scale first employed by Vodanovich et al. (1990). This technique allowed utilization of the factorial approach for greater sensitivity. Survey respondents evaluated each statement from "highly disagree" to "highly agree" based on their experiences with the question. A higher score on the BPS indicated a greater proneness to boredom.

Most of the complacency practices questions asked the respondents to indicate the approximate percentage of the time they engaged in a particular behavior on a 6-point Likert scale. For the first three sections on the PACPS, complacency distraction, crosscheck, and monitoring, a *higher* frequency of occurrence of the questioned behavior indicates a *lower* proneness to a complacency related action. For three of the four questions on the final section, automation over-reliance, a *higher* frequency of occurrence of the questioned behavior indicated a *greater* susceptibility to improperly relying on automation. The scoring system corrected the complacency scores to indicate the proper orientation with the boredom proneness test (high complacency scores indicate a higher proneness to a complacency related practice). This approach allowed the study to tabulate quantitatively a complacency practices score for comparison to the BPS and other criteria. Similar to the factorial technique that allows a more robust analysis of BPS scores (Vodanovich & Kass, 1990), a dimensional approach allows the PACPS to provide a more focused examination of what causes automation complacency.

Instrument Reliability and Validity

The literature has well documented the reliability and validity of the BPS as a full measure the boredom construct (see Vodanovich 2003 for a complete review). A panel of industry and academic experts reviewed the PACPS to ensure proper content validity along with its efficacy in measuring automation complacency concept. All of the behavioral questions on the scale originated from frequently observed actual flight crew experiences as reported to the NASA Aviation Safety Reporting System (see Appendix C). Thus, the scale was conceived from "real world" practices and scenarios experienced by pilots in the course of their daily duties. Finally, the survey was available only to pilots at a major airline meaning the results are indicative of the automation practices from the group the survey generalizes. There is no known dilution of the information from unqualified or "out of population" survey respondents.

Proposed Data Analysis

The Pearson correlation coefficient was the primary statistical tool used to analyze the results. The study used SPSS statistical software and looked for significant associations at both the 0.01 and 0.05 alpha levels (2-tailed). This allowed for a comprehensive cross-referencing of all the variables and enabled identification of significant correlations between multiple dimensions of both the BPS and the complacency practices scale.

A phenomenological study type analyzed the free comments section of the survey regarding automation coping strategies, boredom coping strategies, and general comments. The results section will identify and display any trends in the data. The goal of the free comments section is to identify any other issues of observations not directly addressed by the questions in the survey.

Protection of Human Subjects

Participants who volunteered their time and opinions did so at no jeopardy to themselves. Moreover, none of the behaviors questioned constituted an illegal behavior as defined by the Federal Aviation Regulations. Participants remained anonymous throughout the entire process except for the generalized demographic data queried at the beginning of the survey and could have withdrawn at anytime during the process without consequence. The study author notified and received written permission from both the management of the respective airline and the collective bargaining agent representing the pilots to conduct the survey. The study also obtained written permission to place recruitment posters in the airline's common areas. None of the questions in the survey will enable any person to identify either the pilot or the airline where the pilots work. Finally, the Institutional Review Board at the University of North Dakota reviewed and approved the project including the survey questions, proposed sample, and research methods.

CHAPTER 3

RESULTS

Of the 273 survey respondents, 87.8% were male. The majority (54.4%) fell between the ages of 41-50 years old, with the next highest group between the ages of 51-60 years old (28.2%). Examining flying operations found 64.3% flew narrow-body aircraft in domestic operations (including Canada and Mexico) while 35.7% flew wide-body aircraft in international operations. Finally, regarding the question of aircraft longevity, 54.5% had flown their respective airplane for greater than four years. The next highest group (22.3%) had flown their airplane between 2 to 4 years. The aircraft longevity groups of one to two years and less than one year comprised of 9.9% and 13.4% of the sample respectively.

Research Questions Findings

1. Are pilots who are more prone to boredom more or less likely to commit an automation complacency related behavior?
    - Pearson correlation coefficients indicated a statistically significant positive correlation (r=.181, p=0.01) between boredom proneness and automation complacency practices.
2. Are pilots who have flown their current airplane for greater than four years more or less likely to commit an automation complacency related behavior than a pilot with less than four years experience?

- There are no statistically significant correlations between longevity in aircraft and automation complacency behaviors. Moreover, there are no significant correlations between longevity in aircraft and self-assessed boredom or attention lapses.

3. Are pilots who are more prone to boredom more or less likely to have a self-reported attention lapse?
   - Pearson coefficients indicated a statistically significant positive correlation (r=.171, p=0.01) between boredom proneness and attention lapses.
4. Do pilots who fly wide-body aircraft in international operations self-report higher rates of boredom? If so, does this cause them to make increased amounts of automation complacency mistakes?
   - There are no statistically significant correlations between operation type and self-reported state boredom, boredom proneness, complacency related actions, or attention lapses. The only statistically significant correlation (r=.176, p=0.01) is between operation type and the complacency subscale of monitoring. This suggests pilots in narrow-body aircraft commit a greater number of complacency monitoring related actions.

Data Summary

Table 1 summarizes the correlations between boredom proneness factors and automation complacency related factors. The table only displays significant correlations at the p=0.05 level. Correlations displayed in bold are significant to the p=0.01 level.

Table 1. Boredom Proneness Factors and Automation Complacency

Scales		Boredom Proneness Factors					
		External	Internal	Affective	Time	Constraint	Total
Automation Complacency	Distraction			**.198**	.125		.120
	Crosscheck	.132		**.279**	**.219**	.140	**.187**
	Monitoring	.146		**.196**	.125		.127
	Automation Over Reliance	.137	**-.211**	**.175**	**.214**		
	Total	**.167**	-.138	**.291**	**.219**		**.181**

The Boredom Proneness Scale exhibited good validity with the self-assessment of state boredom (r=.499, p=0.01) and is consistent with other correlations of trait and state boredom (Farmer & Sundberg, 1986; Kass, Vodanovich, & Callender, 2001). The BPS dimension regarding internal stimulation correlated negatively (r=-.190, p=0.01) with attention lapses suggesting pilot who can find stimulation from internal sources experience fewer self-reported attention lapses.

The self-assessment of state boredom when correlated to the BPS factors indicated several significant correlations and is summarized in Table 2. The table only lists significant correlations to the p=0.05 level. Items in bold are significant to the p=0.01 level.

Table 2. Boredom Proneness Factors and Self-assessed Boredom

	Boredom Proneness Factors				
	External	Internal	Affective	Time	Constraint
Self-assessed Boredom	**.470**	**-.255**	**.489**	**.452**	

Finally, the data indicated pilots are much more likely to commit an automation complacency related action and have an attention lapse when they assess themselves as bored. Table 3 summarizes the results comparing complacency related actions and attention lapses to self-assessed boredom. Again, bold items are statistically significant to the p=0.01 level.

Table 3. Complacency Factors/Attention Lapses and Self-Assessed Boredom

	Complacency related factors					Attention Lapses
	Distraction	Crosscheck	Monitoring	Over-reliance	Total	
Self-Assessed Boredom	.140	**.190**	**.252**	**.251**	**.305**	**.293**

DISCUSSION

The data clearly associates both boredom proneness and self-assessed boredom to automation complacency actions and attention lapses. Boredom is becoming a significant factor in modern aviation. In the free comment section, one pilot wrote, "boredom is a huge problem which increases with the length of trip. by [sic] day 4 i [sic] am gone." Another pilot observed, "After boredom on a long flight, it's [sic] hard to 'speed-up' to the [sic] brain activity to fly conscientiously!" The increase in boredom is also associated with the increased level and emphasis on aircraft automation. Modern pilot to aircraft interface designs center the aircraft on the automation, meaning a pilot is required to input many of the operational instructions through the FMC. One pilot observed, "The automation is getting harder to turn off on newer airplanes – need to go heads down into the FMC just to tune a VOR for example." Other comments paralleled this theme and added the concept of dissatisfaction echoing one of the criteria necessary for boredom. Recall that dissatisfaction with the situation is one of the elements necessary to becoming bored (Mikulas & Vodanovich, 1993). A pilot described the effect of automation as "…force[ing] us to become system monitors more than pilots. I must force myself to be actively engaged. Huge decrease in job statisfaction [sic]." Both the quantitative and qualitative support boredom as an increasingly important issue in modern aviation.

