A MIXED METHODS STUDY OF

DESIGNATED PILOT EXAMINERS

EXPERIENCES WITH ADVANCED DISPLAY

TECHNOLOGY AND TECHNOLOGY

ADVANCED AIRCRAFT

By

MICHAEL A. FRIDAY

Bachelor of Science in Electrical Engineering
University of Miami
Coral Gables, Florida
1979

Master of Business Administration
University of Central Oklahoma
Edmond, Oklahoma
2004

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Dissertation Approved:

Dr. Steve Marks

Dr. Fred Hansen

Dr. Todd Hubbard

Dr. Mary Kutz

Dr. James Key

Dr. Mark Payton

Dean of the Graduate College

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CHAPTER I

INTRODUCTION

Aircraft technology and flight training has continued to evolve from its origin at Huff Field in Dayton Ohio circa 1909. Early aircraft were elementary in design when compared to modern general aviation aircraft. Training was also simplistic in nature, most of which was trail-and-error. Unfortunately, the fragile nature of early aircraft and limited training made flight a very risky and hazardous venture. Today technology continues to be introduced into aircraft with the aim at reducing risks, but there is the question of whether the training and certification process has equally progressed.

All aircraft require some degree of instrumentation in order to operate, but they differ in their degree of complexity. The instrumentation can be categorized into: engine and aircraft performance, navigation, communication, and flight management. The complexity of the instrumentation is a function of the aircraft type and the flight environment. The necessity for safety of flight requires redundancy for many of these devices, which further increases cockpit complexity and density. Table-1.1 displays the many elements contained in an aircraft cockpit.

Engine Performance	Aircraft Performance	Navigation	Communication	Flight Management
RPM*	Air Speed	VOR+	VHS+	Weather
Oil Temperature*	Altitude	DME	ELT	Autopilot
Oil Pressure*	Attitude	Loran	Transponder	Flight Planning
Manifold Pressure*	Rate of Climb	GPS		Traffic/Collision Avoidance
Fuel Pressure	Turn Rate	ADF		Terrain/Maps
Fuel Flow*	Air Temperature	Directional & Attitude Control		
EGT*	Vacuum	ILS		
Fuel Quantity		Marker Beacon		

Table-1.1. Aircraft Instrumentation * One per engine + Typically Redundantly Equipped

Until recently these individual equipment items were typically self-contained with their own displays and dedicated controls. Other instruments, such as: altimeters, air speed and rate of climb indicator instruments utilized only vacuum and/or static pressure sources in order to operate. Despite being produced by different manufacturers, these devices had the same basic appearance, operated in a similar manner, and were certified under FAA Technical Standard Orders (TSOs).

Traditional Cockpit Instrumentation

Figure-1.1. Traditional Baron Cockpit

The cockpit arrangement of the instrumentation in traditionally equipped aircraft was also fairly standard. The primary flight instruments: attitude indicator, altimeter, directional gyro, and air speed indicator are arranged in a “T” pattern. This permitted a standardized "scan pattern" in pilot training for monitoring flight status and orientation. The Baron cockpit pictured in Figure-1.1 shows this typical "T" pattern. Engine instrumentation tends to be clustered together, but they are not positioned in a standardized location. The radio stack of communication and navigation gear to the right of the engine controls is shown in a typical traditional cockpit configuration.

Glass Technology

The term "glass cockpit" refers to cockpit that contain flat panel display technology with advanced computational and navigation capabilities. The glass cockpit originated in military aircraft where it became a necessity to display multitudes of mission information within the finite real estate of a military cockpit. With the advancement of microelectronics/microprocessors, glass cockpit displays have taken on even more functionality including flight management and mission planning.

As the glass cockpit technology matured, these devices moved into the commercial sector, appearing first in the Boeing 757 aircraft. Glass cockpits, or Advanced Display Technology (ADT), have become even more wide spread. Today, these devices are standard on new production aircraft and retrofit kits are available for older General Aviation (GA) aircraft. Table-1.2 depicts glass manufacturers and the applicable airframes.

Garmin G1000 Applications	**Avidyne Entegra EXP 5000 Applications**	**Chelton Flight Systems EFIS**	**Aspen Application**
Beechcraft Baron G58	Adam	Beech	Cessna Skycatcher
Cessna 172/182	ATG	Cessna	Diamond DA20
Diamond DA 40,42, 50	Cirrus		
Grumman Cheetah	Columbia		
Mooney	Piper Seneca		
Piper Warrior III	Symphony		

Table-1.2. Integrated Cockpit Systems

Garmin's G1000 features a 10.4" Primary Flight Display (PFD) with 10.4"or 15" Multi-Function Display (MFD). The PFD displays the critical flight information and controls the selection of navigation modes, radio frequencies, and transponder codes. The MFD displays navigation and terrain maps, weather radar information, and air traffic avoidance information. The displays allow multiple formats and overlays of the numerous data types (Garmin G600 Pilot's Guide).

Modern Digital Cockpit

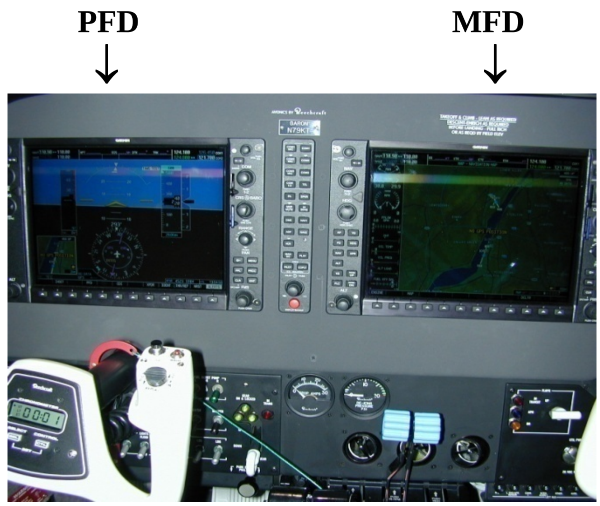

Figure-1.2. Upgraded Baron Cockpit

The information provided on the PFD is highly condensed when compared to the traditional cockpit. Although the attitude and heading are presented in a dial format, the altitude, air speed, rate of climb are presented as a moving tape. The PFD also indicates: navigation and communication frequencies, transponder codes, waypoints, distance, and tracking information along the top and bottom edges of the screen. Additionally, navigation maps and airport databases can be shown on "pop-up" windows (G1000 Product Specification).

Figure-1.2 is another Baron cockpit with the ADT displays. The screen on the left is the PFD and the screen to the right is the MFD. The differences between the two Baron cockpits are clearly visible, especially with respect to format, layout, and density.

As with most other technology, the costs of these systems are decreasing while the capabilities are increasing. Aspen Avionics recently received certification of its EFD500 and EFD1000 systems. These systems are a low-cost retrofit for a standard set of attitude and directional 3.5 inch displays. The system is a drop-in replacement which can be easily installed with minimum effort. The US Air Force Academy is using the Aspens system in its fleet of Diamond DA20s.

Avidyne and Garmin are both producing scaled down versions of their first generation systems at a reduced cost. These systems are targeted at the retrofit market. The continued reduction in the cost of these digital systems will only escalate their incorporation into the general aviation fleet.

Problem Discussion

Recent advances in these smart systems include enhanced situational awareness and most recently synthetic vision. The new features include: terrain, XM weather, traffic information service, airways, airport, and IFR approaches all of which can be displayed in a variety of formats and overlays. This variety and density of informational content, multiple display-formats, new symbology, and computational capability of ADT creates concerns about the effectiveness of current training methodology and certification process. “The common denominator in all these changes is the need to have an adaptable flight training system that will not only maintain but greatly improve the safety and utility of general aviation flight operations” (Wright, 2002). The industry is responding to the challenges posed by the changing technology, but the question is whether the responses are appropriate, effective, and sufficient.

The integrated glass systems contain vast aeronautical databases requiring frequent updates. System software is also routinely updated to correct errors or add new features. These systems permit tailoring of their presentation at the user's discretion. A pilot using a rental aircraft who has limited training on these systems could be placed in a challenging or confusing situation (AOPA Safety Foundation, 2007).   This could lead to a potential safety hazard.

In the past, pilots transitioned into the new technology after years of flight experience. These pilots already understood: the regulations, principals of flight, navigation, and the performance characteristics of their aircraft. The new ADT equipped aircraft, are now entering the environment of primary flight training where pilots are still learning the basics. Table-2 shows the new aircraft production, which is introducing this technology in mass. The introduction of ADT in GA is requiring private pilots to follow a system manager approach to flying similar to the commercial airlines (AOPA 2007). Recently, Avidyne issued Service Bulletin SA-05-001 for their Entegra system after several aircraft mishaps. Fortunately, the aircraft all landed safely, but the bulletin expressed the need for pilots to: recognize a system failure and to effectively utilize cross checking procedures for fault isolation. Apparently, the pilots involved in these mishaps were ill prepared to troubleshoot a faulty ADT system. These systems are demanding more from pilots.

Sarter, Woods, and Billings (1997) reported that traditional training approaches seemed inadequate for preparing operators of the new complex systems. They continued with nature of training rather than the duration requires reconsideration. The mental model of traditionally-trained pilot was "accumulated compartmentalized knowledge of component and simple input-output relation" rather than "overall functional structure of the system to understand its contingencies and interactions" required with the new technology (Sarter, Woods, & Billings, 1997, p. 9). Clearly the new technology is not plug-and-play from a cognitive learning perspective.

These high-tech aircraft are being placed into service at many flight-training facilities yet many training programs have not been adapted to reflect the required changes in learning strategy. An Aviation Monthly 2004 Safety Report stated that pilots were on their own with respect to learning the new technology. The article points out that the one size fits all approach or the traditional method of training is no longer adequate. An AOPA Safety Foundation report stated "training to use nontraditional avionics using traditional methods is not optimal" and goes on further to say "any training institution or CFI that attempts to do in-the-air training on advanced IFR GPS navigators, FMSs, or glass cockpit aircraft before having a through introduction and practice on ground via similar, ground powered aircraft, or at the very least with computer based instruction, is just not performing in the best interests of the client" (AOPA Safety Foundation, 2007, p.19).

The avionics manufacturers, airframe manufactures, and independents (ASA; Jeppesen; ZD Publishing) have developed glass transition training. ZD Publishing, publisher of Max Trescott's G1000 Glass Cockpit Handbook, and Jeppesens both offer a self-study course. Embry-Riddle Aeronautical University (ERAU), University of North Dakota, and Middle Tennessee State University are offering glass cockpit training. ERAU course is ten days in length and includes classroom and flight training (FAA Aviation News, May/June 2007). The FAA has also recognized the changing environment of advanced avionics and ADT and created the FAA Industry Training Standards (FITS) program. While FITS is a step forward for training in advanced technology, it is not a mandatory requirement. Further, the FAA has begun updating certain publications to reflect the changing environment of ADT. Specifically, the Instrument Flying Handbook (FAA-H-8083-15A) has been revised to include the depiction and interpretation of flight information on glass systems.

Discussions with multiple flight centers indicated no structured or generally accepted methodology for training ADT. According to one survey, reading printed media (manuals) are not found to be helpful with advanced avionics because they are not interactive (AOPA Safety Foundation, 2007). It is worth noting that all of the course materials are equipment dependent.

To date, the FAA has not established specific new guidelines for pilot-in-command for these aircraft: no special endorsement or sign-off is required. Related to this matter, the FAA has provided little guidance to Flight Examiners (FEs) that must perform the actual certification of new applicant pilots. Contact with several FEs in Oklahoma has showed this to be a true concern.

An FAA Aviation News article addressed concerns of FAA's GA OPS inspectors or FE not having sufficient training in ADT equipped aircraft to effectively fly these aircraft and utilize the onboard systems. Specifically, the article points out that one manufacturer's glass system does not necessarily respond or display information the same as another's. Also, there is an inability to demonstrate certain system failures without experiencing a true failure.

To determine what concerns DPEs have with advanced technology and the certification process, this researcher contacted five Oklahoma examiners. They indicated guidance lagged technology, a greater need for basic pilotage skills, over dependency on the technology, and difficulty performing partial panel testing as issues with the technology. Based upon this heading check and published material a formal study of a larger DPE body seemed logical.

Statement of the Problem Statement

There is a need to know if Designated Pilot Examiners perceive a problem with the current private pilot certification process with respect to the operation of ADT that could have a negative impact on aircraft safety.

Purpose of the Study

Thomas Kuhn stated: “any new interpretation of nature, whether a discovery of a theory, emerges first in the mind of one or a few individuals. It is they who first learn to see science and the world differently, and their ability to make the transition….“ (Kuhn, 1996, p. 144). Rigner and Dekker stated that “technology shift transforms work in the cockpit and cannot be treated as a separate subject or an add-on the existing training” (Dahlstrom, Dekker, & Nahlinder, 2006, p. 2). The AOPA Foundation executive directed stated in 2005 that “technology emerges as a doubled-edge sword, increasing pilot and aircraft capabilities but frequently at the price of increased workload and education” (Dahlstrom, Dekker, & Nahlinder, 2006, p 3). Robert A. Wright, FAA AFS-800, remarked on this subject that “clearly, an improved flight training paradigm will be needed in any case” and “a new approach to training should be integrated and holistically centered” (Wright, 2002).

