THE IMPACT OF TRANSITION TRAINING ON ADAPTING TO TECHNICALLY ADVANCED AIRCRAFT AT REGIONAL AIRLINES: PERCEPTIONS OF PILOTS AND INSTRUCTOR PILOTS

By

JOHN CARL DI RENZO JR.

Bachelor of Arts in Psychology
Memphis State University
Memphis, TN
1982

Master of Arts in Public Administration
Auburn University
Montgomery, AL
1995

Master of Science in Information Systems
Hawaii Pacific University
Honolulu, HI
1998

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Graduate College of the
Oklahoma State University
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Dissertation Approved:

Dr. Timm J. Bliss

Dissertation Adviser

Dr. Fredrick D. Hansen

Dr. Mary Kutz

Dr. Anthony E. Brown

Dr. A. Gordon Emslie

Dean of the Graduate College

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CHAPTER I

INTRODUCTION

Attempts to instrument aircraft for communications, navigation and for flight without reference to the natural horizon began in earnest in the 1920's (Bilstein, 2001). Since that time, great advances have been made in aviation related technologies. Where once a lack of aircraft systems was the limiting factor for flight into Instrument Meteorological Conditions (IMC), now advanced aviation technologies found in Technically Advanced Aircraft (TAA) present a significant challenge to pilots and crews trying to assimilate and effectively use ever increasing amounts of information.

Today, technologies such as *Glass Cockpits* in technically advanced aircraft are complex and can be difficult to learn and use. These technologies provide ever increasing levels of weather, navigation, obstruction, aircraft systems and other information to the flight deck. Increasingly pilots need both automation skills as well as piloting skills. A modest number of studies primarily conducted at aviation universities such as Embry Riddle University, Middle Tennessee State University and The University of North Dakota have begun to conduct research to determine how to best train pilots to fly TAA (FAA Education and Research, 2006). This training represents a significant departure from traditional training methods.

A more significant body of knowledge, related to technically advanced aircraft, has focused on human factors research. This research generally extols the benefits that automation provides by reducing the human workload in the cockpit, but at the same time cautions against the disadvantage of reducing the human role in systems management/ control and problem solving (i.e. the tendency to over rely upon technology) (Miller & Parasuraman, 2007). Additionally, much of this research has indicated that while the additional information found in TAA is intended to provide increased Situational Awareness (SA) and dramatically increase pilot/crew ability to understand the status of the aircraft at any given moment in time and space; pilots/crews often do not understand the status of advanced technology systems (mode awareness) and/or status of the aircraft (situational awareness) (Chappell, Crowder, Mitchell and Govindaraj, 1997). Further, automation does not always guarantee positive aircraft control and in some situations, can quickly cause distractions and/or information overload the pilot(s) (FAAST, 2008).

Debate about how to best train future airline transport pilots abounds and new concepts regarding the role of active learning in scenario based exercises are beginning to supplant more traditional approaches to flight training (FAA Education and Research, 2006). These new aviation technologies are pervasive and can be found in most aircraft ranging from large commercial aircraft to small General Aviation (GA) aircraft commonly used for initial flight training. Furthermore, the pace of technological advancement is increasing and will continue to present significant challenges for the aviation community (FAA Education and Research, 2006).

Given the proliferation of technically advanced aircraft, pilot training has become a point of critical interest. How should new pilots be trained and what is the effectiveness of that training as they move from the flight school to airline cockpits? Additionally, what is the role of traditional analog instrumentation training verses digital instrumentation training? Is training on analog instrumentation, digital instrumentation or a combination of both best for transition to technically advanced aircraft? Do pilots trained exclusively on traditional instruments experience more difficulty transitioning to technically advanced aircraft as compared to those pilots trained on a combination of analog and digital instrumentation, or as compared to those pilots exclusively trained on digital instrumentation?

For purposes of this study, analog instrumentation, or traditional instrumentation, includes mechanical instruments driven by the Pitot static system, and vacuum pump driven and/or electrically driven gyroscopes.

Figure 1. Steam Gauge Instruments.

For purposes of this study, digital instrumentation found in Technically Advanced Aircraft (TAA) includes computer based or automated instrumentation presented on electronic displays.

Figure 2. CRJ-200 Glass Cockpit in a Technically Advanced Aircraft Commonly (TAA) Used for Regional Airline Training.

This investigation focuses on determining the varied types of training currently available to newly trained pilots in regional airline positions and how these pilots perceive the effectiveness of that training. Additionally, a qualitative component of this study considered Instructor Pilots (IP) perceived views about the role of student pilot previous training and the impact of that training when transitioning to TAA in regional airlines.

Statement of the Problem

The problem addressed in this study is to identify pilot and instructor pilot perceptions of their ability to learn and use advanced aviation technology. These systems are complex and a pilot must possess a significant degree of familiarity with automated systems. This new digital age presents many challenges for both seasoned pilots as well as for those who are new to aviation. A great deal of research has been done in the area of human factors research to determine how pilots interface with complex aviation systems. However, more limited research has been done about how pilots are trained before entering service with the airlines. Much needs to be known about how current training of new pilots/crews prepares them to adapt to technically advanced cockpits in more sophisticated commercial aircraft.

The following hypothesis was set for this investigation:

H_0 The type of instrumentation training (during initial training) has no significant effect on the newly trained regional airline pilot perceived ability to adapt to advanced technology cockpits in more sophisticated and/or newer aircraft.

H_1 The type of instrumentation training (during initial training) has a significant effect on the newly trained regional airline pilot perceived ability to adapt to advanced technology cockpits in more sophisticated and/or newer aircraft.

Purpose of the Study

This investigation will test a hypothesis about pilot and IP observations regarding pilot in training perceived ability to transition to glass cockpits displays found in technically advanced aircraft, given the type of initial instrumentation flight training. This research seeks to determine the differences among pilots trained using various types of instrumentation ranging from aircraft equipped with traditional analog instrumentation to aircraft equipped with glass cockpits. Type of training; therefore, includes students who initially learn using only traditional analog instrumentation; students who initially learn using only digital instrumentation; and students who initially learn using a combination of analog and digital instrumentation. Additionally, this research will report on method of training for each of the three groups. For purposes of this study, *method* refers to whether or not recently trained pilots received traditional *stick and rudder* (i.e. maneuver based training) or whether these pilots received scenario based training or a combination of both.

Traditional systems include analog (steam gauge) instrumentation training in whole or in part that is conducted using actual traditional aircraft, full motion simulators using analog instrumentation, Flight Training Devices (FTD) using analog instrumentation, and/or Computer Based Training (CBT) programs used to familiarize student pilots with traditional cockpits. Digital instrumentation includes any training in whole or in part that is conducted using actual aircraft equipped with glass cockpits, full motion simulators with glass cockpits, Flight Training Devices (FTD) that simulate glass cockpits, and/or Computer Based Training (CBT) programs used to familiarize student pilots with glass cockpits. The study also seeks to determine if the type and method of pilot training using any combination of these training devices allowed the newly trained airline pilot to more readily transition to technically advanced aircraft.

Objectives of the Study

Specifically, this study seeks to determine:

1. The perceived ability of pilots initially trained on only analog systems to adapt to more advanced cockpit technologies.
2. The perceived ability of pilots initially trained on only digital systems to adapt to more advanced cockpit technologies.
3. The perceived ability of pilots initially trained on both analog and digital systems to adapt to more advanced cockpit technologies.
4. The Instructor Pilot perceptions about the newly trained regional airline pilot ability to adapt to technically advanced aircraft.

Assumptions and Limitations of the Study

1. The instrument is a self-reported tool used to measure pilot perception of training effectiveness. Use of actual aircraft with or without digital instrumentation was not available for this study.
2. The study assumes that a *self-selected* set of participants (those who agreed to take the survey) were similar to the larger population of newly trained regional airline pilots.
3. Sample size is considered a limitation of the study.

4. While results are screened for individual difference in aeronautical experience and associated levels of aeronautical decision making, these factors represent a limitation of the study.
5. While results are screened for maturation or other learning that may have occurred other than initial instrument training method, pilots may have received other direct or indirect instruction from other sources.

Summary

The study focuses on the self-reported perception of newly trained regional airline pilots and the perceptions of their Instructor Pilots (IPs). An understanding of perceived abilities is, nonetheless, very important for developing advanced technology training programs. A compelling argument can be made for continued study and training course revisions and refinements based on how confident pilots are when making a transition to technically advanced aircraft. Additionally, technology will continue to rapidly change and evolve. Pilots entering airline service can expect to continually learn new and advanced systems at an ever increasing pace not previously experienced in the airline industry. There is a clear relationship between pilot/crew perceived ability to use and fully understand this new information environment and flight safety issues (Craig, Bertrand, Doman, Gossett, & Thorsby, 2005).

CHAPTER II

REVIEW OF LITERATURE

Introduction

Very little research has specifically considered *type* of initial pilot training as it relates to transitioning to technically advanced aircraft at regional airlines. That is whether or not pilots transitioning to technically advanced regional airlines cockpits did or did not have previous training and/or technical competencies in technically advanced aircraft. A number of studies have focused on *method* of training as it relates to transitioning to technically advanced aircraft (Dornan et al., 2006; Robertson et al., 2006). Conversely, this research primarily centers on determining how effectively pilots assimilate and use new technology, given the type of initial instrumentation flight training. In areas of related research, a significant amount of work has been done regarding pilot/crew ability to assimilate information in a technically advanced cockpit Endsley & Kaber, 1999; Miller et al., 2007). Much has been in the area of human-factors research (such as Crew Resource Management – CRM literature) and attempts to determine the most efficient way for crews to assimilate information and assign responsibilities (Flin, O'Connor & Mearns, 2002; Salas, Wilson, Burke & Wightman, 2006). Several studies (Barrows & Powell, 1999; Chappell, Crowther, Mitchel &

Govindaraj, 1997; Dekker & Wood, 2002; Endsley & Kaber, 1999; Endsley & Wheelwright, 2002; McFarlane & Latorella, 2002; Miller & Parasuraman, 2007; Mosier, Keyes, & Bernhard, 2001; Nikolic & Sarter, 2007; Sarter, 1994; Sarter & Randall, 2007) have considered human-automation interaction on modern flight decks and/or advanced general aviation aircraft. Areas of interest include understanding what the relationship should be between humans and automated systems and which task should be assigned to humans and/or automation and under what conditions such task assignments should be made. Multidisciplinary research data is available to understand the relationships between instruction methods using Computer Based Training (CBT), Flight Training Devices (FTD), Full Motion simulators, and/or actual aircraft during flight instructional. Much of this research has been conducted by aviation university programs considering the value of Maneuver Based Training (traditional methods) verses Scenario Based Training (SBT) for students transitioning to technically advanced aircraft. These studies often seek to determine the true value of Scenario Based Training on a by task basis and have frequently yielded mixed results (Craig, Bertrand, Doman, Gossett & Thorsby, 2005).

In order to understand what is known in this research area, this study reviews a number of research articles and focuses upon several distinct multidisciplinary issues concerning how humans learn complex systems and assimilate large amounts of complex information.

A Short History of Aviation Instrumentation

Aviation instrumentation development began in earnest during the 1920's with improvements in radio voice and radio navigation technologies (Bilstein, 2001). Prior to this time little instrumentation was available and radio technology was often considered unreliable. Early aviation radio technology was large, bulky and considerably heavy given the useful load capacity of airplanes of the time. Transmitters and receivers were originally separate devices and; therefore, used much valuable space aboard aircraft when installed. Other aircraft systems, such as the aircraft ignition system, often generated electromagnetic interference. Radio technology also limited communications. Signal strength (power out of the radios and gain of the receiving antennas) and propagation characteristics (for line-of-site or for signals refracted from the ionosphere) of these early radios also hampered voice and Morris Code radio transmissions (Millbrooke, 1999).

Air navigation became available in 1927 as a result of the Air Commerce Act of 1926 which created the first Federal Airway system. This system was largely composed of radio range finders, marker beacons and visual land marks which allowed for transcontinental air routes. (Bilstein, 2001; Millbrooke, 1999).

A radio capable of receiving Morris Code signals was called a *Code Set* radio and was the first device used for radio navigation. Pilots could navigate to a station from a known range or distance. Four-Course radios were introduced at this time and provided two directional signals using Morris Code. The letters N and A (in Morris Code) each radiated in a figure eight pattern from the radio range transmitter station. Where the two signals overlapped with equal signal strength, the resultant signal produced a continuous *dash* – this signal indicated that the aircraft was on course. The pilot aligned the flight path of the aircraft with a visual display in the cockpit to maintain a constant dash or on-course heading (Millbrook, 1999).

During this period, Daniel Guggenheim and his son Harry contributed significantly to the growth of aviation and aviation technology in the United States. The Guggenheims were a wealthy family who made the bulk of their money from the mining industry. Harry Guggenheim served as an aviator in WWI. From 1925 to 1930 the Guggenheim family donated 2.6 million dollars to advance aviation (Rumerman, 2009).

The Guggenheims established schools and research centers at universities throughout the United States. They created a research fund which was directly used for aviation research. This research focused upon and led to the development of more reliable aircraft engines and instruments. Guggenheim educational activities began in 1925 when the grant was used to establish a School of Aeronautical Engineering at New York University. The fund was also used to make grants for the establishment of Guggenheim schools and research centers at: The California Institute of Technology, Stanford University, The University of Michigan, The Massachusetts Institute of Technology, The University of Washington, Georgia School of Technology, Harvard University, Syracuse University, Northwestern University, and The University of Akron (Rumerman, 2009).

The development of aviation instrumentation is closely linked to the research conducted by Ernst Mach, a renowned physicist, and a number of other researchers prior to 1919. By 1920 significant research had been completed in the area of spatial disorientation and several vestibular illusions causing spatial disorientations in pilots had been identified. Spatial disorientation is categorized as either Type I or Type II disorientation (Previc & Ercoline, 2004). Type I spatial disorientation is *unrecognized* spatial disorientation and the pilot is unaware of his/her misjudgment. This is exclusively the case in Controlled Flight Into Terrain (CFIT) mishaps. Type II spatial disorientation is *recognized* spatial disorientation where the pilot realizes that a conflict exists between his/her natural spatial orientation as compared to that provided by the flight instruments (Previc & Ercoline, 2004).

Another pioneer of the time was Robert Barany who developed many commonly used vestibular tests for pilots. Robert Barany invented the reduced friction chair used in ground-based spatial disorientation training. He won the Nobel Prize for this invention and the reduced friction chair is still in use today as a means of demonstrating susceptibility of vestibular illusions to pilots. Nonetheless, in the early 1920's contentious debate existed in the aviation community regarding the value of instrumented aircraft (Previc et al., 2004).

Spatial disorientation in an aviation context refers to pilot failure to correctly sense the position, motion and/or attitude of the aircraft relative to the earth or other aircraft. Further, this disorientation should not be confused with geographic disorientation - such as is experienced when a pilot becomes lost (Previc et al., 2004).

Spatial orientation, as defined by the US Air Force, is maintained by reference to control instruments (attitude and engine power/trust displays) and performance instruments (altitude, airspeed, heading, vertical velocity, acceleration, angle of attack and turn-and-slip indicators) while geographic orientation is maintained by navigational instruments (bearing-and-course, range and glide slope indicators) (Previc et al., 2004).

Spatial disorientation was referred to as *pilot vertigo* until the 1970's. By the 1980's research was being conducted on a related concept called a *Loss of situational Awareness* (LSA). As defined by Fred Previc, A Loss of Situational Awareness is: The loss of pilot perception of the elements in the aviation environment within a volume of time and space, the comprehension of their meaning, and the projection of their status in the near future. Spatial disorientation is a key element and a subset of a loss of situational awareness (Previc et al., 2004).

Finally, Controlled Flight Into Terrain (CFIT) is a term also commonly associated with spatial disorientation. CFIT accidents occur when an aircraft under the control of the crew, is flown (unintentionally) into terrain or water, with no prior awareness on the part of the crew of the impending disaster. CFIT disasters usually involve a gross misjudgment of altitude and only occur during Type I spatial disorientation (Previc et al., 2004).

In 1917 Elmer Sperry invented the first modern primary flight instrument - the turn indicator. However, his invention did not meet with widespread approval. Many pilots refused to use the turn indicator and continued to argue that flight into Instrument Meteorological Conditions (IMC) was possible (without instruments) if the pilot had the right mental attitude and instinctive abilities. With the help of the Guggenheim fund, Sperry continued development of the first suite of flight instruments designed to allow for flight solely by reference to instruments. In addition to the turn indicator, the suite included the first radio altimeter and artificial horizon. This development was carried out at Mitchel Field, Long Island, NY and was led by then Lt. James Doolittle, a recent PhD graduate from the Massachusetts Institute of Technology (Previc et al., 2004).

Another significant event for the development and acceptance of instrument flying occurred in 1926 at Crissy Field, San Francisco, California when Captain William Ocker experienced the illusion of a tuning sensation (somatogyral illusion) in flight and used the Sperry turn indicator to correctly determine the aircraft attitude. As a result, Capt Ocker became an advocate of instrument flight and also greatly advanced instrument training in the US Army Air Corps (Previc et al., 2004).

The development of Sperry's advanced instrument display (a technically advanced aircraft of its time) allowed Lt. Doolittle to conduct the first *blind* flight at Mitchel Field on 24 September 1929. The flight included take offs and landings solely by reference to instruments in a modified Consolidated NY-2 Husky biplane and opened the era of instrumented flight development and training (Blind Flight, 2009; Previc et al., 2004).

Pilot Automation Interaction

Automated cockpits were designed to reduce workload and provide pilots and crews with real-time information. Clearly, automation provides benefits as many modern systems are too complex for humans to successfully operate (Miller & Parasuraman, 2007). At the same time, however, problems have arisen from an inability to communicate with machines - rather than simply operating machines (Sarter, 1994). A considerable body of research indicates that a breakdown in pilot-automation coordination on advanced flight decks continues to be a significant problem. These breakdowns most commonly are associated with pilot systems monitoring failures and inappropriate pilot responses to breakdowns (Nikolic & Sarter, 2007; Sarter, 1994).

Sarter, Randall &Wickens, 2007 found that pilots frequently failed to confirm systems mode leading to low systems observability and gaps in pilot understanding of complex technology. This research highlights the need for improved automation training to ensure more effective recovery from pilot error when interfacing with complex systems (Nikolic et al., 2007).

Poorly designed automation can increase workload and training, while actually decreasing situational awareness (Miller & Parasuraman, 2007). Since these systems are no longer passive and may operate autonomously, a higher level of awareness of automation status, behavior and intentions is necessary to safely operate modern aircraft (Sarter, 1994). Quite often, however, the machine interface design is not adequate to keep pilots and crews apprised of the systems mode or status. This can lead to a breakdown of the pilot/crews ability to stay abreast of systems status and can lead to *automation surprise* (Sarter, 1994). This level of interaction with aircraft systems can be measured and compared with early aircraft systems which did not as readily tax the pilot/crew abilities to *stay ahead of the airplane* (Miller et al., 2007).

A study conducted by Miller and Parasuraman in 2007 questions what tasks should be automated and at what level or degree of optimal control should automation occur. The trend in technology has been to automate task as fully as possible. However, recent research supports the idea that automation requires that neither humans nor automated systems should be exclusively in charge of most tasks. Rather some intermediate Level of Automation (LOA) is preferred, thus, allowing flexibility for assigning the role of automation to remain under human control. That is, the level of automation should be adjustable during systems operation and system driven adaptation should allow this to occur. This should be accomplished by human supervisory systems control and delegation of tasks to automated systems (Miller et al., 2007).

This research has several implications for the current study since higher levels of automation development have had several outcomes for the human operator. These include (Miller & Parasuraman, 2007):

1. The human tendency to become less aware of changes when they are under another agent control (whether that agent is another human or automation). This phenomenon can lead to complacency and skill degradation - a key interest of the current study.
2. The human operator trust or confidence in the automated system. High levels of automation frequently lack operator acceptance particularly when automation controls highly complex and highly-critical aircraft systems.
3. The tendency of automation to create both high and low workload extremes. An example is the mental workload required for the human to interact with the system. For instance, programming advanced cockpit technologies is often not a trivial task and in many cases is not intuitive.

Miller and Parasuraman (2007) suggest that the optimal solution to these human-automation interaction problems is to develop flexible, multi-level machine-based delegation systems.

In a similar study of undergraduate university students conducting simulated tasks on Gateway computers, Endsley and Kaber (1999) came to much the same conclusion. Their research addressed the optimum LOA taxonomy for human/machine interface. This taxonomy allowed for ten levels of human/machine interaction ranging from the human doing the whole job (selecting all options) up to the point of turning implementation of selected options over to the computer, to the computer doing the whole job (selecting options and implementing options) and notifying the human if the computer decides the human should know (Endsley et al., 1999). The result of the study indicated that optimal performance was realized when humans selected the options and automation implemented the human selected options. However, this was true only under normal operating conditions; when automation systems failed, operator performance and recovery suffered (Endsley & Kiris, 1995; Endsley et al. 1999). The current investigation also considers pilot performance when automation systems fail.

Another area of interest related to the machine-human interface is determining how the human cognition process adapts to high levels of automation. In a study by Mosier, Keyes and Bernhard, researchers studied the effects of automation on pilot ability and willingness to use less salient forms of information. This led to a concept called automation-related coherence error or pilot tendency to utilize automated cues as a heuristic replacement for more vigilant information seeking and processing (Mosier, Keyes & Bernhard, 2001). There was a tendency for the pilot/crew to place an over reliance on sophisticated automated cockpit systems. This study and previous studies indicate that the type and saliency of automated displays matter. Displays in the cockpit should not only support intuitive processes, such as quick detection of an abnormal condition; but should also present information in such a way that will support analysis by the pilot/crew (Mosier et al., 2007). The key lies in how the information is presented, or in other words, the machine-human interface.

McFarlane and Latorella (2002) describe this problem as one that may require the use of intelligent agents and strategies to overcome human cognitive limitations exacerbated by technology in a multitasking environment. This increased availability of information in the cockpit will cause pilots to become interrupted while performing simultaneous task. Consequently, pilots may require computer interfaces that can manage and coordinate human-interruption coordination. Such interfaces may use a number of interruption strategies to include: immediate, negotiated, mediated and scheduled interruptions. The availability of such interfaces will enhance situational awareness and will provide for interactive tools allowing pilots to switch back to original task (McFarlane et al., 2002).

In a similar study, Lani and Wickens investigated the potential *Compellingness* of flight deck tunnel displays to cause the pilot to engage On-going Task (OT). Tunnel displays use the concept of a *Tunnel in the Sky* to present a three-dimensional view of a desired flight path (Barrows & Powell, 1999). Because these displays are highly realistic, concern exists that pilots will monitor tunnel displays at the expense of other systems and the outside world; therefore, making tunnel displays more resistant to interruptions such as those caused by automated *Interrupting Task*. Again, modality is considered significant and good evidence exist that auditory cues are more likely to capture the pilots attention then visual cues (Lani & Wickens, 2007).

Given automation interface and design concerns, the next logical question is what should be automated. Dekker and Wood addressed this in 2002 when investigating what tasks Men-Are-Better-At as opposed to what task Machines-Are-Better-At (MABA –

MABA). Dekker and Woods (2002) suggest dividing task between humans and machines by considering four different groups of systems functions:

1. Information Acquisition
2. Information Analysis
3. Decision and Action Selection
4. Action Implementation

The accuracy of automation design hinges on how well automation effects are grounded in human factors research and how well automation designers can abandon traditional approaches in favor of an approach that seeks to determine which tasks are better suited for humans and which are better suited for machines (Dekker & Wood, 2002).

Crew Resource Management

Given the sheer volume and complexity of information available on the flight deck, the aviation industry has responded by providing instruction in Crew Resource Management (CRM). A great many studies (Flin, O'Connor & Mearns, 2002; Salas, Wilson, Burke & Wightman, 2006) have already been done on this topic. The findings indicate that in addition to understanding the complex technologies involved, a number of other management and interpersonal skills are required. According to Flin (2002), these include six work packages:

1. Situational Awareness
2. Decision Making
3. Communications
4. Team Work

5. Personal Resources
6. Leadership

After receiving CRM training, researchers wanted to know whether or not these skills were actually transferred to the cockpit. To ensure that they are, some organizations are undertaking periodic CRM testing. Formal checking of CRM skills may become a requirement to commercial licensing in the future (Flin et al., 2002). This research indicates that, for operations requiring crews, not only technical skills, but interpersonal skills are required to manage advanced technology cockpits (Flin et al., 2002).

Salas, Wilson, Burke and Wightman (2006) question the effectiveness of CRM training and suggest that several critical needs must be addressed before CRM has the desired results. They argue that the true impact of this training is not truly understood. After a detailed review of 58 CRM studies the researchers concluded that CRM training is generally well accepted and; therefore, has a positive impact on crew attitudes. To the extent that attitudes are positive, Salas, Wilson, Burke and Wightman (2006) argue that some evidence exist that CRM is effective. However, they also argue that after twenty years of CRM training a dearth of evidence exist to establish a cause and effect relationship between the training received and desired behavioral changes in the cockpit. In fact, a number of studies continue to indicate that the number of accidents involving a breakdown of CRM have remained constant over time despite training.