Internal and External Stimulation

Examining some of the personality constructs identified in the Boredom Proneness Scale helps identify some of the underlying dimensions of boredom reported in the sample. Table 2 summarizes the correlations between self-assessed boredom and the BPS subscales. The external, affective, and time subscales of boredom proneness correlated positively to state boredom while the internal subscale correlated negatively. This finding suggests that pilots who are more adept at finding internal sources of stimulation are less likely to self-report themselves as bored. Table 1 also displays a statistically significant negative association between the need for internal stimulation and automation complacency, especially the complacency subscale of over reliance. Thus, pilots who are better adept at finding internal sources of stimulation are less bored, and engage in less complacency related behaviors. Of the survey respondents, 85.3% indicated they hand fly as much as possible, an action that offers intrinsic rewards and could satisfy the need for internal stimulation. These pilots may be more practiced at hand flying due their need for the intrinsic satisfaction found in the action and thus less reliant on the automation. This could explain why pilots who scored higher on the internal dimension of boredom proneness committed less automation over reliance actions. The survey question that queried participants on how they occupied their time revealed the vast majority, 85.3% and 64.5%, engaged in an internally stimulating behavior such as reading and logic puzzles respectively. Another pilot wrote how he or she admired the scenery at altitude, an intrinsically pleasing act, by writing, "When weather permits, I enjoy watching the world go by below. In doing so, I mentally keep tabs on where we are (big picture)…" Another wrote how he or she enjoys "observ[ing] night sky, landscape etc." One pilot described the importance of internal stimulation through reading by writing, "If it were not possible to read during cruise my boredom level would be significantly higher." All of these actions are intrinsically rewarding activities and constitute an internal source of stimulation.

By contrast, the pilots who indicated a greater need for external stimulation indicated a small but positive association with automation complacency behaviors (see Table 1) and self-assessed boredom (see Table 2). The increase in self-assessed state boredom is possibly due to the limited environment in a flight deck that is largely devoid of external stimulation sources. In some aircraft, the flight deck space is small making movement difficult. Moreover, many airline policies forbid some externally stimulating activities such as video entertainment thus limiting those sources for the pilots who need them. Of all the survey respondents, 97.8% indicated that chatting with their fellow aviators in the flight deck (an external source of stimulation) was a means of preventing boredom. One pilot rather candidly wrote, "…for me, the boredom level is directly related to how interesting my F/O [first officer] is. I get more bored when I cannot engage anyone in conversation." In a similar vein, another pilot wrote that he or she enjoyed "chat[ing] with [the] flight attendants" and yet another stipulated "…boredom is a very large part of my flying time, thank God for the other guy in the cockpit." Since external sources of stimulation are limited in the flight-deck environment, pilots who are more adept at internal stimulation sources appear better able to handle the boredom, and are less likely to engage in a complacent behavior. In other words, pilots who can find stimulation from intrinsic sources are better able to cope with boredom in a flight deck environment.

The key term is the word cope, since the pilots the sample generalizes all require individual ways to deal with the boredom on their flights. This could explain the lack of significant differences between pilots who fly wide-body international operations versus narrow-body domestic. Each person has found an individual coping mechanism to deal with the boredom for their unique situation whether they are flying short legs in domestic operations or extended legs in the international realm. According to the free comments in the completed surveys, these mechanisms can range from "…eat[ing] pistachios on red eyes…" to "study[ing] for law school." One particular pilot developed a game he or she could play with the other pilot using the navigation fix page in the airplane's FMC. In each case, the individual pilot has determined his or her own unique strategy to remove the emotional aspect of boredom found when there are inadequate individual coping mechanisms.

Affective and Time Responses

The affective subscale of the BPS is described as an individual having an "…emotional reaction to boredom" (Vodanovich & Kass, 1990, p. 118; Vodanovich, 2003, p. 571; Wallace, Vodanovich, & Restino, 2003, p. 638). An individual with a high score on the BPS questions that relates to this subscale suggests that he or she has not developed an adequate boredom coping mechanism and is dealing irrationally with their boredom. For example, a high score indicating agreement with question 9, "Many things I have to do are repetitive and monotonous," might suggest a person has not found any good mechanisms that reduce the undesired characteristics of repetitiveness and monotony present in their particular situation. The individual is reacting on an affective level rather than developing strategies to reduce the emotional response to a situation. Thus, a high score on the affective subscale in this survey might indicate a pilot has difficulty finding an optimum method to deal with his or her boredom. That individual then reacts emotionally to boredom inducing situations.

A similar concept exists with the BPS subscale of time, defined in the literature as "…items related to the use of time" (Vodanovich & Kass, 1990, p. 118). These questions probe an individual's perception of time and boredom. As with the affective subscale, a high score on the questions related to time could indicate inadequate coping strategies. As another example, a high score indicating agreement with question 14, "Much of the time I just sit around doing nothing" could suggest a person who has difficulty finding coping strategies when the underlying cause is time. All of the questions on this subscale involve how a subject perceives the passage of time, and whether adequate mechanisms can relieve any potential boredom caused by this construct.

Table 2 displays the correlation between self-reported boredom and Boredom Proneness factors. Of the five boredom dimensions, subjects who scored high on the affective subscale reported high self-assessed, or state, boredom suggesting that individuals who respond to boredom at an emotional level are more likely to experience boredom. Contrast this with the statistically significant negative correlation between the internal dimension of the BPS and self-assessed boredom ($r=-.255$, $p=0.01$) symptomatic of pilots adept in finding internal stimulation reporting less state boredom. In the free comments section, a pilot described his or her emotional reaction to boredom in the following manner:

> I was much more attentive on the 737-200 than I have been on the Airbus. Despite my intent to not rely too heavily on automation, it is easy to do. I am so bored/unhappy at [redacted] that I just put in for a voluntary furlough. I was more attentive when I was happier in my job, which is part of my reason for leaving.

The Boeing 737-200 is a non-automated aircraft that requires extensive pilot involvement when compared the Airbus A320. Interestingly, this individual pilot self-assessed his or her boredom level as "very bored most of the time," which is one level below the maximum self-assessment level. Only 9.2% of the pilots in the sample rated themselves in this category. Of all the survey respondents, only one person (0.4%) self assessed their boredom level at the maximum level.

This finding parallels the data listed in Table 3, which positively associates greater self-assessments of boredom with automation complacency related actions (r=.305, p=0.01) and attention lapses (r=.293, p=0.01). In summary, a pilot who has a greater emotional reaction to boredom (as determined by the BPS affective subscale) and who may not have developed adequate coping skills and mechanisms self-report higher states of boredom as described in Table 2. Finally, the pilots who self-report higher states of boredom are associated with greater complacency related behaviors and attention lapses as demonstrated in Table 3 meaning pilots who score high on the affective subscale commit a greater number of complacency related practices. The data in Table 1 support this hypothesis. Isolating the affective subscale of the BPS finds a statistically significant positive correlation to automation complacency practices.

Attention Lapses

Isolating the BPS affective subscale with the self-reported frequency of attention lapses measure also indicates a statistically significant positive association (r=.288, p=0.01). This association is significant especially when compared to how the BPS internal subscale associates with attention lapses (r=-.190, p=0.01). As with the issue of complacency practices, this could indicate that pilots who respond emotionally to boredom or who have not developed coping mechanisms experience attention lapses or cognitive failures at an increased frequency. This finding also parallels the work by Wallace et al. (2003) who reported subjects who scored high on the affective and time subscales of the BPS positively correlated with a greater amount of cognitive failures during multiple tasks ($r=.52$ for affective, $r=.53$ for time, $p<0.001$). According to Parasuraman et al. (1993), the airplane environment is a multiple task environment particularly when monitoring and supervising the automation is involved.

Risk

The issue of risk may be a mitigating factor in automation complacency (Riley, 1996). This topic may help explain the relatively weak association between boredom proneness and automation complacency actions. Riley (1996) argued that previous research on vigilance, an important component in automation supervision, neglected the concept of risk due to the reliance on desktop simulators for their practical data. These desktop simulators tested vigilance by observing how often the sample subjects noticed a change in the display – a task that carries no risk to it. The qualitative portion of the survey strongly support the concept of how perceived risk influences automation vigilance and supervision. When asked about what strategies pilots utilize to ensure proper automation behavior, the variations of the term "crosscheck" appeared 25 times in the free text. This suggests that despite any perceived reliability, consistency, or level of trust, the many of the pilots in this survey are deliberately monitoring the automation to ensure proper operation. One pilot emphatically wrote that he or she, "Do[es] NOT trust the auto system so avoid surprises [sic] that it seems to produce." Another wrote how after

"…15000 PIC hours and 35 years…most mistakes have been witnessed or personally executed already." These pilots appear to be aware of the consequences of an automation vigilance mistake, and are taking active steps to increase their monitoring during critical phases. As an example, a pilot wrote how he or she, "…ask[s] the F/O if he agrees with the inputs before executing (Boeing)…" Yet another wrote,

> Always confirm the Flight Mode Annunciations (FMA). Keep your eyes moving and ears listening. Do not lean back in your seat and think nothing bad can/will happen. Always think about what to do next before the automation actually does it.