The purpose of this study is to identify what changes, if any, are required for the certification of private pilots with ADT. Since DPEs are the final step in the certification process of an applicant pilot, it is thought that interviews with these individuals might confirm or reject some of the concerns being raised.

Further it is hoped that if specific knowledge and/or skills gaps are identified then the training programs and the certification process can be modified so that pilots can be prepared to fully exploit the capabilities and benefits of the new technology without becoming overwhelmed or being placed in an unsafe situation.

Research Questions

How could the current FAA certification process be modified for a private pilot to more safely operate in the National Airspace System with the introduction of advanced technology in GA aircraft?

1. How do DPEs perceive **safety** has been impacted with the introduction of advanced technology in GA aircraft?
2. What **regulatory and guidance** changes do DPEs perceive are needed with the introduction of advanced technology into GA aircraft?
3. What **training and knowledg**e requirement changes do DPEs perceive are needed with the introduction of advanced technology in GA aircraft?
4. What **Practical Test** requirement changes do DPEs perceive are needed with the introduction of advanced technology in GA aircraft?

Definitions

Conceptual Definitions:

- "Automation surprise" occurs when the behavior of automation system does not match the mental model of behavior for that system held by the operator (Sherry, Feary, Polson, & Palmer, 2000).
- "Glass cockpit" is a cockpit containing flat panel display technology with advanced navigation and computational capability.
- "Safety of flight" refers to items whose failure could cause loss of aircraft or aircrew immediately upon failure or subsequently if the failure remained undetected (DCMA, 2011).
- "Incident" is an occurrence other than an accident that affects or potentially affects safety (NFES-2659).
- "Accident" (aircraft) is an occurrence during normal operations that results in death/serious injury or substantial damage to the aircraft (NFES-2659).
- "Critical flight information" is the parameters required to physically fly the aircraft including: attitude, heading, altitude, and air speed.

Operational Definitions:

- Primary Flight Training (PFT) is operationally defined here to be working towards a private pilot certificate.
- Advanced Technology Systems (ATS) or Advanced Display Technology (ADT) is equipment that replaces multiple stand-alone indicators and controls with a single display technology.

- Technology Advanced Aircraft (TAA) is an aircraft equipped with advanced cockpit automation or “glass”.
- Student Pilot is operationally defined here as one who is working towards new airman ratings.
- Private Pilot is operationally defined here as one who is rated to be pilot in command under visual flight rules (VFR).
- Instrument Pilot is operationally defined here as one who is rated to be pilot in command under instrument flight rules (IFR).

CHAPTER II

REVIEW OF LITERATURE

Introduction

John Di Renzo, Jr., recently completed a dissertation study on the perceptions of pilot and instructor pilots in transitioning to TAA in Regional airlines. Di Renzo (2009) investigated the effect of varying degrees of exposure and training with technology on transition to sophisticated flight deck. "Both the analog only group and analog/digital group appeared to transition to TAA equally well" (Di Renzo, 2009, p.104). It appeared that the type of flight experience whether analog or digital was less important than total flight time. Also the instructor pilot commented that pilots over 50 had difficulty with the technology. Interestingly, the instructor pilots suggested that the 18 to 21 year old pilots lacked the discipline to master the technology.

Renzo's study reported that the transitioning pilots did not have a problem with automation mode despite the research of Sarter and others to the contrary. The instructor pilots suggested that the transitioning pilots may not have enough experience with the technology to recognize the situation. The instructor pilots also indicated that student pilots often have problems reprogramming the automation in flight. The researcher suggested that the student pilots "may not fully appreciate the complexity of the technology" (Di Renzo, 2005, p115).

Finally the Di Renzo study commented that future research should investigate "how training methodology should evolve…. during initial training" (Di Renzo, 2009, p117). This affirmation was echoed in a Dornan, Beckman, Gossett, and Craig (n.d.) study on FITS training. The study stated that "the current training format in the industry was insufficient to exploit the additional safety features of TAA" (Dornan, Beckman, Gossett, and Craig, n.d., p 1). The study went on to say that "there was a critical need to develop TAA training program in the GA community" (Dornan, Beckman, Gossett, and Craig, n.d., p 1).

This research expands upon the body of knowledge in this area of advanced avionics in GA aircraft by investigating the private pilot certification process and the possible safety impact of the technology from a Designated Flight Examiners perspective. The certification process includes: regulation and guidance from the FAA, training and knowledge requirements for both the DPE and new pilots, and the practical examination.

Safety

The FAA is charged through Title 49 Section 44701 of United States Code with setting the standard for safety with respect to air transportation. This charter was granted to the FAA by the Federal Aviation Act of 1958. The implementation policy to "protect the public interest" is established in the Policy Statement of the Federal Aviation Administration - Order 1000.1A (Wright, 2002).

The FAA is developing a system safety approach, known as SAGA, that emphasizes risk management, training and education, and the proper use of technology in lieu of the existing system focused around advisory circulars, handbooks, and practical test standards (Wright, 2002).

According to the 2005 NTSB report, there are 215,837 GA aircraft in service of which only 2,857 were newly manufactured (NTSB, 2009). As discussed earlier, most newly manufactured aircraft come with the advanced avionics. Due to the large number of traditional GA aircraft equipped with conventional avionics versus a 1.3% annual replacement factor, the true impact of technology advances on safety in general aviation may not be evident for a number of years.

The NTSB study of 8000 piston aircraft between 2002 and 2006 equipped with Advanced Display Technology indicated ATA aircraft had higher fatal accident rate then the conventionally equipment aircraft (NTSB, 2010). In the NTSB report, the NTSB recommended (1) enhanced pilot knowledge and training requirements, (2) require OEMs to provide better information on managing system failures, (3) more training on Advanced Display Technology in initial and recurrent flight proficiency including variation in equipment design and operations, (4) more Advanced Display Technology training materials, (5) integrate simulators into training programs, and (6) more reporting of malfunction/defects (NTSB, 2010).

The National Transportation Safety Board (NTSB) produces an "Annual Review of Aircraft Accident Data". The 2009 report shows a 3% increase in the number of general aviation accidents from 2004 to 2005. Highlights from the report indicate that: private pilots represent 45% of all accident and they typically had fewer than 1000 total hours and less than 100 hours in make and model (NTSB, 2009). It was reported that 74% of the accidents reported in 2005 were single-engine piston aircraft (NTSB, 2009).

Nineteen percent of the fatalities occurred during instrument meteorological conditions (IMC) and accidents occurring at night had a higher fatal rate (NTSB, 2009). This report clearly depicts the greatest likelihood for a GA accident is with private pilots in single-engine aircraft flying in IMC or at night.

Behavior of Automation

Sarter, Woods, and Billings (1997) stated that automation has improved precision and economy of operations, but unanticipated problems and failures have also occurred. They explained that the most serious problem is the interaction breakdown between humans and automation. Mode awareness, Sarter, Woods, and Billing suggest, is the ability of the operator to track and anticipate automation's behavior (1997). A breakdown in mode awareness can result in being surprised by the automation. Olsen and Sarter (2000), surveyed pilots and asked whether they experienced instances where automation did too much or too little. Seventy-eight percent of pilots reported being surprised by the automation, 26% experienced automation doing more than expected, 36% experienced automation doing less than expected, and 38% experienced automation doing both more and less than expected (Olsen & Sarter, 2000, p.335). This researcher asked the DPEs in the survey whether they had similar experiences with the automation in GA aircraft.

Risk Taking Behavior

There are a number of risky taking behaviors that may be contributing to the increase in accidents. Research has shown that often pilots are often overly optimistic about potential risks, like VFR into IMC, and overconfident in their abilities to avoid or deal with specific risks (Wilson & Fallshore, 2001). The Wilson and Fallshore study suggest that education efforts need to specifically address pilot confidence and abilities.

A common complaint from instructors and examiners is failing to monitor outside the aircraft. Research has indicated that pilots of ADT equipped aircraft spend even less time looking outside of the aircraft when compared with traditionally equipped aircraft (Damos, John, & Lyall, 1999). Their research suggest programming FMS type instrumentation requires more time than resetting instruments and radios in traditional aircraft. It is also suggested that viewing time is affected by the phase of flight, traffic density, and other variables (Damos, John, & Lyall, 1999). The requirement still exists according to FAR part 91, that VFR pilots are solely responsible for keeping clear of obstacles, prohibited/restricted areas, terrain, clouds, and other traffic.

With automation's capabilities to reduce pilot workload, there is the risk for pilots to become complacent or fall into the passenger-in-command role (FAA Aviation News , March/April 2007). Others have suggested "that reliance on automated systems may engender a certain level of scan complacency among glass experienced pilots" (Young, Fanjoy, & Suckow, 2006, p. 13). Researcher Rudisill reported that younger pilots are "computer keen" and "fixated" on automation. This coupled with the lack of experience, prevents these pilots from "knowing when to throw it away" (Rudisill, 1995, p. 5).

Further, an FAA Aviation News article offered "with all this information prominently displayed, a pilot may become so comfortable flying closer to hazardous weather or terrain without using the proper situation awareness and risk management techniques" (Glista, 2010, p. 6)

This research asked examiners whether they perceived ADT was creating additional risk taking behaviors (survey question) and what could be done (interview question).

Pilot & Conventional Navigation Skills

As mentioned earlier, there has been discussion whether conventional navigation skills have been degraded with ADT. These new systems have the ability to display real-time moving aeronautical maps. The systems show present position, ground track, and ground speed based upon GPS input. If a flight plan with destination is programmed, the systems will calculate estimated-time-of-arrival (ETA) and course to destination. The systems will control the entire flight if coupled to an onboard autopilot.

The instructor pilots in the Di Renzo study re-iterated that notion that flying TAA has a negative impact on pilot's basic "stick and rudder skills". Eight four percent of the total group of pilots and instructor pilots claimed that TAA "made them safer pilots" but not necessarily better pilots (Di Renzo, 2009, p109). Young, Fanjoy, and Suckow (2006) reported that pilots regularly flying TAA tend to become complacent reducing "psychomotor experience" or the ability to smoothly fly manual approaches and "less effective cross-checking". Di Renzo suggested that further research into the "effects of TAA training on safety and the retention of basic piloting skills" was appropriate (Di Renzo, 2009, p117).

UK research found that "scan and basic manual skills deteriorated or changed with automation use" (Rudisill, pg 4, 1995). Sherman and Arch posit, "Will the student pilot become overly reliant upon the moving map displays and loose basic pilotage skills?" (2005). This research study specifically asked whether ADT and TAA aircraft have led to degraded conventional navigation skills and if so, how training and testing should address it?

FAA Guidance & Regulations

The governing regulations concerning general aviation flight training are contained in the Federal Aviation Regulations (FAR) Part 61 for certification of pilots, flight instructors, and ground instructors and Part 141 for pilot schools (Wright, 2002). These regulations have not seen substantial changes since 1977 even though FAA officials have noted: “emerging changes in system safety philosophy and changes in NAS flight procedures and in flight technologies may call for a new approach to flight training” (Wright, 2002, p. 6). Susan Parson of the FAA offered on regulations, “they are meant to direct the pilot’s path toward practices that contribute to safe operation and away from activities that undermine it” (Parson, 2011, p. 14). The question is what changes to regulation may be needed to affect practices that led to safer operation of advanced technology.

Complex Aircraft Endorsement

The current definition of a complex aircraft is outdated. FAR 61.31(e) defines a complex aircraft as ” an airplane that has a retractable landing gear, flaps, and a controllable pitch propeller; or, in the case of a seaplane, flaps and a controllable pitch propeller”. The FAR does not address the recent advances in avionics. A pilot must receive training a one-time ‘endorsement’ from an authorized instructor to demonstrate proficiency in that complex airplane. Therefore, current regulations do not require a pilot to be formally tested or have an instructor endorsement when transitioning into the glass environment (Glista, 2010). One questions whether Advanced Display Technology equipped aircraft should require a specific endorsement (survey question). FITS researchers from Middle Tennessee University suggest that a logbook endorsement be required for pilots flying under IFR conditions with GPS aircraft equipped (Dornan, Beckman, Gossett, & Craig, n.d.). Current glass systems are an order of magnitude more complex than the stand alone GPS systems Middle Tennessee was investigating.

FAR 61.31 also has a requirement for 'type ratings' for large or turbine powered aircraft. Again a pilot must receive training and 'endorsement' from an authorized instructor to demonstrate proficiency in that type aircraft. Thomas Glista commented that transitioning between various manufacturers of TAA with differing glass systems may be significantly challenging (Glista, 2010). This begs the question whether a pilot license for TAA should be type or model specific (survey question)?

Non-Standard Equipment

The certification of the airborne avionics is not the prime focus of this research study, but it does impact the training and certification of private pilots. The certification of aircraft parts (systems) falls under Title 14 Part 21 of US Code. The minimum performance standards and approval process for airborne equipment is further governed by a myriad of Technical Standard Orders (TSOs) and Advisory Circulars (ACs).