FAA Industry Training Standard (FITS)

The FAA Industry Training Standard (FITS) program is an FAA program that partners with industry and academia to provide advanced technology training to General Aviation (GA) pilots. It is designed as an evolutionary approach to change that is responsive to technology advancements in aviation. The FAA has developed and will continue to develop training products to meet new technology training needs (FAA Education and Research, 2006).

The purpose of the FITS program is to provide General Aviation (GA) pilots access to up-to-date information and training, especially given the impact of new technology on GA pilots as evidenced by an observed increase in fatal accidents in TAA (Craig et al., 2007; FAA Education and Research, 2006). New developments in aviation that impact flight training include the ever increasing complexity of the National Airspace System (NAS) and the FAA Operational Evolution Plan (OEP) designed to modernize the air traffic control system and improve throughput at the thirty-five busiest airports (FAA Education and Research, 2006). Furthermore, new airspace and operational changes have occurred since September 11, 2001. The rapid development and diffusion of new cockpit technologies continues to create significant challenges for the GA community. New and innovative ways to conduct flight training must be developed to ensure flight safety. New technologies that perform similar functions do not necessarily look or function alike and pilot interaction with the new technology is not necessarily intuitive. Therefore, a one-size-fits all approach to flight training is not adequate (FAA Education and Research, 2006).

The goals of the FITS program as listed at the FAA web page (http://www.faa.gov/training_testing/training/fits/) under *Program Plan* and are as follows:

- Maintain at least an equivalent level of safety
- Train single pilot operations in turbine powered aircraft to operate at the same level of safety as a two pilot crew in air transportation
- Develop and prove a training program that is innovative and more effective and goes beyond the current training programs available
- Set a new standard for the insurance industry
- Training should be real-world scenario based, problem solving and case study training with definable metrics for evaluation on aeronautical decision making, information management and risk management.
- Write new terminology, tasks, standards and curriculum
- A new standard for single pilot, transportation operation (piston & jet)
- A single standard for operations in RNP (Required Navigation Performance) airspace operating to new destinations
- A way to collect and share best practices for all users

What is significant to this study is the change in training emphasis. Formally, the FAA focused on training flight maneuvers (stick and rudder skills) to meet Practical Test Standard (PTS) proficiency requirements. This is referred to as Maneuver Based Training (MBT). However, with the advent of ever changing technically advanced aircraft, the FAA is now focusing on Scenario Based Training (SBT) training as the best method for teaching GA pilots to fly technically advanced aircraft. Scenario Based Training shifts the student role to that of an *active learner* by emphasizing thinking and decision making skills (FAA Education and Research, 2006).

A number of studies (Fiorino, 2005; Dornan et al., 2006; Dornan, Craig, Gossett & Beckman, 2006) have been conducted, primarily by researchers from university flight programs, to address these new training issues. For example, a review of technically advance aircraft training was reviewed by Fiorino from Middle Tennessee State University (MTSU) in 2004. He reviewed a university program that developed from the NASA Small Aircraft Transportation System (SATS) project. The focus of the NASA SATS program was to build a future air transportation system where many smaller aircraft operate on a point-to-point basis (Fiorino, 2005; Dornan, Craig, Gossett & Thorsby, 2005). SATS Flight Education Research (SAFER) students from Middle Tennessee State University learned to fly technically advanced aircraft from the very start in their training using a scenario-based syllabus. The intent of the first non-scientific study was to determine if pilots trained in technically advanced aircraft met or exceeded the FAA practical test standards for an integrated private and instrument pilot course. This was the first such FAA FAR Part 141 approved course (Fiorino, 2005; Dornan et al., 2006).

MSTU students flew DA40, Garmin 1000 equipped aircraft. The students in this study initially experienced setbacks with the expanded curriculum. The MTSU students experienced 59 pre-solo *setbacks* (repeated lessons) as compared to 17 for traditional flight students. However, by the end of the program the students had earned their integrated private/instrument rating in an average of 88.66 flight hours as compared to 134.3 flight hours for traditional students (Fiorino, 2005; Dornan et al., 2006).

A second empirical study (Dornan, Craig, Gossett & Beckman, 2006) was conducted at MTSU. The second study sought to determine if the improved performance of the FITS students was due to the MTSU curriculum or whether the performance was related to the enhanced technology (the reader should note that this is in contrast to the current study which seeks to determine if initial instruction in technically advanced aircraft improves transition to technically advanced aircraft in a regional airlines). The second study compared students who obtained the instrument rating in TAA aircraft using a traditional syllabus to students who obtained the instrument rating in TAA aircraft using a FITS syllabus (Dornan, Craig, Gossett & Beckman, 2006).

This study tracked *setbacks* (repeated lessons) and *bottlenecks* (lessons that took more than the recommended time to complete) between the two groups and found that both groups experienced seven *bottlenecks*. However, the FITS group experienced significantly fewer *setbacks*. This study concluded that the FITS training program was most likely responsible for the training benefits (Dornan et al., 2006).

A second MTSU study (French, Blickensderfer, Ayers & Connolly, 2005) also sought to determine how the FITS trained pilots compared to the traditionally trained pilots in the are of Aeronautical Decision Making (ADM) and found that the FITS group was much more conservative and set higher personal minimums for flight into IMC than did the traditional group. To determine the difference in ADM between the two groups the researchers (French, et al., 2005) asked the following types of questions:

- How comfortable are you to fly alone in the IFR environment?
- How comfortable are you to fly alone in IMC?
- How comfortable are you to shoot an ILS approach to minimums?
- What are your personal minimums?

The reader should note the similarity of these questions as compared to the questions posed to the Pinnacle Airline pilots in training.

A study conducted at Embry Riddle University (French et al., 2005) also considered the differences between Maneuver Based Training (MBT) and Scenario Based Training (SBT) by comparing three groups of student pilots across eight flight tasks. The groups included a No Training Group, a Maneuver Based Training Group and a Scenario Based Training Group. The study compared pilots flying these tasks on a TAA Cirrus SR210 simulator. The study incorporated a double blind design as neither the student pilots nor the raters were aware of the research project. All students also completed subjective questionnaires to determine perceptions of workload, situational awareness, self-efficacy, and decision making skills (French et al., 2005).

The results of the study indicated no significant difference between the Maneuver Based Training (MBT) group and the Scenario Based Training (SBT) group for the following events:

- GPS Use
- Take-off and Departure MFD Use
- Flight Planning
- Pre-Take-Off Tasks
- En-route Tasks

However, a statistically significant difference was noted for the following events:

- Autopilot Use
- Pre-flight Preparation
- Re-route Task
- Approach
- Missed Approach

The results of this study indicate that Scenario Based Training (SBT) may lead to improved piloting skills and navigation skills. However, both Scenario Based Training (SBT) and Maneuver Based Training (MBT) appeared to be equally effective for a number of other tasks. Additionally, the Scenario Based Training (SBT) group was more likely to report a reduced workload, an improved self efficacy, and better situational awareness as compared to the Maneuver Based Training (MBT) group. The results of this study indicate that Scenario Based Training (SBT) is as good as Maneuver Based Training (MBT), often better and never worse than Maneuver Based Training (French et al., 2005).

In 2006, Robertson, Petros, Schumacher and Ulrich from The University of North Dakota (UND) also conducted research to assess the effectiveness of FITS training as compared to traditional training. The specific goals of the UND study were to evaluate the effectiveness of FITS training to improve judgment and decision-making skills (Aeronautical Decision Making), to improve automation management skills (pilot performance), and to improve situational awareness. The study used a pre-test/post-test research design to compare problem-based learning (PBL/FITS), self-study (Non-FITS), and non-PBL (Non-FITS) methods of instruction (Robertson, Petros, Schumacher, & Ulrich, 2006).

The purpose of the UND study was to determine if FITS is better than maneuver-based training in developing aeronautical decision-making (judgment and decision-making) skills (Robertson et al., 2006).

This study used an experimental research design to determine if Problem-Based Learning (PBL) significantly enhances the development and transfer of Higher Order Thinking Skills (HOTS) in aviation education (Robertson et al., 2006).

The study randomly assigned pilots to one of three groups including a Control Group (Self-Study), a Treatment Group (FITS/Problem-Based) and an Alternate Treatment Group (Maneuver-Based). All groups received the same pre-test and post-test. The Mooney Bravo (Non-TAA) simulation was used for the pre-test and the Cirrus SR22 (TAA) aircraft was used for training and the post-test (Robertson, Schumacher, McHorse & Ulrich, 2006).

The results of the UNT study demonstrated significant differences in the indicators of pilot performance, situational awareness, and aeronautical decision-making in favor of the FITS/PBL group. The findings did not demonstrate that training practices need to be changed to include an emphasis on cognitive skills needed in aeronautical decision-making and/or critical thinking. Improvements observed in the UNT study might have occurred as results of better training and not necessarily demonstrate improved cognitive thinking skills (Robertson et al., 2006).

The TAA training standards tested in the UND study were designed to prepare pilots to transition to a technically advanced aircraft. In the UND study, transition training did not address the acquisition and development of psychomotor skills required for initial pilot training. Rather, the UND research team assumed that the FAA specified aeronautical knowledge and aeronautical skills required of a pilot already exist in the pilots who were undergoing transition training to TAA (Robertson et al., 2006). Given this assumption, researchers may question whether or not training in non-TAA is preferred to training in TAA during initial flight training and whether or not *type* of initial training is an important factor and/or consideration when transitioning to TAA.

Summary

This chapter reviews the history of instrumentation and summarizes what is known about pilot perceived ability to transitioning to technically advanced aircraft. Very little research has specifically considered *type* of initial pilot training as it relates to transitioning to technically advanced aircraft at regional airlines. However, a few studies have focused on *method* of training as it relates to transitioning to technically advanced aircraft.

A significant amount of work has been done regarding pilot/crew ability to assimilate information in a technically advanced cockpit and much has been in the area of human-factors research including topics such as crew resource management and human-automation interaction on modern flight decks. Much of the available research, specifically addressing training issues, has been conducted by aviation university programs and a good deal of that research focuses on comparing maneuver based training (traditional methods) to scenario based training (FITS training) for students transitioning to technically advanced aircraft. FITS training address *method* of training and, in some cases, attempts to eliminate *type* of training as a significant factor when transitioning to TAA. This investigation attempts to isolate *type* of training as a factor for pilot perceived ability to undergo transition training. Since this is a relatively new research area, a multidisciplinary approach to the literature review provides the best summarization of what is known in this area.

CHAPTER III

METHODOLOGY

This research project required newly trained regional airline pilots to make a self-assessment of ease of transition into technically advanced aircraft after completing advanced systems training with Pinnacle Airlines. Pilots were administered a questionnaire focusing on level of experience, initial training type and methodology, and overall level of perceived proficiency/ability at the completion of training. Additionally, Pilots in Training (PT) were asked about their perceived level of comfort flying Technically Advanced Aircraft (TAA) under varying circumstances - such as hand flying the aircraft to minimums in Instrument Meteorological Conditions (IMC) or when in an emergency situations. The study sought to answer the following four research questions:

1. What is the perceived ability of pilots initially trained on only analog systems to adapt to more advanced cockpit technologies?
2. What is the perceived ability of pilots initially trained on only digital systems to adapt to more advanced cockpit technologies?
3. What is the perceived ability of pilots initially trained on both analog and digital systems to adapt to more advanced cockpit technologies?

4. What are Instructor Pilot perceptions/observations of newly trained regional airline pilot ability to adapt to technically advanced aircraft as compared to the perceptions of the Pilot in Training (PT)?

Each class of Pinnacle students was trained for approximately six weeks at Pinnacle Airlines primary training facility in Memphis, Tennessee. Pilots learned to fly technically advanced aircraft such as the CRJ-200 to FAA FAR Part 121 standards. The training included technology training on systems such as: Flight Management Systems (FMS), Electronic Flight Instrumentation Systems (EFIS), Engine Indication and Crew Alerting Systems (EICAS), Aircraft Systems and Operation, Crew Resource Management (CRM) and Emergency Procedures, Swept Wing Aerodynamics and Aircraft Performance, and the company Flight Operations Manual (FOM).

Instructor Pilots (IPs) were administered an open-ended questionnaire in order to compare their perceptions with those of the newly trained pilots. They were asked their opinions/observations across a number of subjects including, but not limited to:

- Benefits of Scenario Based Training (i.e. method of training)
- Maintenance of basic flying skills in a highly automated cockpit environment
- Benefits of the *Type* of initial flight training received by students (i.e. analog only, digital only, or a combination of analog and digital training)
- Student level of comfort flying technically advanced aircraft after completing training

Population

The total number of pilots trained at Pinnacle Airlines during the period of this investigation was 1,080 pilots. Individual classes of pilots received six weeks of training at the airlines training facility in Memphis, Tennessee over a 36 month period ending in October 2008. The training was specifically designed to allow pilots to transition to technically advanced aircraft such as the Bombardier, CRJ -200 and the Bombardier, CRJ-900. The total number of Instructor Pilots (IPs) providing instruction to the Pilots in Training (PT) was 25 for the same 36 month period.

Figure 3. Bombardier, CRJ-200 Technically Advanced Aircraft (TAA) Commonly Used for Regional Airline Training.

Sample

The Pilot in Training sample was selected from pilots receiving initial training in technically advanced regional airline aircraft in 2006, 2007 and 2008 at Pinnacle Airlines in Memphis, Tennessee. The Pilot in Training sample included 46 male pilots and 2 female pilots (N = 48). A second sample included 4 Instructor Pilots (IPs) who provided training at Pinnacle Airlines during this period. The sampling technique used a non-probabilistic convenience sample due to the difficulty involved in selecting a random sample from the population of 1,080 pilots who had undergone training during this period. Pilots in training voluntarily completed the survey at the end of each 6 week training class. Additionally, recent course graduates volunteered to complete the survey at their base of operations location.

The Instructor Pilots (IPs) sample also used a non-probabilistic convenience sample. Instructor Pilots were asked for their perceptions of student learning given the type of prior aviation technology instruction and method of instruction during initial pilot training. Twenty-five instructor pilots provided instruction during this period. Four of these pilots participated in the study.

While convince sampling is less rigorous than random sampling, it does provide useful information especially because access to the larger population of pilots was not possible and/or feasible. This sample of pilots training at Pinnacle Airlines primarily differs from a random sample because pilots from the population under investigation volunteered to take the assessment. Why some volunteered and other did not is unknown. In all other aspects, the pilots are similar to the pilots completing training during the period of this investigation. Findings from this study are necessarily less definitive and replication of the study, or any study using a convenience sample, should be undertaken.

Quantitative Sample Size

An adequate sample size of approximately 128 participants is required for an ANOVA with an alpha level of .05, an effect size of .5 and a statistical power level of .80 (Soper, 2009).

Sample size is calculated after determining the alpha level, statistical power and effect size. The alpha level is arbitrary and is set by the researcher. The alpha level for this investigation was set at .05 and represents the probability that any observed differences between the groups were due to chance (Creswell, 2005). That is, there are only 5 chances in 100 that the sample does not reflect the population from which it was drawn. The alpha level was set by the research and was considered adequate for this investigation.

While a result may be statically significant, it does not mean that the difference is important or meaningful in a practical sense (Creswell, 2005). By setting the alpha level to .05, there is only a 5% chance of rejecting the null hypothesis when it is actually true (Type I error). Conversely, a Type II error occurs when the researcher fails to reject the null hypothesis when the alternative hypothesis is actually true (Creswell, 2005).

Statistical power measures the probability of committing a Type II error. Similar to setting alpha level, setting power to detect an effect is done by the researcher and is arbitrary**.** Power is expressed as power = 1 - ß, where ß is the probability of a Type II error. Typically Power is set at 0.80 (Murphy & Myors, 2004). Therefore, setting the power at .80 means there is a 20% chance of committing a Type II error. The higher the power, the less likely a Type II error will occur.

The effect size is the quality of the strength of the difference between the two variables and is used to determine whether the difference between the groups is meaningful in a practical sense (Creswell, 2005). That is, to determine if statistical significance is meaningful in a practical sense. Therefore, when there is a statistically significant difference between experimental groups, calculating effect size allows the researcher to determine if the difference is truly meaningful. An effect size of .8 or greater is considered large; .5 is considered medium; and .2 and below is considered small (Murphy & Myors, 2004). The larger the effect size, the more meaningful is the difference between the group means.

Qualitative Sample Size

Determining sample size for qualitative data is not as straight forward as it is for quantitative data. A common qualitative method for doing so is *grounded theory*. Grounded theory is a process where a research postulates theory that is grounded in the collected data (Strauss and Corbin, 1998). Data may be collected through a number of ways such as by interview, observation, memos and other means. The idea behind grounded theory is to generate enough data to discover patterns in the data, concepts, categories, properties, etc. (Strauss and Corbin, 1998). Appropriate sample size occurs when questions under investigation become *theoretically saturated*. That is, continued expansion of sample size no longer produces new data. There is no set number of respondents required for saturation (Strauss and Corbin, 1998).

Procedures

The self-assessment questionnaire of Pilots in Training volunteering to take the survey can be found in Appendix A. The initial mailing of surveys was sent directly to the Chief Instructor Pilot responsible for training at Pinnacle Airlines. Postage was provided to the Chief Instructor for return of the surveys. The Chief Instructor Pilot administered the survey to student pilots as each class of pilots completed their six week training course. Additionally, a second mailing of surveys was provided to Pinnacle Airlines (again to the Chief Instructor Pilot) for distribution via company channels. In this case postage was provided with each individual survey. With the assistance of Pinnacle Airlines management, the questionnaires were made widely available to all Pinnacle Airline pilots who had completed the training within the preceding 36 months. This was done in order to encourage and increase participation.

Non-response is always a problem for survey research. High response rates help ensure that respondents are representative of the population being surveyed and ensure external validity. However, some research suggests that response rate is less important when conducting research on homogenous populations (Clark & Boser, 1995). The population for this study is considered homogeneous; however, not all research supports Clark's conclusion.

Larson and Poist (2003) suggest several response inducements and incentive to increase response rates. These include, but are not limited to:

- Pre-notification of survey recipients
- Personalization of survey mailings

- Monetary incentive
- Follow-ups

Research in this area indicates that monetary rewards and follow-up tends to increase response, but personalization of survey mailings is ineffective (Larson & Poist, 2003).

Erwin and Wheelwright (2002) reported on several benefits to monetary incentives. Some research indicates that as monetary incentive amounts increase, response rates increase. Additionally, cash incentives may increase the speed of survey return. Some respondents believe that they should be paid for completing surveys and express more favorable attitudes towards surveys containing monetary rewards. As of the time of Erwin's and Wheelwright's research, the amount of monetary incentive required to achieve positive results remained unknown.

After the first mailing produced disappointing results, an offer was made to provide pilots in training with a monetary reward for answering the survey. However, the Chief Pilot discouraged providing such an incentive and recommended a personal appeal be made to student pilots instead. The pilots responding to the second mailing received a personalized note from the researcher requesting their participation. Responses to the second mailing were much more positive than the first. Of the 48 pilots responding to the survey, 42 (87.5%) responded to the second mailing which included the personal note. One of the respondents even included a request for a completed copy of the research project.

Instrument Description

The questionnaire was selected as the best means of ascertaining Pilot in Training (PT) attitudes regarding training in TAA provided by Pinnacle Airlines. The questionnaire presented 32 demographic and research questions. Ten multiple-choice questions were presented and 22 Likert scale questions were presented. The multiple-choice questions were used to collect demographic information and to determine student pilot level of experience and comfort with TAA. Question 7 was used to assign pilots to one of three groups. These groups include: pilots receiving primary instrumentation training on analog instruments only; pilots receiving primary instrumentation training on analog and digital instruments; and pilots receiving primary instrumentation training on digital instruments only.

Likert scale questions were used to determine pilot attitudes/perceptions about how initial training and proficiency with analog and/or digital systems affects ability to transition to advanced cockpits. For any given question, a score of 5 indicates strongly agree, 4 agree, 3 neutral, 2 disagree and 1 strongly disagree. While this was not a representative sample, this sampling method did allow an opportunity for a significant number of newly trained pilots to participate in the study. In general, the group of newly trained pilots at the regional airlines surveyed is very similar to newly trained regional airline pilots found at other airlines.

Instrument Validity and Reliability

Validity allows researcher to draw meaningful and justifiable inferences from the sample data (Creswell, 2005). Reliability means that individual scores from an instrument should be reasonably constant or stable across repeated presentations of the instrument (Creswell, 2005). While a survey instruments may be reliable, it may not be valid because it may not measure what it was designed to measure (Key, 2005).

The instruments used in this investigation (i.e. pilot in training survey and the instructor pilot survey) were validated by testing with a small group of pilots and aviation industry professionals. For the pilot in training survey, this resulted in the elimination and replacement of questions 31. The original question 31 asked about pilot in training perceptions about type of training and was considered redundant. Questions 8, 20, 21, 22 and 31 were reworded to improve the clarity of these questions. Finally, five other demographic questions were eliminated resulting in the survey decreasing from 37 to 32 questions. The survey was originally considered too lengthy and concern was expressed that respondents would not fully complete the survey. There were no changes to the instructor pilot instrument.

Generalizability

Generalizability is the degree to which a sample is representative of the population under investigation (Fraenkel & Wallen, 2003). Given an adequate sample of approximately 128 participants for an ANOVA with an alpha level of .05, an effect size of .5 and a statistical power level of .80 (Soper, 2009), the results of this study would constitute a representative sample and would be generalizable to the population of 1,080 pilots trained at Pinnacle Airlines during the 36 month period under investigation. However, this sample was composed of only 48 respondents and is; therefore, a much less representative sample.

Generalizability for the qualitative data must also be representative of the population under investigation. This investigation only had four instructor pilots volunteer to take the survey. There was no discovery of patterns in the data, concepts, categories, properties, etc. Clearly, the sample size was not large enough. Appropriate sample size occurs when questions under investigation become *theoretically saturated*. There is no set number of respondents required for saturation (Strauss and Corbin, 1998). The questions under investigation in this study did not become saturated.

Participants

Participants included three groups of pilots who were categorized as follows:

1. Pilots receiving only analog initial and instrument flight training using Computer Based Training (CBT), Flight Training Devices (FTD), full motion simulators, and/or actual aircraft where N = 32.
2. Pilots receiving Analog and Digital initial and instrument flight training using Computer Based Training (CBT), Flight Training Devices (FTD), full motion simulators, and/or actual aircraft where N = 12.
3. Pilots receiving digital only initial and instrument flight training using TAA cockpit Computer Based Training (CBT), Flight Training Devices (FTD), full motion simulators, and/or actual TAA where N = 1.

Note: Three pilot surveys were eliminated from the analysis for non-response to one or more survey questions.

For purposes of this study, *analog only* training was conducted on *Steam Gauge* instruments using the pitot static system and suction pump or electrically driven gyroscopic instrumentation (see Figure 1). In other words, traditional Airspeed Indicators, Attitude Indicators (AI), Altimeters, Heading Indicators (HI), Turn and Bank Coordinators and Vertical Speed Indicators (VSI) and other instrumentation where these instruments are powered by the pitot static, suction pump and/or electrical system. Analog only training also included any Computer Based Training (CBT) devices, Flight Training Devices (FTD) and/or simulator that represented an analog instrument as defined above.

For purposes of this study, *digital* instrumentation training was conducted on CBT devices, FTDs and/or simulators that represented Airspeed Indicators, Attitude Indicators (AI), Altimeters, Heading Indicators (HI), Turn and Bank Coordinators and Vertical Speed Indicators (VSI) and other instrumentation where these instruments were displayed on computer screens and powered by the electrical system (i.e. Glass Cockpits). Note, these instruments are found on the Primary Flight Display (PFD).

The study also incorporated a qualitative component to assess Instructor Pilots (IP) perceptions and opinions about how the Pilots in Training (PT) adapted to technically advanced aircraft training. A separate questionnaire of five open-ended questions was presented to twenty-five instructor pilots - four IPs responded. Instructor pilots were encouraged to answer the open-ended questions in as much detail as possible.

Design of the Study

This study used a mixed method design to allow the researcher to make an interpretation whether the results from both sets of data (quantitative and qualitative) support or contradict each other. The quantitative component used a non-probability sample of Pilots in Training (PT) to gather data about student pilot perceptions regarding transition to technically advanced cockpits. The qualitative component used an open-ended opinion survey given to the regional airline Instructor Pilots (IPs) to determine their attitudes regarding the ability of newly trained regional airline pilot ability to learn and use advanced cockpit technology.

The use of a mixed method design; therefore, simultaneously collected both quantitative and qualitative data to compare and corroborate information from the two surveyed groups (pilots in training and instructor pilots). The results were then used to better understand the research problem. This use of two strands of qualitative and quantitative data allows for the integration of the data and provides the ability to make more meaningful inferences from the results (Creswell, 2007).