Thus, the concept of risk is a critical bias when considering automation vigilance and monitoring issues and strongly supportive of the findings by Riley (1996).

The common thread with almost all of the free comments regarding this issue involves an acute awareness of the consequences of an automation mistake. For example, an altitude deviation is an important topic with both tragic and legal consequences. Many of the comments written by pilots involve their individual strategy to prevent altitude violations. One individual pilot summed up the concept when he or she wrote how the "fear of FAA punushment [sic] causes more attention to detail."

Finally, 55% of the pilots in the sample indicated they were more likely to experience an abnormal event, such as an unstabilized approach, when supervising the automation versus hand flying. This finding strengthens the argument regarding risk and automation complacency. Since the majority of respondents believe they are more likely to have an event of some sort whilst flying on automation, they may be more inclined to monitor the automation a little closer to avoid any abnormal happenings. One pilot wrote,

> I never trust the automation. My first 'glass' was the 737-300 where we were dual qualified with the -200 [737-200, a non-glass airplane]. We had no school or simulator so we learned by 'trial and error.' This resulted in a healthy distrust of the automation.

In a similar vein, a pilot described a flight that utilized a procedure new to crew. Since this was a new technique associated with considerable risk, the vigilance performance by the crew increased. They described the experience by writing,

> Just last week I flew a TA (tailored arrival) test into LAX. The automation reduced thrust to flight idle about 50 NM east of "FICKY" and remained in idle until the turn to final at LAX. Perhaps 12-15 mins of throttles in idle. Since this was a test program we were monitoring the flight VERY closely.

Another pilot described his or her level of trust in the automation by writing, "Treating the automation like a bad copilot and watching everything the airplane is doing while in 'transitional' mode." Finally, a pilot described an automation related incident he or she had as a young helicopter pilot in the Coast Guard that almost resulted in an accident with numerous fatalities. At the end of the comments the pilot concluded, "Since then, I trust nothing." Clearly, the amount of risk involved in an operation determines the vigilance performance in the population group the sample generalizes.

Similar to the individual techniques pilots utilize to cope with boredom, the pilots in this survey have developed individual strategies to cope with the automation. A pilot wrote how he or she, "hold my ID in my hand for a cockpit 'reminder' of this that I need to do." However, this concept is not limited to just remembering tasks. Several pilots described how their individual method to solving the issue of automation over-reliance and boredom involves utilizing the automation in sub-optimum ways as a means of coping. For example, one pilot wrote, "Very rarely do I let VNAV descend the plane. Will use Vertical speed or level change. Will reference VNAV TOD." Another wrote, "I prefer VSpd to VNav for descents, utilizing the green arc." Both of these pilots have found coping strategies that require an increased level of pilot involvement. Using the vertical navigation, or VNAV, feature requires monitoring the automation while it conducts the descent whereas using vertical speed involves direct pilot input to manage the flight. Numerous comments reflect how pilots have developed other unique methods to ensure proper automation performance.

Significance

The implications of this research could involve topics such as employee selection, training, and operational procedures and are not limited to the airline industry. The data suggests that individuals who are better able to find internal sources of stimulation are better at staving off boredom, commit less complacency related actions, and have fewer attention lapses. This may influence how organizations select individuals tasked with vigilance and monitoring duties especially over extended periods of low stimulation where boredom might become an issue. This is congruent with the findings by Vodanovich et al. (1997) who, after examining boredom proneness and work values, found that individuals high in boredom proneness may be better suited for work positions that offer, "…external [and] tangible rewards" (pg. 262). Low boredom prone individuals are better suited for positions that "…emphasize intrinsic reward strategies" (pg. 262). Individuals who are better able to generate internal stimulation may be better in environments that emphasize intrinsic rewards, and may perform better on vigilance and monitoring actions.

An organization's training syllabus could also reflect the findings in the data. Since the concept of risk directly affects vigilance, training courses could expose and emphasize high-risk scenarios to students along with potential consequences of improper automation related actions. One pilot in the survey lamented how the airline's training courses overvalues automation training at the expense of manual skills. He or she concluded their remarks by writing,

> Automation has made us weaker pilots. Throw a pilot in a sim [simulator] and have them do a raw datat [sic] NDB approach without the goodies and they will struggle and some will fail…And our airline doesn't train/check for this in the sims.

Another wrote very candidly how,

> The fleet tries all sorts of ridiculous solutions with no success but refuses to accept that the problem [a Boeing 757 fuel configuration issue] is the over reliance to automation and the mindset it has produced in the pilots assigned to this fleet.

Both of these individuals describe a perceived training shortcoming where the training department has not adequately emphasized the risks involved with a particular action through demonstrated practice. Since the study results have proven that the concept of risk is a significant influence on automation complacency, a powerful mitigation step might revolve around increasing the exposure individuals have to the consequences of complacent actions. The teaching methods can include awareness training through ground-based lessons or simulator scenarios based on common automation incidents.

Finally, operating procedures need to recognize the impact of boredom on vigilance and provide individuals with some latitude in finding sources of stimulation. One particular pilot summed up this issue by writing,

> Unlike what official FAA and airline policy dictates, I find it absolutely crucial to find non-aviation items to engage the mind. In over 30 years of flying I have yet to encounter a by-the-book pilot that focuses entirely on the flying that I considered safe. All it does is put you to sleep or to make [sic] you so bored that you miss the obvious.

This parallels the findings of Kishida (1977), who found that individuals would seek additional stimulation during monotonous tasks by engaging in "subsidiary behaviors."

These behaviors may have the effect of slightly reducing monitoring performance, but prove effective in reducing boredom. Therefore, policies that ban hand flying and activities such as non-essential reading could prove counterproductive. While these activities may slightly degrade monitoring performance, the benefits gained in reducing boredom and its associated problems outweigh the risks. Operational policies and training need to emphasize the risk involved with engaging in a "subsidiary behavior" at an inappropriate time, but should provide some latitude for individuals to utilize this as a coping mechanism when appropriate.

Weaknesses

One of the problems inherent in surveys of this nature is the reliance on self-assessment for some of the behaviors. Some participants may have answered questions regarding automation practices based on how they want to operate versus how they actually operate. Although question construction emphasized reporting of the deliberateness of a particular action (How often do you *deliberately*…), some of the respondents may have diluted the answers based on their perceptions of themselves.

Future Studies

Automation complacency is a topic not isolated to just aviation. Future studies will be applicable to any profession that requires a high degree of vigilance and monitoring in automated settings that are conducive to boredom. Such settings could involve safety critical activities with low margins for error such as nuclear power-plant operations, transportation of the public, and even extended duration space flight.

There are several possibilities for further research. One possible avenue could involve employee selection criteria. Since individuals who are better able to relieve boredom through internal sources commit fewer automation complacency errors, organizations can bias their selection processes and testing techniques to better identify these people. Further research can identify an optimum personality profile for individuals employed in the positions described above. Once this profile is established, additional research can help ascertain the best methods to identify and select the individuals best suited for these positions.

The issue of attention lapses is increasingly becoming prominent. Further research on employee behavior through direct observation instead of written surveys regarding how and when boredom affects cognitive failure and attention lapses will prove useful in combating many automation issues. Once the underlying criteria is adequately established, research on improved procedure and checklist designs that could help mitigate any possible attention lapse related mistakes could prove valuable in combating the problem. These procedures should emphasize Crew Resource Management principles and should incorporate research on how organizations could revise their training syllabi to give students a better awareness of the issues of boredom, attention lapses, and automation complacency.

The National Transportation Safety Board (NTSB) has identified pilot fatigue in their "MOST WANTED Transportation Safety Improvements" (National Transportation Safety

Board, 2009). Determining what effect, if any, pilot fatigue has on automation complacency and boredom is another possible area of research. One pilot wrote regarding fatigue, "Alert means good attention and/or more handflying [sic]. Fatigued means more mistakes and/or more automation."

Finally, research regarding the optimum level and type of automation interface with the operator will be beneficial in mitigating the problems associated with the changing role of the modern airline pilot. This includes researching how to transfer information to the pilot through advanced information displays, better ways to emphasize specific information, and methods of transferring situational information through non-visual means in order to provide the optimum balance between operator involvement and supervision or monitoring. As written by several pilots in the free comments section, too much automation leads to a lower level of operator involvement and decreased situational awareness of the aircraft's current state resulting in boredom. In some cases, the automation is handling events without notifying the pilot of the actions it is taking further removing the pilot from the physical operation of the flight. Yet de-automating aircraft is not feasible due to need for the advanced technology the industry requires in solving many of the future infrastructure issues. Determining the best way to present information to the operator will be crucial in addressing the complex issue of boredom and automation complacency.