Of particular concern is that the Advanced Display Technology operates differently between manufacturers. Specifically, TSO-C113c governs multipurpose displays and recommends certain color depictions, however they are not mandated. An FAA Safety Briefing article noted "variations exist in the way weather data are sliced, diced, and displayed by the manufacture – and these differences are not always intuitive" (Saini, 2010, p. 22). With the influx of many suppliers of the new technology into the market place, the potential for pilot confusion with variations in equipment is real. This concern was also identified by a DPE during the development of the research instrument which led to the incorporation of this survey question: should the FAA require more standardization of ADT with respect to display format and functionality?

Related to this issue is the most appropriate representation of flight data. Conventional flight instrumentation was discrete analog gages. Modern ADT often utilize a mixture of display representations. Research has shown that the speed and accuracy of decision making often is influenced by the format of the display, i.e. graphical or textual (Williams, 2000). Adding to the complexity of this issue, is the variation in user characteristics. "There is no best display for every user performing every task in every context" (Zhang, Johnson, Malin, & Smith, n.d., p.7).

Pilot Training & Knowledge

Methodology for Training Pilots in Traditional GA

A formal methodology for training pilots dates back to 1911 when the Wright brothers were teaching the first military airmen including Lt. Kenneth Whiting and Hap Arnold. "The world's first pilot had given a great deal of thought to the business of flight instruction" (Crouch, 1989, p 436).

Orville and Wilbur Wright created the first aircraft simulator: they took an earlier model aircraft: mounted it on sawhorses and connected the control system to a series of pulleys to produce movement. This was meant to teach the control laws of flight without putting the student pilot at risk. As part of the training program, the Wright brothers believed that the student should have an understanding of the aircraft's construction and maintenance features (Crouch, 1989).

It is worth noting that so early in aviation history that pilots were expected to understand how things worked! Today this is even more the case. Pilots learning to fly in the glass cockpit environment should have an understanding of the design (logic) behind advanced avionics along with the basic of flight. This leads back to the FAR 61.31(e) discussion above on the "complex endorsement" being model specific.

The psychology of flight training has been established by leading researchers Telfer, Biggs, and others. They have recognized that teaching pilots, especially in a flight environment, require tailoring of many standard teaching practices.

The FAA has made significant improvements to many of the flight training handbooks which incorporate many advance concepts. Table 2.1 depicts some of these documents and their status.

Document	Title	Revision	Status
FAA-H-8083-3A	Airplane Flying Handbook		Analog Cockpit
FAA-H-8083-15A	Instrument Flying Handbook	2007	Complete re-write to include advanced display technology
FAA-H-8083-9A	Aviation Instructor's Handbook	2008	Revision includes CRM/SRM, risk management, scenario based training
FAA-H-8083-25A	Pilot's Handbook of Aeronautical Knowledge	2008	Incorporates some automation concepts

Table 2.1. FAA Training Documents

The content of flight instruction is dictated by the Federal Aviation Administration. The Airplane Flying Handbook and Pilot's Handbook of Aeronautical Knowledge contain the bulk of content that must be mastered. Sequencing of instruction is also fairly structured, in that, everything in flight instruction builds upon previous knowledge. Instructors truly only have latitude over the instructional delivery methods. Typical instructional strategies include: pretest, behavioral objects, overviews, advanced organizers, questioning, and sample items (Telfer & Biggs, 1988).

Much of pilot training revolves upon "rote learning" or "brittle skills" memorization. Items that a pilot must memorize include: checklists, aircraft performance factors, standard approach and contact procedures, and standard operating procedures. It is this researcher's concern that rote learning of sophisticated navigation suites might jeopardize safety.

First, rote learning is less efficient than coding for memory utilization (Telfer & Biggs, 1988). This might lead to misrecollection or confusion under high stress situations (state anxiety) that might occur during in-flight emergencies. Second, learning is hard to undo. With advanced navigation packages, they are software driven and frequently updated. Additionally, there is no standardization in the man-machine interfaces among various manufacturers' glass systems. The programming/operator keystrokes are entirely different, so what works on one system will not work on another. Therefore, what was once an autonomous reaction/function by the pilot now requires special/additional/focused attention. In the worst case scenario, there is the potential for misprogramming: leading to a possible flight hazard. Casner suggest that teaching "how it works" rather than "by rote" is more effective at transferring knowledge to other related situations (Casner, 2005).

Further, glass systems display large amounts of information. According to Dahlstrom, Dekker, and Nahlinder (2006), the sheer volume of information is a "potential detriment to the attention and mental workload of the students" (p. 6). A course manager in this study stated "in the beginning that amount of information on the PFD (glass display) was beyond the capacity of the student" (Dahlstrom, Dekker, Nahlinder, 2006, p. 9). These researcher also reported that some student have problems finding the right information at the right time (Dahlstrom, Dekker, Nahlinder, 2006). Additionally, for pilots transition for steam gage instrumentation to a glass environment requires a change in conventional instrument scan procedure.

Learners have a finite capacity to process information. The instructor is faced with the dilemma of how much training to provide the student over what period of time. According to Telfer & Biggs (1988), it depends upon the student's ability and motivation. Also, cognitive abilities in pilots have shown to vary with age. Variation with age affects psychomotor skills, information processing, attention and executive abilities, learning, and memory (Hardy, Satz, D'Elia, & Uchiyama, 2007). The student pilot must absorb volumes of information. The FAA's Airplane Flying Handbook and Pilot's Handbook of Aeronautical Knowledge contain the general aeronautical information that must be learned. Each aircraft that a pilot flies also has an operations manual and associated check list that also must be assimilated. With the advent of advanced glass technology, there is an additional level of knowledge that must be absorbed. The Garmin G600 Pilot's Guide is 240 pages in length and the associated Cockpit Reference Guide is 60 pages in length. These technical documents have highly detailed content much of which must be rote learned. Some researchers have suggested a phased approach to learning these complex systems where a student learns only those features of the system that are required for their level of training. A Lund University research report stated “in the beginning the amount of information on the PFD was beyond the capacity of the students” (Dahlstrom, Dekker, & Nahlinder, 2006, p. 9)

A Special Airworthiness Information Bulletin was published in August of 2010 for certain Honeywell GPS navigation systems. A software error caused the loss of GPS navigation under some flight situations. The report recommended that the pilot be prepared to revert to alternate forms of navigation if the condition occurs (FAA, 2010). This condition requires a pilot operating these systems to have “specific knowledge” of this potential hazardous situation and the ability to detect the condition. Considering the complexity and variations between manufacturers, how should a pilot’s knowledge and ability be tested with these ADT systems?

Cockpit or Crew Resource Management (CRM) has been a major topic of discussion in the operation of modern airliners. The benefit of CRM training has generally been positively received by its participants and some level of learning/behavioral change occurs (Salas, Burke, Bowers, & Wilson, 2001). The focus of CRM is to promote: error avoidance, early detection of errors, and minimization of consequences from errors (Salas, & et al, 2001). As such, CRM applies equally to the entire pilot population. Author Thomas Turner suggests that due to the inherently risky nature of aviation, even a private pilot needs to consciously manage risk, an element of CRM (Turner, 1998). Today with advanced technology moving into the GA and light aircraft fleet, some in the aviation community believe it is time to include CRM elements into GA pilot training curriculums. Sarter, Woods, and Billings (1997), stated “creating partially autonomous machine agent is, in part, like adding a new team member” (p.7). Robert Wright, industry consultant and former FAA AFS-800 official, specifically suggested including whether more emphasis should be placed on “higher order pilot skills”, like risk management, single pilot resource management, and automation management (survey question) into this research study. Since airlines are required by FAR part 121 to include CRM into training curriculums to optimize the human/machine interface, then why has this not been a requirement for GA training considering the influx of advanced technology (FAA, 2004)?

An FAA Aviation News article stated that “for anyone to be able to competently utilize all the features found in the new TAA requires some very good training and practice in safe conditions” (FAA Aviation News, May/June 2007, p. 4).

Aviation Flight School Responses

Middle Tennessee State University (MTSU) has been evaluating that FAA Industry Training Standard (FITS) concept for training co-developed by Embry-Riddle Aeronautical University and the University of North Dakota. MTSU presented a paper on the lessons learned from their evaluation of the FITS concept. One of the lesson learned involved the need to modify their ground school curriculum for the students flying their Diamond DA-40s. The students are required to complete the Garmin G1000 tutorials. Module quizzes are taken to enforce learning. MTSU included class discussions on “the appropriate use of the technology” throughout the private pilot ground school (Dornan, Beckman, Gossett, and Craig, n.d., p 5).

Although Middle Tennessee State University has been very progressive in their flight training curriculums many universities have failed to embrace the new technology. Fanjoy and Young (2004) have reported the high cost of the avionics and training material/aids as the major deterrent. Also they reported that the existing training programs are already “overloaded with required courses and subject matter” (Fanjoy & Young, 2004, p. 16).

Other researchers suggest that higher order skills should be introduced into the pilot curriculums. A NASA and DOT report suggests that the cockpit be described as an information-processing system since its behaviors are not solely those of the human (Palmer, Hutchins, Ritter, & VanCleemput, 1991). Hubbard suggests that since human error (behavior) is primarily responsible for 80% of aircraft accidents, we should pursue Crew Resource Management (CRM) methods to change attitudes and dangerous behaviors (Hubbard, 2007). Hansen recommends the addition of risk management and system safety processes into collegiate aviation programs to reduce accident rates (Hansen, 2005). FAA officials have also commented on the need for including risk management and Aeronautical Decision Making (ADM) in general aviation operations (Wright, 2002). The question remains, what additional higher order skills should be included in primary aviation training with advanced technology (survey question)?

Simulators in Flight Training

The Wright brothers recognized the need to simulate flight. They built the first aircraft simulator out of an earlier model Wright Flyer. It was suspended through a series of ropes and pulleys and connected to the aircraft's control mechanisms in order to simulate aircraft motion (Crouch, 1989). This crude aircraft simulator allowed student pilots to train without jeopardizing their safety or the safety of the aircraft. There is also an economic benefit to simulation; this benefit becomes even more significant as the size and complexity of the aircraft increases.

Ed Link re-introduced the concept of an aircraft simulator in 1930 with the Link Flight Trainer. In 1933, instrument flight capability was added to the trainer. The Link Flight Trainer was massed produced during World War II in order to meet the demand of training 500,000 pilots (Roberson Museum and Science Center, 2000). Today, flight simulators are being produced by Flight Safety International and L-3 Link Division to meet the training need of airline and military pilots.

The advances in microcomputer technology now make flight simulation accessible to the general public on a standard personal computer. There are numerous simulation packages available to simulate a variety of aircraft platforms. Garmin has a free software simulation downloadable from their internet site for their G1000 glass system. Research has shown that even low fidelity simulation programs are beneficial in flight training for developing cognitive learning templates (Dennis & Harris, 1998). Dahlstrom, Dekker, and Nahlinder (2006) have suggested that utilization of devices such as the G1000 simulator serve as good procedural or "part-task" trainers that facilitate learning in a safe environment.

Despite the advances in training and training devices, none of these are required by FARs. However, the FAA does permit personal computer-based aviation training devices (PCATDs) during instrument training. The governing document is Advisory Circular 61-126. Interestingly, it is often the insurance companies that are dictating the requirements for pilot transitioning into the new technology (Glista, 2010).

Final Practical Test

The guidelines for conducting a fight examination are contained in FAA Order 8710.3E, Designated Pilot & Flight Engineer Examiner Handbook. The examiner must utilize a “written plan of action” for conducting a Practical Test (PT) in accordance with the Examiner Test Guide. The practical test requires demonstration of aeronautical knowledge in accordance with AC60-25 and demonstration of aeronautical skill or flight proficiency. The applicant must also provide: documentation of completing the knowledge test in accordance with 14CFR$61.39(b), a valid medical certificate, a Form 8710-1 Application for Certification, and an appropriate airworthy aircraft.

An FAA Aviation News article remarked that “the inspector giving the test must not only know how to fly the aircraft, but the inspector must know the correct way to simulate various flight conditions” (FAA Aviation News, May/June 2007, p. 2).

The governing document for the final certification of a private pilot is the ‘Private Pilot Practical Test Standards’. The document is used by the student pilot and the Designated Pilot Examiner to conduct the flight check which is the final step in certifying a new pilot. Outside of certain documents that must be provided, the Private Pilot

Practical Test Standards outlines the knowledge, skills, and abilities that must be successfully demonstrated during the check ride.

Upon close examination of the document, it is clear that it has not been updated to reflect any advancement in technology. Under Area of Operations: preflight preparation task D: cross-country flight planning, the process is totally manual with no mention of programming way-points into a Global Positioning System (GPS) receiver or advanced glass system (FAA, 2008, pg 1-2). Also, the advanced avionics require updating of their aeronautical databases to ensure the most current information is utilized. The preflight checklist does not mention the necessity for this action. The research survey attempted to determine whether ADT has adversely affected pre-flight planning.

Under Area of Operations: preflight preparation task G: operation of systems, the student pilot is required to exhibit knowledge of operations with electrical, avionics, pitot-static vacuum/pressure and associated flight instruments (partial list) (FAA, 2008, pg 1-4). In a Technology Advanced Aircraft or an aircraft modified with a glass system, the avionics, pitot-static system, and flight instruments are tightly integrated into one system. This research study questions whether knowledge of advanced avionic system's operations should be a knowledge element.