A mixed method research design was selected because both a quantitative and qualitative perspective is useful to understanding the topic under investigation. Research methods should be pragmatic and should consider how to best obtain useful answers to the research questions (Johnson & Onwuegbuzie, 2004).

The quantitative component used an Analysis of Variance (ANOVA) statistical analysis design. The ANOVA was used to compare the means of the independent groups. An ANOVA is used to statistically analyze variance both within and between each of the groups (Fraenkel & Wallen, 2003). Ideally, the variance between groups is greater than the variance within groups. An ANOVA is an appropriate statistical test when analyzing a group comparison of one or more independent variable and one dependent variable (Creswell. 2005).

Three assumptions should be met when using an ANOVA. These include:

- Independence – Groups are independent of each other and no correlation exists between independent variables.
- Normality – the sample comes from a normal distribution.
- Homogeneity of Variance – Assumes that variances of the observations in the individual groups are equal.

The Shapiro Wilk W test it used to test for *normality*. That is it test to ensure the respondent sample comes from a normally distributed population. The test calculates a W statistic to tests if a sample comes from a normal distribution. Small values of W indicate a departure from a normal distribution (Shapiro & Wilk, 1965).

The Levene test is used to test for homogeneity of variance. It is assumed that the group variances are statistically equal. If this assumption is not valid, then the resulting *F* test is invalid. Additionally, the Levene test is robust for violations of normality. It tests the assumption of the null hypothesis. That is, that the population variances are equal and no significant differences exist between the research groups. Typically, if the p-value of the Levene test is less than .05, it is unlikely that differences between the sample variances (groups) are due to random variation and the null hypothesis is rejected (Levene, 1960).

The participants were selected from a convenience sample as outlined above. A questionnaire was administered to gather self-reported data about pilots training technique and perceived ability to adapt to more advanced cockpits. The questionnaire was administered to a convenience sample of student pilots, who had recently completed Technically Advanced Aircraft (TAA) training at Pinnacle Airlines based in Memphis, Tennessee. The significance level was set at alpha = .05.

This mixed method study used a *Triangulation Design*. That is, quantitative and qualitative data were simultaneously collected. Later, during the analysis phase, the data were merged and used to understand the results. This allowed the researcher to make an interpretation whether the results from both data sets support or contradict each other (Creswell, 2005).

Variables

The dependent variable for this study is the perceived ability of the pilots to transition to a technically advanced cockpit. The three (3) Independent Variables for the study were:

- Group 1 (Analog Only Training): Type of training received prior to transition to Regional Airline Technically Advanced Aircraft (TAA) when trained on Analog Instrumentation Only using CBT devices, FTDs, full-motion simulators and/or actual aircraft.
- Group 2 (Analog and Digital Instrumentation Training): Type of training received prior to transition to Regional Airline Technically Advanced Aircraft (TAA) when trained on Analog and Digital Instrumentation using CBT devices, FTDs, full-motion simulators and/or actual aircraft.

- Group 3 (Digital Only Instrumentation Training): Type of training received prior to transition to Regional Airline Technically Advanced Aircraft (TAA) when trained on Digital Instrumentation Only using CBT devices, FTDs, full-motion simulators and/or actual TAA.

<u>Procedure for Gathering the Data</u>

Student Pilots were presented a questionnaire at the end of their training. A few (six or 12.5%) of the students received the questionnaire before leaving the training facility. However the majority of the students (forty-two or 87.5%) received the questionnaire through company distribution channels at their assigned base of operation. Prior to being presented the questionnaire, students were presented with the research consent forms and were advised that their responses would be anonymous. Neither the participant name nor the company name appeared on the questionnaire. The consent form and a copy of the questionnaire for the student pilots are available in the appendices of the study.

Instructor pilots were presented with an open-ended questionnaire. They also received the research consent form and were advised that their responses would be anonymous. Neither the participant name nor the company name appeared on the questionnaire. The consent form and a copy of the questionnaire for instructor pilots are available in the appendices of the study

Summary

This chapter outlines the methodology of the study. The investigation used a mixed method design to determine both Pilot in Training (PT) and Instructor Pilot (IP) perception of the students transition to technically advanced aircraft based on type of initial flight training. The three groups of subjects included: PTs initially trained on analog instrumentation only, PTs initially trained on analog and digital instrumentation, and PTs initially trained on digital instrumentation only.

Two surveys instruments were used. The pilots in training completed a thirty-two question, multiple choice survey and the IPs completed a five question open-ended survey. The surveys were sent to Pinnacle Airlines in two separate mailings. Distribution of the surveys was made through Pinnacle Airlines Chief Instructor Pilot and company distribution channels. The surveys were presented, with the research consent form to both PTs and IPs.

The quantitative component of this investigation used an Analysis of Variance (ANOVA) statistical design. A convenience sample of pilots willing to participate in the study was used. A personalized note was included with the second mailing to increase participation.

The qualitative component used a grounded theory statistical design. A convenience sample of pilots willing to participate in the study was used.

CHAPTER IV

FINDINGS

Introduction

Purpose of the Study

This investigation will test a hypothesis about pilot and IP observations regarding pilot in training perceived ability to transition to glass cockpits displays found in technically advanced aircraft, given the type of initial instrumentation flight training. This research seeks to determine the differences among pilots trained using various types of instrumentation ranging from aircraft equipped with traditional analog instrumentation to aircraft equipped with glass cockpits. Type of training; therefore, included students who initially learned using only traditional analog instrumentation; students who initially learned using only digital instrumentation; and students who initially learned using a combination of analog and digital instrumentation. Additionally, this research reports on method of training for each of the three groups. For purposes of this study *method* refers to whether or not recently trained pilots received traditional *stick and rudder* (i.e. maneuver based training) or whether these pilots received scenario based training, or a combination of both.

Objectives of the Study

Specifically, this study seeks to determine:

1. The perceived ability of pilots initially trained on only analog systems to adapt to more advanced cockpit technologies.
2. The perceived ability of pilots initially trained on only digital systems to adapt to more advanced cockpit technologies.
3. The perceived ability of pilots initially trained on both analog and digital systems to adapt to more advanced cockpit technologies.
4. The Instructor Pilot perceptions about the newly trained regional airline pilot ability to adapt to technically advanced aircraft.

Demographic Data and Return Percentages

The student pilot questionnaire consisted of a total of 32 questions, 22 of which were closed-ended, multiple-choice, data collection questions. Ten questions were demographic questions used to determine pilot level of experience and determine group assignments. The twenty-two multiple choice questions were Likert Scale questions used to compare the two groups. Group Three, the Digital Only Training Group, was dropped from the analysis because only one pilot was in this group. This was because there can be no variance within Group Three if that group has only one member. The instructor pilot questionnaire consisted of five open-ended questions.

Forty-eight student pilots were surveyed from a population of 1,080 student pilots that underwent training during the 36 month period. This sample represents 4.44% of the student pilot population. This sample size is small and is considered inadequate for analysis. Four instructor pilots were surveyed from a population of 25 that provided instruction during this period. This sample represents 16% of the instructor pilot population. This sample size is small and is considered inadequate for analysis.

This study included three groups of student pilots:

1. Pilots receiving only analog initial and instrument flight training using Computer Based Training (CBT), Flight Training Devices (FTD), full motion simulators, and/or actual aircraft where N = 32.
2. Pilots receiving Analog and Digital initial and instrument flight training using Computer Based Training (CBT), Flight Training Devices (FTD), full motion simulators, and/or actual aircraft where N = 12.
3. Pilots receiving only digital initial and instrument flight training using TAA cockpit Computer Based Training (CBT), Flight Training Devices (FTD), full motion simulators, and/or actual TAA where N = 1.

Group Three (pilots receiving digital training only) was eliminated from the statistical analysis since there was only one pilot in this group. An ANOVA can not be done for this group because a group with only one member has no within group variance. Groups One (pilots receiving analog training only) and Group Two (pilots receiving analog and digital training) were statistically analyzed using an analysis of variance (ANOVA).

Additionally, three pilot surveys were eliminated from the analysis for non-response to one or more survey questions.

The quantitative component of this study administered a closed-ended survey to 48 pilots, 46 (95.83%) of which were Male, and two (4.17%) were Female. The majority of respondents were between the ages of 22-30 years of age (34, 70.83%), had been flying between 5-10 years (20, 41.67%), and had logged more than 2,501 Flight Hours (20, 41.67%). Most respondents learned to fly at a FAA FAR Part 141 Pilot School (24, 50%) and had not been recently hired as a Regional Airport Pilot (33, 68.75%). The results are summarized in Table 1.

Table 1

Frequency and Percent of Demographic Characteristics

		n	%
Gender	Male	46	62.16
	Female	2	2.70
Age	22-30	34	70.83
	31-39	10	20.83
	40-49	4	8.3
Experience as Pilot (yrs)	Less than 1 Year	1	2.08
	1-3 Years	5	10.42
	3-5 Years	15	31.25
	5-10 Years	20	41.67
	10-20 Years	5	10.42
	More than 20 Years	2	4.17
Hours Logged	500 Hours or Less	1	2.08
	501-1,000 Hours	3	6.25
	1,001-1,500 Hours	5	10.42
	1,501-2,000 Hours	12	25
	2,001-2,500 Hours	7	14.58
	2,501 Hours of More	20	41.67
Pilot School	FAA Part 141	24	50
	FAA Part 61	19	39.58
	Other	5	10.42
Newly Hired Regional Airline Pilot	Yes	15	31.25
	No	33	68.75

The respondents were asked to provide information regarding their flying experience. The majority of respondents indicated that they learned to fly on analog instruments only (35, 72.92%). A significant number received No Digital Training/TAA training during initial instruction (17, 35.42%). Most pilots had a total of 1-2 Years of Glass Cockpit experience (15, 31.25%). Furthermore, the majority of respondents had logged between 50-100 hours of IMC time (21, 43.75%). The results are summarized in

Table 2

Frequency and Percentage of Flight Experience Characteristics

		n	%
I first learned instrument flying	On analog only	32	66.67
	CBT Software	2	4.17
	FTD	11	22.92
	Analog Actual Aircraft	2	4.17
	Digital in Actual Aircraft	1	2.08
Received TAA Primary Instruction	0-5 Hours	13	27.08
	6-10 Hours	5	10.42
	11-20 Hours	4	8.33
	21-40 Hours	6	12.50
	No Digital Training	17	35.42
Glass Cockpit Experience	6 Months - 1 Year	11	22.92
	1 Years- 2 Years	15	31.25
	2 Years- 3 Years	10	20.83
	3 years- 5 Years	8	16.67
	5 years - 10 Years	3	6.25
In IMC, I have logged	10 Hours or Less	0	0
	10-25 Hours	0	0
	25-50 Hours	4	8.33
	50-100 Hours	7	14.58
	100-500 Hours	28	58.33
	More than 500 Hours	9	18.75

Data Summarization

To examine the difference on the 22 scale questions by group (Analog vs. Analog/Digital), an analysis of variance (*ANOVA*) was conducted. When conducting the *ANOVA*, the assumptions of *ANOVA* were assessed.

Three assumptions should be met when using an ANOVA. These include:

- Independence – Groups are independent of each other and no correlation exists between independent variables. This assumption was met.
- Normality – the sample comes from a normal distribution. This as was not met.
- Homogeneity of Variance – Assumes that variances of the observations in the individual groups are equal. This assumption was not met.

The Shapiro Wilk W test it used to test for *normality*. That is it test to ensure the respondent sample comes from a normally distributed population. The test calculates a W statistic to tests if a sample comes from a normal distribution. Small values of W indicate a departure from a normal distribution. The assumption of normality was violated for this investigation, as indicated by significant Shapiro-Wilkes W tests (Shapiro & Wilk, 1965).

The Levene test is used to test for homogeneity of variance. It is assumed that the group variances are statistically equal. If this assumption is not valid, then the resulting *F* test is invalid. Additionally, the Levene test is robust for violations of normality. It tests the assumption of the null hypothesis. That is, that the population variances are equal and no significant differences exist between the research groups. Typically, if the p-value of the Levene test is less than .05, it is unlikely that differences between the sample variances (groups) are due to random variation and the null hypothesis is rejected (Levene, 1960). The assumption of homogeneity of variance was not met for this investigation.

While *ANOVA* is robust against these violations if the groups are approximately equal, the groups are not approximately equal (no more than 1.5 times as different), increasing the likelihood of committing a Type I error because of the violation of normality and increasing the likelihood of committing a Type II error because of the violation of homogeneity of variance. The model was not significant, Wilkes' $\lambda = 0.25$, F (44, 40) = 0.90, $p = 0.63$, Partial η^2 (effect size) = 0.50, Power = 0.67, indicating that no significant difference exists on the 22 scale questions by group (Analog vs. Analog/Digital).

A low Wilkes score of 0.25 indicates a departure from a normal distribution for this population and constitutes a violation of one of three assumptions necessary for an ANOVA. However, the ANOVA is robust against this violation. An *F* score of .90 is calculated as a grand mean of the individual *F* scores for each of the 22 Likert scale questions and was adjusted for degrees of freedom and for respondents that were dropped from the sample (see Table 3 below for the individual *F* scores). As is the case with most of the individual *F* scores, the grand mean *F* score is low and is not significant.

The p score of .063 is larger than .05 which was set as the alpha. Therefore, there is greater than a .05 or 5% chance that an error will occur and cause a Type I error (i.e. rejecting the null hypothesis when it is actually true).

Effect size was .05 and is a measure of the quality of the strength of the difference between the two variables and is used to determine whether the difference between the groups is meaningful in a practical sense. An effect size of .05 is considered medium. The greater the effect size, the more meaningful is the statistical difference identified by the *F* Score. Since most of the *F* Scores were not statistically significant, the effect size is irrelevant.

The Power was 0.67. Power was set at .80 for this investigation. Setting the power at .80 means there is a 20% chance of committing a Type II error. A Type II error occurs when the researcher rejects the alternative hypothesis (i.e. fails to reject the null hypothesis) when the alternative hypothesis is actually true. The higher the power, the less likely a Type II error will occur. A power of 0.67 means that there is a 33% chance of committing a Type II error. Since most of the *F* Scores were not statistically significant, the power is irrelevant.

The results are summarized in Table 3 and means and standard deviations are presented in Table 4. When evaluating Table 3, the reader should note that even in cases where the *F* score is greater than the Significant *F*, the effect size and power are extremely low.

Table 3

ANOVA on the Twenty-Two Scale Questions by Group (Analog vs. Analog/Digital)

Source	*df*	*F*	Significant *F*	Partial η^2 Effect Size	Power
Q10	2	0.72	.491	0.03	0.16
Error	41	(42.74)			
Q11	2	2.09	.137	0.09	0.41
Error	41	(47.92)			
Q12	2	2.02	.145	0.09	0.39
Error	41	(15.14)			
Q13	2	1.65	.205	0.07	0.33
Error	41	(25.92)			
Q14	2	0.01	.994	0.00	0.05
Error	41	(60.78)			
Q15	2	0.27	.763	0.01	0.09
Error	41	(23.24)			
Q16	2	0.03	.972	0.00	0.05
Error	41	(21.88)			
Q17	2	0.07	.929	0.00	0.06
Error	41	(22.65)			
Q18	2	0.35	.710	0.02	0.10
Error	41	(54.96)			
Q19	2	0.10	.906	0.01	0.06
Error	41	(30.04)			

Table 3 (cont'd)

Source	*df*	*F*	Significant *F*	Partial η^2 Effect Size	Power
Q20	2	0.60	.553	0.03	0.14
Error	41	(17.05)			
Q21	2	0.45	.642	0.02	0.12
Error	41	(10.74)			
Q22	2	0.79	.459	0.04	0.18
Error	41	(40.96)			
Q23	2	0.50	.610	0.02	0.13
Error	41	(44.46)			
Q24	2	1.36	.268	0.06	0.28
Error	41	(40.14)			
Q26	2	0.26	.770	0.01	0.09
Error	41	(44.16)			
Q27	2	0.48	.625	0.02	0.12
Error	41	(25.83)			
Q28	2	0.44	.649	0.02	0.12
Error	41	(10.68)			
Q29	2	0.33	.723	0.02	0.10
Error	41	(23.87)			
Q30	2	0.09	.917	0.00	0.06
Error	41	(41.37)			

Table 3 (cont'd)

Source	*df*	*F*	Significant *F*	Partial η^2 Effect Size	Power
Q31	2	0.42	.661	0.02	0.11
Error	41	(34.10)			
Q32	2	1.89	.164	0.08	0.37
Error	41	(41.37)			

Note. Number in parenthesis represents mean square error.

Table 4

Means and Standard Deviations on the Twenty-Two Scale Questions by Group (Analog vs. Analog/Digital)

	Group	n	SD	M
Q10	Analog	35	1.86	1.00
	Analog/Digital	12	1.50	0.90
Q11	Analog	34	3.09	1.00
	Analog/Digital	12	2.42	1.38
Q12	Analog	35	1.49	0.66
	Analog/Digital	12	1.17	0.39
Q13	Analog	35	2.11	0.83
	Analog/Digital	12	1.58	0.67
Q14	Analog	35	3.03	1.18
	Analog/Digital	12	2.92	1.24
Q15	Analog	35	3.63	0.69
	Analog/Digital	12	3.75	0.87
Q16	Analog	35	2.06	0.76
	Analog/Digital	12	2.00	0.74
Q17	Analog	35	1.74	0.74
	Analog/Digital	12	1.75	0.62

Table 4 (cont'd)

	Group	n	SD	M
Q18	Analog	35	2.40	1.14
	Analog/Digital	12	2.08	1.00
Q19	Analog	35	4.37	0.88
	Analog/Digital	12	4.33	0.65
Q20	Analog	35	1.74	0.66
	Analog/Digital	12	1.50	0.52
Q21	Analog	35	1.51	0.51
	Analog/Digital	12	1.50	0.52
Q22	Analog	35	2.23	1.06
	Analog/Digital	12	2.00	0.60
Q23	Analog	35	3.23	1.09
	Analog/Digital	10	3.60	0.84
Q24	Analog	35	3.63	0.88
	Analog/Digital	11	3.55	1.21
Q26	Analog	35	2.77	1.00
	Analog/Digital	12	2.58	1.00

Table 4 (cont'd)

	Group	n	SD	M
Q27	Analog	34	2.35	0.77
	Analog/Digital	11	2.45	0.82
Q28	Analog	35	1.46	0.51
	Analog/Digital	12	1.58	0.51
Q29	Analog	35	1.74	0.70
	Analog/Digital	12	1.83	0.94
Q30	Analog	35	2.69	0.96
	Analog/Digital	12	2.50	1.09
Q31	Analog	35	3.03	0.89
	Analog/Digital	12	3.25	0.97
Q32	Analog	35	3.00	1.00
	Analog/Digital	12	3.58	0.90

Pilot in Training (PT) Survey Instrument Graphic Results

Pilot in Training (PT) Survey graphic results are as follows:

Survey Question 1

1. Gender

☐ Male ☐ Female

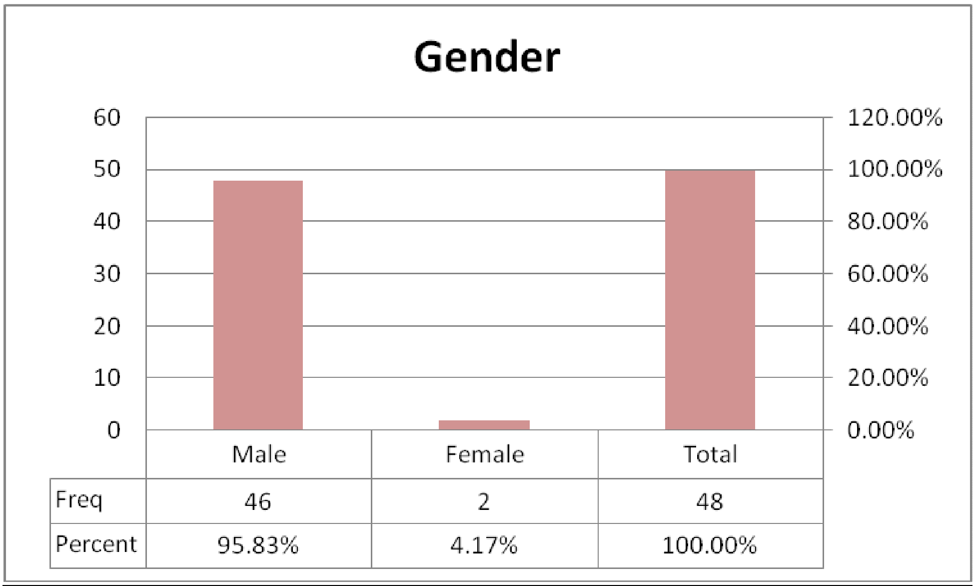


Figure 4. Gender

The pilots sampled in this study were predominately male (95.83%); but not exclusively male; 4.17% of the pilots surveyed were female. This study is reasonably representative of the United States civil airmen population. Based on 2003 FAA U.S. Civil Airmen Statistics, 6.03% of certificated pilot were female (FAA Data and Statistics, 2003).

Survey Question 2

2. Age

☐ 22-30 ☐ 31-39 ☐ 40-49 ☐ 50-59 ☐ 60 and above

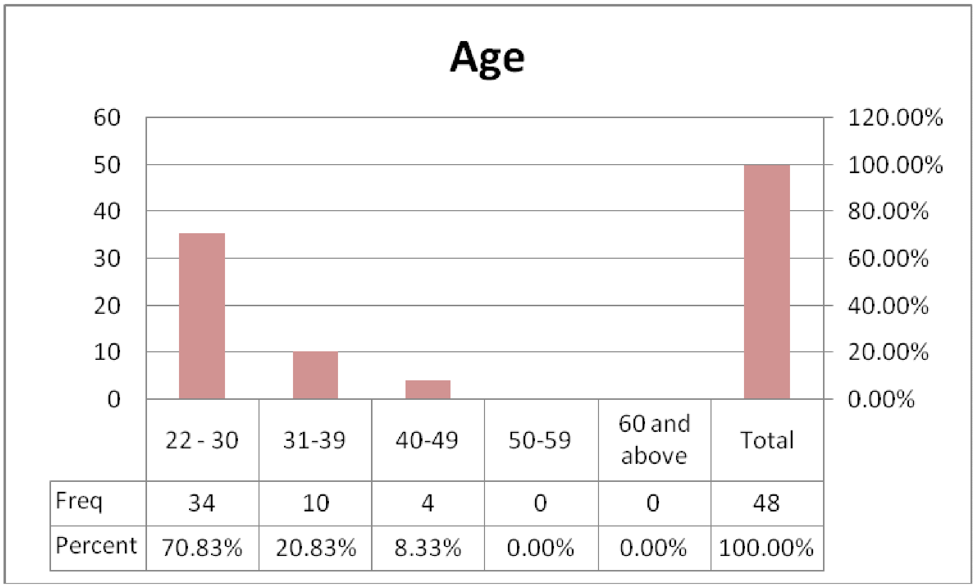


Figure 5. Age

The pilots sampled for this study were predominately younger pilots. The majority of the pilots surveyed were between 22 – 30 years old (70.87%). A smaller percentage of pilots were between 40- 49 (20.83%) years old and no pilots in this sample were older than 50 years old.