APPENDICES

Appendix A

Boredom Proneness Scale

1. It is easy for me to concentrate on my activities.
2. Frequently when I am working, I find myself worrying about other things.
3. Time always seems to be passing slowly.
4. I often find myself at "loose ends," not knowing what to do.
5. I am often trapped in situations where I have to do meaningless things.
6. Having to look at someone's home movies or travel slides bores me tremendously.
7. I have projects in mind all the time, things to do.
8. I find it easy to entertain myself.
9. Many things I have to do are repetitive and monotonous.
10. It takes more stimulation to get me going than most people.
11. I get a kick out of most things I do.
12. I am seldom excited about my work.
13. In any situation I can usually find something to do or see to keep me interested.
14. Much of the time I just sit around doing nothing.
15. I am good at waiting patiently.
16. I often find myself with nothing to do – time on my hands.
17. In situations where I have to wait, such as a line or queue, I get very restless.
18. I often wake up with a new idea.
19. It would be very hard for me to find a job that is exciting enough.
20. I would like more challenging things to do in life.
21. I feel that I am working below my abilities most of the time.
22. Many people would say that I am a creative or imaginative person.
23. I have so many interests, I don't have time to do everything.
24. Among my friends, I am the one who keeps doing something the longest.
25. Unless I am doing something exciting, even dangerous, I feel half-dead and dull.
26. It takes a lot of change and variety to keep me really happy.
27. It seems that the same things are on television or the movies all the time; it's getting old.
28. When I was young, I was often in monotonous and tiresome situations.

Appendix B

Pilot Automation Complacency Practices Scale

Subscale: Complacency Distraction

1. On the majority of your flights, if ATC issues a runway change or other event that causes an FMS reprogram, how often do you *deliberately* check the automation mode (managed/VNAV PATH/open descent/level change etc.)?
2. On the majority of your flights, if ATC issues a runway change or other event that causes an FMS reprogram, how often do you *deliberately* check to ensure any altitude crossing restrictions are still programmed?
3. If you are interrupted by an event (such as a cabin issue, restroom break, etc.) how often do you *deliberately* check the aircraft's automation mode after the event?
4. When ATC issues a direct-to or a new flight plan routing or another later event that requires an FMS reprogram, how often do you *deliberately* check to ensure the NAV mode is engaged?

Subscale: Complacency Crosscheck

1. On your flights, how often do you *deliberately* check that the FMS is programmed with the correct SID, en route path, and STAR against the flight plan and/or ATC clearance?
2. When receiving a direct-to instruction or programming the FMS and *more than one waypoint with the same name is displayed*, how often do you check the position (frequency, distance LAT/LONG) of the selected waypoint to ensure it is the desired one?
3. When issued a departure or an arrival route, how often do you check to ensure the correct routing and/or altitude-crossing restrictions are programmed in the FMS against the Jeppesen or other kind of chart?
4. If ATC issues you a "direct-to" instruction, how often do you switch to the plan view to ensure the aircraft is actually proceeding to the correct waypoint?
5. When operating at an airport with parallel runways (for example Runways 35L and 35R), how often do you *deliberately* check (during the approach briefing or any other time) to ensure the correct runway and/or localizer frequency is programmed in the FMS and/or the NAV radios?

6. When inputting performance data (such as V-speeds, center of gravity, and weight information), how often do you deliberately check the data for accuracy and/or reasonableness?

Subscale: Complacency Monitoring

1. When issued an altitude crossing restriction, how often do you monitor the aircraft's computed vertical path using mental math and/or raw-data information?
2. On the majority of your flights when ATC issues an altitude crossing restriction, how often do you *deliberately* monitor your proximity to the top of descent (TOD) point and, if applicable, ensure the automation has captured the descent path?
3. For the majority of your flights when conducting flight maneuvers (starting a descent, starting a climb, leveling off from a climb/descent, engaging NAV etc.), how often do you *deliberately* monitor the aircraft's mode to ensure it is doing what is desired?
4. When issued a SID that is "navable" by the FMS (not an RNAV SID), how often do you *deliberately* back up your lateral guidance with raw-data information and/or mental computations?
5. For the majority of your flights, how often do you track the *actual* waypoint time and fuel burn against the *predicted* values during cruise?
6. On your flights, how often do you *deliberately* watch the altimeter to ensure the automation has captured the *correct* (assigned) altitude after a climb and/or descent?
7. Please list some of the strategies you use to ensure the automation is behaving correctly.

Subscale: Complacency Automation Overreliance

1. Think about the occasions where you have been "behind the airplane" with the autopilot on. For those times, how often did you turn the automation off when correcting (no autopilot or auto-thrust) versus keeping the automation on?
2. During high workload situations when FMS reprogramming is required, how often have you found yourself fixating on the FMS?
3. For the majority of your flights, how often have you found yourself focusing on the Flight Director to the exclusion of other guidance cues (LOC/GS indication, map view, RMI, etc.)?

4. Please rate how confident you are in being able to turn off all the automation (autopilot and auto-thrust) and hand fly the aircraft in any weather condition day or night should the automation start behaving unexpectedly.
    a. Very confident
    b. Confident
    c. Somewhat confident
    d. A little confident
    e. Not confident at all

Additional Survey Questions

1. Do you think you are more likely to have some kind of abnormal event (for example, an unstabilized approach or "getting behind the airplane" when flying on automation or when hand flying (no autopilot and auto-thrust)?
    a. Automation
    b. Hand Flying

2. Thinking about the majority of your flights, please rate the average level of <u>boredom</u>.

Not bored at all	A little bored	Somewhat bored	Bored	Very bored some of the time	Very bored most of the time	Very bored all the time

3. Please indicate all the methods you use to stay occupied during cruise. Check all that apply and fill in where necessary.
    a. Read books, magazines, newspapers etc.
    b. Logic puzzles (crosswords, Sudoku, etc.)
    c. Chat with fellow pilot(s)
    d. Daydream
    e. Read aviation technical manuals, FOM, etc.
    f. Actively monitor progress of flight and/or automation.
    g. Activity not listed above. Please list your personal technique.

4. Thinking about your flights, do you sometimes find yourself having *lapses of attention or situational awareness?* Do these lapses cause you *to forget to do basic activities, or things you would not ordinarily do?* If so, approximately how frequently do they occur?
    a. Less than once every 15 flights
    b. Once per 10 flights
    c. Once per 7 flights
    d. Once per 5 flights
    e. Once per 2 flights
    f. Once per flight

5. My automation philosophy is:
    a. Automation on as soon as possible after departure
    b. Automation on as long as possible when landing
    c. I hand fly as much as possible
        i. Autopilot ON after Departure

5,000 AGL	10,000 AGL	FL180	FL250	FL290	Cruise Alt

        ii. Autopilot OFF during Arrival

FL290	FL180	15,000	10,000 AGL	5,000 AGL	3,000 AGL

        iii. If the altitude is not listed, please indicate your engagement/disengagement altitude

6. If you like, please write down any comments you may have about automation, boredom, or this survey.

Appendix C

Selected evidence from NASA ASRS reports

Subscale: Complacency Distraction:

ACN 787579	WE WERE NAVIGATING TO LAX ON THE SEAVU1 ARR. INSIDE OF KONZL, UPON CROSSING KONZL SOCAL APCH CLEARED US TO DESCEND VIA THE SEAVU1 FOR THE ILS TO RWY 24R. I WAS THE NON FLYING PLT AND CHANGED THE APCH IN THE FMC FROM THE ILS RWY 25L TO THE ILS RWY 24R. AT THE TIME OF THE CHANGE THE ACFT WAS ON AUTOPLT DESCENDING VNAV PTH, WHEN THE AIRPLANE REVERTED TO VNAV SPD DURING THE RWY CHANGE. THE CAPT AND I WERE CLARIFYING THE RWY CHANGE WITH EACH OTHER AND I WAS VERIFYING THE LEGS FOR THE TRANSITION AND APCH WHEN I THEN NOTICED THE AIRPLANE REVERTED TO VNAV SPD AND DESCENDED BELOW THE CATAW RESTRICTION OF 14000 FT OR MORE. ACFT DESCENDED AND CROSSED CATAW AT 13500 FT. THERE WAS NO INQUIRY FROM ATC NOR WAS THERE ANY TA ADVISORIES OR RESOLUTION. VNAV PTH WAS REENGAGED AND THE FLT CONTINUED WITHOUT FURTHER INCIDENT. AUTOMATION, WHEN IT WORKS WELL IS A GREAT THING, BUT HAS ITS PITFALLS AS WELL. THOSE OF US WHO FLY IN AND OUT OF LAX FREQUENTLY KNOW THAT ATC WILL CHANGE RWYS ON THIS ARR AT AN INCONVENIENT AND HIGHLY DISTRACTING TIME. BOTH PLTS NEED TO MONITOR ANY CHANGES TO RTE AND VERIFY THAT THE MODIFICATION HAS NOT CHANGED THE PATH AS WELL.