Under Area of Operations: Preflight Procedures Task A: Preflight Inspections, the student pilot is required to exhibit knowledge of "how to detect possible defects " (FAA, 2008, pg 1-6). Detecting a defect with a tightly integrated system is complex, since the attitude, heading, and turn rate instrument display utilize the same reference source. Unless the Flight Examiner is highly familiar with the specific system, they might not be aware of the serviceability of the system either. In a recent Overhaul & Maintenance article, Lufthansa Technik reports that on average 30% of reported avionics failures by airline pilots were not confirmed. The article stressed “the importance of educating pilots on the nature of today’s avionics” (Seidenman & Spanovich, 2009). What is the probability that a low-time general aviation pilot would detect faulty advanced glass avionics without specific training or training emphasis when professional airline pilots fail 30% of the time? The same issue applies to “simulating emergencies” (FAA, 2008, pg 1-33). The researcher also asserts that with the new technology new problems are created. The glass systems are highly dependent upon the availability of the GPS satellites. Determining the integrity of the GPS system should be a knowledge element.

Under Area of Operations: Airport and Seaplane Base Operations Task A: radio communications and ATC light signals, the student pilot is required to “select appropriate frequencies” (FAA, 2008, pg 1-9). In a traditional general aviation aircraft, tuning aircraft radios is fairly uniform; however integrated glass systems are tuned and displayed differently. Unless the Flight Examiner is highly familiar with the specific system, they might not be aware of the frequency selected.

Under Areas of Operation: Navigation, A Task: Pilotage and Dead Reckoning, the student is required to demonstrate pilotage and dead reckoning skills (FAA, 2008, pg 1-24). In a traditional general aviation aircraft, the navigation radios can simply be turned off. This is not the case in glass systems. How is this demonstrated in a glass equipped aircraft? The same issue applies to demonstration of “lost procedures” (FAA, 2008, pg 1-25). The problem of performing partial instrument panel failure with glass systems has already been identified (Sherman & Deak, 2005). It has not been determined what other tasks or procedures from the current Practical Test Standards are difficult or potentially dangerous to perform with glass systems (interview question).

FAA Order 8710.3E permits the use of simulators for the Practical Test in lieu of an actual aircraft. There are restrictions on which simulators are acceptable but it offers an avenue for quickly setting up scenarios or profiles and testing a pilot's ability in a controlled safe environment. Garmin, the G1000 manufacturer, provides a PC based procedural trainer. Would this or an equivalent simulator be value-added to the practical portion of the pilot certification process (survey and interview question)?

Examiner Training & Knowledge

An FAA Aviation News article clearly states that "with the proliferation of the new technologically advanced aircraft …. GA OPS inspectors with years of experience and thousands of hours in traditional aircraft…..needed to be trained in the new flat-panel cockpits" (FAA Aviation News, May/June 2007, p. 1). However, the flight proficiency requirements for Designated Flight Examiners are by aircraft type and model. There is no requirement for proficiency with the avionics.

The FAA Aviation News article reported that "testing a relatively low-time applicant...it is conceivable that the inspector might have to assume control of the aircraft to prevent an accident" (FAA Aviation News, May/June 2007, p. 1-2). Beyond safely operating the aircraft in an emergency, the DPE's prime responsibility is evaluating the proficiency of the pilot applicant. Generally an examiner must have a higher level of expertise than the person being examined.

The FAA conducted a pilot program to provide TAA specific training to their Aviation Safety Inspectors (ASIs). The ASIs inspect TAA, check certified flight instructors, and conduct surveillance of DPEs. The program required completing an overview of three major ADT systems currently in use by GA. The participants were then required to demonstrate their proficiency with those systems (Chidester, Hackworth, & Knecht, 2007).

Since the FAA determine there was a need to provide TAA specific training to their ASIs for surveillance on DPEs, then it seems reasonable that similar training would be desirable for the DPE certifying pilot applicants. It needs to be determined what additional training and knowledge requirements are needed by the Designated Flight Examiner community (survey and interview question).

CHAPTER III
METHODOLOGY

Overview

Many in the industry perceive that the certification process, including training and testing requirements as established by the FAA, have not kept pace with advances in aircraft technology. The aircraft and avionics manufacturers, and other third party sources, have developed various training packages for the new technology. Surprisingly, there is no general accepted approach to training the advanced technology and none of this training is mandated by the FAA. The methodology executed in this research is a mixed method study to investigate the private pilot certification process from the Designated Pilot Examiners perspective.

This mixed method study follows a sequential exploratory design where first quantitative data is collected and analyzed, then second qualitative data is collected and analyzed, and finally both analysis are integrated and interpreted (Creswell, Clark, Gutmann, & Hanson, 2003). Since there are limitation to all data collection methodologies, using multiple methods can help minimize the disadvantages of either methodology (Creswell, Clark, Gutmann, & Hanson, 2003).

The first phase of this study is a quantitative survey of DPEs to gather their professional qualification, flight experience, and overall perceptions about the impact of advanced technology in certain key areas of interest. The second phase is qualitative interviews to probe deeper into the areas of interest and explore potential solutions.

The quantitative methodology was the best means to summarize the examiners qualifications, experience, and training. It also permitted trending of the examiners opinion to determine where general consensus lied and where it did not. This identified the key areas to be addressed by the interview questions and the exact individuals to be interviewed.

The qualitative phase of the study was envisioned to be the best methodology for obtaining answers to the research questions, since it is meant to be a detailed examination of a particular setting (Bogdan & Bilklen, 2003). This research study utilized a case study structure to: discuss the problem and its context, describe the issues involved, and document the lessons to be learned (Lincoln & Guba, 1985). Researchers Bogdam and Bilken stated “qualitative researchers believe that reading the same question to each subject assures nothing about the response” (Bogdam & Bilklen, 2003, 100). This researcher had no expectations of the responses forthcoming. It was only hoped that the answers to the research questions would expand the body of knowledge in the area of flight training and testing, and possibly enhance safety.

Typical of a qualitative research and case studies is the rich, detailed, and in-depth information gathered (Berg, 2004). Typical of all research, qualitative and quantitative, is the question of how broad a social area to cover (Berg, 2004). In this study, the social unit selected was the FAA Designated Pilot Examiners. This social unit was selected because they are: the final step in the pilot certification process, required to be Certified Flight Instructor themselves, the most proficient in their training and their skills, and a sufficient population to draw upon. The study investigated whether the current FAA certification process was sufficient with the advanced technology from the examiners perspective.

This research followed the case study concept of a board exploratory beginning and then narrowing to particular set of subjects and topics (Bogdan & Biklen, 2003). This was accomplished by a self-administered survey to a large group followed by a subset of respondents being interviewed with specific questions.

Research Question

How could the current FAA certification process be modified for a private pilot to safely operate in the National Airspace System with the introduction of advanced technology in GA aircraft?

Pilot Study

During the development of the research, this researcher contacted five local DPEs and obtain their thought on the effect of advanced technology in primary flight training. They indicated: guidance lagged technology, a greater need for basic pilotage skills, an over dependency on the technology, and difficulty performing partial panel testing as issues with the technology. Based upon this heading check and published material, a formal study of a larger DPE body seemed logical. To ensure that the research remained on course, contact was made with leading researchers and industry experts during the formulation of the research plan and the associated research instruments.

Research Design

The research protocol (IRB Application # Ed10112) was approved by the Oklahoma State University Internal Review Board on the September 8, 2010 and amended on January 14, 2011. These approvals are contained in Appendix G.

Population

The target population of this field study was all FAA Designated Pilot Examiners (DPE). On July 10, 2009 the entire DPE database, containing approximately 1076 records, was downloaded from the FAA public website. Each record contained the Examiner's name, address, telephone number, FSDO office, and qualified aircraft.

Survey Protocol

Survey Sampling

This research utilized a random selection from the total DPE population of 1076. Therefore, every member of the DPE population had an equal opportunity of being selected (Fraenkel & Wallen, 2003, p. 270). The Stat Trek website was utilized to generate a table of 250 random numbers ranging from 1 to 1076 (Appendix A). These numbers directed the sequence which DPE would be selected from the total population in the FAA Designated Pilot Examiners database. An initial sample of 100 DPEs were identified. These participants were contacted by telephone requesting their support.

Survey packets were mailed to the participants. Each packet included a participant letter from the researcher, a consent form, the survey, and a postage paid return envelope. Each of the surveys was individually coded with an alphanumeric survey number to correlate and track responses. A survey response matrix was created that tracked the status of the surveys. It contained: the survey number, the mailing date, the return date. Another matrix correlated the survey number to DPE identifier. These matrices were created to ensure no one document would permit matching survey responses to an actual person.

Another survey of all DPEs conducted by the FAA received a 64% response rate (Hackworth, King, Cruz, Thomas, Roberts, Bate, and Moore, 2007). This researcher believed that due to the high interest of this topic, personal contact/appeal, the surveys ability to voice DPEs concerns, and support request letter, that a similar response rate was achievable. Of the initial mailing of 100 survey packets, only one survey could not be delivered to the address of record. This survey was re-mailed to the participant's current address. A response rate of 46% was actually achieved with an average response time of 12 days. A 2001 Oklahoma State University School of Hotel and Restaurant Administration comparison of survey methods found that mail, fax, and email had response rates of 26%, 17%, and 44% respectively with response times of 16, 4, and 6 days also respectively (Cobanoglu, C., Warde, B., & Moreo, P. J., 2001). Although this research did not achieve the 64% response rate of the FAA survey it did exceed the typical response rate of 26%.

Survey Instrument

The survey was divided into sections. Each section corresponded to a research question. Additionally, there was a demographic section that profiled the flight experience, examiner qualifications, and advance technology experience of each Designated Pilot Examiner responding.

The literature review found a number of surveys with elements that were adopted in this researcher's survey instrument. The analysis, depiction of the data, and some findings were also directly usable in this researchers study.

Assessment of Advanced Cockpit Displays for General Aviation Aircraft - The Capstone Program researched by William, Yost, Holland, and Tyler (2002) assessed the safety impact of advanced technology on Part 135 operators in Alaska. Questions concerning pilot flight experience, navigational skill degradation, traffic and terrain alerting, and demonstration of technology during flight checks were directly re-usable in this research.

Streamlining Software Aspects of Certification: Report on the SSAC Survey researched by Hayhurst, Dorsey, Knight, Leveson, and McCormick assessed the efficacy of the FAA operational flight software certification process. Questions concerning the adequacy of FAA regulations and guidance were directly adaptable to this research.

The Private Pilot Practical Test: Survey Results from Designated Pilot Examiners and Newly Certified private Pilots researched by Hackworth, King, Cruz, Thomas, Roberts, Bates, and Moore examined whether the FAA DPEs were consistently applying the Practical Test standards. One question concerning whether flight instructors were adequately preparing first-time applicants for their Practical Test was utilized.

The survey length was four pages. It contained: twenty-five YES/NO questions, nine check block questions, and six fill-in questions. Considerable effort was applied to reducing the number of questions and shorting responses to permit completing of the survey within 25 minutes. Check block responses were utilized to reduce the number of fill-in-the-block responses. The reduction in survey length also reduced the cost of duplication and mailing.

This researcher reviewed numerous surveys for format and visual appeal. It was important that the survey appear professional, organized, and pleasing to the eye. This was intentionally done to aid in increasing the response rate and reflecting a feel of importance.

Much of the information needed to respond to the survey was readily available in the Examiner's Testing Activity Log required by FAA Order 8710.3E.

Verification of Survey

The survey was verified through three (3) levels of review: advisor, industry experts, and target population. Each level had one or more individual review cycles. The first reviews were by dissertation advisories which were focused primarily on scope, management, and executability. Dr. Fred Hansen, Dr. Mary Kutz, and Dr. Steve Marks were the first level reviewers. The second level review was by industry experts which were concerned with the technical content of the instrument. Mr. Robert A. Wright, a former FAA official, and Mr. Eric Baird, a current FAA official, clarified terminology and offered content improvements. The third and final level of review was by a few members of the target population. The purpose of their review was for clarity. Responses from these DPEs reviews were not included in the final data collection.

Survey Gathering

The survey packet containing the survey, cover sheet, and informed consent form is contained in Appendix B. It was duplicated and assembled with an accompanying postage paid return envelope. The researcher's return address was pre-stamped on the return envelope. Both the mail and return envelopes were clearly stamped with "RESEARCH MATERIAL". This additional marking was meant to distinguish the survey from junk mail. Mailing labels were made for the 100 randomly selected DPEs. The survey packets were assembled and mailed between September 27 and September 29, 2010. The survey cost is documented in the Table 3.1.

Item	Cost
Survey Duplication (6 sheets @ 0.04/sheet * 100)	24.00
Inkjet Address Labels	8.19
9 x 12 Mailing Large Envelop (100 count)	7.99
#10 Return Envelop (100 count)	7.29
Research Material Stamp	17.99
Return Address Stamp	26.99
Survey Mailing Postage ($1.05 ea * 100)	105.00
Survey Return Postage (0.44 ea * 100)	44.00
Total Cost	$241.45

Table 3.1 Survey Costs

Prior to each mailing date, telephone contact was attempted to each of the DPEs informing them of the research study and the forthcoming survey. The contact was in accordance with the research plan/application approved by the IRB. Interestingly, once the DPEs recognized the caller was a researcher, not a solicitator, most were very receptive and interested. If an answering machine was reached, the information about the research and contact information was left as a message. A log was created documenting the date of telephone contact, survey mailing date, and survey return time.