Survey Question 3

3. I have been a pilot for (select the best answer):

☐ Less than one year ☐ 1 to 3 years ☐ 3 to 5 years

☐ 5 to 10 years ☐ 10 to 20 years ☐ more than 20 years

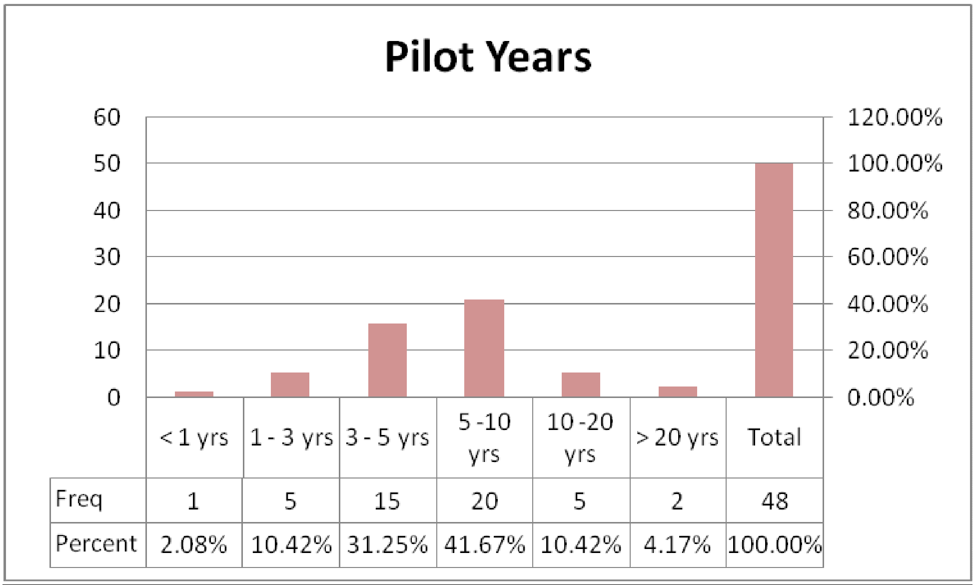


Figure 6. Pilot Years

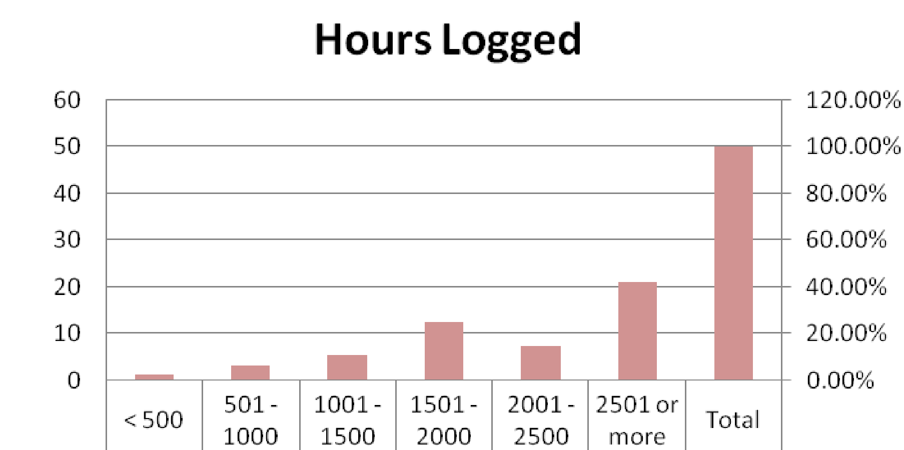
Pilots in this study reported *Pilot Years*, or the number of years they had been a pilot, as shown in the above graph. Pilot reporting that they had been a pilot for three years or less represented 43.75% of the sample. Pilots reporting that they had been a pilot for five to ten years represented 41.67% of the sample, and pilots reporting that they had been a pilot of more than ten years represented 14.59% of the sample.

Survey Question 4

4. I have logged (select the best answer):

☐ 500 hours or less ☐ 501 to 1,000 hours ☐ 1,001 to 1,500 hours

☐ 1,501 to 2,000 hours ☐ 2,001 to 2,500 hours ☐ 2,501 hours or more



	< 500	501 - 1000	1001 - 1500	1501 - 2000	2001 - 2500	2501 or more	Total
Freq	1	3	5	12	7	20	48
Percent	2.08%	6.25%	10.42%	25.00%	14.58%	41.67%	100.00%

Figure 7. Hours Logged

The data shows that 18.75% of the pilots surveyed had 1,500 or less of flight experience when trained by the regional airlines. However, 81.55% of the pilots surveyed indicated that they had more than 1,500 hours of flight experience. While some of the pilots sampled had minimal flight experience, the majority sampled appeared to have more extensive flight experience.

Survey Question 5

5. I learned instrument flying

☐ Under FAA Part 141

. ☐ Under FAA Part 61

☐ Other ________________________________ (Please specify)

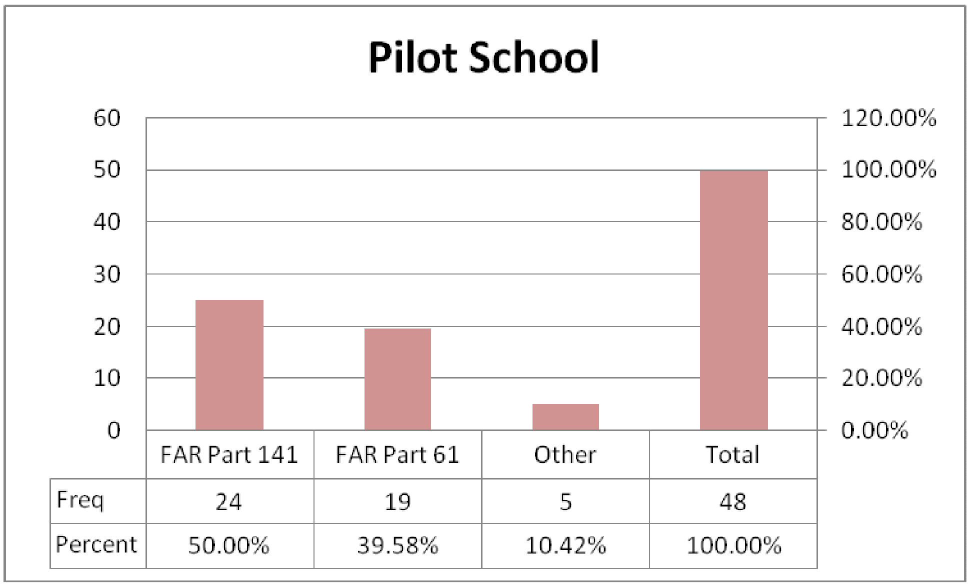


Figure 8. Pilot School

Half of pilots (50%) in this sample received FAR Part 141 flight instruction, 39.58% reported that they had received FAR Part 61 flight instruction, and 10.42% indicated that they had received other primary flight instruction.

Survey Question 6

6. I am a newly hired regional airline pilot (12 months or less):

☐ ☐
Yes No

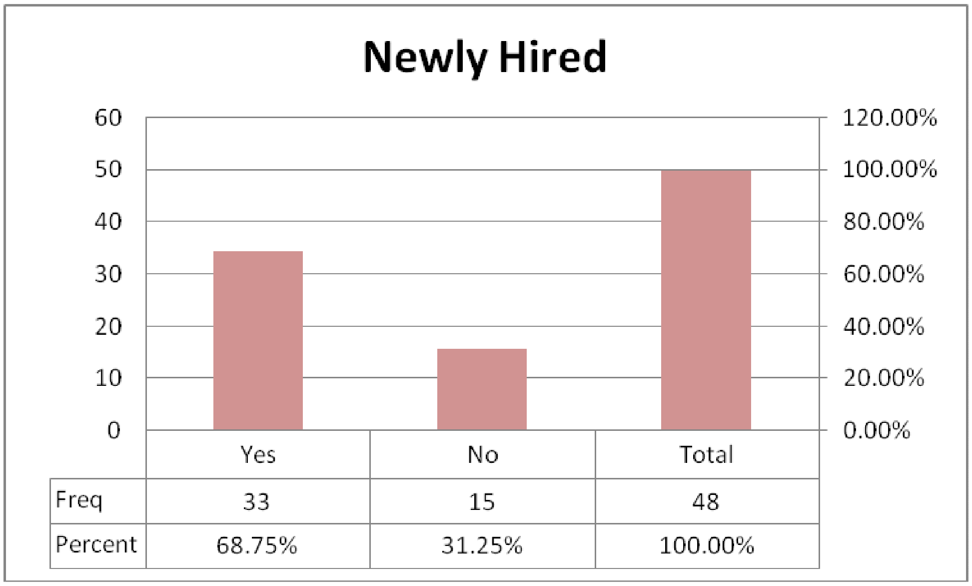


Figure 9. Newly Hired

The majority of pilots surveyed reported themselves as already working for regional airlines before receiving TAA training (68.75%). However, more than a third of the pilots (31.25) reported themselves as Newly Hired Regional Airline Pilots before receiving TAA training.

Survey Question 7

7 . I first learned instrument flying (answer **ALL** that are appropriate):

☐ On analog instruments **only** prior to hire by the airlines

☐ On analog instruments using a Computer Based Training (CBT) software product prior to hire by the airlines

☐ On analog instruments using a Flight Training Device (FTD) prior to hire by the airlines

☐ On analog instruments using a full-motion simulator prior to hire by the airlines

☐ On analog Instruments in an actual aircraft prior to hire by the airlines

☐ On digital instruments using a Flight Training Device (FTD) prior to hire by the airlines

☐ On digital instruments **only** prior to hire by the airlines

☐ On digital instruments using a Computer Based Training (CBT) software product prior to hire by the airlines

☐ On digital instruments using a Flight Training Device (FTD) prior to hire by the airlines

☐ On digital instruments using a full motion simulator prior to hire by the airlines

☐ On digital Instruments in an actual aircraft (e.g. glass cockpit) prior to hire by the airlines

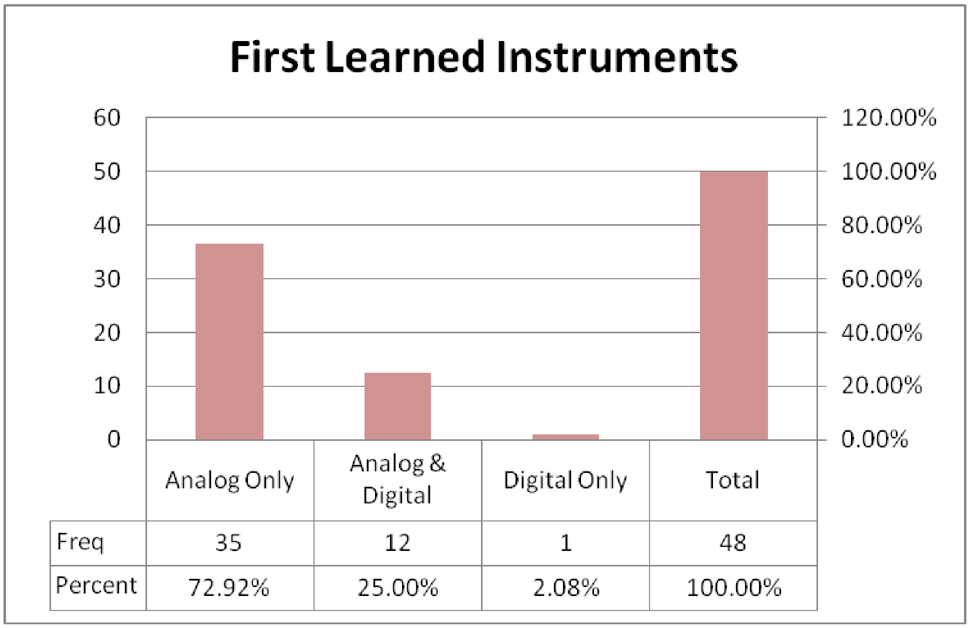


Figure 10. First Learned Instruments

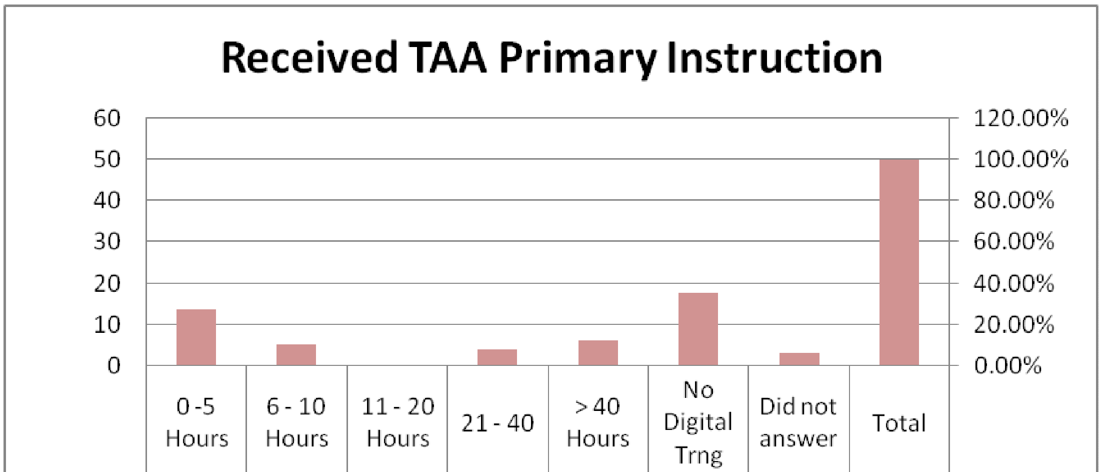
Question 7 was used to determine group assignment for the three groups in the study. The majority of pilots surveyed (72.92%) reported receiving only analog instrument training; 25% reported receiving analog and digital instrument training, and only 2.08% (one pilot) reported receiving only digital instrument training.

Survey Question 8

8. During my primary flight training, I received advanced technology cockpit instruction (e.g. Garmin 1000) for:

☐ 0 -5 ☐ hours 6 – 10 hours ☐ 11 – 20 hours

☐ 21 – 40 hours ☐ More than 40 hours ☐ N/A I did not receive any digital training



	0 -5 Hours	6 - 10 Hours	11 - 20 Hours	21 - 40	> 40 Hours	No Digital Trng	Did not answer	Total
Freq	13	5	0	4	6	17	3	48
Percent	27.08%	10.42%	0.00%	8.33%	12.50%	35.42%	6.25%	100.00%

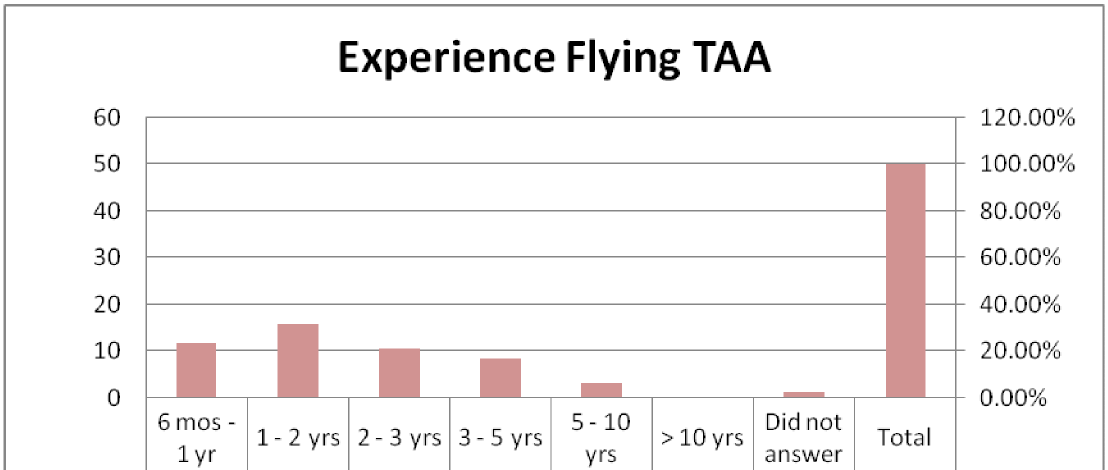
Figure 11. Pilots Receiving TAA Primary Instruction

More than half of pilots (62.5%) of this sample reported receiving five hours or less of advanced technology training. Approximately 19% reported receiving a moderate number of hours of advanced technology training, and only 12.5% reported receiving significant levels of advanced technology training (more than 40 hours). Three pilots (6.25%) did not answer the question.

Survey Question 9

9. I have experience flying technically advanced aircraft using glass cockpits for:

☐ 6 mouths to 1 year	☐ 1 year to 2 years	☐ 2 year to 3 years
☐ 3 years to 5 years	☐ 5 years to 10 years	☐ more than 10 years



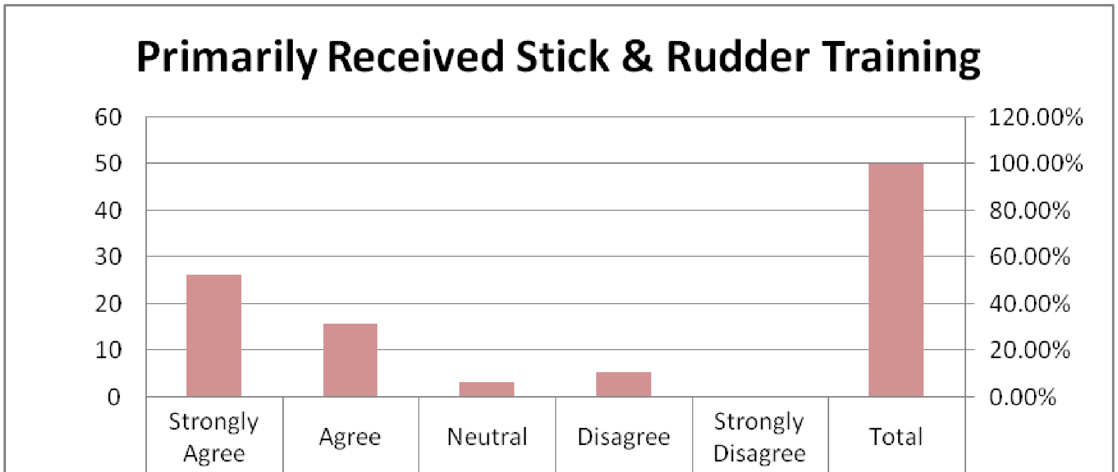
	6 mos - 1 yr	1 - 2 yrs	2 - 3 yrs	3 - 5 yrs	5 - 10 yrs	> 10 yrs	Did not answer	Total
Freq	11	15	10	8	3	0	1	48
Percent	22.92%	31.25%	20.83%	16.67%	6.25%	0.00%	2.08%	100.00%

Figure 12. Pilots Experiencing Flying TAA

More than half of pilots (54.17%) of this sample reported having two years or less of advanced technology experience. Twenty-one pilots (43.75%) reported having more than two years advanced technology experience, and one pilot (2.08%) did not answer the question.

Survey Question 10

10. During initial training, I primarily received Stick and Rudder training (i.e. training flight maneuvers to the PTS)



	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree	Total
Freq	25	15	3	5	0	48
Percent	52.08%	31.25%	6.25%	10.42%	0.00%	100.00%

Figure 13. Pilots Primarily Receiving Stick and Rudder Training

The majority of pilots (forty/83.3%) of this sample reported that they had primarily received Stick and Rudder training to the PTS. Five pilots (10.4%) disagreed that they had primarily received Stick and Rudder training to PTS, and three pilots (6.25%) provided a neutral response to this question.

Survey Question 11

11. During initial training, I primarily received Scenario Based (i.e. FITS type) training

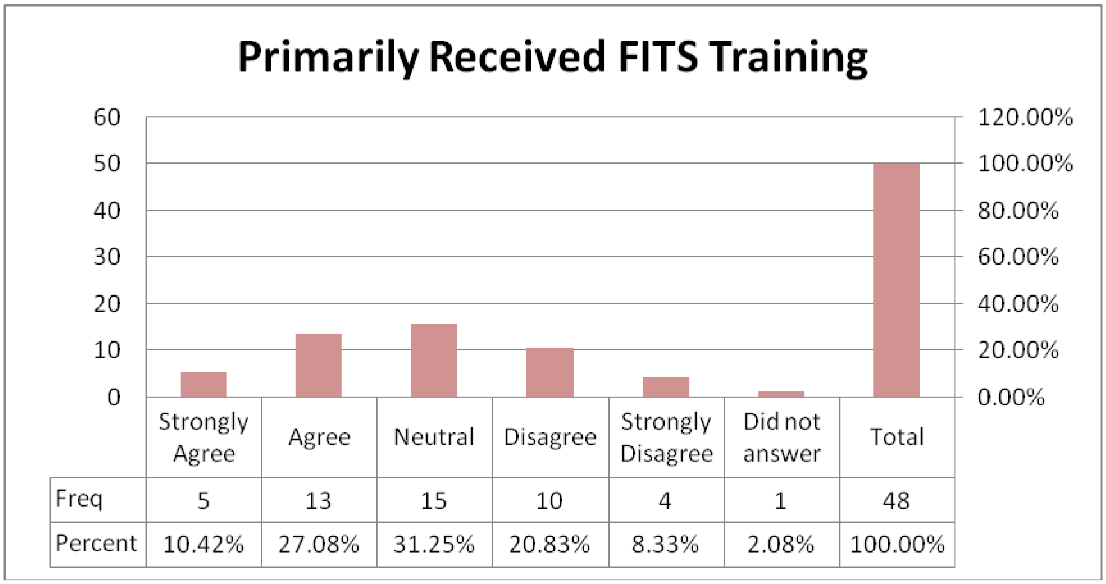


Figure 14. Primary FITS Training

Eighteen pilots (37.5%) of this sample reported that they had primarily received FITS training. Fourteen pilots (29.16%) disagreed or strongly disagreed. Fifteen pilots (31.25%) provided a neutral response to this question, and one pilot (2.08) did not answer the question. Pilots cannot *primarily* receive both stick and rudder training and *primarily* FITS (see question 10 above). While a pilot study of the questionnaire was conducted, the responses to this question may indicate that some pilots did not understand the question, or that some do not fully understand FITS training.

Survey Question 12

12. My initial flight training emphasized mastering flight maneuvers to the PTS

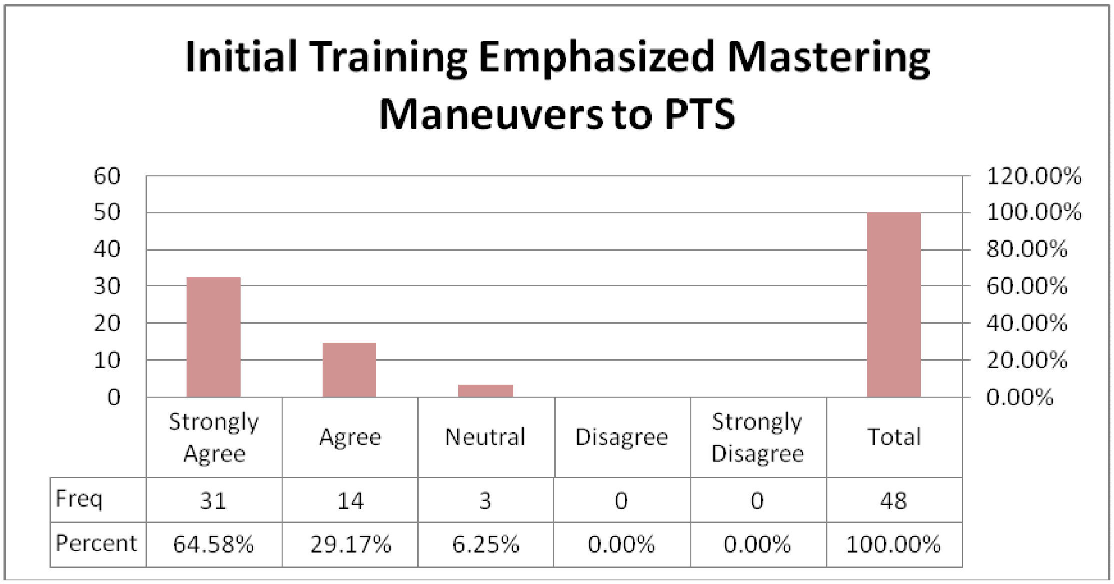
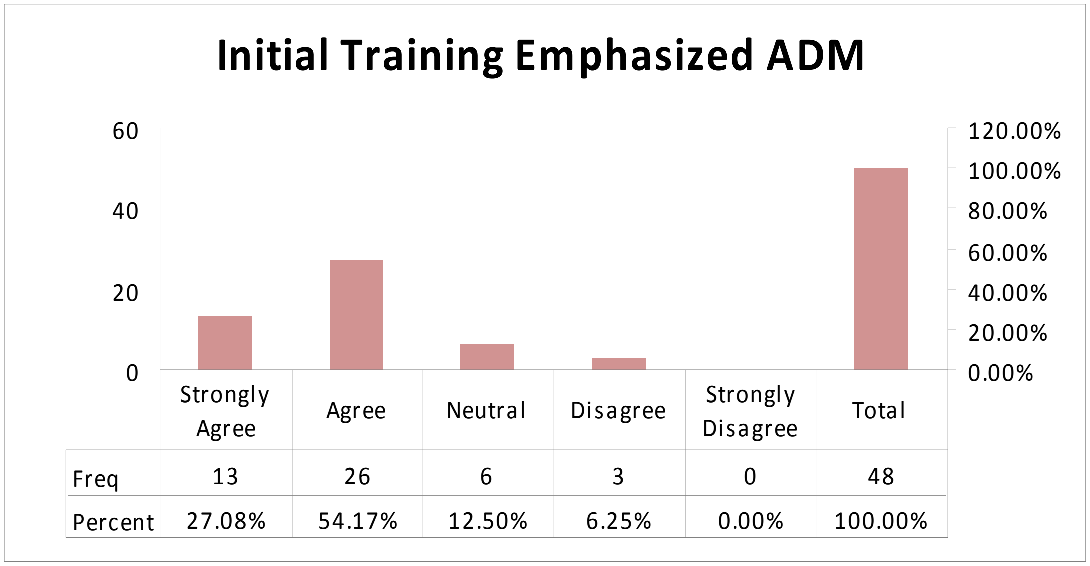


Figure 15. Initial Training Emphasized Mastering Maneuvers to PTS

The majority of pilots (forty-five/94%) of this sample reported that their initial training emphasized mastering maneuvers to the PTS. Three pilots (6.25%) provided a neutral response to this question. Note: both Stick and Rudder training and FITS training require mastering maneuvers to the PTS.