ACN 782769	FLT PLAN LOADED AT GATE ALONG WITH DEST RWY (ILS 1) AND NEW ALT CONSTRAINTS PER FDC NOTAMS AND COMPANY MESSAGES. WHILE ENRTE, RECEIVED DIRECT ESL ON ELDEE 3 ARR. LATER ISSUED CROSS 35 MI W ESL AT FL290. ENTERED INTO FMS. ATIS ADVISED LDA -- DME 19. CHANGED RWY IN FMS, BUT IN DOING SO, CLRED SOME XING RESTRS ON ELDEE 3, AND REVERTED SOME RESTRS TO OLD RESTRS. ALSO, WAYPOINTS THAT MAKE UP 19 ARR (HOOOK, CAPTL, ETC) WERE NOT LOADED. ALSO SLOWED IN ANTICIPATION OF HOLDING FOR HVY RAIN AND TSTM ON FIELD. CLRED TO DSND VIA ELDEE 3, FO INSERTED AND VERIFIED. FMS WAS BEHIND CALCULATING XING AT DRUZZ (15000 FT), AND SIMULTANEOUSLY FO ANNOUNCED HE WAS 'REFRESHING' THE XING RESTR AT DRUZZ. CAPT SCROLLED VERT SPD TO MAKE DRUZZ AT 15000 FT, AND COMMANDED 8000 FT IN THE ALT WINDOW, THE LOWEST ALT ON THE ARR. CREW BECAME DISTR BY NEW FIXES AND RESETTING ALT RESTRS, AND ACFT DSNDED BELOW 15000 FT AFTER DRUZZ. FO NOTICED AND CALLED OUT. CAPT DISCONNECTED AUTOPLT AND BEGAN CLB. FO CALLED ATC TO ADVISE. ATC STATED, 'MAINTAIN 13000 FT, DSND VIA ELDEE 3, YOU'RE FINE.' FLT COMPLETED WITHOUT INCIDENT. NO TFC CONFLICTS.

ACN789688	ATC CHANGED ARR RWYS WHILE WE WERE DSNDING ON THE STAR. WE WERE BOTH CONSUMED IN REPROGRAMMING THE FMC AND FAILED TO NOTICE THAT THE AUTOPILOT HAD DEFAULTED TO V/S. BEFORE EITHER OF US NOTICED WE HAD DSNDED BELOW A CROSSING RESTR. FOLLOW SOP WHEN REPROGRAMMING MED INFORMATION, ALWAYS HAVE THE MONITORING PLT MONITORING THE ACFT ALTITUDE AND POSITION.

ACN 778170	THIS FMS ACFT FLEW A FLAWLESS VNAV DSCNT FROM FL370 NON-STOP TO IDLE TO 11000 FT. I HAD PROGRAMMED THE FMS TO CROSS ZZZZZ AT 11000 FT AND 310 KTS. THE ACFT CAPTURED 11000 FT AND LEVELED OFF. THIS WAS FOLLOWED IMMEDIATELY BY THE SPD BEING DRIVEN TO 224 KTS WITH THE THROTTLES RETARDING. IN THE INITIAL CONFUSION I SELECTED SPD SELECT AND ROTATED THE SPD BACK TO 310 KTS. A VERY BRIEF DISCUSSION ENSUED AS TO WHY IT DID THAT. FO PULLED UP THE DSCNT PAGE AND VERIFIED THAT IT SAID ZZZZZ AT 11000 FT AND 310 KTS. MY FO THEN CALLED OUT 'ALT!' WE HAD DSNDED TO 10700 FT. I DISENGAGED THE AUTOPLT AND CLBED BACK TO 11000 FT. ATC DID NOT MENTION IT. ALL I CAN THINK THAT HAPPENED WAS THAT WHEN I SELECTED SPD SELECT WE STILL HAD SOME RESIDUAL DOWN VVI AND WERE NOT COMPLETELY IN FMS ALT HOLD THAT CREATED THE INSIDIOUS DSCNT. HAD I SELECTED ALT HOLD PRIOR TO SPD SELECT, AS WE DO EXITING PERFORMANCE IN ANY OTHER AIRPLANES, THIS WOULDN'T HAVE HAPPENED. HOWEVER, I DON'T UNDERSTAND WHY IT FLEW SUCH A PERFECT DSCNT, LEVELED OFF WITH INSTRUCTIONS TO CROSS ZZZZZ AT 11000 FT AND 310 KTS THEN SLOWED THE SPD TO 224 KTS. WHY NOT 240 KTS? AND WHY WOULD IT DO THAT WITHOUT CAPTURED AT THE 11000 FT ALT? FROM A HUMAN FACTORS POINT OF VIEW, IT WAS VERY LATE (FOR ME), DARK, AND THE 'SURPRISE' DISTR OF AN UNCOMMANDED SPD REDUCTION TO UNIQUE SPD (224 KTS VERSUS 240 KTS) WERE JUST ENOUGH TO KEEP ME FROM CATCHING THE SOLID HARD 11000 FT LEVELOFF. SUPPLEMENTAL INFO FROM ACN 778175: REFLECTING BACK ON THE INCIDENT, I WOULD VENTURE TO GUESS THAT THE CAPT MIGHT HAVE PRESSED 'SPD SELECT' AS THE AUTOPLT WAS COMPLETING ITS ALT CAPTURE AT 11000 FT, THUS PUTTING THE ACFT INTO A VERT SPD DSCNT JUST AS IT APCHED 11000 FT. WE BOTH WERE TAKEN BY SURPRISE AS TO HOW IT GOT INTO VERT SPD BUT, REGARDLESS OF THE CAUSE, THE MOST IMPORTANT LESSON LEARNED IS THAT YOU SIMPLY CANNOT TURN YOUR BACK ON THE ACFT AND THE OP OF ITS AUTOMATION EVEN FOR A BRIEF MOMENT.

Subscale: Complacency Crosscheck

ACN 767359	ILS FREQ WAS WRONG ON APCH INTO BOS 109.9 INDICATED FOR 110.3 WAS SUPPOSED TO BE INDICATED FOR ILS APCH INTO RWY 4R FOR BOS. PROB OCCURRED ON APCH WITH ILS AND GS ARMED. WRONG FREQ NOTICED WITH MOMENTARY INDICATION OF PURPLE LOC INTERCEPT INDICATED. PLT SWITCHED BACK TO NAV BUT BY THE TIME FIELD WAS IN SIGHT. TWR INDICATED ACFT WAS BELOW GS AT MILTT BUT ACFT WAS LEVEL AND TRACKING TO CROSS MILTT AT RECOMMENDED ALT. ILS FREQ 109.9 HAPPENS TO COINCIDE WITH DCA 18 WHICH WAS ACFT DEP POINT. CALLBACK CONVERSATION WITH RPTR REVEALED THE FOLLOWING INFO: THE PROBLEM WAS APPARENTLY CORRECTED BY MAINTENANCE WITH A SOFTWARE RELOAD INTO THE FMGC. MORE DILIGENCE DURING THE APPROACH BRIEFING WOULD HAVE CAUGHT THIS DISCREPANCY.

ACN 778731	FMS RWY CHANGE FROM RWY 26R TO RWY 27L ACCOMPLISHED, BUT LOCALIZER FREQUENCY CHANGE WAS NOT. ON 240 DEG VECTOR TO LOCALIZER RWY 27L, ACFT INTERCEPTED LOCALIZER RWY 26R. IMMEDIATE CORRECTION MADE TO LOCALIZER RWY 27L. CLRNC FOR RWY 27L CONFIRMED WITH ATC. SUBSEQUENTLY CLRED VISUAL RWY 27L. NO CONFLICT OCCURRED.