The collection period ran from October 2, 2010 through November 9, 2010 - a total of 39 days. There were no follow-up phone calls made. Of the 100 surveys mailed, 46 were completed and returned. Surprisingly, none were returned undeliverable. The response/participation rate was 46% and the average response time was 12 days.

Survey Analysis

The survey responses were coded into an Excel Spreadsheet. The majority of the survey consists of twenty-five YES/NO questions. There were nine check block questions and six fill-in responses. Only one of the fill-in questions was narrative reserved for remarks. Therefore, the survey lends itself nicely to spreadsheet aggregation.

If the respondent choose to leave an item blank, then it was coded “NR” for no response. Also, if both YES and NO were selected, it was coded “UD” for undecided. Occasionally a respondent would mark a block “NA” and it was coded as such. There were a few occurrences where non-responses appeared to be an oversight and a follow-up email was sent to request the data. The email responses have been retained to document the integrity of the data.

A peer review of the survey coding was accomplished to verify the accuracy of the coding process. A sample of five responses was verified with no errors identified.

The analysis of the survey was descriptive. The majority of the responses were reduced to bar/pie frequency distribution charts, where the horizontal axis represents the response categories and the vertical axis is frequency counts of respondents. Appendix C contains an aggregate of all the DPE responses.

In all, the analysis answered the problem statement that Designated Pilot Examiners do perceive an impact on safety with the certification process of new pilots in technically advanced general aviation aircraft.

Interview Protocol

Interview Sampling

The sampling for the interview was purposeful. This researcher used his special knowledge about the examiner group to select subjects who represent the most experienced certifying airmen with the technology (Berg 2004). The demographic section of the survey was the source of selection criteria. The primary factor for the selection was those with the highest number of Practical Tests in TAA or Advanced Display Technology, and the secondary factor was years as an examiner.

An initial section of twelve potential participants was accomplished. Additional selections proved unnecessary. An interview schedule was developed that included: the order of preference based upon the selection criteria, contact information, scheduling information, actual interview date and time, ending time, interview length, and digital recorder folder.

Many of the DPEs were commercial pilots and scheduling convenient interview times proved to be challenging. As a whole, the DPEs were extremely enthusiastic about participating. Sampling and interviewing concluded with number ten when it became apparent that no significant new information was being generated. DPE ranked number five could never be reached and contact was made with DPE ranked number twelve before number eleven.

Interview Instrument

The interview type was semi-standardized with a number of predetermined questions (Berg 2004). The same basic questions were asked of each participant, but there was some flexibility in wording. The ordering of the questions was sequential. Probing questions were asked for clarification. Participant questions and clarifications were answered. The researcher's language level was adjusted to be relatable to the participant (Berg 2004). This interview structure was consistent with the semi-standardized approach.

This research utilized an Interview Guide (Appendix D) as the bases for executing the interviews. The guide outlined the management of the interview including: confidentiality, interview length, interview method, and recording method. The guide included the purpose of the study along with consent form and IRB disclosure requirements.

The guide contained thirteen open-ended critical questions. These questions focused the interview on the research problem of understanding the participant's perception about the pilot certification process with the introduction of advanced avionics in GA aircraft. Probing questions were utilized to undercover underlining rationales and potential course of action.

Interview Gathering

This researcher applied Yin's five research skills for conducting qualitative case studies: have an inquiring mind, be a good listener, be adaptable and flexible, have a grasp of the issues, and be unbiased in the interpretation of the data (Yin, 1998; Berg, 2004). Telephone interviews were conducted due to the geographic disbursement of the participants. This was appropriate because there was a fairly specific set of predetermined questions in mind (Berg, 2004). The collection period ran from January 27, 2011 through February 26, 2011 with ten DPEs being interviewed. The interviews were in accordance with the Interview Guide that contained thirteen standard questions. Additional probes were only used to keep DPEs on subject, clarify responses, or obtain specific information. This researcher followed the "Ten Commandments of Interviewing" of: establishing a rapport, remembering purpose, being natural, demonstrating awareness, being business like, interviewing at appropriate time/sight, limiting monosyllabic responses, being respectful, preparing/practicing, and being appreciative (Berg, 2004, p. 110-111). The interviews were schedule for 30 minutes in length and the average interview was 26.6 minutes with a range of 14 to 47 minutes. The interviews were digital recorded, uploaded into a laptop PC, and then manually transcribed by the researcher into a MS-Word document (Appendix E).

Interview Analysis

Due to the nature of flight research, the researcher expected the coding to revolve mostly along process codes, activity codes, event codes and strategy codes. "*Process codes* are words and phrases that facilitate categorizing sequences of events, changes over time, or passage from one type or kind of status to another" (Bogdam & Bilklen, 2003, 164). “Codes that are directed at regularly occurring kinds of behavior are what we call *activity codes*” (Bogdam & Bilklen, 2003, 164). “Event codes point to particular happening that occurs infrequently or only once” (Bogdam & Bilklen, 2003, 165). “Strategies refer to the tactics, methods, techniques, maneuvers, ploys, and other conscious ways people accomplish various things” (Bogdam & Bilklen, 2003, 165). From these types of codes, major and subcodes were expected to drill down from top level concepts to details or explanations (Bogdam & Bilklen, 2003, 174).

The interview transcripts were first coded for key themes. These themes were entered into an EXCEL spreadsheet matrix corresponding to the applicable DPE index and interview question (Appendix F). The themes for each question were individually color coded and labeled. This revealed whether a theme was isolated to one or more individuals. From there major and subcodes were identified and labeled.

This qualitative analysis of the interview responses did answer how the certification process could be modified, so that the safety of new pilots in technically advanced general aviation aircraft can be enhanced.

Limitations

The research presented here documented the experiences of a select group of FAA Designated Flight Examiners dealing with new pilots and the advanced technology. The survey in this study randomly sampled 100 DPEs from the total population of 1076 from the FAA DPE database with 46% choosing to participate. The survey results reflected only 4.3% of the population, therefore no generalization to the total population is offered.

With respect to the qualitative interview, ten DPEs were purposefully selected based upon the researcher's defined criteria. Although generalizing these results to the whole population is not possible, a significant amount of experience among DPEs is reflected in the results.

Delimitations

There were a number of delimitations associated with this research. The first delimitation was the survey sample size of 100. Another delimitation was the number of interview questions. Based upon the survey results, other areas of interest could have been probed by the interview. The thirteen questions selected were meant to keep the interview time in the range from 30 to 45 minutes. This was suggested to keep the participants engaged.

The tone and phrasing used by the researcher in the interview could have been a delimiter. This researcher attempted to minimize this effect by following the canned script contained in the interview guide. Also the research tried to limit his remarks and comments until the conclusion of the interview. Clarification of the questions was only at the request of the interviewee. The entire interview transcriptions are contained in Appendix E so other researchers can determine the accuracy and completeness of the findings presented.

Threats to Validity

In order to accurately portray the case of the DPE, multiple sources of data were utilized to create a fuller understanding of the phenomena typical referred to as triangulation (Bogdan & Biklen, 2003). According the Berg (2004), triangulation is not merely the consolidation of data sources but rather to relate them in order to counter the threat to validity or means of confirmation. This researcher reviewed the published material of leading researchers in aviation flight training and cognitive research. A pilot study of local examiners explored their thoughts and concerns on the affect of technology on training in general aviation aircraft. This was followed by a survey sent to a larger population to discern their opinions. Based upon the survey, interviews were held to probe into the personal experiences of examiners and seek potential courses of action.

This researcher also employed Wolcott's nine points to satisfy the correctness and credibility associated with this qualitative study, namely to: talk a little and listen a lot, accurate recording of information, start writing early, include primary data for all to see, present all sides fairly, be candid, solicit feedback, be balanced in reporting (proportional), and write coherently and consistently (Wolcott, 1990; Hall-Greene, 2002).

CHAPTER IV

FINDINGS

Purpose of the Study

The purpose of this study is to identify what changes, if any, are required for the certification of private pilots with ADT. Since DPEs are the final step in the certification process of an applicant pilot, it is thought that interviews with these individuals might confirm or reject some of the concerns being raised.

Research Questions

How could the current FAA certification process be modified for a private pilot to safely operate in the National Airspace System with the introduction of advanced technology in GA aircraft?

1. How do DPEs perceive **safety** been impacted with the introduction of advanced technology in GA aircraft?
2. What **regulatory and guidance** changes do DPEs perceive are needed with the introduction of advanced technology into GA aircraft?
3. What **training and knowledg**e requirements changes do DPEs perceive are needed with the introduction of advanced technology in GA aircraft?
4. What **Practical Test** requirements changes do DPEs perceive are needed with the introduction of advanced technology in GA aircraft?

Survey Results

The survey had two purposes. First, the survey was meant to profile the general population of DPEs exposure to advanced technology. This profile identified the aircraft flown, the type of advanced technology, how they prepared themselves for exploiting the technology, number of practical tests given, and their perceptions of the current requirements for pilot certification in advanced technology and its impact on safety. Lastly, the survey was the means to select DPEs for an in depth interview into what may be needed to improve the process for preparing pilots for the advancing technology. Forty-six surveys were returned from the 100 mailed to the examiners.

Flight Experience Section

Ratings Held

The FAA issues various pilot certificates based upon the types of flying and aircraft. Figure-4.1 profiles the FAA pilot certificates (ratings) held by the DPEs responding to this survey. As one might expect, the examiners appointed to be representatives of the FAA for pilot certification were highly qualified holding multiple ratings

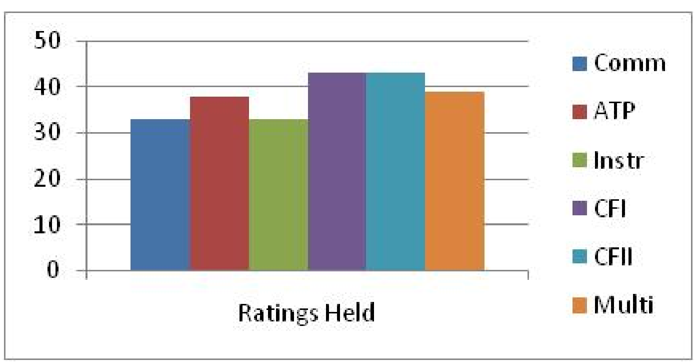

Figure-4.1. Rating Held by DPEs.

Flight Times

The survey requested the DPEs to report civilian, military, VFR, and IFR total flight hours and flight hours for the last 12 months. The purpose of this request was to identify the experience level of the participant and whether they were exposed to civilian and/or the military environments.

Some DPEs choose not to report the breakdown and only reported the aggregate flight hours. The average total flight hours for the 46 DPEs that responded to the survey was 14,249. The DPEs reported an average of 289 flight hours within the past 12 months. Thirty-one DPEs reported only civilian flight experience, 10 DPEs reported both civilian and military flight experience, and 5 DPE did not report either.

Designated Pilot Examiners' Qualifications Section

The survey profiled the DPEs' experience and qualification as FAA examiners. DPE experience range from two years to sixty-one years with an average of 17.4 years. Within the past 12 months, DPEs averaged 70 practical tests each of which 8.8 were given in ADT/TAA. Worth noting is that 17 of 46 DPEs, or 37%, reported giving no practical tests in ADT/TAA within the past 12 months.

DPEs are designated to perform various Practical Tests in various types of aircraft. The types of Practical Tests designated by the FAA to DPEs include: Private, Commercial, Airline Transport Pilot (ATP), instrument, Certified Flight Instructor (CFI), and Certified Flight Instructor Instruments (CFII). The DPEs are also designated to which kind of aircraft they are permitted to give Practical Tests.

The survey profiled the DPEs qualification and the results are contained in Figure-4.2. The vast majority of DPEs were authorized to give multiple Practical Tests in airplanes. Six DPEs were authorized to perform Practical Tests in helicopters. There were 16 DPEs that were authorized to perform Practical Tests in hang gliders, Light Sport Aircraft (LSA), and sail planes or aircraft requiring a type rating.

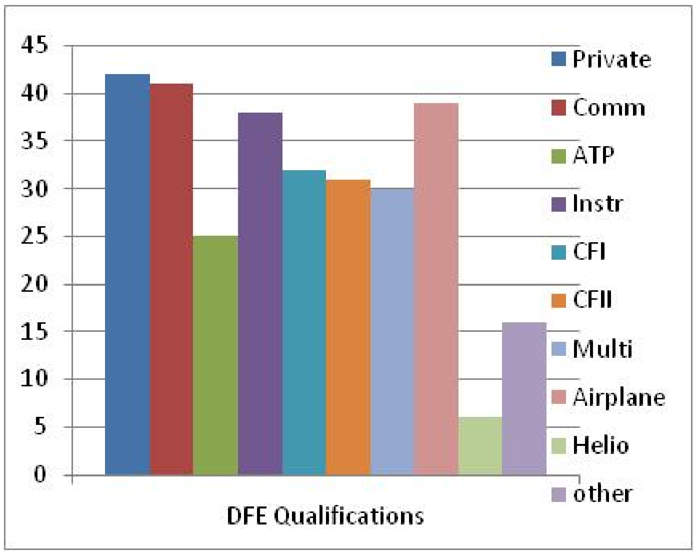

Figure-4.2. DPEs Qualifications.