Survey Question 13

13. My initial flight training emphasized Aeronautical Decision Making (ADM)



	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree	Total
Freq	13	26	6	3	0	48
Percent	27.08%	54.17%	12.50%	6.25%	0.00%	100.00%

Figure 16. Pilots Whose Initial Training Emphasized Aeronautical Decision Making (ADM)

The majority of pilots (thirty-nine/81.25%) of this sample reported that their initial flight training emphasized ADM. Three pilots (6.25%) disagreed that their initial flight training emphasized ADM, and six pilots (12.5%) provided a neutral response to this question.

Survey Question 14

14. My primary instrument training prepared me for flying Technically Advanced Aircraft (TAA) with the airlines

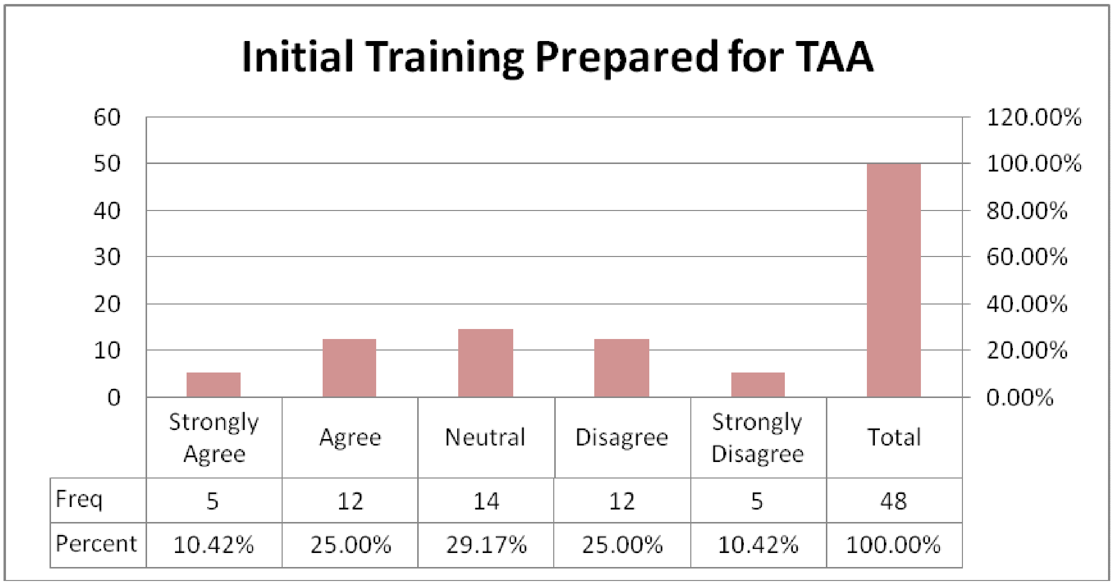


Figure 17. Initial Training Prepared for TAA

Seventeen pilots (35.4%) of this sample reported that their initial flight training had prepared them for flying TAA. An equal number (seventeen/35.4%) disagreed or strongly disagreed that their initial flight training had prepared them for TAA. Fourteen pilots (29.2%) provided a neutral response to this question. Interestingly, despite the fact that no statistical significance was found between the research groups, pilots in this survey seemed to be split about whether or not their training prepared them to fly TAA - regardless of type of training.

Survey Question 15

15. I prefer to fly analog instruments

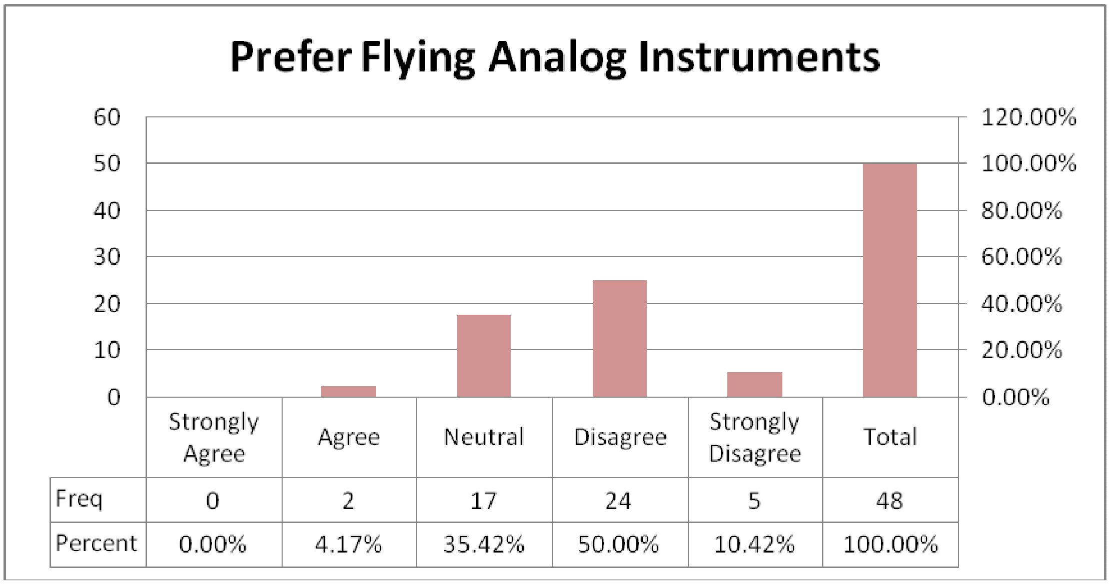


Figure 18. Pilots Who Prefer Flying Analog Instruments

Two pilots (4.17%) agreed that they did prefer to fly analog instruments after completing transition training. The majority of pilots (29/60.42%) of this sample reported that they did not prefer to fly analog instruments after completing transition training. Two pilots (4.17%) agreed that they did prefer to fly analog instruments, and seventeen pilots (35.42%) provided a neutral response to this question.

Survey Question 16

16. I prefer to fly digital instruments

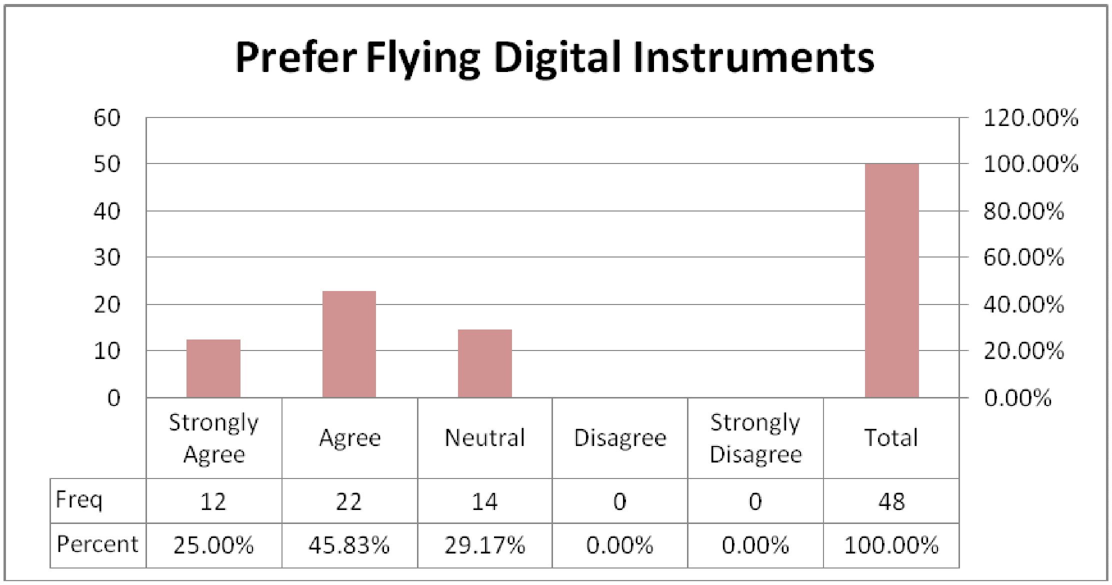


Figure 19. Pilots that Prefer Flying Digital Instruments

Thirty-two pilots (70.83%) agreed that they did prefer to fly digital instruments after completing transition training. No pilots disagreed and 14 pilots (29.17%) provided a neutral response to this question. A majority of pilots responding to questions 15 and 16 preferred to fly digital instruments after completing the transition training. However, it also appears the approximately 1/3 of the pilots were non-committal and chose a neutral response to this question.

Survey Question 17

17. In an emergency, I am comfortable transitioning to analog instruments and *hand flying* the airplane.

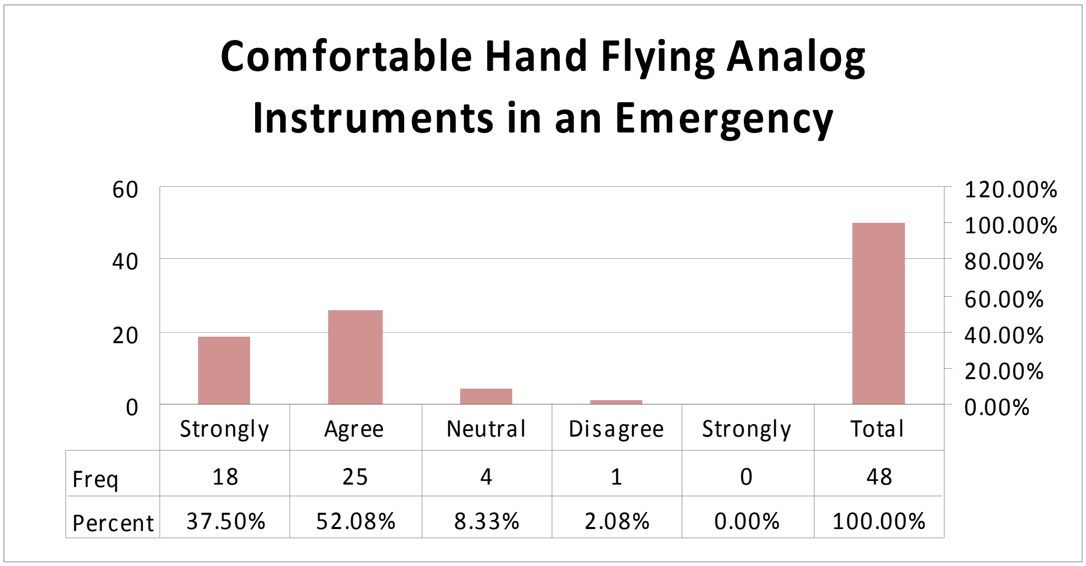


Figure 20. Pilots Comfortable Hand Flying Analog Instruments in an Emergency

Forty-three pilots (89.58%) strongly agreed or agreed that they were comfortable transitioning to analog instruments and hand flying the airplane. Only one pilot (2.08%) disagreed. Four pilots (8.33 %) provided a neutral response to this question.

Survey Question 18

18. In an emergency, I am comfortable transitioning to analog instruments and *hand flying* the airplane on an instrument approach to minimums in IMC.

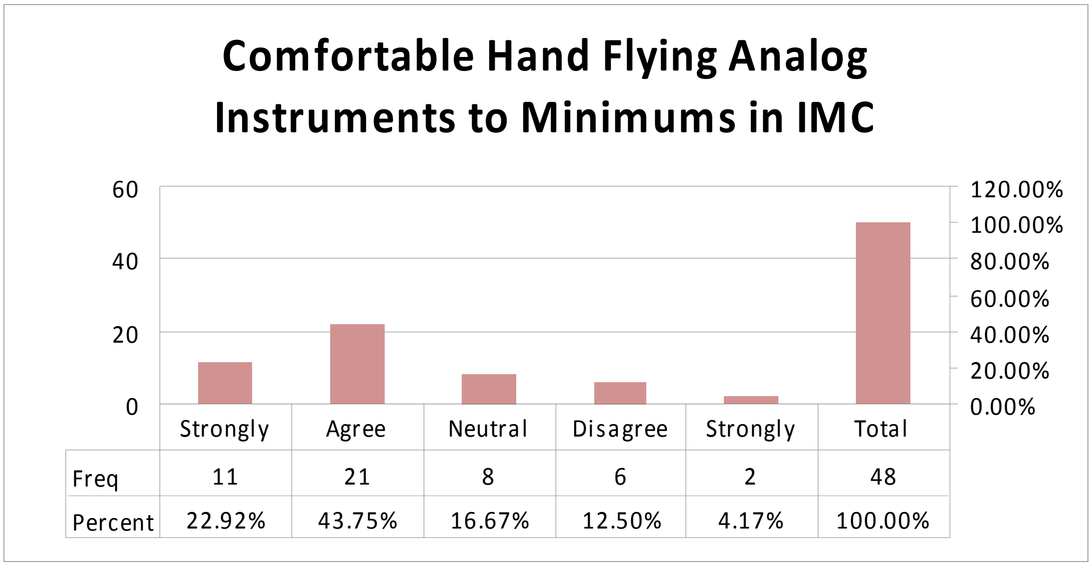
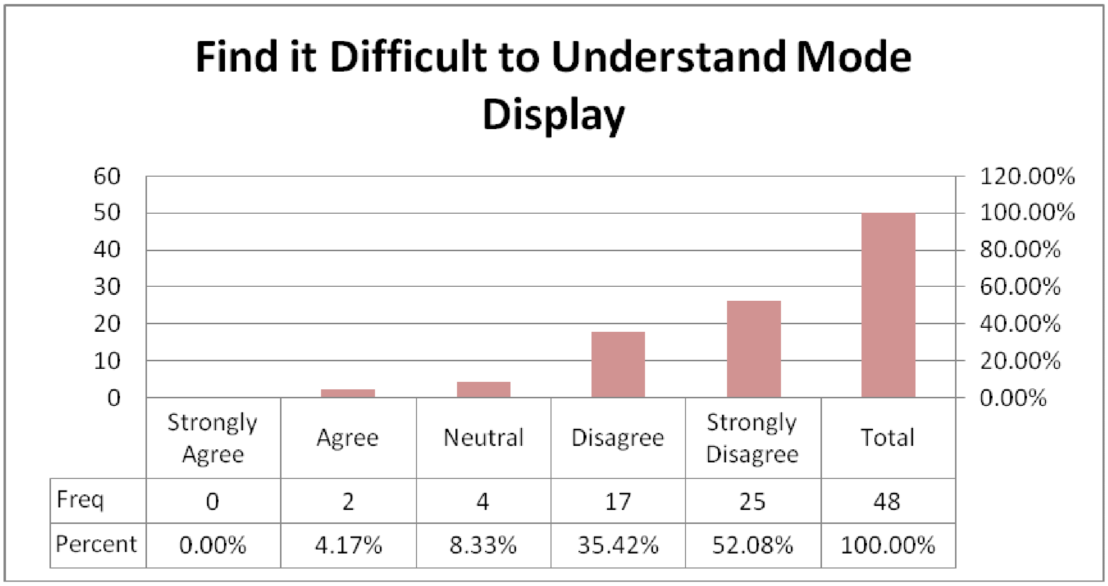


Figure 21. Pilots Comfortable Hand Flying Analog Instruments to Minimums in IMC

Approximately 2/3 of the pilots (32/66.67%) strongly agreed or agreed that they would be comfortable transitioning to analog instruments and *hand flying* the airplane on an instrument approach to minimums in IMC. Eight pilots (16.67%) indicated that they would be not be comfortable transitioning to analog instruments and *hand flying* the airplane on an instrument approach to minimums in IMC. Eight pilots (16.67%) provided a neutral response to this question.

Survey Question 19

19. I sometimes find it difficult to understand the status or mode displayed using a glass cockpit



	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree	Total
Freq	0	2	4	17	25	48
Percent	0.00%	4.17%	8.33%	35.42%	52.08%	100.00%

Figure 22. Pilots Finding it Difficult to Understand Mode Display

The majority of pilots (42/87.5%) strongly disagreed or disagreed that they sometimes find it difficult to understand the status or mode displayed using a glass cockpit. Two pilots (4.17%) agreed that they sometimes find it difficult to understand the status or mode displayed using a glass cockpit. Four pilots (8.33%) provided a neutral response to this question.

<u>Survey Question 20</u>

20. Glass cockpit displays are easy to monitor and comprehend

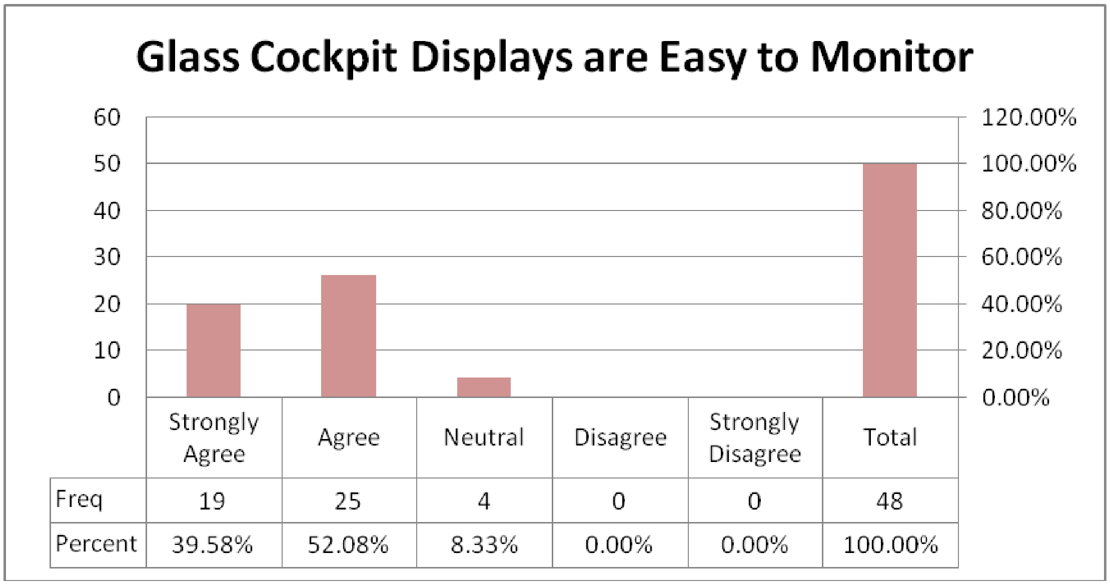
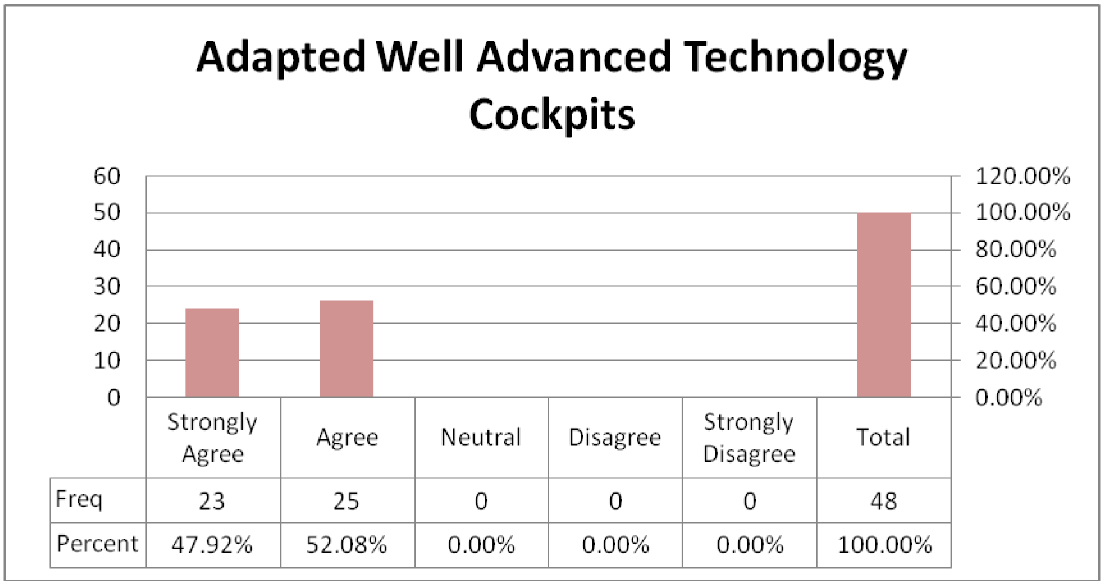


Figure 23. Pilots Finding Glass Cockpit Displays Easier to Monitor

The majority of pilots (44/91.66%) strongly agreed or agreed that Glass cockpit displays are easy to monitor and comprehend. No pilots disagreed and only four pilots (8.33%) provided a neutral response to this question.

Survey Question 21

21. I have adapted well to flying advanced technology cockpits



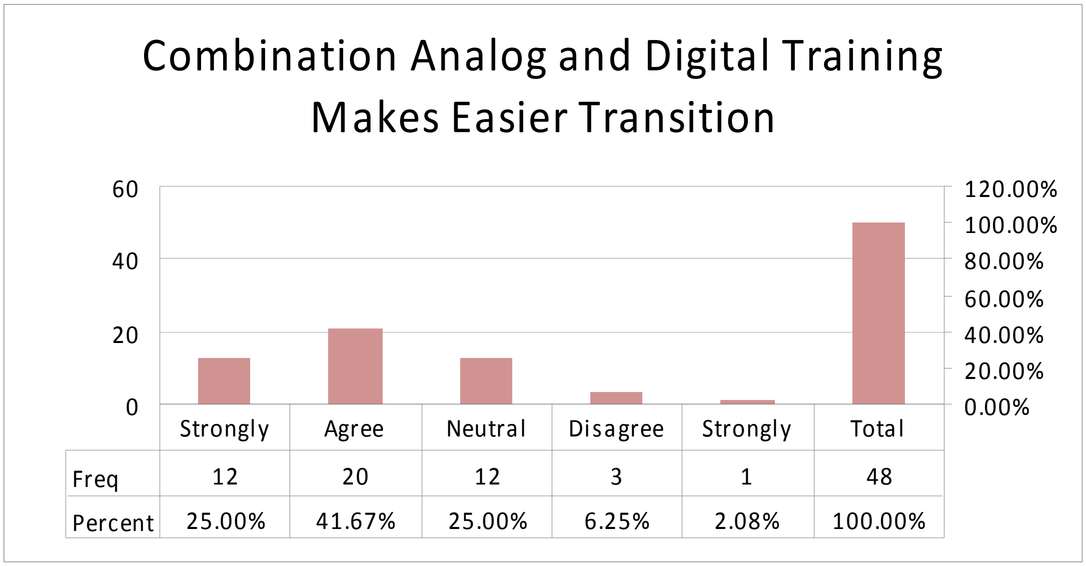
	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree	Total
Freq	23	25	0	0	0	48
Percent	47.92%	52.08%	0.00%	0.00%	0.00%	100.00%

Figure 24. Pilots Adapting Well to Advanced Technology

All pilots (48/100%) strongly agreed or agreed that they had adapted well to flying advanced technology cockpits.

Survey Question 22

22. I believe a combination of analog and digital training makes it easier to transition to technically advance technology cockpits



	Strongly	Agree	Neutral	Disagree	Strongly	Total
Freq	12	20	12	3	1	48
Percent	25.00%	41.67%	25.00%	6.25%	2.08%	100.00%

Figure 25. Pilots Finding Combination of Analog and Digital Training Makes Transition Easier

The majority of pilots (32/66.67%) strongly agreed or agreed that a combination of analog and digital training makes it easier to transition to technically advanced cockpits. Four pilots (8.33%) disagreed that a combination of analog and digital training makes it easier to transition to technically advanced technology cockpits. Twelve pilots (25%) provided a neutral response to this question.