ACN 584168	AT ROTATION ON TKOF IN NGO NOTICED A BUMP THAT FELT LIKE IT CAME FROM THE GEAR AREA. WE LOOKED AT THE EICAS GEAR SYNOPTIC PAGE TO SEE IF WE HAD BLOWN A TIRE ALONG WITH CHKING ALL OTHER SYS. EVERYTHING CHKED NORMAL. DURING THIS TIME WE GOT SEVERAL INSUFFICIENT FUEL MESSAGES, HOWEVER DISMISSED THEM BECAUSE THE WINDS HAD NOT BEEN COMPLETELY PROGRAMMED IN THE FMC. AFTER WE GOT TO ALT 33000 FT THE FO BROUGHT TO MY ATTN THAT PROGRESS PAGE 2 CALCULATED FUEL WAS COMING UP AT APPROX 68000 LBS AND NO TOTAL FUEL WAS INDICATED ON 6L PROGRESS PAGE 2. I SENT A MESSAGE TO DISPATCH AND MAINT CTL TO SEE IF THEY MIGHT HAVE AN IDEA HOW TO CORRECT THE PROB. SHORTLY AFTER WE DISCOVERED THE WRONG INFO ON THE CALCULATED FUEL BLOCK ON THE PERFORMANCE PAGE AND CORRECTED IT. THIS ALLEVIATED THE PROB. AT THIS POINT WE BECAME MORE CONCERNED ABOUT A POSSIBLE TAIL STRIKE, KNOWING OUR TKOF NUMBERS WERE WAY OFF. THE FO AND I DISCUSSED THIS AND WHAT ACTION, IF ANY, SHOULD BE TAKEN. AFTER CHKING ALL SYS THERE WERE STILL NO INDICATIONS OF ANYTHING ABNORMAL. AFTER DISCUSSING THIS WITH THE FO, I DECIDED TO WAKE THE CAPT, THE RELIEF PLT, TO GET HIS INPUT, WHICH WAS TO CONTINUE. I AGREED, THINKING THAT WE SIMPLY HAD HIT A BUMP ON THE RWY. AFTER ARRIVING IN DTW, WE INSPECTED THE TAIL SECTION AND CONFIRMED THERE HAD BEEN A TAIL STRIKE. CALLBACK CONVERSATION WITH RPTR REVEALED THE FOLLOWING INFO: RPTR ADVISED THAT THIS INCIDENT WAS THE SUBJECT OF AN INVESTIGATION BY THE ACR AND THE FAA. NO PROBABLE CAUSE SHORT OF A FINDING OF LIKELY PLT ERROR IN PROGRAMMING THE PERFORMANCE INITIALIZATION PAGE WAS REACHED. THE ASSUMPTION IS THAT SOMEHOW AN IMPROPER MANUAL ENTRY WAS MADE TO THE FUEL ON BOARD LINE OF THE PERFORMANCE INITIALIZATION PAGE WHICH OVERRODE THE AUTOMATIC FMC CALCULATION WHICH NORMALLY IS UTILIZED BY THE FMC FOR DEVELOPMENT OF THE TKOF V-SPDS. THE SPECIFICS OF HOW THIS OCCURRED WAS UNRESOLVED. THE RPTR AND THE ANALYST AGREED THE LACK OF AN INDEPENDENT CALCULATION METHOD FOR COMPARISON TO THE FMC DEVELOPED SPDS WAS INSTRUMENTAL IN ALLOWING THE ERROR TO GO UNDISCOVERED.

ACN 784091	WE WERE FILED SJC.LOUPE1.LIN FOR OUR FLT TO ZZZ. THE FMGC WAS CHKED AND VERIFIED WITH THE PAPER CHART. CLBING OUT OF SJC, WE FOLLOWED THE LOUPE1 PROC BY TURNING TO A HDG OF 120 DEGS AT 1.8 DME FROM SJC. WHILE ON THAT HDG, DEP TOLD US TO GO DIRECT TO SJC AND RESUME THE DEP. I PUNCHED IN DIRECT TO SJC. DID NOT NOTICE THAT 2 WAYPOINTS HAD DROPPED OUT. SO AFTER THE SJC VOR WE WENT TO LIN INSTEAD OF PROCEEDING TO DYBLO THEN LIN. ATC NOTICED THE DEV AND INQUIRED WHERE WE WERE GOING. THAT IS WHEN WE NOTICED THE ERROR IN THE FMGC. DEP CTLR THEN CLRED US DIRECT TO LIN. THERE WAS NO TFC CONFLICT. WE LATER CONFIRMED THAT WE BOTH CHKED THE DEP PRIOR TO TKOF AND IT WAS CORRECT IN THE FMGC. NOT SURE WHY THE DEP WAYPOINTS DROPPED OUT, BUT WILL REMEMBER TO ALWAYS DOUBLECHK THE BOX.

Subscale: Complacency Monitoring

ACN 755370	SHORTLY AFTER THE TOP OF CLB AT FL300, THE STICK SHAKER ACTIVATED. AT FIRST, I THOUGHT THAT IT MIGHT BE AN ERRONEOUS ACTIVATION, BECAUSE THE ACFT ATTITUDE LOOKED NORMAL, WE WERE IN LEVEL FLT, AND I HAD NOT NOTICED ANY CHANGE IN ACFT WIND NOISE, PITCH ANGLE, OR TRIM. I NOTED THAT MY AIRSPD WAS APPROX 220 KIAS. I CALLED OUT TO THE FO, WHO WAS PF, THAT IT MIGHT BE A FALSE STICK SHAKER. I THEN NOTED HIS AIRSPD, WHICH WAS ALSO VERY LOW. I CALLED OUT LOWER THE NOSE, BUT BY THIS TIME HE HAD ALREADY ADVANCED THE THROTTLES, DISCONNECTED THE AUTOPLT AND BEGUN A DSCNT. WE ALSO HAD INOP EEC'S TO CONSIDER. I INFORMED BRASILIA CTR OF THE SITUATION, AND THEY CLRED US INTO AIRSPACE FROM 280 TO 300. WE REGAINED AIRSPD AND RETURNED TO NORMAL CRUISE. OUR LOWEST ALT WAS APPROX 28700 FT. AS WE WERE DISCUSSING WHAT MIGHT HAVE HAPPENED, THE AUTOTHROTTLES STARTED TO PULL THE THROTTLES BACK FOR NO REASON. AT THIS POINT, WE DISCONNECTED THEM. THIS ACFT HAD A RECENT HISTORY OF AUTOTHROTTLE MALFUNCTIONS, MOST OF WHICH DESCRIBED UNCOMMANDED DISCONNECT. HOWEVER, THERE WAS ONE DESCRIBING AN AUTOTHROTTLE MALFUNCTION LIKE WE HAD, BUT I WAS NOT AWARE OF IT BECAUSE IT WAS FURTHER BACK THAN I HAD REVIEWED. I AM GUESSING THAT THE AUTOTHROTTLES HAD RETARDED FROM CLB TO A BELOW CRUISE PWR SETTING, AND IN THE DARK WE DID NOT DETECT THE THROTTLE POS. AT ABOUT THIS TIME, I WAS PREPARING MY CHARTS FOR POS RPTS, AND THE FO WAS EDITING THE FMS. ALTHOUGH I ALWAYS ATTEMPT TO MAKE SURE ONLY 1 PLT IS HEADS DOWN AT A TIME, I CANNOT SAY FOR SURE WHAT HAPPENED IN THIS CASE. IN RETROSPECT, I PROBABLY SHOULD NOT HAVE ACCEPTED THIS TRIP, WHICH STARTED OUT IN ZZZ1 AND REQUIRED ME TO DEADHEAD ON VERY SHORT NOTICE TO ZZZ2 AND FLY THE ALL-NIGHTER TO SBGL. I WAS AWAKE FOR ALMOST 30 HRS, FOLLOWED BY A 34 HR LAYOVER AND ANOTHER ALL-NIGHTER, DURING WHICH THIS EVENT HAPPENED. OBVIOUSLY, I WAS NOT PERFORMING AT MY BEST.