Technology Experience Section

Key to this research study was the DPEs' experience with the advanced technology. The newly designed aircraft coming off the production line with Advanced Display Technology are more appropriately referred to as Advanced Technology Aircraft (ATA) or Technical Advanced Aircraft (TAA). Older aircraft are also being retrofitted with the Advanced Display Technology systems.

The survey inquired about what Advanced Technology Aircraft experience the DPEs had (Figure-4.3). Of the newly design aircraft, Cirrus, Diamond, and Columbia were the most popular. No DPEs indicated any experience with Adam or ATG aircraft. The other category was meant to be a catch-all for the new aircraft but it was typically used by the DPEs to reflect retrofitted aircraft.

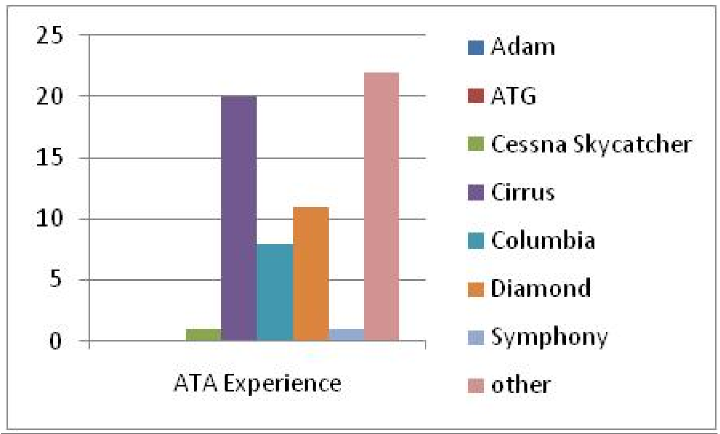

Figure-4.3. DPEs' Advanced Technology Aircraft Experience.

Numerous manufacturers offer Advanced Display Technology (ADT) and the number of these manufacturers is growing. The survey profiled what Advanced Display Technology was in use by the DPE population. Figure-4.4 reflects this experience from the 46 DPEs that choose to respond. The Garmin, Avidyne, and Bendix/King systems were the most common in use. Interestingly, 8 of the 46 DPEs responding (17 %) reported no experience with any Advanced Display Technology.

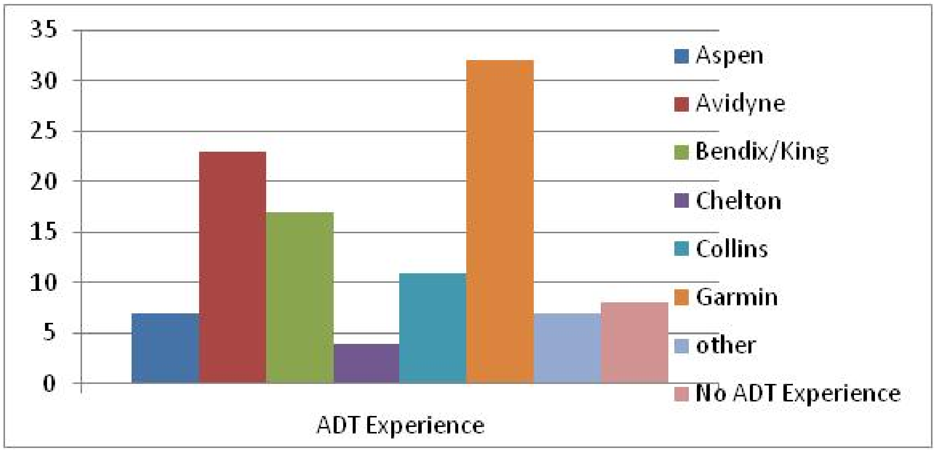

Figure-4.4. DPEs' Advanced Display Technology Experience.

Examiner's Perceptions Section

The heart of the survey dealt with DPEs' perceptions of the certification process and performing Practical Tests in Advanced Technology Aircraft. The survey contained sections designed to explore perceptions on: FAA guidance and regulations, safety impacts, knowledge and training requirements, performing practical test, and examiner training.

FAA Guidance & Regulations

This section dealt with DPE perceptions about the adequacy of FAA: guidance, regulations, licensing requirements, and support from their local Flight Standards District Office (FSDO). Figure-4.5 and Figure-4.6 summarize their responses.

The DPEs were asked whether they were satisfied with the current FAA guidance and regulations for certifying new Airmen in Advanced Display equipped aircraft. Of the DPEs responding to the survey, the majority (64%) are indeed satisfied (Figure-4.5).

The DPEs were asked whether the experience, practical test, and knowledge requirements were adequate. Again, the majority of DPEs responding agree that these requirements are adequate (56%, 66%, and 67% respectively). Several DPEs commented in the remarks section of the survey that the insurance companies often dictate the experience requirements for flying TAA/ADT equipped aircraft.

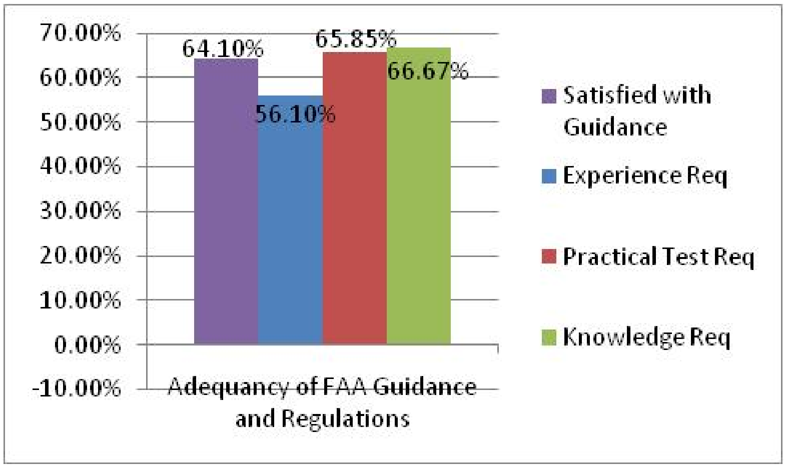

Figure-4.5 Adequacy of FAA Guidance and Regulations

The DPEs were asked whether pilot licenses should specify either traditional or ADT equipped aircraft. The response was overwhelmingly "NO" at 86% (Figure-4.6). Asked if a Flight Instructor's logbook endorsement should be required for ADT equipped aircraft, 65% of the DPEs responding agreed with a one-time logbook endorsement but only 44% agree that the endorsement should be model specific (Figure-4.6). Interestingly, one DPE commented in the remarks section of the survey that a pilot transitioning from ADT to conventional steam gauges should also have a CFI endorsement. Four DPEs also commented in the survey about the need for CFI endorsement for technology. "I do believe there should be an endorsement for TAA aircraft." This DPE was more specific about variants in equipment: "I believe that TAA aircraft should require an endorsement specific to the model of glass/aircraft". This DPE was concerned about the endorser qualifications: "This endorsement should come from a CFI who has demonstrated his knowledge an understanding of a type specific equipped aircraft to the FAA". Finally, this last DPE was most concerned with flight conditions: "A sign off for conventional/TAA operations in IMC/IFR should be required".

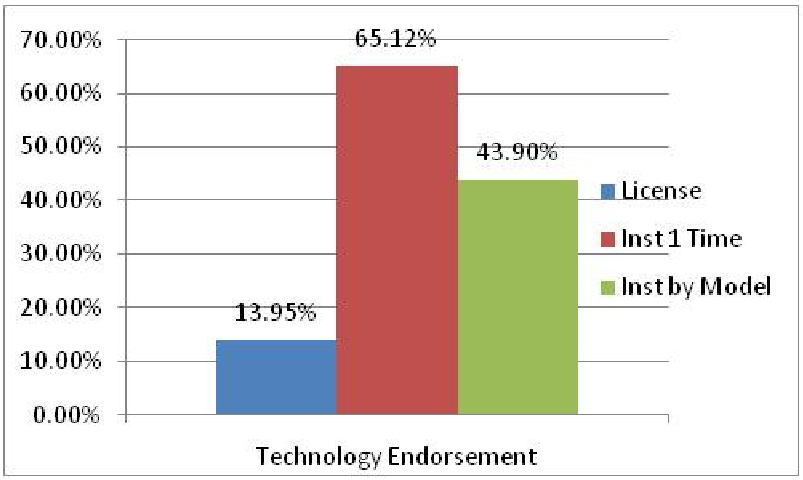

Figure-4.6. Technology Endorsement

<u>Safety</u>

One of the expected benefits of Advanced Display Technology with its advanced computational capability and new sensors was to improve safety. This section of the survey addressed the examiners' thoughts on the safety effects of this technology.

Advanced Display Technology primarily utilizes Global Positioning Systems (GPS) and navigation databases to plot position and course in real-time on a moving map. Examiners were asked if Advanced Display Technology has degraded "conventional navigation skills" and 81% agreed. Conventional navigation skills include dead reckoning, pilotage, and NAVAID navigation techniques used primarily in traditional cockpits. One DPE commented in the survey's remarks section: "far too much reliance on TAA at the expense of sacrificing basic flying skills".

Traditionally, pilots manually research airport directories, navigation maps, and approach charts as part of the pre-flight planning process. With Advanced Display Technology, this information in contained within the equipment's databases. Examiners were asked if Advanced Display Technology had changed their pre-flight planning process with respect to navigation, weather, and terrain/obstacles en route and 60% agreed.

Advanced Display Technology with its advanced computational capability, navigation databases and new sensors has the ability to alert the pilot to potential dangers. A series of questions in the survey explored the impact of this new capability. Examiners were asked if Advanced Display Technology had ever alerted them to a potential conflict with weather, traffic, or terrain that otherwise would have gone unnoticed and 62% agreed. Asked if ADT had either "alerted" or "failed to alert" them to a navigation error: 15 DPEs reported alerts, 9 DPEs reported failed to alert, and 4 DPEs reported both alert and failed to alert conditions. Asked if ADT had either "helped" or "hampered" them in any potential serious situation: 20 DPEs reported ADT helped, 3 DPEs reported ADT hampered, and 7 DPEs reported that ADT had both helped and hampered. Finally, DPEs were asked whether they experienced situations in which automation did less or more than expected. Twelve DPEs reported situations where ADT did more than expected, 15 reported situations where ADT did less than expected, and 4 reported both conditions.

With the ability of Advanced Display Technology to alert pilots of potential danger, examiners were asked whether they perceived an effect on risk-taking behavior with usage of this technology in various flight conditions (Figure-4.7). The DPEs believed that ADT affects the following: flying in lower visibility (23 DPEs), flying in hazardous weather (21 DPEs), flying lower altitudes (12 DPEs), flying closer to terrain (11 DPEs), and flying closer to other aircraft (6 DPEs). Twelve DPEs believe ADT had no effect on risk-taking behavior.

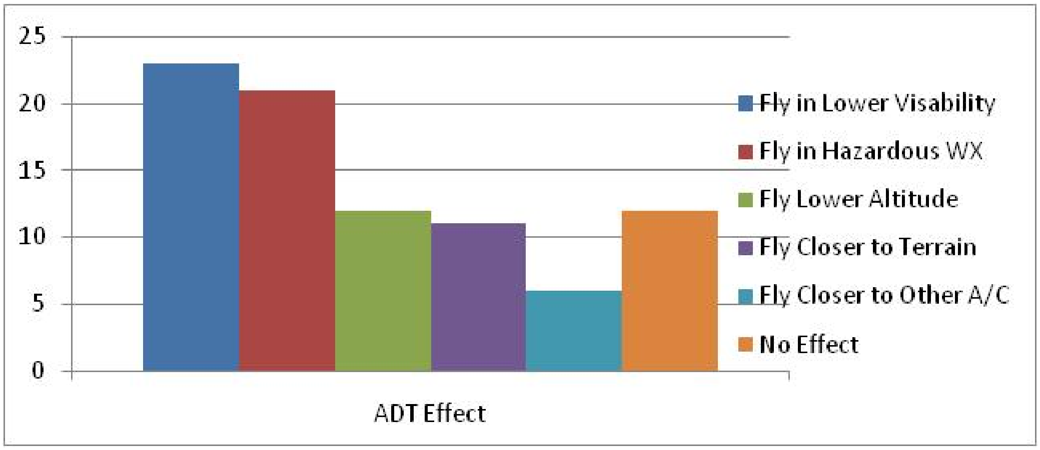

Figure-4.7. Advanced Display Technology Effect on Behavior

There are numerous manufactures of Advanced Display Technology with new entrants into the marketplace occurring routinely. There is no requirement for standardization in display or functionality. The DPE were asked whether the FAA should require more standardization of Advanced Display Technology with respect to display format and functionality and 72% agreed.