Survey Question 23

23. I believe that pure digital training makes it easier to transition to advance technology cockpits

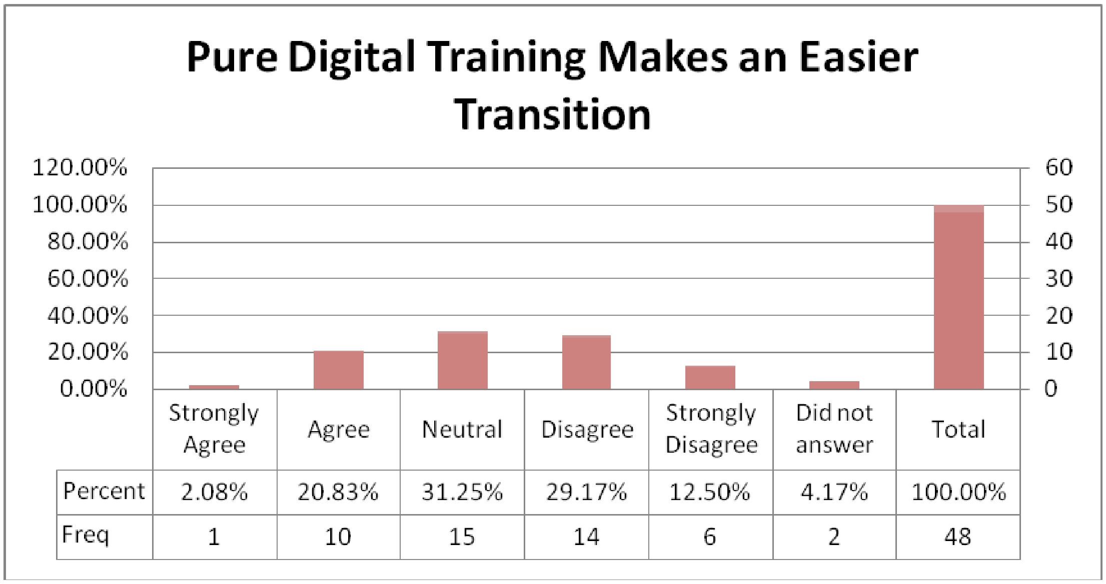
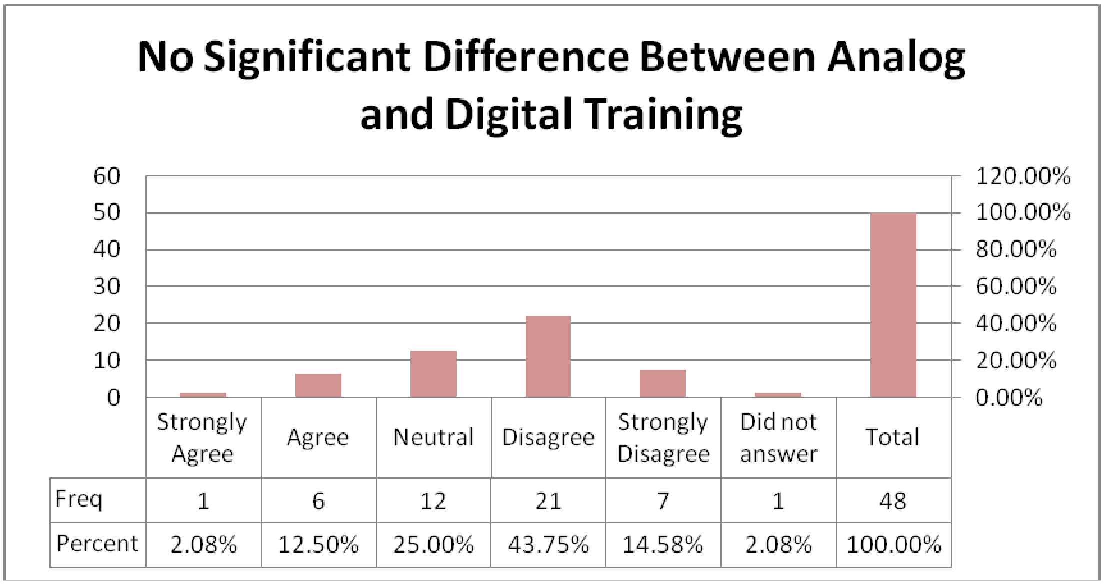


Figure 26. Pilots Preferring Pure Digital Training to Make Transition Easier

Eleven pilots (22.91%) strongly agreed or agreed that pure digital training makes it easier to transition to advance technology cockpits. Twenty pilots (41.67%) disagreed that pure digital training makes it easier to transition to advance technology cockpits. Fifteen pilots (31.25%) provided a neutral response to this question. Note: of the forty-eight pilots surveyed, only one reported he/she initially learned to fly exclusively on digital instruments.

Survey Question 24

24. I believe there is no significant difference between analog and digital training when transitioning to advance technology cockpits



	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree	Did not answer	Total
Freq	1	6	12	21	7	1	48
Percent	2.08%	12.50%	25.00%	43.75%	14.58%	2.08%	100.00%

Figure 27. Pilots Believing No Significant Difference Between Analog and Digital Training

Seven pilots (14.13%) strongly agreed or agreed that there is no significant difference between analog and digital training when transitioning to advanced technology cockpits.

Twenty-eight pilots (58.33%) strongly disagreed or disagreed that there is no significant difference between analog and digital training when transitioning to advanced technology cockpits. Twelve pilots (25%) provided a neutral response to this question. One pilot (2.08%) did not answer the question.

Survey Question 25

25. I have logged:

☐ 10 or less hours in IMC ☐ 10 to 25 hours in IMC ☐ 25 to 50 hours in IMC

☐ 50 to 100 hours in IMC ☐ 100 to 500 hours in IMC ☐ > 500 hours in IMC

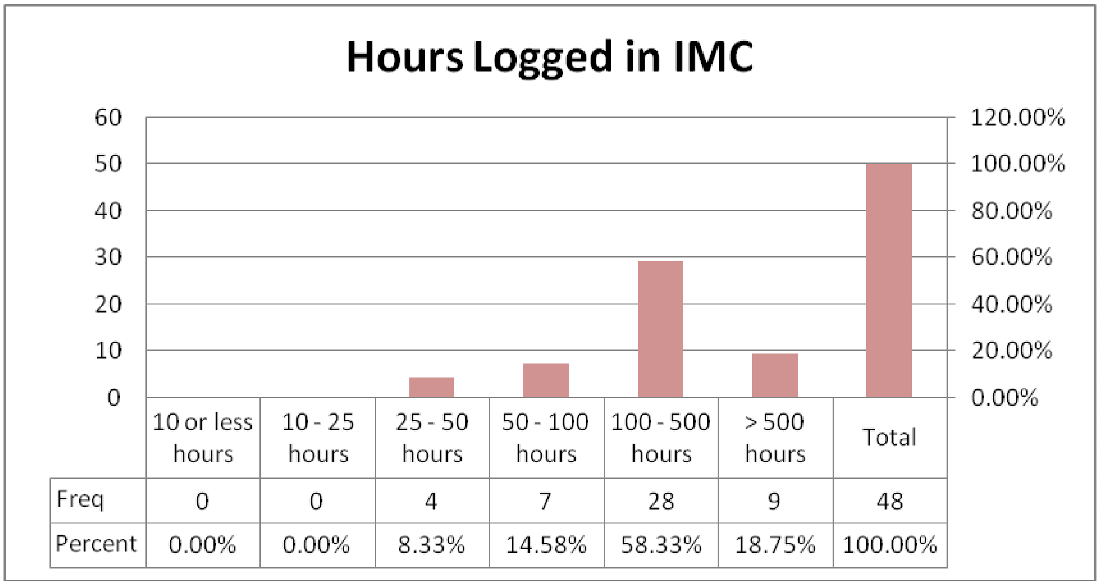


Figure 28. Hours Logged in IMC

Four pilots (8.33%) logged 25 -50 hours in IMC. Seven pilots (14.58%) logged 50 - 100 hours in IMC. The majority of pilots (twenty-eight/58.33%) logged 100 – 500 hours in IMC. Nine pilots (18.75) logged more than 500 hours in IMC.

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Survey Question 26

26. I believe that more hours flown in IMC makes transitioning to an advanced technology cockpit easier.

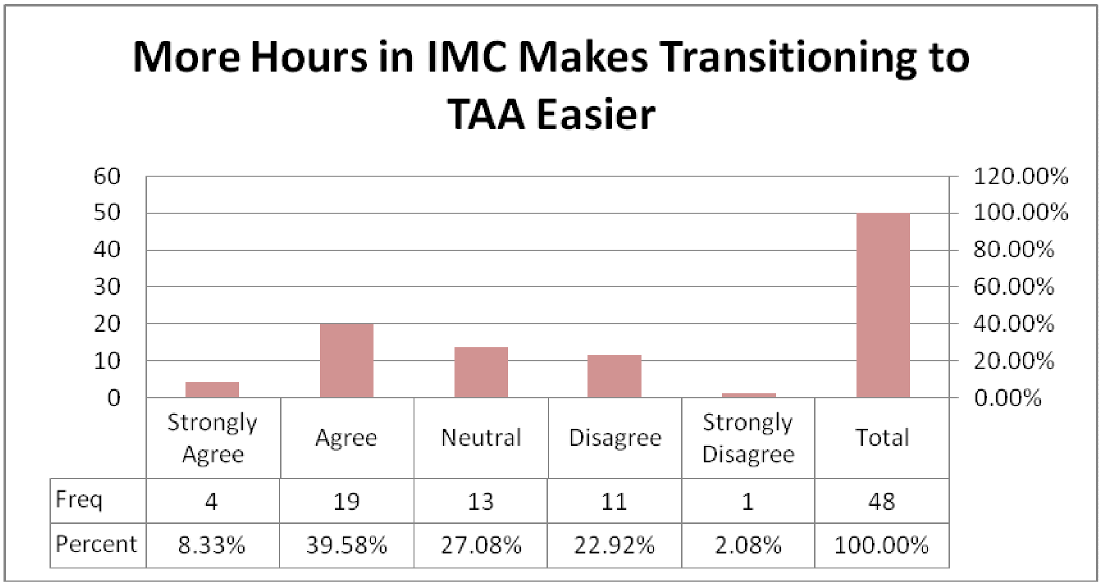
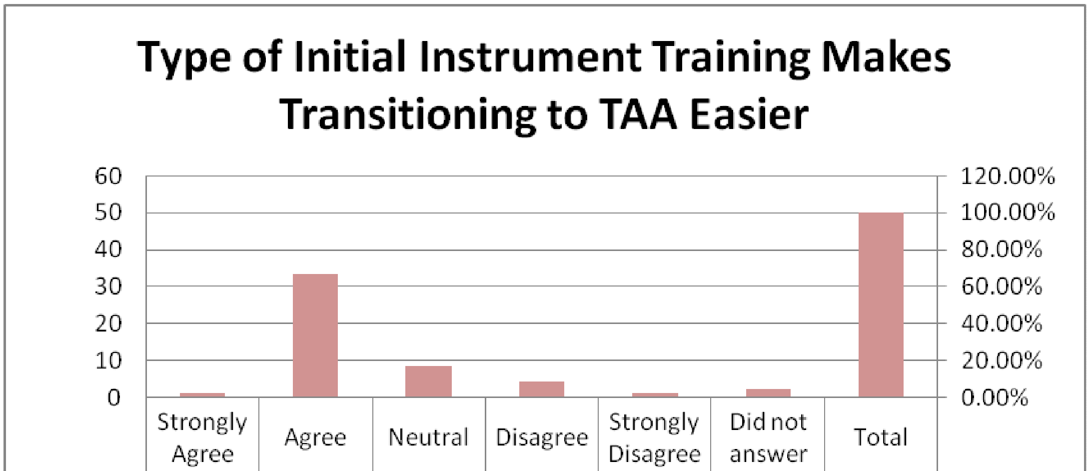


Figure 29. Pilots Opinions that More Hours Flown in IMC Makes Transitioning to a TAA Cockpit Easier

Twenty-three pilots (47.91%) strongly agreed or agreed that more hours flown in IMC makes transitioning to an advanced technology cockpit easier. Twelve pilots (25%) disagreed or strongly disagreed that more hours flown in IMC makes transitioning to an advanced technology cockpit easier. Twelve pilots (25%) provided a neutral response to this question.

Survey Question 27

27. I believe that the type of initial instrument training (analog, digital or both) makes transitioning to an advanced technology cockpit easier.



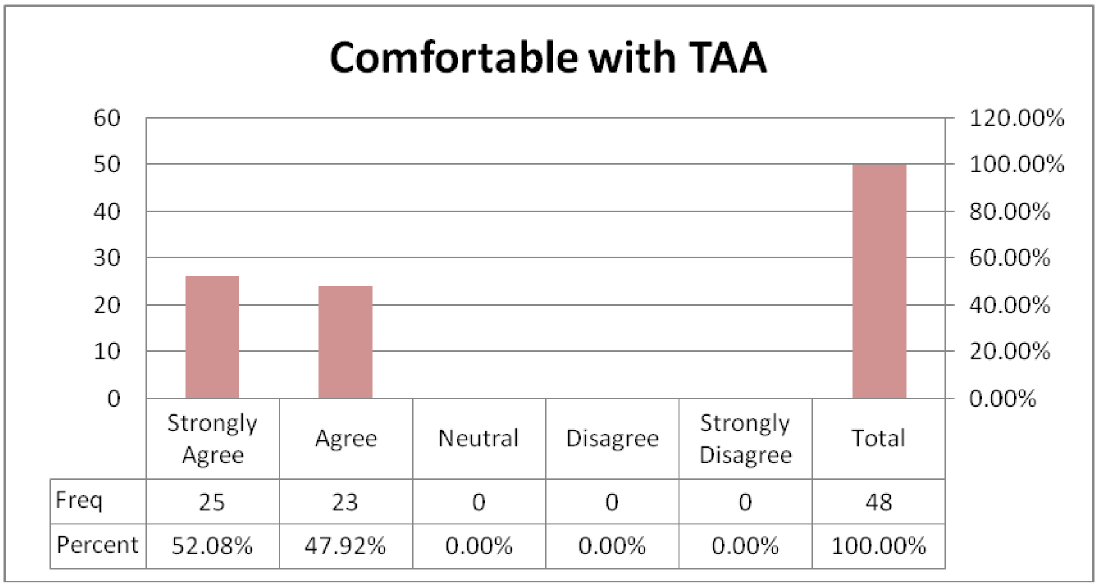
	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree	Did not answer	Total
Freq	1	32	8	4	1	2	48
Percent	2.08%	66.67%	16.67%	8.33%	2.08%	4.17%	100.00%

Figure 30. Pilots Opinions that Instrument Training (Analog, Digital or Both) Makes Transitioning to a TAA Cockpit Easier

Thirty-three pilots (68.75%) strongly agreed or agreed that the type of initial instrument training (analog, digital or both) makes transitioning to an advanced technology cockpit easier. Five pilots (6.25%) disagreed or strongly disagreed that the type of initial instrument training (analog, digital or both) makes transitioning to an advanced technology cockpit easier. Eight pilots (16.67%) provided a neutral response to this question. One pilot (2.08%) did not answer the question. This result is particularly interesting since a majority of pilots (68.75%) believe that the type of training makes a difference when transitioning to TAA; however, the statistical results for this investigation indicate that there is no significant difference between the two groups of pilots analyzed in the study.

<u>Survey Question 28</u>

28. In general, I am comfortable with advanced technology cockpits



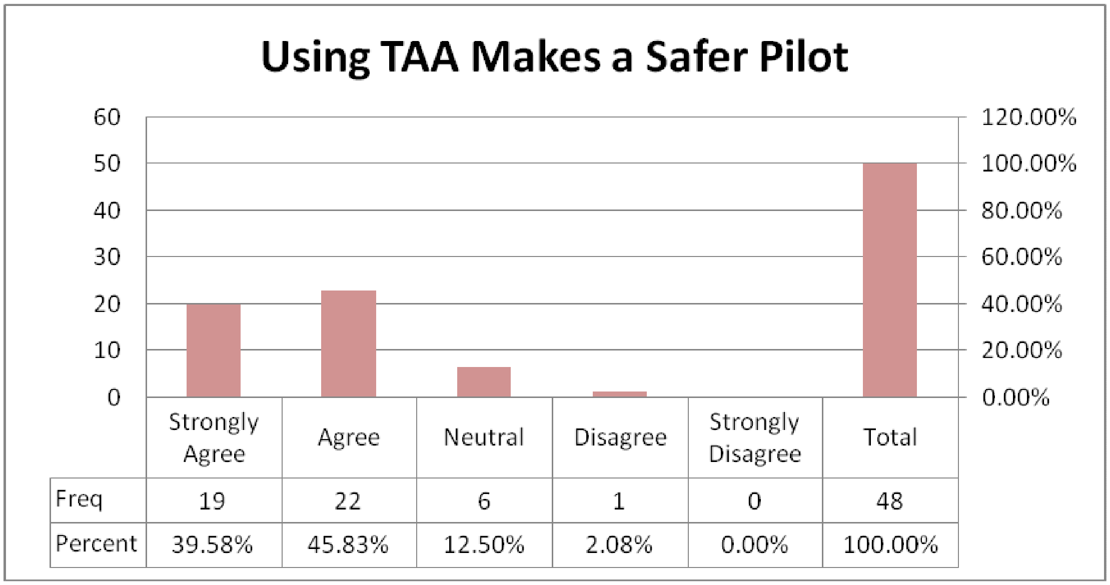
	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree	Total
Freq	25	23	0	0	0	48
Percent	52.08%	47.92%	0.00%	0.00%	0.00%	100.00%

Figure 31. Pilots Level of Comfortable with TAA Cockpits

Forty-eight pilots (100%) strongly agreed or agreed that they are comfortable with advanced technology cockpits.

Survey Question 29

29. I think using advanced technology makes me a safer pilot



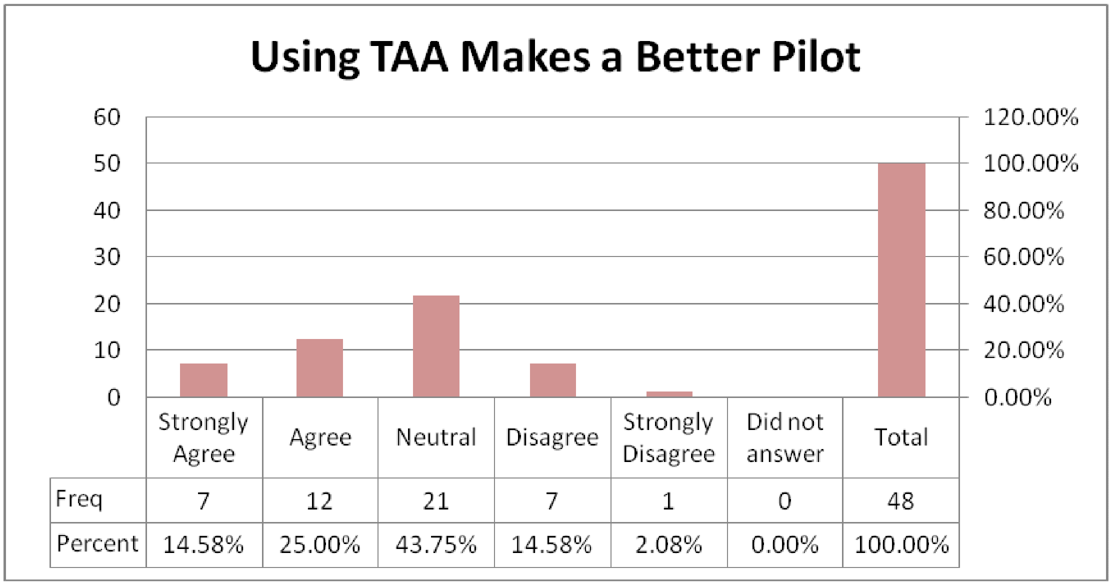
	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree	Total
Freq	19	22	6	1	0	48
Percent	39.58%	45.83%	12.50%	2.08%	0.00%	100.00%

Figure 32. Pilots Opinion that Using Advanced Technology Makes a Safer Pilot

Forty-one pilots (85.41%) strongly agreed or agreed that using advanced technology makes a safer pilot. Only one pilots (2.08%) disagreed that using advanced technology makes a safer pilot. Six pilots (12.5%) provided a neutral response to this question.

Survey Question 30

30. I think using advanced technology makes me a better pilot



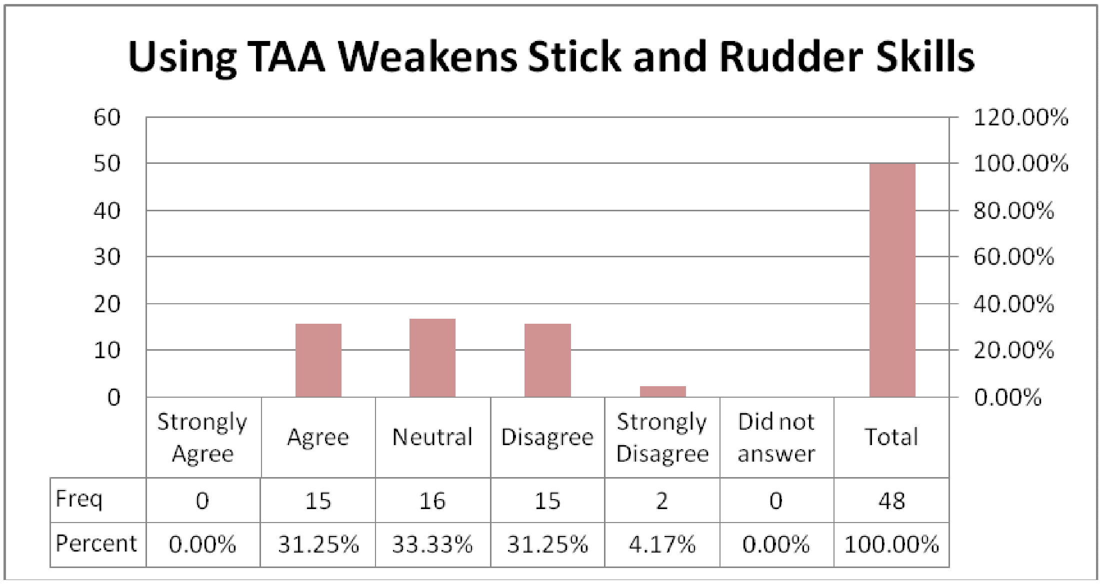
	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree	Did not answer	Total
Freq	7	12	21	7	1	0	48
Percent	14.58%	25.00%	43.75%	14.58%	2.08%	0.00%	100.00%

Figure 33. Pilots Opinion that Using Advanced Technology Makes a Better Pilot

Nineteen pilots (39.58%) strongly agreed or agreed that using advanced technology makes a better pilot. Eight pilots (16.66%) disagreed or strongly disagreed that using advanced technology makes a better pilot. Twenty-one pilots (43.75%) provided a neutral response to this question. This result is also particularly interesting. The majority of pilots surveyed are non-committal (neutral) to the idea that the technology makes them a better pilot. However, the majority of pilots (41/81.47%) do believe that the technology makes them safer pilots (see question 29 above).

Survey Question 31

31. I think using advanced technology weakens my basic piloting (Stick and Rudder) skills



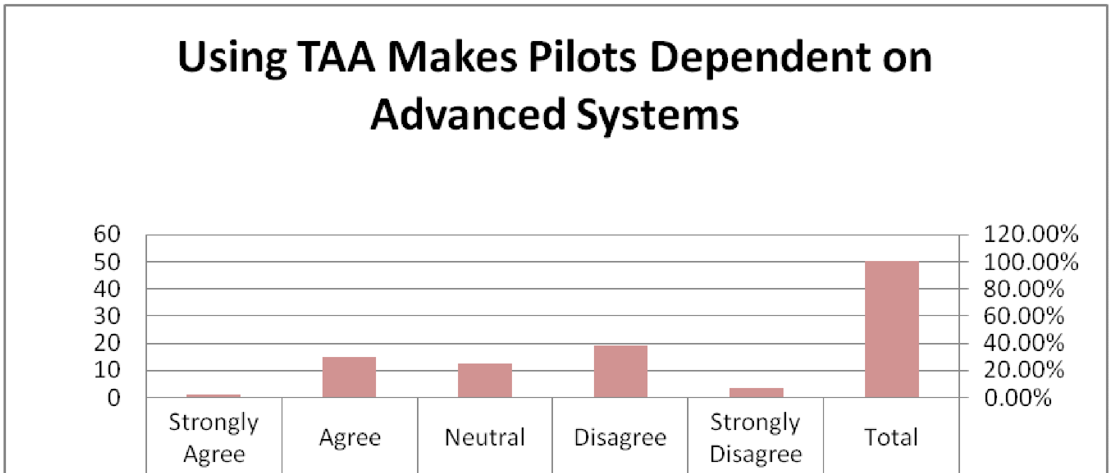
	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree	Did not answer	Total
Freq	0	15	16	15	2	0	48
Percent	0.00%	31.25%	33.33%	31.25%	4.17%	0.00%	100.00%

Figure 34. Pilots Opinions that Using Advanced Technology Weakens Basic Piloting (Stick and Rudder) Skills

Fifteen pilots (31.25%) agreed that using advanced technology weakens basic piloting (stick and rudder) skills. Seventeen pilots (35.42%) disagreed or strongly disagreed that using advanced technology weakens basic piloting (Stick and Rudder) skills. Sixteen pilots (33.33%) provided a neutral response to this question. Once again the results for this question are particularly interesting. The pilots surveyed are nearly evenly split on this question.

Survey Question 32

32. I think using advanced technology makes me dependent on these systems and, therefore, has a negative impact on my Stick and Rudder skills



	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree	Total
Freq	1	14	12	18	3	48
Percent	2.08%	29.17%	25.00%	37.50%	6.25%	100.00%

Figure 35. Pilots Opinions that Use of Advanced Technology Creates Dependence and has a Negative Impact on Stick and Rudder Skills

Fifteen pilots (31.25%) strongly agreed or agreed that using advanced technology makes them dependent on these systems and, therefore, has a negative impact on Stick and Rudder skills. Twenty-one pilots (43.75%) disagreed or strongly disagreed using advanced technology makes them dependent on these systems; and has a negative impact on Stick and Rudder skills. Twelve pilots (25%) provided a neutral response to this question. The results for this question are also particularly interesting. The pilots surveyed once again appear to be split on this question regardless of type initial instrumentation received.