ACN 711446	FLYING THE CHANNEL 1 DEP, VENTURA TRANSITION FROM SNA. THE RTE WAS ENTERED CORRECTLY. I ALSO CHKED THE FIRST 3 LEGS BUT DON'T REMEMBER LOOKING AT THE FOLLOWING ONES. AFTER TKOF ON THE 175 DEG HDG AND IN A CLEAN CONFIGN, I ENGAGED THE AUTOPLT WITH LNAV ENGAGED. WE WERE CLBING TO ONLY ABOUT 6000 FT. AFTER AWHILE THE AUTOPLT TURNED THE ACFT. THE MAP AND FLT DIRECTORS WERE CTRED. SHORTLY THEREAFTER WE NOTICED AND ATC ASKED WHERE WE WERE GOING. WE WERE GOING DIRECTLY TOWARDS SXC ON A 230 DEG HDG. WE HAD NOT DONE THE 200 DEG HDG TO THE 084 DEG RADIAL. ATC TOLD US TO GO DIRECTLY TO SXC. NO FURTHER COMMENTS FROM ATC. WE CHKED THE FMC AND IT SHOWED WE HAD CHANNEL 1 DEP AND THE VENTURA TRANSITION AS ACTIVE. WE CHKED AND THE DEP IN THE FMC HAD THE 200 DEG HDG AND 084 DEG RADIAL IN THE LEGS PAGE. THE FO SAID HE HAD SEEN ALL OF THE LEGS PRESENT BEFORE THE TKOF. WE HAD NOT GONE DIRECTLY TO A FIX, NOR CLOSED ANY DISCONTINUITIES. I SHOULD ALWAYS COMPARE THE ACFT'S ACTUAL FLT PATH TO THE 10-3A PAGE. SAFETY SHOULD VERIFY THAT THE DEP WILL BE FLOWN CORRECTLY WITH THE CURRENT DATABASE LOADED IN THE ACFT FLEET. CALLBACK CONVERSATION WITH RPTR REVEALED THE FOLLOWING INFO: THE RPTR STILL DOES NOT KNOW WHY THE FMC WENT DIRECT TO SXC INSTEAD OF FOLLOWING THE CHANL1. UPON ARR AT DEST THE CREW LOADED THE RTE THEY HAD JUST FLOWN, AND ALL THE POINTS LOADED CORRECTLY. THE RPTR HAS NOT BEEN BACK TO SNA SINCE THE INCIDENT.

ACN 693397	AT FL380 NEARING TOP OF DSCNT FOR XING BEARZ INTXN AT 11000 FT PRESET ON LEGS PAGE OF FMC, WE WERE GIVEN A XING RESTR OF 35 MI SE OF FWA AT FL340. I MISKEYED THE XING ON FIRST ATTEMPT IN FMC AND THEN BY THE TIME IT WAS PROPERLY ENTERED WE WERE AT THE NEW DSCNT POINT. BECAUSE OF BRAIN SLIPPAGE, AFTER WE HAD VNAV SPD AND HAD STARTED DOWN, I TRIED TO INSTALL THE 320 KT SPD REQUESTED ON THE CRUISE PAGE. THIS MESSED UP THE PROFILE AND WE WENT HIGH ON THE PROFILE WHILE THE FMC RECOMPUTED. BY THE TIME I STARTED TO CORRECT FOR THE HIGH ON PROFILE CONDITION IT WAS TOO LATE TO MAKE 35 MI SE FWA XING AT FL340. WE WERE AT APPROX FL347 AT THE XING. WE WERE CLOSE ENOUGH I THOUGHT THAT WE DID NOT NEED TO TELL ATC. ATC'S ONLY COMMENT WAS, 'WHEN YOU'RE LEVEL FL340, GO DIRECT OXI.' SUPPLEMENTAL INFO FROM ACN 693398: WHILE IN CRUISE AT FL380 WE WERE ISSUED AN ENRTE DSCNT TO CROSS 35 MI SE OF FWA AT FL340. WE STARTED THE DSCNT AND CHKED IN WITH ZID AT THE SAME TIME. THE ACFT WAS ON AUTOPLT AND DSNDING VIA THE VNAV PATH. AFTER I, AS THE PNF, VERIFIED THE ACFT WAS FOLLOWING THE PATH PROPERLY AT THE BEGINNING OF THE DSCNT, I DIVERTED MY ATTN TO OTHER AREAS OF THE COCKPIT (REQUESTING WX, CHKING LNDG WTS, ETC) AND DID NOT LOOK BACK AT THE PATH UNTIL THE ACFT WAS APCHING THE 35 MI FIX. AT THIS POINT I NOTICED THE PATH INDICATOR WAS MISSING FROM THE DISPLAY AND IT WAS OBVIOUS THAT WE WERE GOING TO MISS THE XING RESTR BY SEVERAL HUNDRED FT. WE CROSSED THE 35 MI FIX AT FL346 (600 FT HIGH). AFTER WE LEVELED I ASKED THE CAPT WHY THE AIRPLANE CAME OFF PATH(AS I WAS HEADS DOWN AND DIDN'T SEE WHAT HAPPENED) AND WAS INFORMED THAT HE CHANGED THE CRUISE ALT IN THE CRUISE PAGE TO FL340 WHICH DELETES THE VNAV PATH FOR ANY ASSIGNMENTS AT OR ABOVE THAT. I SHOULD HAVE NEVER LET MY ATTN GET DIVERTED WHILE IN THE DSCNT FOR A RESTR LIKE THAT. I WAS LULLED INTO A FALSE SENSE OF SECURITY BECAUSE THE DSCNT WAS SO SHORT (ONLY 4000 FT WHICH ON PATH TAKES ABOUT 2 MINS) AND BECAUSE THE VNAV PATH WORKED SO WELL ONCE IT STARTED THE DSCNT I FALSELY ASSUMED IT WOULD WORK AND IT WOULD NOT BE CHANGED (WHICH IT WAS). I ALSO SHOULD HAVE SEEN THE CAPT TYPING ON THE FMC BUT FOR SOME REASON EITHER DIDN'T OR IT DIDN'T REGISTER THAT HE MIGHT BE CHANGING SOMETHING WHICH WOULD AFFECT OUR XING.

ACN 685324	SHEAD DEP TO OAK, FO FLYING, AUTOPLT ENGAGED COMMAND MODE. ASSIGNED 11000 FT, DIALED IN MODE SELECTOR WINDOW. OUT OF 11000 FT, FO REDUCED PITCH TO APPROX 500 FPM TO ACCELERATE TO FMC CLB SPD. AT ABOUT 300 KTS AND 10300 FT WE GOT MODERATE CHOP. FO INCREASED PITCH TO SLOW, PULLING UP TO APPROX 3000+ FPM. ALTHOUGH THE AFDS WENT TO ALT ACQUIRE, I KNEW (THE HGS WAS MY FIRST INDICATION, I'M AN HGS FLYER) THE AUTOPLT WOULD OVERSHOOT THE LEVELOFF. I DISCONNECTED THE AUTOPLT (APPROX 10600 FT) AND MANUALLY LEVELED OFF USING THE HGS AND RETARDING THE THRUST LEVERS. WE TOPPED OUT BTWN 11300 AND 11400 FT BEFORE LEVELING AT 11000. THE DEP CTLR HAD ISSUED US G-4 TFC AT 10 O'CLOCK POS, 12500, DSNDING ON THE ARR, AND ASKED US IF WE WERE LEVELING AT 11000 FT. I TOLD HIM THE AUTOPLT HAD OVERSHOT THE LEVELOFF, BUT WE WERE NOW LEVEL AT 11000. WE DID NOT RECEIVE A TCAS TA OR RA AT ANY TIME. LEVEL AT 11000 FT, I GAVE THE ACFT BACK TO THE FO, HE RE-ENGAGED THE AUTOPLT AND WE CONTINUED TO OAK. AT CRUISE I DISCUSSED THE EVENT WITH THE FO, EXPLAINING THAT THE OVERSHOOT WAS NOT AN AUTOPLT MALFUNCTION, BUT THAT HE HAD 'ASKED TOO MUCH' OF THE AUTOPLT WHEN HE INCREASED THE RATE OF CLB SO MUCH SO CLOSE TO LEVELOFF ALT, ESPECIALLY WITHOUT A LARGE PWR REDUCTION. I APOLOGIZED FOR TAKING THE ACFT SO SUDDENLY AND DISCONNECTING THE AUTOPLT, BUT EXPLAINED THAT THE HGS GAVE ME THE CLUE THAT THE AUTOPLT WAS NOT GOING TO 'HACK' THE LEVELOFF BEFORE HE REALIZED THAT IT WAS GOING TO OVERSHOOT. THE HGS IS GOLDEN FOR SITUATIONAL AWARENESS. THE TIME FROM THE FO'S INITIAL PULL-UP IN RESPONSE TO THE CHOP, TO MY LEVELING MANUALLY AT 11000 FT WAS QUITE SHORT.