Pilot Knowledge & Training

This section of the survey explored the adequacy of the current knowledge and training requirements applicants must meet before taking their Practical Test. The DPEs were asked whether the FAA training requirements were adequate for certifying a private pilot in ADT and 60% of examiners agreed the requirements were adequate. Asked if Instructors were adequately preparing “first time” private pilot applicants for their PT in ADT equipped aircraft 61% agreed. The DPEs were asked if the existing off-the-shelf training material was adequate for training with ADT and 56% agreed. Finally, the examiners were asked if more emphasis should be placed on "higher order pilot skills" and the response was overwhelmingly yes at 85%. Higher order pilot skills include risk management, single pilot resource management, and automation management. One DPE commented in the remarks section that the "key (to TAA) is workload management".

Final Practical Tests

The Practical Test (PT) is the final step in a pilot's quest for licensing. The FAA designates the authority for performing the PT to the DPE. This section of the survey explored the technology preference and task demonstration during a PT.

The DPEs were asked whether PT should be based upon the technology flown whether traditional steam gauges or ADT and 72% agreed. When asked whether Flight Reviews should be taken in the type of technology flown, 77% of examiners agreed. Flight Reviews are given by instructor to licensed pilots every two years to maintain currency.

Examiners were asked if they were required to demonstrate a specific feature or task associated with ADT during an FAA flight check and 49% agreed they had. When asked if they required demonstration of a specific feature or task associated with ADT during a PT, 93% agreed they do require a specific demonstration. DPEs were asked if there were tasks or procedures that were difficult to perform/demonstrate in ADT equipped aircraft and 72% agreed there were tasks that are difficult to perform. One examiner commented that performing partial panel operations was difficult in ADT. Asked if a procedural/aircraft simulator would be more suitable for demonstrating certain features or tasks associated with advanced avionics, 71% agreed a simulator would be more appropriate.

Several examiners commented that they believed that the PT standards should be re-written due to variations in aircraft. One examiner suggested that if there was more standardization in ADT, then the re-write of a new PT standard would be easier. Practical Test Standards are the guide the DPE must follow when a PT is given.

Examiners' Training & Knowledge

There are numerous avenues available for training with advanced technology. The aircraft and avionics manufacturers offer a variety of on-site or self study classes. There are flight centers and training organizations, including collegiate flight programs, which offered on-site training as well. Third party training sources also exist.

The examiners were asked what training they had to prepare themselves for flying in advanced technology cockpits. Figure-4.8 shows that self taught /CBT (28), Third Party Training (20), and Aircraft Manufacturer Training (15) were utilized the most. Also "other" training reported (11) included: another pilot, formal training program by airline or school, and web-based tutorial. The question was asked whether the DPEs thought that their training prepared them for the new technology and 76% believed so. The DPEs were also asked whether they believed the FAA should provide ADT specific training and 55% believed so as well.

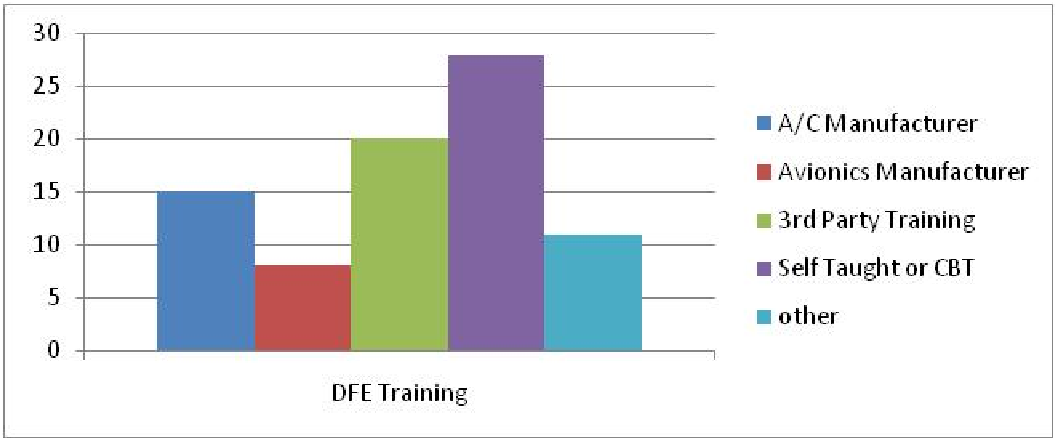

Figure-4.8. DPE Advanced Technology Training Method

Remarks

The DPEs were given the opportunity to write in remarks. From 46 responses, 50% chose to provide comments. An analysis of the comments offered the following generalizations: ADT is a distraction keeping pilots from looking outside the cockpit; ADT has many benefits but dependency can be dangerous; CFIs and DPEs need to be current and experienced with ADT in order to adequately instruct or certify pilots.

Follow-up Interview

The DPEs were asked whether they would be willing to participate in a follow-up telephone interview. Of the 46 DPEs responding to the survey, 87% were willing to assist further and five declined outright.

Interview Results

Ten interviews were performed to delve deeper into the survey responses with a subset of the DPEs. The areas covered by the interview included: FAA regulations, safety, pilot training and testing, flight demonstration, examiner needs, and other comments. Thirteen questions were asked and synopses of the responses are provided below. Some responses were more appropriate for inclusion in another question, so those responses were moved to the more appropriate area. The transcriptions are available for those interested in reading the actually responses by question.

FAA Guidance & Regulations

Question #1 - Results from the DPEs survey indicate that 64% of DPEs were satisfied with the current FAA guidance and regulations for certifying new airmen in Advanced Display Technology equipped aircraft. What changes, if any, do you perceive are needed?

Three DPEs specifically discussed a need for a regulatory change to require a technology logbook endorsement for either conventional instrumentation or ADT. Cross training would require the second technology endorsement for the alternate technology. One DPE thought the ADT endorsement should be model specific. Related is a consensus among examiners that the flight instructors and examiners document and demonstrate their own proficiency with each technology.

Three DPEs expressed a need for Practical Test Standard changes specifically with respect to general advancement of technology, depth of testing (how much), clarification of term “discretion of the examiner”, limiting ADT capabilities during cross countries, automatic recovery procedures, and increased emphasis on Aeronautical Decision Making (ADM).

Training requirement changes were mentioned by two DPEs that addressed the need for formalized training curriculums, the need to tailor training to be more aircraft and technology specific, and more emphasis on emergency procedures associated with ADT. It was recommended that perhaps this formalized training curriculum be a regulatory requirement. Also recommended were training manual revisions to: the Airplane Flying Handbook for inclusion of more pictures and visual aids related to ADT and more emphasis on Aeronautical Decision Making (ADM) in The Pilots Handbook of Aeronautical Knowledge.

One DPE was openly anti-regulation stating it is not possible to regulate for every contingency, and continued with "you can't regulate common sense". Finally, one DPE had nothing to offer with respect to this question.

Question #2 - With respect to "pilot experience requirements", what changes, if any, do you perceive should be required as a result of advances in technology?

The majority interviewed, seven in all, perceived <u>no</u> changes were needed with respect to pilot experience requirements. They rationalized that the "train to proficiency" actually drives the required flight hours. One examiner remarked that minimum (pertaining to hours) does not mean proficient and legal (meeting requirements) did not mean safe. A single examiner suggested that because the technology makes cross country flights easier, the number of them required could be reduced.

Several examiners were more concerned with the experience/qualifications of the flight instructors. It was suggested that the FAA should require flight instructors to have training in the various ADT systems. This would aid in the quality of flight instruction.

Safety

Question #3 - Results from the DPEs survey indicate that 81% of DPEs perceive that conventional navigation skills have been degraded as a result of Advanced Display Technology. How should training and continuing training be changed to ensure proficiency with conventional navigations skills?

Most of the examiners were concerned about some pilots' predominant focus and dependency on the ADT. One DPE stated "they're not playing a video game". The examiners were also concerned whether some pilots could successfully transition back to pilotage and dead reckoning navigation if they lost the technology. Most thought not! Also it was offered that there appears to be a general tendency for pilots not to look outside the aircraft with ADT equipped aircraft and this may be contributing to the increased number of mid-air collisions.

The majority of the examiners interviewed perceived that resolving the loss of conventional navigation skills resided with the flight instructors and the examiners. One examiner explained, "I've decided it's not the technology that's getting us, it depends on the instructor and the quality of the instructor that gets us".

Examiner recommendations were that flight instructors should spend more time on the basics including conventional navigation skills and utilize technology trainers in the classroom environment to free up cockpit time. Also, while teaching the capabilities of the technology, instructors should teach all the NAV modes including VOR navigation. Specifically, instructors should turn-off the technology and have the student fly home by manual means including ground based referencing and pilotage techniques. Pilot should be reminded to maintain their situation awareness and be prepared to recover from unusual attitudes/situations with or without the technology. Two examiners remarked that some NAV modes, like LORAN and NDB, were obsolete and not worth the instructional time.

The DPEs were clear in that examiners should test applicants for proficiency with their conventional navigation skills and fail those applicants that cannot perform. Again, the DPEs stated their time with the applicants is limited to a few hours and the instructors know best the applicants abilities or lack thereof.

Question #4 - Advanced Display Technology has the ability to alert and aid a pilot in potentially serious situations. At the private pilot level, what features and capabilities should be taught and tested?

Many perceived that all the features of ADT should be taught. One examiner offered, "they are relying so heavily…you better make that sucker walk and talk". Another examiner stated, "these things are all great when used as a tool….when used as a crutch then it becomes dangerous". Again, there is a concern about the dependency on the technology.

Some of the specific ADT features examiners identified to be taught and tested include: terrain and collision avoidance, fuel usage and management, weather, alerts/warnings, Traffic Advisory (TA)/Resolution Advisory (RA), and automatic recovery features. Pilots need to be aware of the limitations of these features including: when it will work for them, and when it will not. More specifically with respect to alerts and warning, pilots need to be able to determine the criticality of an alert or warning. Finally, one DPE remarked that a good instructor teaches everything in the airplane but not at the exclusion of practical airmanship.

Question #5 - How might training and testing address issues like "automation surprise"?

Most of the DPEs interviewed thought that "automation surprise" was related to deficiencies in training and ineffective instrument scan. Several did not perceive this as an issue at all.

Two DPEs indicated that instructors were not preparing students and went on to suggest some instructors were not prepared themselves. Two DPEs remarked that training curriculums need to specifically address: automation management, various warning/alert functions, and autopilot. The students must be taught to correctly identify whether equipment is working properly or not and the associated warning/alert indications. Again, the examiners accepted their own responsibility to ensure applicants demonstrate proficiency with the aircraft and its systems.

Two DPEs perceived that inappropriate instrument scan technique was the issue.

Specifically, one DPE offered that the format of ADT may not be optimal for rapid cognitive recognition. This examiner provided an example of an aircraft that approached stall speed on climb-out. He perceived that the format of the moving tape airspeeds indicators may have contributed to this incident. One DPE emphasized that pilots need to have their attention outside the aircraft and not fly-off the automation.

Question #6 - Results from the DPEs survey indicate that 70% of DPEs perceive that Advanced Display Technology has created an environment for "risk taking behavior" i.e. flying in lower visibility or over reliance on technology. How could training be modified to reduce this "risk taking behavior"?

Eight of the DPEs interviewed perceived the problem with risk taking behavior is a training issue. Two specifically perceived it to be an Aeronautical Decision Making problem and instructors need to train this risk-taking behavior out of them. Two thought the behavior was individually driven and not necessarily a function of the technology. Two DPE have not experienced either a change to risk taking behavior or the behavior itself.

With respect to training changes, the DPEs expressed a need to ensure pilots: obtain a thorough weather briefing and comprehend its significance, understand their own personal minimums and what they can handle, and system knowledge/management including the autopilot. One examiner thought that having pilots take a deep look into actual aircraft accidents might get them to relate with the pilot involved in the accident and cause a change in their own behavior.

There was a concern that the weak pilot will use the technology to prop them up and the onset of synthetic vision will worsen the risk taking behavior. One DPE suggested that the FAA issue an Advisory Circular (AC) advising flight instructors to watch for certain behaviors and how to correct them. Again, the examiners offered that their exposure to the applicants is limited to a few hours during the Practical Test, making determination of risk taking behavior difficult.

Pilot Training & Knowledge

Question #7 - Results from the DPEs survey indicate that 85% of DPEs perceive that more emphasis should be placed on teaching "higher order" pilot skills. What specific "higher order" pilot skills should be taught and tested at the private pilot certificate level?

Three examiners stated that teaching and testing of "higher order skills" was not a new concept, but thought there may not have had enough emphasize on this in training. This group of examiners identified: single cockpit resource management, Aeronautical Decision Making (ADM), risk management, automation management, situation awareness, controlled flight into terrain, icing/anti-icing, and ability to change plans on the fly as higher order skills. Two DPE thought that "higher order" pilot skills were a new buzz word or an ambiguous concept.

Again, training was the solution offered. Several examiners expressed that building scenarios, Scenario Based Training (SBT), was the best approach to teaching these skills rather than rote learning. One examiner suggested that if you are going to teach scenarios, then the testing also needs to be scenario based.

Two DPEs were most concerned that applicants can just do the basics, "fly the airplane", and be proficient at that.

Question #8 – Should training and testing require applicants to understand "how the system works"?

The examiners were pretty much all in agreement on this question. They do not see a need to understand the "nuts & bolts" of advanced technology. Rather, they need to understand what it will do for me, how do I use it, and how do I know it's not working. One DPE expressed that much of the details behind the "magic" is just not readily available. They contend a general knowledge of the system is sufficient. Another DPE explained that the mechanical nature of older technology drove a necessity to know more due to the numerous error sources and deficiencies. Modern electronics are more accurate, have built-in compensation, and do not fail often.