Instructor Pilot (IP) Open-Ended Questionnaire and Qualitative Component Results

The qualitative component was administered using an open-ended opinion survey of airline Instructor Pilots (IPs) to determine their opinions regarding the ability of newly trained regional airline pilot ability to learn and use advanced technology. Four of 25 (16%) Instructor Pilots from the school responded to the questionnaire. Not all IPs answered all questions and, in some cases, opinions varied. However, there were also areas of strong concurrence among the IPs. Four of 25 instructors is not an adequate sample for this qualitative research component. This is especially true when considering that only one IP answered all questions; however, the responses that were provided add value to the study and were; therefore, included. Additionally, these comments may provide insight for areas of future research.

The questions for the IP survey were:

1. Do you believe that scenario based training improves the ability of a pilot/crew to master technically advanced aircraft? Why or why not?
2. What is your opinion regarding the impact of technically advanced aircraft on the ability of pilots/crews to maintain stick and rudder skills?
3. Do you believe that the type of initial flight training has an impact on the ability of new regional airline pilot transition to technically advanced aircraft? If so, what in your opinion is the best mix/type of initial training?
4. In your opinion, is there a significant performance difference among newly hired pilots based on their initial type of flight training? If so, which pilots perform at higher levels and why?

5. In your opinion are none, some, or all of your students completing training at Pinnacle Airlines completely comfortable flying advanced technology aircraft? Why or why not?

Table 5

Instructor Pilot Survey Question Number 1

QUESTION/RESPONDENT: Question 1: Do you believe that scenario based training improves a pilots'/crew's ability to master technically advanced aircraft? Why or why not?	Instructor Pilot Response:
Instructor Pilot 1	No. I believe that basic aviation skills should be achieved first. A student should be able to fly aircraft in all modes (auto, semi auto and manual) before attempting scenario based training. Until the student feels comfortable with all Glass Cockpit and scenario training.
Instructor Pilot 2	I believe scenario based training improves pilots' abilities . . . period. I don't think it makes you any better for an antique DC-9 or a CRJ.
Instructor Pilot 3	Yes it does improve crew's ability in advanced aircraft in that there is a relationship to realistic type flying one can expect.
Instructor Pilot 4	Yes, a scenario based training event encourages the student to consider and deal with multiple variables occurring in real time as opposed to a single profile/emergency etc. . . . It is especially valuable for upgrade candidates.

Table 6

Instructor Pilot Survey Question Number 2

QUESTION/RESPONDENT: Question 2: What is your opinion regarding the impact of technically advanced aircraft on the pilot's/crews' ability to maintain Stick and Rudder skills?	Instructor Pilot Response:
Instructor Pilot 1	Because the pilots rely so much on and use the automation, basic aviation skills suffer. Additional periodic (Quarterly, Semiannually) simulator refreshers would help overcome this.
Instructor Pilot 2	Flying a glass cockpit aircraft diminishes the stick and rudder skills of that used for general aviation.
Instructor Pilot 3	Advanced aircraft such as a CL-65, a pilot becomes a manager of automation and computers. It takes away stick and rudder skills unless the pilot flies aircraft without the auto-pilot.
Instructor Pilot 4	Students have a tendency to rely on automation too much and often, after a problem, they attempt to change automation settings when they should just fly.

Table 7

Instructor Pilot Survey Question Number 3

QUESTION/RESPONDENT: Question 3: Do you believe that the type of initial flight training has an impact on new regional airline pilots' ability to transition to technically advanced aircraft? If so, what in your opinion is the best mix/type of initial training?	Instructor Pilot Response:
Instructor Pilot 1	No Response.
Instructor Pilot 2	I have seen the best performance come from pilots who learned to fly gliders first.
Instructor Pilot 3	Yes. Having a background from a bridge program helps, nevertheless, it does not replace experience and logged aircraft time.
Instructor Pilot 4	No Response.

Table 8

Instructor Pilot Survey Question Number 4

QUESTION/RESPONDENT: Question 4: In your opinion, is there a significant performance difference among newly hired pilots based on their initial type of flight training? If so, which pilots perform at higher levels and why?	Instructor Pilot Response:
Instructor Pilot 1	No Response.
Instructor Pilot 2	The low time pilots that go to a regional jet specific training course like Jet U. or Simuflite are far below a pilot who has flown KingAirs for 500 hours.
Instructor Pilot 3	No Response.
Instructor Pilot 4	-Bridge program students seem more technically proficient, but have more trouble with the big picture and decision making - CFI, freight dogs, etc . . . have trouble with the level of automation and standardization.

Table 9

Pilot Survey Question Number 5

QUESTION/RESPONDENT: Question 5: In your opinion are none, some, or all of your students completing training at Pinnacle Airlines completely comfortable flying advanced technology aircraft? Why or why not?	Instructor Pilot Response:
Instructor Pilot 1	Not all pilots are comfortable completely comfortable. Those with computer skills appear to be most comfortable. Those who have had previous experience as part of a crew using advanced technology are most comfortable/
Instructor Pilot 2	About 25% wash out that I have seen. The 'career change at 50 years of age' or the 'rich kid spoiled brat 18 – 21 years old' are the two worst types. Both are at opposite ends of the spectrum. One can't get it because they are too old and the other expects it to be handed to them because that's how life has been since birth. Both types are frustrating to work with. Little progress/success is usually made.
Instructor Pilot 3	No Response.
Instructor Pilot 4	No Response.

Summary

This chapter outlines the findings for the quantitative and qualitative components of the investigation. While the results are somewhat surprising, the data did yield useful information. Each of the three groups of pilots in training is discussed in detail as is the instructor pilot group. Both the quantitative and the qualitative analysis are explained. The sample sizes for both groups of respondents were inadequate. Two of three assumptions for use of an ANOVA were violated; however, the assumption of independence was not violated and is essential when conducting an ANOVA. While the qualitative component did not have an adequate sample, the instructor pilot survey comments were retained and reported because they added value to the study and allowed a comparison to be made with the pilot in training perceptions.

CHAPTER V

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

Introduction

This investigation tested a hypothesis about pilot and IP observations regarding pilot in training perceived ability to transition to glass cockpits displays found in technically advanced aircraft, given the type of initial instrumentation flight training. This research sought to determine the differences among pilots trained using various types of instrumentation ranging from aircraft equipped with traditional analog instrumentation to aircraft equipped with glass cockpits. The research design, therefore, focused on *type* of training which included students initially trained using only traditional analog instrumentation; students initially trained using only digital instrumentation; and students initially trained using a combination of analog and digital instrumentation. Additionally, this research reports on method of training for each of the groups. For purposes of this study, *method* referred to whether or not recently trained pilots received traditional *stick and rudder* (i.e. maneuver based training) or whether these pilots received scenario based training or a combination of both.

Statement of the Problem

The problem addressed in this study is to identify pilot and instructor pilot perceptions of their ability to learn and use advanced aviation technology. These systems are complex and a pilot must possess a significant degree of familiarity with automated systems. This new digital age presents many challenges for both seasoned pilots as well as for those who are new to aviation. A great deal of research has been done in the area of human factors research to determine how pilots interface with complex aviation systems. However, more limited research has been done regarding how pilots are trained before entering service with the airlines. Much needs to be learned about how new pilot/crew training prepares them to adapt to technically advanced cockpits in more sophisticated commercial aircraft.

The study attempted to answer the following research questions:

1. What is the perceived ability of pilots initially trained on only analog systems to adapt to more advanced cockpit technologies?
2. What is the perceived ability of pilots initially trained on only digital systems to adapt to more advanced cockpit technologies?
3. What is the perceived ability of pilots initially trained on both analog and digital systems to adapt to more advanced cockpit technologies?
4. What are the perceptions/observations of Instructor Pilots related to the ability of the newly trained regional airline pilot to adapt to technically advanced aircraft compared to the perceptions of the Pilot in Training (PT)?

Summary of Findings

This study failed to disprove the null hypothesis. That is, the type of instrumentation training (during initial training) has no significant effect on the newly trained regional airline pilot perceived ability to adapt to advanced technology cockpits in more sophisticated and/or newer aircraft. However, the study was important because it demonstrated that this relationship did not exist for this group of airline transport pilots. The results of the study pose some very interesting questions for future research.

While this result was surprising, it is nonetheless, instructive. What seems to be a fairly obvious relationship between exposure to and use of technically advanced instrumentation, when transitioning to TAA, apparently does not exist for this group of airline transport pilots. Both the analog only group and the analog/digital group appear to transition to TAA equally well. The digital only group was not analyzed because only one pilot was reported to have been exclusively trained on digital instrumentation.

The perception of pilots, initially trained on analog systems only, is that they easily transition to TAA. However, this was consistent with each of the other groups. All pilots regardless of group strongly agreed or agreed that they had adapted well to flying technically advanced aircraft.

Instructor Discussion

Instructor Pilots did not comment on *type* of instruction as it pertains to transitioning to TAA; that is whether or not the student pilots had previous exposure to and training in TAA. Rather, instructor pilot opinions focused on success or failure, when transitioning to TAA, in terms of:

- Type of aircraft flown (e.g. more positive results were reported for student pilots who previously flew glider aircraft and/or had significant experience in large twin aircraft such as the KingAir.)
- Total logged flight time
- Participation in bridge programs
- Type of flying experience (e.g. less favorable results were reported for prior cargo pilots and Certified Flight Instructors)
- Computer/automation skills
- Age

Some of the Instructor Pilot comments indicate that low time pilots receiving simulator training at regional jet specific courses and/or airline bridge programs were not as successful as those pilots who had built flight time in larger twin engine aircraft. Pinnacle Airlines does recognize a number of bridge programs. These programs allow pilots with lesser flight experience, than that required for new hire pilot candidates, to gain the experience and ratings necessary to be successful in the Pinnacle Airlines Initial Pilot Training Program. However, some instructor pilot comments also indicated that regional jet specific training did make some students more technically proficient and indicated that computer skills were a factor for success. Interestingly, these comments seem to indicate that both experience (in terms of total hours logged) and familiarization with automation are salient factors to success when transitioning to TAA.

Regarding instructor pilot comments, there was no indication whether more successful/experienced pilots previously flew traditional analog instrumented aircraft or whether they flew more technically advanced aircraft. This may be an indication that, in the opinions of these instructor pilots, *type* of flight experience is not as important as overall logged flight time when transitioning to TAA.

There were also some surprising comments about age as a factor in successfully transitioning to technically advance regional aircraft such as the CRJ-200. Some instructor pilot comments indicated that older pilots and young pilots had trouble transitioning. The instructor pilots speculated that the older pilots (over 50 years of age) have more difficulty transitioning because they cannot master the technology and younger pilots (18 – 21 years of age) lack the discipline required to successfully complete the rigorous transition program. Learning this new technology is significantly different than learning the older technology. Obviously, understanding systems programming, mode awareness, and the complex functionality of advanced aviation technology is difficult and does take an investment of time and practice. Sarter et al., 2007 noted that there are often gaps in pilot understanding of complex automation modes. Some pilots may actually be unaware of automated mode changes and experience difficulty monitoring automation systems. The need to interact with automated systems requires new performance based systems monitoring strategies (Sarter et al., 2007) that are very unfamiliar to pilots flying traditional aircraft and clearly requires technical savvy and diligence to learn.

Most instructors surveyed also believed that scenario based training improved a pilots ability to transition to TAA. The majority opinion was that scenario based training provides a more realistic training environment and that it causes the student pilot to ‘consider and deal with multiple variables occurring in real time’. However, at least one instructor pilot thought that student pilots first need to learn basic aviation skills before attempting scenario based training.

An opinion that is commonly shared throughout the aviation community, and strongly supported by the instructor pilots in this study, is the belief that flying technically advanced aircraft has a negative impact on *stick and rudder* flying skills. Most instructors in this study believed this was the case and made recommendations for additional/periodic training to overcome a loss of flying skills. Interestingly, a few of these comments indicated that pilots should sometimes turn off the technology and just fly the aircraft.

Pilot in Training Discussion

The majority of pilots in training (68.75%) did believe that the type of initial instrumentation training received did make a significant difference when transitioning to TAA (question twenty-seven). However, as previously noted there was not a significant difference between the two groups when comparing them in terms of ease of transition (question 21). Survey questions twenty-two and twenty-four also indicated that a majority (58.33%) believed this relationship exists. Most pilots in this study believed that the *type* of training (analog, analog and digital, or pure digital) did make a difference when transitioning to TAA. However a smaller number of student pilots disagreed and twenty-two pilots (41.76%) of those surveyed did not believe that *digital only* training made this transition easier (question twenty-three). Question twenty-two indicated that in the opinion of these student pilots, a combination of analog and digital training might make transition to TAA easier. Despite these student pilot opinions, these differences were not noted between the two groups.

Question fourteen also provided an interesting insight into the pilot perceptions. While most pilots reported themselves as having little to no difficulty adapting to TAA (question 21); and while they, nonetheless, believed that initial type of training did make a difference (questions 22, 24, 27); all pilots as a group were split about whether their initial training had prepared them for transition to TAA. This seems to indicate that while the pilots believed type of training was important and also believed their individual transitions were uneventful; they did not necessarily believe that their initial training had prepared them for the transition. The reasons for this finding are unclear.

The majority of pilots in training almost unanimously agreed (or were neutral) in their opinions that they did not have difficulty understanding mode display and/or monitoring and understanding glass cockpit displays (questions 19 and 20). This perception differs greatly from that found in a preponderance of past research. Much of the human factors research indicates that mode display and the presentation and salience of the human-machine interface design can make the use and comprehension of highly complex automated systems difficult. Sarter et al., 2007 and others have documented commercial airline pilots tendency to misunderstand systems mode and to respond inappropriately due to a lack of mode awareness. Miller et al., 2007 found a number of issues related to situational awareness such as the human tendency to become less aware of changes when they are under the control of another agent or the tendency of automation to create both high and low workload extremes. Perhaps the student pilots in this study did not have enough experience with TAA to fully appreciate or recognize a lack of mode awareness.

Student pilot opinions for the effects of TAA training on stick and rudder skills were somewhat different than the opinions offered by instructor pilots. The results of question thirty-one indicated that the student pilots were almost evenly split on this issue. Approximately 1/3 of student pilots felt that stick and rudder skills were weakened when flying TAA, approximately 1/3 of student pilots were unsure, and approximately 1/3 of student pilots disagreed that flying TAA weakened stick and rudder skills. Additionally, the majority of student pilots (89.58%) reported that they were comfortable hand flying analog instruments in an emergency (question seventeen). A smaller majority (66.67%) were also comfortable hand flying analog instruments to minimums in Instrument Meteorological Conditions (IMC) (question eighteen).

Questions 29 and 30 also yielded interesting results. While no significant differences were found between groups, the vast majority of pilots from both groups believed that flying TAA made them safer pilots (85.4%), but were less certain if TAA made them better pilots (39.58%). However, the majority (70.83%) preferred flying TAA (question sixteen). Questions concerning stick and rudder skills; the ability to hand fly the aircraft in emergency and/or IMC; and the concepts of safer pilots verses better pilots may be interrelated. This group of airline transport pilots seems to believe that flying TAA made them safer, but were less convinced as a group that it made them better pilots. Additionally, they were less comfortable as a group to hand fly analog instruments to minimums in IMC.

The majority (83.3%) of student pilots indicated that they primarily received stick and rudder training to the PTS (question 10). However, in question 11 some pilots (37.5%) indicated that they had primarily received Scenario Based FITS training. Pilots cannot *primarily* receive both types of training. Students may not have understood this particular series of questions, or it is possible that they do not fully understand Scenario Based FITS training. While FITS training does require mastering flight maneuvers to the PTS, it is also credited with allowing pilots to learn superior aeronautical decision making skills and increasing situational awareness. Robertson et al., 2006 suggested that the specific strengths of FITS training was significant improvement in pilot performance, situational awareness, aeronautical decision making and that FITS had no relative weakness as compared to non-FITS training. French et al., 2005 came to much the same conclusions suggesting that FITS training improved piloting and navigation skills. However, FITS training was not significantly different than Maneuver Based Training for several other tasks. Apparently, there is much more to learn regarding the role of FITS training during primary flight instruction. The second Middle Tennessee State University study undertaken by Dornan et al., 2006 was conducted to lend some clarity to the issue of whether the technically advanced equipment found in TAA or whether FITS training was responsible for the benefits uncovered in a previous Middle Tennessee State University study (Dornan, 2005). This is similar in concept to the current study with the exception that the current study seeks to determine if early exposure to the technology is related to an ease of transition to TAA at regional airlines. As previously stated, pilots in this study were nearly evenly split (question 14) when asked if their initial training had prepared them for TAA.

Implications

An obvious implication of this research is that exposure to technically advanced aircraft during initial flight training is not as important to transitioning to regional airline cockpits, later in a flying career, as previously thought. Since both groups of student pilots, those receiving initial training on analog only instrumentation and those receiving initial training on analog and digital instrumentation, reported no significant difficulty transitioning to TAA, no evidence exists from this investigation to support the early introduction and training of TAA. However, the sample of pilots in this investigation is most likely responsible for this outcome. Since most pilots were trained on analog systems first and since only one pilot was exclusively trained on digital instrumentation, equal numbers of respondents in each of the original three groups was not possible. That is, the assumption of homogeneity of variance was violated. Had equal numbers of respondents been available in each of the original three groups of pilots, a small sample size of forty-eight pilots may not have been such a limiting factor. *ANOVA* is robust against this violation if the groups are approximately equal, the groups are not approximately equal (no more than 1.5 times as different) increasing the likelihood of committing a Type II error because of the violation of homogeneity of variance.

If one assumes the findings are valid, then the acquisition of basic flying skills may be more important to success then the timing of introduction to technically advanced aircraft. Based on instructor pilot comments, factors such as experience in terms of hours logged and type of aircraft flown (without regard for instrumentation) may have a graeter bearing on success when transitioning to TAA. Additionally, factors such as age and life experience may be correlated to success in regional airline TAA training programs.

Another fairly obvious implication of the study is that it was conducted too early. That is, as of the time of this study, most pilots are still receiving initial instrumentation training on analog instruments in a maneuver based training environment.

This group of pilots also indicated that they did not perceive significant difficulty understanding mode displays despite quite a large amount of evidence from previous studies to the contrary. Perhaps this result was due to the student pilot experience level in TAA. All student pilots, regardless of group assignment, were relatively new to TAA. Sarter et al. (2007) found that pilots can be oblivious to changes of mode or status of displays. Additionally, at least one instructor pilot commented that student pilots 'attempt to change automation settings when they should just fly'. This comment might indicate a lack of mode awareness and/or systems status awareness while observing the student pilot interface with the automation. Or perhaps student pilots did not report a lack of mode awareness and/or systems status awareness because the level of training received ensured high levels of proficiency and comfort with TAA at course completion.

Limitations

The most significant limitation of this study was sample size. This was true for both the quantitative and qualitative components of the investigation. For a population of 1,080 pilots a sample size of 128 pilots would have been preferred and would have been much more representative of the population under study (Soper, 2009). The sample size was calculated based on setting the alpha level to .05, the effect size to .05 and the desired statistical power to .80 (note: alpha level, effect size and power are set by the researcher).

The *Digital Only* group was extremely underrepresented. This is most likely the case because most pilots, even those receiving initial flight instruction at FAA FAR Part 141 flight schools (50% of this sample), are still much more likely to learn using traditional analog instrumentation (72.92% of this sample) than technically advanced instrumentation. Had the groups been of equal size, then sample size would not have been as important an issue for this investigation.

No significant difference exists between the groups across each of the 22 Likert scale question. The power for each question was low increasing the probability of a Type II error (that is the probability of accepting a null-hypothesis when it should have been rejected). Power may be increased by increasing sample size. Statistical power measures the probability of committing a Type II error. Similar to setting alpha level, setting power to detect an effect is done by the researcher and is arbitrary**.** Power is expressed as power = 1 - ß, where ß is the probability of a Type II error. Typically Power is set at 0.80 (Murphy & Myors, 2004). Therefore, setting the power at .80 means there is a 20% chance of committing a Type II error. The higher the power, the less likely a Type II error will occur. None of the results for power in this study approach the .80 standard.

Another obvious problem for this study is homogeneity. Even when assigned to one of the two groups, most pilots had more in common training-wise than not. There was not a significant variance between and within groups. For instance, most pilots were young and had been flying for three years or less. Additionally, half of the pilots learned to fly at a FAR Part 141 school and almost two thirds of the pilots initially learned on analog instruments only (72.92%). Perhaps this study should be undertaken at some point in the future when more pilots learn to fly instruments in a *digital only* environment. As of the time of this writing, and given the results of this investigation, it appears that relatively few pilots are exclusively learning to fly in advanced technology cockpits.

Conclusions

Most student pilots (68.75%) in this investigation agreed that type of initial instrument training does matter when transitioning to TAA. However, no evidence from this investigation was found to support this widely held opinion. Additionally, pilots were evenly divided in their belief that their initial flight training had prepared them for transition to TAA. The obviously conclusion is that a closer examination of initial flight training is warranted. Even if initial flight training is adequate, as would appear to be the case given the pilot response to ease of transition, why do so many pilots perceive that it was not and what changes to initial flight training might change this perception.

Despite the fact that two groups of student pilots were compared in this investigation, the groups were of significantly unequal size and the vast majority received analog only training. Perhaps both groups of student pilots, as a whole, are much more similar than they are different. Most of these student pilots learned to fly, in full or in part, on analog instrumentation. While the instructor pilots were not asked about their initial training, it is likely that they too primarily learned to fly on only analog instrumentation. Therefore, it may be concluded that this study was undertaken too early. Apparently, there are not yet enough pilots receiving initial instruction in TAA to make this comparison between groups.

A review of the human factors research indicates numerous problems with the use and certainly the design of automation in complex commercial aircraft. However, only a minority of pilots in this study reported difficulty understanding the status of automation or mode display in advanced cockpits. Since all of these students were transitioning to TAA, it is possible that they did not yet have enough experience to make a judgment about mode display or systems state. Additionally, instructor comments seemed to indicate that student pilots may experience problems when programming systems during flight. This appears to be an indicator that this group of student pilots may not fully appreciate the complexity of the technology. Indeed, as is the case in most aviation training courses, completion of this training (to include the check ride) may constitute only the beginning of the learning process rather than mastery of the subject matter.

Research sited in this investigation has demonstrated the benefits of scenario based training for some aspects, but not all aspects, of learning to fly TAA. A majority of student pilots (83.3%) reported that they had primarily received stick and rudder training, but some pilots reported that they had also primarily received FITS training. Clearly, the pilots reporting primarily receiving both types of training did not understand the question (despite researcher attempts to pilot test the study) or they did not understand the difference between the two methods of training. Given that the majority (72.92%) also indicated that they first learned instruments on only analog instruments, and given that FITS was initially designed to instruct students in TAA, these pilots may not clearly understand the differences between each method of training. The majority of student pilots in this investigation may have had their first scenario based flight training experience in the Pinnacle Airline training program and may not fully appreciate the i*ndustry training* standards component of FITS. That is for some pilots in this investigation, the FITS initial training methodology and the industry training standards are not conceptually the same idea. If most received primarily stick and rudder training to the PTS, they may not have had a frame of reference to make this distinction. To be absolutely fair; however, it is important to note that scenario based FITS training does not eliminate the requirement to master the maneuvers to the PTS.

Finally, there is a least one more significant conclusion to be drawn from the responses of this group of airline transport pilots. The majority (85.41%) believed that using TAA makes them safer pilots; however, only 39.58% strongly agreed or agreed that using TAA makes them better pilots. Clearly, this group of airline transport pilots was much less certain that using TAA made them better pilots. Additionally, as a group, their responses were almost evenly divided when asked if TAA weakens stick and rudder skills. When asked if TAA makes pilots dependent on advanced systems, more pilots disagreed than agreed, but once again the pilots were divided in their opinion. A significant number 31.25% agreed and that TAA did cause dependence on advanced technology and 25% were neutral (uncertain) in their response to the question. Apparently, significant concern exists regarding the effects of TAA on basic flying skills. This perception was also noted in the IP survey results. A possible conclusion of this study then is that concern does exist among these pilots that TAA weakens stick and rudder skills and to some degree may cause dependence on advanced systems.

The qualitative instructor pilot component of this investigation appears to lend credence to the idea that other factor besides type of initial training are more directly linked to success or failure when transitioning to more technically advanced aircraft.

These factors include the total number of flying hours logged, age, type of aircraft flown, the quality and efficiency of bridge programs, automation skills and other areas of interest.

Much still needs to be learned about how to best train future pilots. This study raises many more questions than it answers. Examples of such questions include:

- What are the effects of TAA training on safety and the retention of basic piloting skills?
- What are the effects of age and life experience when transitioning to TAA?
- What level of computer literacy is required for successful transition to TAA?
- What technology design and particularly what human-machine interface is best suited when transitioning to TAA?
- Do pilots always recognize their ability to determine mode display and/or systems status or are these skills that develop only with time and experience?
- How should training methodology evolve as TAA become more widely used during initial training?