Subscale: Complacency Automation Over-reliance

ACN 784827	FO OF A319 MAKES NUMEROUS AUTOFLT MANAGEMENT AND MENTAL ERRORS ON APCH CULMINATING IN MANUALLY DESCENDING WHILE THE AUTOTHRUST SYSTEM WENT TO CLIMB THRUST AS PROGRAMMED. FLAP OVERSPEED RESULTS. [Note: This is the ASRS synopsis. The pilot narrative is rather lengthy]

ACN 660940	I WAS THE FO ON THIS FLT. WE WERE ASSIGNED THE LOOP 4 DEP OUT OF LAX. ALL WAS FINE UNTIL ABOUT 2000 FT AS WE HAD JUST MADE OUR TURN TO 235 DEGS. THEN THE CTLR TOLD US TO COMPLY WITH THE ALT RESTRS. SINCE WE WERE IN A RUSH TO DEPART DUE TO A WHEELS UP TIME, THE CAPT NEVER BRIEFED THE DEP (FIRST MISTAKE). HE WAS HAND FLYING, SO I WORKED THE FCP. I GAVE THE CAPT HDG HOLD FOR 235 DEGS. WHEN THE CTLR GAVE US THE VERT RESTR, THE CAPT PRESSED NAV ON THE FCP. THE NORMAL PROC IS TO ASK THE PNF (ME) TO DO THIS. SO THIS CAUGHT ME OFF GUARD. THE CAPT SAID SOMETHING ABOUT TURNING TO MAKE THE ALT RESTR AND ENGAGED THE AUTOPLT ALSO, TURNING THE VERT SPD WHEEL (NOTICED LATER, THE WRONG WAY). I WAS LOOKING AT MY DEP PLATE OR OUTSIDE AND DIDN'T NOTICE AT FIRST (DISTR), BUT THE ACFT WENT INTO APCH MODE AND THE AUTOTHROTTLES CAME BACK INSTEAD OF STAYING AT CLB PWR. AS I TRIED TO FIGURE THIS OUT, THE CAPT SAID HE WOULD LEAVE THE SLATS OUT AND HE GOT SLOW (APPROX 200-230 KTS). HE SAID TO MAKE THE CLB RESTR (10000 FT OVER LAX). MEANWHILE, I WOULD TURN OFF THE AUTOTHROTTLES AND PUSH UP THE PWR, AND HE WOULD DISCONNECT AND RECONNECT THE AUTOPLT SEVERAL TIMES. I TOLD HIM IF HE WOULD MAINTAIN A CLB AT 230 KTS, WE WOULD MAKE THE RESTR ACCORDING TO THE FMS VERT PROFILE. YET BECAUSE THE FLT DIRECTOR WAS IN A DSCNT, HE KEPT LOWERING THE NOSE. I KEPT TELLING HIM TO KEEP THE NOSE UP AND ALSO FIDDLED WITH THE THROTTLES AS THEY KEPT COMING BACK. THIS WAS BASICALLY A MESS AS WE TURNED INBOUND TO LAX. I MADE SURE HE KEPT THE AUTOPLT OFF AS WE GOT CLOSER TO LAX. I DON'T THINK WE MADE 10000 FT EXACTLY AT LAX, BUT IT WAS CLOSE. THE CTLR WAS MORE CONCERNED WITH THE SLOW SPD WITH ACFT BEHIND US. EVENTUALLY WE GOT BACK TO CLB MODE AND A FEW MINS LATER I REALIZED WE HAD SPUN THE VERT SPD WHEEL THE WRONG WAY. EITHER THIS, OR GOING TO NAV ON A MANUAL LEG IN FMS HAD CAUSED THE FMS TO GO INTO APCH MODE. IN HINDSIGHT, I SHOULD HAVE SLOWED DOWN THE TIME ON GND TO BRIEF (THE CAPT WAS MORE CONCERNED EARLIER WITH GETTING CATERING BEFORE LAUNCH THAN WITH THE WHEELS UP TIME). ALSO, I SHOULD HAVE RECOGNIZED HIS INCORRECT INPUTS TO THE FCP, AND BEEN MORE ASSERTIVE IN EITHER HANDLING THE FCP OR TAKING THE ACFT FROM HIM AS HE WAS CLRLY MIXED UP. WE LET THE AUTOMATION GET THE BETTER OF US, AND SHOULD HAVE TRANSITIONED TO BASIC FLYING SKILLS.

ACN 775962	WHILE ARRIVING ON HONIE ARR, WAS GIVEN VERY LATE DSCNT TO 14000 FT. THEN WAS SLOWED TO 280 KTS, MAKING XING RESTR AT HONIE IMPOSSIBLE. MISSED XING BY AT LEAST 5 MI. THEN WAS GIVEN NEW DSCNT TO 12000 FT. SET UP NEW CRUISE ALT IN FMS AND PLANNED FOR THE HONIE VNAV ARR WITH A RWY 27L ILS. VERY CLOSE TO FOGOG, ATC GAVE US 11000 FT WITH A RESTR TO STILL CROSS FOGOG AT 11000 FT AND THEN CONTINUE DSCNT ALONG HONIE ARR. PLUGGED IN A NEW CRUISE ALT AND STARTED DSCNT TO 11000 FT. HAD 4000 FT IN THE ALT WINDOW AS THIS WAS THE FINAL ALT ALONG THE ARR. TRIED TO PLUG IN 210/110 AT FOGOG. FMS WOULD NOT ACCEPT THIS. I SAW TOP OF DSCNT WAS PRIOR TO FOGOG. TRIED SEVERAL TIMES, SEEMS I THOUGHT I HAD MADE A TYPO. ACFT STARTED A DSCNT APPROX 2 MI PRIOR TO FOGOG. AT 10600 FT, ATC MADE STRONG SUGGESTION WE WERE NOT AT FOGOG AND TO RETURN TO 11000 FT. CLICKED OFF AUTOPLT, PULLED BACK AND PUSHED THROTTLES UP, RETURNED TO 11000 FT. I SIMULTANEOUSLY HAD ATC YELLING AT US, TCAS GOING OFF, AUTOPLT WARNING, AND FO DEBATING ATC. CALLED ATC ON THE GND, HAD A VERY GOOD CONVERSATION WITH SEVERAL CTLRS. ATC WAS GOOD ENOUGH TO TELL ME THERE HAD NOT BEEN A LOSS OF SEPARATION. IT SEEMS ON THE SURFACE THAT MAKING THE XING RESTR IS SIMPLE ENOUGH. HOWEVER, MAKING THE FMS MAKE THE CHANGE THAT CLOSE IN TO THE FIX AND THEN FLY IN VNAV FOR THE REST OF THE ARR IS, WELL, VERY CHALLENGING TO SAY THE VERY LEAST. IT SEEMS EVEN THOUGH I NOTICED THE TOP OF DSCNT WAS PRIOR TO FOGOG, I FIGURED I COULD GET THE RESTR TYPED INTO THE FMS IN TIME. WHEN THE FMS DIDN'T ACCEPT MY INPUTS, I GOT OVERLY FOCUSED ON WHAT I MIGHT BE DOING WRONG THAT IT WOULDN'T ACCEPT MY INPUT. IN THE FUTURE, I RATHER IMAGINE I'M GOING TO FLY ARRS IN THE INDICATED AIRSPD MODE.

ACN 530651	AUTOTHROTTLES MALFUNCTIONED ON TKOF ROLL, RWY 18L CVG. TKOF WAS CONTINUOUS. IT WAS THE COPLT'S LEG, AND HE IS NEW (LESS THAN 2 MONTHS) ON THE ACFT. CLEAN-UP WAS NORMAL. I MADE 1 ATTEMPT TO RESET AUTOTHROTTLE SYS -- IT DID NOT RESET. TWR PASSED US TO APCH AS WE PASSED 5000 FT FOR 6000 FT INITIAL LEVELOFF. COPLT BEGAN LEVELOFF FOR 6000 FT AND FAILED TO REDUCE PWR. HE LATER STATED THAT THIS WAS THE FIRST TIME HE'D FLOWN WITHOUT AUTOTHROTTLE EXCEPT ON APCH. AT THE MOMENT, I NOTICED OUR SPD GOING THROUGH 280 KTS FAST APCH WAS GIVING US A CLB TO 8000 FT. I HEARD AND BELIEVE I REPEATED 9000 FT. I SET 9000 FT IN THE ALT WINDOW. WE WERE ON THE ROCKET DEP THAT HAD A HARD LEVELOFF AT 6000 FT. COPLT FOLLOWED COMMAND BARS FOR LEVELOFF, EVEN THOUGH WE WERE CLRED HIGHER. I WENT HEADS DOWN TO DELETE 6000 FT RESTR IN THE FMS. HE PULLED NOSE UP TO HELP BLEED SPD, NOW OVER 300 KTS. WE CLBED RAPIDLY TOWARD 9000 FT. ALL WAS WELL, SPD RETURNING TO NORMAL. AT 8400 FT DEP CALLED AND SAID 'ACR X, I SAID 8000 FT !' I REPEATED '8000 FT?' HE SAID '8000 FT.' COPLT PUSHED OVER TO RETURN TO 8000 FT. I SAW 8600-8700 FT BEFORE WE STARTED DOWN. AS WE REACHED 8700 FT, ABOUT TO LEVEL OFF, DEP CLRED US TO 13000 FT. HE MADE NO MENTION OF CONFLICTS -- NO TARGETS ON TCASII.

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