Research is this area remains inconclusive. Perhaps it is too early to determine how best to conduct initial training of pilots in TAA. Technically advanced aircraft are apparently not yet widely enough available for pilots undergoing initial training. However, the numbers of technically advanced aircraft are steadily increasing in general aviation and at pilots schools. As is the case with the FITS literature, this type of investigation should continue.

Future Research

Future investigations might consider both T*ype* of training and perhaps *Method* of training as dependent variables. Additionally, research should be undertaken with a higher level of research funding. For example, using actual aircraft and/or full motion (high fidelity) simulators in future studies may be of value when trying to determine the best type and method of training for pilots transitioning to TAA. In this investigation, questionnaires were used to report student pilot perceptions about ease of transition and level of skill. Future research should attempt to measure pilot proficiency on actual tasks possibly in a scenario generated exercise.

Future research may be conducted using a larger sample of pilots randomly assigned to each of the three groups. Perhaps gaining access to a large flight training program at a regional airline for an extended period of time would allow a more thorough analysis of the role of previous training when transitioning to TAA.

Additionally, future research may be conducted by investigating different dependent variables. Perhaps factors such as type of aircraft flown, total logged flight time, participation in bridge programs, type of flying (e.g. FAR 121, FAR 135, FAR 91), computer/automation skills, age, and other factors are more relevant to success when transitioning to TAA than is type of training.

Future research may also be conducted by changing the population under investigation. For example studying General Aviation (GA) pilots transitioning to TAA or considering FAR Part 141 programs specifically designed for professional pilot programs may contribute to the body of knowledge in this area.

Based on the results of this study, future research may consider comparing pilots primarily flying TAA with pilots primarily flying analog instrumentation for proficiency at instrument skills. Does flying TAA make pilots more dependent on the technology? Are instructor pilots correct in their opinion that stick and rudder skills suffer as a result of flying TAA.

Learning to safely and effectively fly technically advanced aircraft will continue to challenges both commercial and general aviation aviators. A comprehensive understanding about how to best train future pilots will continue to be of paramount concern in the aviation community and continued research is necessary. To date, most research has focuses on human factors issues such as the design of human-machine interfaces. More research is needed in the area of technically advanced instrumentation training. Technically advanced systems are not intuitive and the many modes of operation, programming features and display options can be overwhelming. Additionally, these systems vary from platform to platform. Even now concerns exist that training advanced aviation instrumentation may become platform specific. As is evidenced by this study, much more needs to be done to isolate the specific variables necessary to fully understand and master training of technically advanced aircraft in a dynamic and rapidly changing technology environment.

Summary

This chapter summarizes the finding and conclusions of this research project. While the results of this study were surprising, they do provide a better insight into the perceived ability of regional airline pilots to transition to technically advanced aircraft. This investigation continues an ongoing research effort to understand how best to train pilots transitioning to technically advanced aircraft. As is the case with most research, this investigation poses many more questions than it answers. It is a significant undertaking because it advances understanding of how pilots undergoing TAA training perceive their ability to do so. The findings of this investigation also provide many useful ideas for future research projects.

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APPENDIXES

APPENDIX A

CONSENT FORM

Oklahoma State University Institutional Review Board

Date:	Monday, January 14, 2008
IRB Application No	ED07120
Proposal Title:	Technically Advanced Aircraft: The Newly Hired Regional Airline Pilot's Perceived Ability to Adapt to Glass Cockpit Technologies at Pinnacle Airlines - Based on Initial Instrumentation Training
Reviewed and Processed as:	Exempt

Status Recommended by Reviewer(s): Approved   Protocol Expires: 1/13/2009

Principal
Investigator(s

John C. Di Renzo	Mary Kutz
22821 John Silver Lane	6108 Winfield Dr.
Cudjoe Key, FL 33042	Okla. City, OK 73162

The IRB application referenced above has been approved. It is the judgment of the reviewers that the rights and welfare of individuals who may be asked to participate in this study will be respected, and that the research will be conducted in a manner consistent with the IRB requirements as outlined in section 45 CFR 46.

☒ The final versions of any printed recruitment, consent and assent documents bearing the IRB approval stamp are attached to this letter. These are the versions that must be used during the study.

As Principal Investigator, it is your responsibility to do the following:

1. Conduct this study exactly as it has been approved. Any modifications to the research protocol must be submitted with the appropriate signatures for IRB approval.
2. Submit a request for continuation if the study extends beyond the approval period of one calendar year. This continuation must receive IRB review and approval before the research can continue.
3. Report any adverse events to the IRB Chair promptly. Adverse events are those which are unanticipated and impact the subjects during the course of this research; and
4. Notify the IRB office in writing when your research project is complete.

Please note that approved protocols are subject to monitoring by the IRB and that the IRB office has the authority to inspect research records associated with this protocol at any time. If you have questions about the IRB procedures or need any assistance from the Board, please contact Beth McTernan in 219 Cordell North (phone: 405-744-5700, beth.mcternan@okstate.edu).

Sincerely,

Shelia Kennison, Chair
Institutional Review Board

SUJECT: Informed Consent Information Sheet

Project Title: *Technology Advancement: The Pilot's Ability to Adapt to Advanced Technology Systems Based on Initial Instrumentation Training*

Investigator:

John C. Di Renzo Jr. MPA, MSIS and doctoral candidate Educational Studies: Aviation and Space Sciences Program, Oklahoma State University

Purpose:

Your participation in this dissertation research project is much appreciated. This study is designed to ascertain the optimal training methodology for pilots transition to technically advance cockpits. We are interested in learning more about how you were trained and how easily you made your transition to advanced commercial cockpits.

This research will test hypotheses about how effectively pilots assimilated and use new technology such as multi-function displays, and other information technology systems based upon initial pilot training methodology.

Newly hired pilots at Pinnacle Airlines are being asked to participate because they have recently undergone advanced technology training in technically advanced aircraft.

Pilots will be asked questions about their perception of how their flight initial training prepared them for flying technically advanced aircraft at Pinnacle Airlines.
Procedures:

As a newly trained commercial airline pilot, you will be asked to complete a survey to determine your perceptions about how your initial pilot training prepared you to fly technically advanced commercial aircraft in the regional airlines. Additionally, regional airline flight instructors will be administered an open-ended survey to determine their perceptions/opinions of how the newly hired pilots performed during training based on the newly hired pilots initial flight instruction.

The survey will take about five to ten minutes to complete and will be presented in one trial.

Risks of Participation:

There are no known risks associated with this project which are greater than those ordinarily encountered in daily life.

Benefits:

There will be no direct benefit to participants. The knowledge gained from this research project will help aviation educators understand how to best train future pilots to transition to technically advance cockpits.

Confidentiality:

The records of this study will be kept private. Any written results will discuss group findings and will not include information that will identify you. Research records will be stored securely and only researchers and individuals responsible for research oversight will have access to the records. It is possible that the consent process and data collection will be observed by research oversight staff responsible for safeguarding the rights and wellbeing of people who participate in research.

Data will be collected using a questionnaire and participant responses will be anonymous. Only aggregate data/findings will be reported. The researcher will provide Pinnacle Airlines with a postage paid envelop to return all surveys. The data will be stored in a locked container in the researcher's office. Once the data is complied, all surveys will be destroyed and only aggregate data will remain.

Compensation:

Unfortunately, there will be no compensation offered for participation in this study.

Contacts:

The Primary researcher is John Di Renzo. He is a doctoral student in the College of Education at Oklahoma State University. He can be contacted at:

(580) 678-8603
john.direnzo@jiatfs.southcom.mil
john.direnzo@okstate.edu

If you have questions about your rights as a research volunteer, you may contact Dr. Sue C. Jacobs, IRB Chair, 219 Cordell North, Stillwater, OK 74078, 405-744-1676 or irb@okstate.edu.

Participant Rights:

I understand that my participation in this research survey is totally voluntary. If I choose, I may withdraw my participation at any time. I also understand that if I choose to participate, that I may decline to answer any question that I am not comfortable answering.

Participant Recruitment Script

Your participation in the dissertation research project is much appreciated. This study is designed to ascertain the optimal training methodology for pilots transition to technically advance cockpits. We are interested in learning more about how you were trained and how easily you made your transition to advanced cockpits.

If you chose to participate, please read the below consent form and then complete a short questionnaire. Any information you provide will be held in the strictest confidence and no information personally identifying your information will be retained. This study will report aggregate information/findings only.

If you are interested in the results of the study, you may request a copy of the dissertation by contacting the researcher at: john.direnzo@jiatfs.southcom.mil or john.direnzo@okstate.edu .

Thank you for your participation.

AUTHORIZATION TO USE AND DISCLOSE INFORMATION

This survey should not take you more than 5 or 10 minutes to complete.

I have freely chosen to participate in this Oklahoma State University study voluntary, anonymous research survey designed to provide information to improve training of pilots transitioning to advanced cockpits. Upon completion of the research study, results will be available by contacting the research at: john.direnzo@jiatfs.southcom.mil or john.direnzo@okstate.edu .

This survey will be provided to Pinnacle Airlines instructor personnel for distribution. I agree to permit the University of Oklahoma Principal Investigators, Collaborators and Staff, to obtain, use and disclose the anonymous information provided as described below.

Conditions and Stipulations

1. I understand that all information is confidential. I will not be personally identified in any reports. I agree to complete a survey for research purposes and that the data derived from this anonymous survey may be made available for the general public in the form of public presentations, journals or newspaper articles, and/or in books.
2. I understand the survey involves questions about my training experiences during flight training and my subsequent ability to transition to advanced technology cockpits. Beyond demographics, all questions will address flight experience and training issues.
3. I understand that my participation in this research survey is totally voluntary. If I choose, I may withdraw my participation at any time. I also understand that if I choose to participate, that I may decline to answer any question that I am not comfortable answering.
4. I understand that I can contact the primary researcher at: john.direnzo@jiatfs.southcom.mil or john.direnzo@okstate.edu if I have any questions about the research survey and my rights as a participant. I am aware that my consent will not directly benefit me, but will provide data for the researcher and Oklahoma State University to improve advanced aviation technology training for future aviation students.

APPENDIX B

QUESTIONNAIRE

<u>Instructions</u>. The target audience for this survey is newly hired pilots at a regional airline who have recently completed initial airline training. Please answer all questions as accurately as possible from your perspective as a newly hired regional airline pilot. If you do not know the answer to a question, leave it blank and go to the next question. Please CIRCLE or CHECK the best response for each question.

Thank you for your participation.

<u>Demographic Section:</u>

1. Gender

☐ Male ☐ Female

2. Age

☐ 22-30 ☐ 31-39 ☐ 40-49 ☐ 50-59 ☐ 60 and above

3. I have been a pilot for (select the best answer):

☐ Less than one year ☐ 1 to 3 years ☐ 3 to 5 years

☐ 5 to 10 years ☐ 10 to 20 years ☐ more than 20 years

4. I have logged (select the best answer):

☐ 500 hours or less ☐ 501 to 1,000 hours ☐ 1,001 to 1,500 hours

☐ 1,501 to 2,000 hours ☐ 2,001 to 2,500 hours ☐ 2,501 hours or more

5. I learned instrument flying

☐

☐ Under FAA Part 61

☐ Other ________________________________ (Please specify)

6. I am a newly hired regional airline pilot (12 months or less):

☐ Yes ☐ No

Data Collection Section (Select the best answer).

7. I first learned instrument flying (answer **ALL** that are appropriate):

☐ On analog instruments **only** prior to hire by the airlines

☐ On analog instruments using a Computer Based Training (CBT) software product prior to hire by the airlines

☐ On analog instruments using a Flight Training Device (FTD) prior to hire by the airlines

☐ On analog instruments using a full-motion simulator prior to hire by the airlines

☐ On analog Instruments in an actual aircraft prior to hire by the airlines

☐ On digital instruments using a Flight Training Device (FTD) prior to hire by the airlines

☐ On digital instruments **only** prior to hire by the airlines

☐ On digital instruments using a Computer Based Training (CBT) software product prior to hire by the airlines

☐ On digital instruments using a Flight Training Device (FTD) prior to hire by the airlines

☐ On digital instruments using a full motion simulator prior to hire by the airlines

☐ On digital Instruments in an actual aircraft (e.g. glass cockpit) prior to hire by the airlines

8. During my primary flight training, I received advanced technology cockpit instruction (e.g. Garmin 1000) for:

☐ 0 -5 hours	☐ 6 – 10 hours	☐ 11 – 20 hours
☐ 21 – 40 hours	☐ More than 40 hours	☐ N/A I did not receive any digital training

9. I have experience flying technically advanced aircraft using glass cockpits for:

☐ 6 mouths to 1 year	☐ 1 year to 2 years	☐ 2 year to 3 years
☐ 3 years to 5 years	☐ 5 years to 10 years	☐ more than 10 years

10. During initial training, I primarily received "Stick and Rudder" training (i.e. training flight maneuvers to the PTS)

Strongly Agree Agree Neutral Disagree Strongly Disagree

11. During initial training, I primarily received "Scenario Based" (i.e. FITS type) training

Strongly Agree Agree Neutral Disagree Strongly Disagree

12. My initial flight training emphasized mastering flight maneuvers to the PTS

Strongly Agree Agree Neutral Disagree Strongly Disagree

13. My initial flight training emphasized Aeronautical Decision Making (ADM)

Strongly Agree   Agree   Neutral   Disagree   Strongly Disagree

14. My primary instrument training prepared me for flying Technically Advanced Aircraft (TAA) with the airlines

Strongly Agree   Agree   Neutral   Disagree   Strongly Disagree

15. I prefer to fly analog instruments

Strongly Agree   Agree   Neutral   Disagree   Strongly Disagree

16. I prefer to fly digital instruments

Strongly Agree   Agree   Neutral   Disagree   Strongly Disagree

17. In an emergency, I am comfortable transitioning to analog instruments and "hand flying" the airplane.

Strongly Agree Agree Neutral Disagree Strongly Disagree

18. In an emergency, I am comfortable transitioning to analog instruments and "hand flying" the airplane on an instrument approach to minimums in IMC.

Strongly Agree Agree Neutral Disagree Strongly Disagree

19. I sometimes find it difficult to understand the status or "mode" displayed using a glass cockpit

Strongly Agree Agree Neutral Disagree Strongly Disagree

20. Glass cockpit displays are easy to monitor and comprehend

Strongly Agree Agree Neutral Disagree Strongly Disagree

21. I have adapted well to flying advanced technology cockpits

Strongly Agree Agree Neutral Disagree Strongly Disagree

22. I believe a combination of analog and digital training makes it easier to transition to technically advance technology cockpits

Strongly Agree Agree Neutral Disagree Strongly Disagree

23. I believe that pure digital training makes it easier to transition to advance technology cockpits

Strongly Agree Agree Neutral Disagree Strongly Disagree

24. I believe there is no significant difference between analog and digital training when transitioning to advance technology cockpits

Strongly Agree Agree Neutral Disagree Strongly Disagree

25. I have logged:

☐ 10 or less hours in IMC	☐ 10 to 25 hours in IMC	☐ 25 to 50 hours in IMC
☐ 50 to 100 hours in IMC	☐ 100 to 500 hours in IMC	☐ More than 500 hours in IMC

26. I believe that more hours flown in IMC makes transitioning to an advanced technology cockpit easier.

Strongly Agree Agree Neutral Disagree Strongly Disagree

27. I believe that the type of initial instrument training (analog, digital or both) makes transitioning to an advanced technology cockpit easier.

Strongly Agree Agree Neutral Disagree Strongly Disagree

28. In general, I am comfortable with advance technology cockpits

Strongly Agree Agree Neutral Disagree Strongly Disagree

29. I think using advanced technology makes me a safer pilot

Strongly Agree Agree Neutral Disagree Strongly Disagree

30. I think using advanced technology makes me a better pilot

Strongly Agree Agree Neutral Disagree Strongly Disagree

31. I think using advanced technology weakens my basic piloting (Stick and Rudder) skills

Strongly Agree Agree Neutral Disagree Strongly Disagree

32. I think using advanced technology makes me dependent on these systems and, therefore, has a negative impact on my "Stick and Rudder" skills

Strongly Agree Agree Neutral Disagree Strongly Disagree

APPENDIX C

INSTRUCTOR PILOT (IP) OPEN-ENDED QUESTIONNAIRE

<u>This section is to be answered by Instructor Pilots only</u>. Please provide as much detail as possible.

1. Do you believe that scenario based training improves a pilot/crew ability to master technically advanced aircraft? Why or why not?

2. What is your opinion regarding the impact of technically advanced aircraft on the pilot's/crews' ability to maintain "Stick and Rudder" skills?

3. Do you believe that the type of initial flight training has an impact on new regional airline pilots' ability to transition to technically advanced aircraft? If so, what in your opinion is the best mix/type of initial training?

4. In your opinion, is there a significant performance difference among newly hired pilots based on their initial type of flight training? If so, which pilots perform at higher levels and why?

5. In your opinion are none, some, or all of your students completing training at Pinnacle Airlines completely comfortable flying advanced technology aircraft? Why or why not?

APPENDIX D

DEFINITIONS

AC - Advisory Circular. The FAA issues Advisory Circulars (AC) to inform the aviation public in a systematic way of non-regulatory material.

Advanced Flight Training Device - is a training device that has a cockpit that accurately replicates a specific make, model, and type of aircraft cockpit, and handling characteristics that accurately model the aircraft handling characteristics.

AIM - Airmen Information Manual. This is an FAA manual is designed to provide the aviation community with basic flight information and ATC procedures for use in the National Airspace System (NAS) of the United States.

ATP - Airline Transport Pilot. A pilot holding the Airline Transport Pilot Certificate (ATP) has the highest level of aircraft pilot certification. Those certified as Airline Transport Pilots are authorized to act as pilot-in-command of an aircraft in air carrier service.

Automation Competence - The demonstrated ability to understand and operate the automated systems installed in the aircraft.

Automation Surprise - Occurs when the automation behalves in a manner that is different than what the operator expected.

Automation Bias - The relative willingness of the pilot to trust and utilize automation systems.

CBT - Computer Based Training. Special software training programs executed on a computer which are particularly effective for learning how to use automation.

CFI - Certified Flight Instructor. A pilot who holds an FAA certified pilot instructor certificate.

CFIT - Controlled Flight into Terrain. An accident in which an otherwise serviceable aircraft under the control of the crew, is flown (unintentionally) into the terrain, obstacles or water, with no prior awareness on the part of the crew of the impending collision.

CFR - Code of Federal Regulations. An FAA published Code of Federal Regulations (CFRs) to make regulatory requirements used in aviation readily available to the aviation community.

CRM - Crew Resource Management. A concept used to improve the resource management skills of pilots and others in the aviation system.

Data Link Situational Awareness Systems - Systems that feed real-time information to the cockpit (weather, traffic, terrain, flight planning). This information may be displayed on a PFD and MFD.

FAA - Federal Aviation Administration. An independent agency of the U.S. government charged with controlling the use of U.S. Airspace to obtain the maximum efficiency and safety.

FITS - FAA Industry Training Standards is a voluntary program and is a joint project of the FAA sponsored Center for General Aviation Research (CGAR).

GA - General Aviation. Airplane operations other than military or commercial airlines that weigh less than 12,500 pounds.

GPS - Global Positioning System. A US satellite based navigational system owned and operated by the US Defense Department which provides precise, global, and continuous position capability.

IFR - Instrument Flight Rules. Is a set of aviation regulations for flying the aircraft using only the airplane instruments in the cockpit.

IMC - Instrument Meteorological Conditions. Weather conditions bad enough that the pilot is controlling the aircraft only by reference to instruments.

IP - Instructor Pilot. Pilot who provides advanced technology flight instruction to regional airline pilots.

MBT - Maneuver Based Training. Is a traditional approach to training that trains maneuvers to the PTS.

MFD – Multi Function Display. Any system that combines primary navigation, systems and Situational Awareness (SA) information into a single electronic display.

PIC - Pilot-In-Command. The pilot at the controls of the aircraft.

PFD - Primary Flight Display. Any display that combines the primary six (6) flight Instruments, plus other related navigation and Situational Awareness (SA) in to a single electronic display.

PT - Pilot in Training. Student pilot taking flight lessons.

PTS - Practical Test Standards. The FAA written standards for testing a pilot.

Reliability - The degree to which a test consistently measures something; however, it may not necessarily be what it is intended to measure.

SATS - Small Aircraft Transportation System Project. A NASA project aimed at building the future air transportation system.

SATS Aviation Flight Education Research (SAFER). A program where student pilots fly technically advanced aircraft using a scenario-based syllabus.

SBT - Scenario Based Training. A training system that uses highly structured script of real-world experiences to address flight training objectives. This scenario base training can occur during initial, transition, upgrade, recurrent and special training.

SRM - Single Pilot Resource Management is the art and science of managing all of the resources (both on-board the aircraft and from outside sources) available to a single pilot to ensure that the successful outcome of the flight is never in doubt.

TAA - Technically Advanced Aircraft. An aircraft that combines some or all of the following design features: advanced cockpit automation system (PFD, MFD) for IFR/VFR flight operations, automated engine and systems management, and integrated auto flight/autopilot systems.

VFR - visual flight rules. A set of aviation regulations in which a pilot may operate an aircraft by visual references to the environment outside the cockpit

VITA

JOHN CARL DI RENZO JR.

Candidate for the Degree of

Doctor of Education

Thesis: THE IMPACT OF TRANSITION TRAINING ON ADAPTING TO TECHNICALLY ADVANCED AIRCRAFT AT REGIONAL AIRLINES: PERCEPTIONS OF PILOTS AND INSTRUCTOR PILOTS

Major Field: Applied Educational Studies

Biographical:

Personal Data: Born in Upper Darby, Pennsylvania, May 22, 1954, to John and Emeralda Di Renzo.

Education: GED 1975; Bachelor of Arts in Psychology, Memphis State University, Dec 1981; Master of Arts in Public Administration, Auburn University, May 1995; Graduate of US Air Force Air Command and Staff College, Montgomery, AL, June 1995; Master of Science in Information Systems, Hawaii Pacific University, Honolulu, HI, June 1998. Completed the requirements for the Doctor of Education in Aviation and Space Science degree at Oklahoma State University, May, 2009.

Professional Experience: Twenty-five years of service in the United States Marine Corps and the United States Army. Marine Corps Non-commissioned officer in Marine aviation. Commissioned Officer in the U.S. Army Signal Corps. Management Information Systems Instructor at Cameron University. FAA Certified Flight Instructor – Instrument. Chief Flight Instructor Western Oklahoma State College. Division Chief in the C4I Directorate of the Joint Interagency Task Force South, U.S. Southern Command.

Professional Membership: Pi Alpha Alpha Honor Society (Political Science – 1995), Pi Sigma Alpha Honor Societies (Public Administration - 1995), Epsilon Delta Pi Honor Society (Computer Science – 1998)

Name: John Carl Di Renzo Jr. Date of Degree: May, 2009

Institution: Oklahoma State University Location: Stillwater, Oklahoma

Title of Study: THE IMPACT OF TRANSITION TRAINING ON ADAPTING TO TECHNICALLY ADVANCED AIRCRAFT AT REGIONAL AIRLINES: PERCEPTIONS OF PILOTS AND INSTRUCTOR PILOTS

Pages in Study: 147 Candidate for the Degree of Doctor of Education

Major Field: Applied Educational Studies (Aviation)

Scope and Method of Study: The purpose of this study was to test a hypothesis about pilot and instructor pilot perceptions of how effectively pilots learn and use new technology, found in Technically Advanced Aircraft (TAA), given initial type of instrumentation training. New aviation technologies such as *Glass Cockpits* in technically advanced aircraft are complex and can be difficult to learn and use. The research questions focused on the type of initial instrumentation training to determine the differences among pilots trained using various types of instrumentation ranging from aircraft equipped with traditional analog instrumentation to aircraft equipped with glass cockpits. A convenience sample of Pilots in Training (PT) and Instructor Pilots (IP) was selected from a regional airline. The research design used a mixed methodology. Pilots in training completed a thirty-two question quantitative questionnaire and instructor pilots completed a five question qualitative questionnaire.

Findings and Conclusions: This investigation failed to disprove the null hypothesis. The type of instrumentation training has no significant effect on newly trained regional airline pilot perceived ability to adapt to advanced technology cockpits. Therefore, no evidence exists from this investigation to support the early introduction and training of TAA. While the results of this investigation were surprising, they are nonetheless, instructive. Even though it would seem that there would be a relationship between exposure to and use of technically advanced instrumentation, apparently there was no perceived relationship for this group of airline transport pilots. However, a point of interest is that these pilots were almost evenly divided in their opinion of whether or not their previous training had prepared them for transition to TAA. The majority also believed that the type of initial instrumentation training received does make a difference when transitioning to TAA. Pilots believed that TAA made them safer pilots, but were not convinced it made them better pilots. The results of this investigation raise many new questions and provide a number of ideas for future research projects.

ADVISER'S APPROVAL: Dr. Timm Bliss