Final Practical Test

Question #9 - According to survey results, 93% of DPEs require demonstration of specific features or tasks associated with Advanced Display Technology. What specific features/tasks do you require or think should be demonstrated during a Practical Test?

Half of the examiners required the applicant to be knowledgeable on everything installed in the airplane presented at the time of the PT. Of course they conceded that there are practical limits to what can be tested within a few hours. Specific demonstration tasks mentioned by the examiners were: loading routes, changing radio frequencies, setting transponder codes, timing and INSET function, GPS point-to-point navigation, and VOR tracking/intercepting. Specific features mentioned include: autopilot, weather, terrain, emergency procedures, nearest airport, and OBS mode.

Question #10 – Should applicants be required to demonstrate system failures and troubleshooting procedures?

Most DPEs were not very specific about system failures and troubleshooting, but the examiners expected the applicant to know if the system is working properly and what are you going to do about it. If the system has failed, two DPEs preferred the applicant utilize the Reference Manual for troubleshooting. One examiner was concerned about a pilot's ability to discern between those actions requiring: immediate action based upon rote memorization and non-immediate action based upon checklist. Apparently this examiner has seen this as an issue. Two DPEs offered that quite often failures must be verbalized as there is a general reluctance to pull circuit breakers. One DPE suggested that a simulator would be a more appropriate venue for simulating system failures. Finally one DPE was direct and stated applicants should be able to turn the automation OFF and fly themselves to an airport without even engine instruments. Another examiner stated that the better understanding a pilot has, then the quicker you can troubleshoot the fault and not get all worked up over it.

Question #11 – Seventy-two percent of DPEs expressed difficulty performing certain tasks/procedures (e.g. partial panel) with Advanced Display Technology. Specifically, what tasks or procedures are difficult to perform/demonstrate in Advanced Display Technology equipped aircraft?

Partial panel proved to be the only area for discussion on question #11. Most examiners thought it was a concept that did not apply to modern ADT. The new systems have a reversionary mode that allows key flight information to be displayed on the alternate display. The examiners believed the chances of a complete system failure were remote. Most examiner perform partial panel by covering areas of the display or dimming them down. Here again, many examiners question whether this is a realistic simulation of what a pilot might actually experience in a partial system failure. The examiners identified differing abilities to dim (blank) displays between manufacturers. It was commented that the manufacturers have provided some guidance on this issue.

Examiners Training & Knowledge

Question #12 – Fifty-five percent of DPEs responding to the survey think the FAA should provide Advanced Display Technology examination training to DPEs. What additional training elements, if any, could improve the DPEs ability to certify pilots in advanced technology equipped aircraft?

Everyone had something to say about this question. Overwhelmingly, the DPEs interviewed believed that the examiners were ultimately responsible for their own training and proficiency. Several believed that some mandatory training should be required before performing PTs with advanced technology. Two DPEs expressed displeasure with their required bi-annual training clinics; claiming the clinics do not cover true concerns of examiners but were rather mostly about paperwork. Two DPE suggested that an Examiner Reference Guide or handouts covering variations in equipment operation, equipment specific testing, and failure modes would be valuable. Support from their local FSDO was mixed, one DPE was satisfied with support and another felt they had little to offer.

Closing Comments

Question #13 - Do you have any further comments, recommendations, or concerns you care to offer regarding this research topic or pilot certification in ADT or TAA?

To conclude the interview, participant offered the following additional comments concerning Integrated Airmen Certification and Rating Application (IACRA), use of automation, bias in accepting technology, and accidents. IACRA is utilized by DPEs to input Practical Test (PT) results, but one DPE expressed a need for immediate response from the “help desk” and another DPE thought there should be a manual means for issuing a “temporary certification” when there are IACRA system exceptions. One DPE identified an age bias in accepting technology: the younger being very adept. One DPE expressed a need for applicants to be well prepared for their PT. Finally, a DPE stated that the number of aircraft accidents proves we collectively need to help pilots manage risk associated with operating ADT equipped aircraft.

CHAPTER V

CONCLUSION

Introduction

All aircraft require some degree of instrumentation, but they differ in degree of complexity. Until recently these individual equipment items were typically self-contained with their own displays and dedicated controls. Despite being produced by different manufacturers, these devices had the same basic appearance and operated in a similar manner. With the advancement of microelectronics/microprocessors, glass cockpit technology has become prevalent in General Aviation and taken on even more functionality. Most newly designed aircraft, like Diamond, Cirrus, and Columbia, are only offered with glass cockpits. Aircraft technology and flight training have continued to evolve from its origin. The question is whether training and the certification process are keeping pace with the ever increasing speed of technology change in General Aviation.

Statement of the Problem

There is a need to know if Designated Pilot Examiners perceive a problem with the current private pilot certification process with respect to the operation of ADT that could have a negative impact on aircraft safety.

Summary of the Findings

<u>Safety</u>

According to the survey, 69% of DPEs responding perceived that ADT has created additional risk taking behavior by pilots. Risk taking behavior was defined in this research as flying in: lower visibility, hazardous weather, lower altitudes, closer to terrain, or closer to other aircraft. The interviews revealed that dependency/complacency on the technology and failure to monitor outside the aircraft were additional risk taking behaviors. One examiner remarked "the airplanes (TAA) do make you feel so comfortable, almost artificially so". Recent inclusion of synthetic vision into GA aircraft was thought to make matters even worse. The interviews suggested flight instructors were the ones most appropriate to identify and take action against the risk-taking behaviors.

One other safety issue identified by the interviews was a lack of preparedness by some flight instructors and examiners with the technology. One examiner said, you cannot teach what you do not know. It is unclear how wide spread this lack of proficiency may be. It was suggested that flight instructors and examiners must also demonstrate their proficiency with advanced technology prior to instructing or performing practical tests. One examiner insightfully remarked "it's not the technology that's getting us…it depends on the instructor and the quality of the instructor that gets us".

FAA Guidance & Regulations

The survey indicated that 64% of DPEs are generally satisfied with the FAA's guidance and regulations pertaining to certifying new airmen specifically with Advanced Display Technology and TAA. However, 65% of examiners agree that pilots should have a logbook endorsement for the technology flown. Further, 44% of examiners perceived the endorsement should be equipment model specific. One examiner expressed "my fear is people that learn in the Technically Advanced and proceed to the non- Technically Advanced … they are missing some building blocks that should be there".

Another change suggested by 72% of DPEs in the survey was that the FAA should require more standardization in display format across various manufacturers. In interviews, it was suggested that analog needle representations might be more appropriate for airspeed and altitude in lieu of numerical and tape representations.

Finally, as discussed in the preceding section, a regulatory change should be considered to require flight instructors and examiners to also formally document their proficiency with advanced technology.

Pilot Training & Knowledge

According to the survey, 60% of examiners perceived that the established general training requirements were adequate. However, the survey also indicated that 81% of DPEs perceived conventional navigation skills have degraded and 85% perceived more emphasis should be placed on "higher order" pilot skills. It was pointed out in the interviews that the self study approach to training with technology was inadequate: a structured training curriculum incorporating technology trainers in the classroom was needed. Furthermore, training curriculums must teach the proper application and use of the technology but not at the exclusion of basic navigation skills. The DPEs also indicated that only 62% of pilot applicants were adequately prepared by their CFIs according to the survey. It appears that there is plenty of room for improvement and a standardized ADT training curriculum is badly needed.

According to the survey, 67% of examiners perceive the knowledge requirements are adequate. The interview specifically asked whether knowing “how things worked” was important. The examiners were not concerned with the intimate details of advanced technology. They approached this discussion from a practical perspective. What will this equipment do for me? Is it working properly? If not, can I get it back?

Fifty-six percent of examiners perceived that off-the-shelf training materials are adequate. The FAA has been including material on advanced technology in many recent revisions to various handbooks, but it was recommended that additional changes to the Airplane Flying Handbook and The Handbook of Aeronautical Knowledge would be welcomed.

It appears from this research that the Scenario Based Training (SBT) approach may be a more appropriate method for teaching advanced technology. The FAA FITS program embraces the SBT concept. Unfortunately, this approach to training is not mandatory at this time. The examiners have clearly stated that the problem is not the technology but rather the training delivered. Additionally, it was pointed out that if your teaching method is scenario based, then your test approach needs to also be scenario based.

Final Practical Test

The survey indicated that 66% of examiners perceived the Practical Test Standards (PTSs) were adequate. Concerning the actual airmen test, 73% perceived the Practical Test (PT) given at licensing should be based upon the actual technology flown and 77% perceived the bi-annual flight reviews should also be given in the technology flown. From the interviews, the DPEs recommended: restructuring certain tests to be more compatible with new technology, increased emphasis on "higher order" skills, and elimination of certain ambiguities in the PTSs. The examiners were clear on the necessity to ensure pilot applicants meet the requirements of the PTSs especially with respect to demonstrating proficiency with conventional navigation skills.

Advisory Circular 61-126 permits limited use of Personal Computer-Based Aviation Training Devices (PCATD) during instrument training. The survey indicated that 71% of examiners perceived simulators may be more suitable for demonstrating certain ADT features. This researcher suggests the FAA evaluate the potential benefits of simulators or PCATD used during the certification process.

Examiner Training & Knowledge

From the survey, 55% of examiners would like the FAA to provide more ADT specific training to the examiner population. However the responses from the survey indicated that the examiners and Certified Flight Instructors (CFIs) need to take responsibility for their own training and be proficient in the technology flown. The examiners' training method for ADT was dominated by self taught followed by 3rd party training and then aircraft manufacturer's training. By a margin of 3 to 1, the examiners perceived their training for advanced technology was adequate. Finally, the examiners did recommend that the mandatory FAA bi-annual DPE clinics be more substantive with respect examiners' needs rather than administrative issues.

Limitations and Assumptions of the Study

Advanced Display Technology only recently entered the general aviation market. Little research has been accomplished on its impact. The research presented here documented the experiences of a select group of FAA Designated Pilot Examiners dealing with new pilots and advanced technology.

The survey in this study randomly sampled 100 DPEs from the total population of 1076 from the FAA DPE database with 46% participating. The survey results reflected only 4.3% of the population. Therefore, no generalization to the total population is offered. With respect to the qualitative interview, the sample was purposeful and selection was based upon the researcher defined criteria. Although generalizing these results to the whole population is not possible, a significant amount of experience among DPEs is reflected in the results. It is hoped this study has identified areas where more targeted research can be performed.

Conclusions

Research Question #1 - How do DPEs perceive **safety** has been impacted with the introduction of advanced technology in GA aircraft?

- Designated Pilot Examiners perceive there are instances where safety has been negatively impacted by additional risk taking behavior on the part of private pilots with the introduction of advanced technology in GA aircraft.

Research Question #2 - What **regulatory and guidance** changes do DPEs perceive are needed with the introduction of advanced technology into GA aircraft?

- Designated Pilot Examiners perceive that regulatory guidance is generally adequate with respect to technology advances in GA aircraft. However, pilots, instructors, and examiners need to demonstrate and document their proficiency with the technology.

Research Question #3 - What **training and knowledg**e requirement changes do DPEs perceive are needed with the introduction of advanced technology in GA aircraft?

- Designated Pilot Examiners perceive that additional changes are needed with training and knowledge requirements associated with technology advances in GA aircraft. Specifically, training curriculums and material need to be modified to include the unique requirements for advanced technology. Also, a scenario-based training approach appears to be a more holistic way to structure a private pilot training program, especially with advanced technology.

Research Question #4 - What **Practical Test** requirement changes do DPEs perceive are needed with the introduction of advanced technology in GA aircraft?

- Designated Pilot Examiners perceive that Practical Test requirements are generally adequate but certain elements like partial panel are no longer applicable with advanced technology. With a move towards SBT, some examiners believe the Practical Test should also be scenario based.

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In conclusion, this research into the perception of examiners experiences with Advanced Display Technology indicates there are incidents where safety is being negatively impacted as a result of the current certification process for new airmen. Surprisingly, the DPEs perceived little need for changes to the FAA's rules and regulations. Rather, the greatest need is for more structure and standardization in the pilot training curriculum with advanced technology and the monitoring/enforcement of training objectives. To that end, instructors and examiners must be proficient in the technology that they are teaching and certifying pilots in. This research re-enforces the findings in the NTSB study of glass cockpits in light aircraft (NTSB, 2010).

Recommendations

Results from this research indicate that certain FAA rules and regulations governing the certification process of new airmen with advanced technology need revision. This researcher intends to petition the FAA Administrator, through the ruling making process of FAR 11.72, to require: a private pilot logbook endorsement by a CFI for the type of technology flown (FAR 61.31); CFIs to document and demonstrate proficiency in advanced technology prior to performing instruction (FAR 61.187); and DPEs document and demonstrate proficiency in advanced technology prior to performing check rides (AC 8710.3E, Ch2, Para 2.0).

It is also recommended that the FAA continue to revise training materials and training approaches to better support the advances in technology. This research has indicated that the SBT approach may be more appropriate for advanced technology. The FAA should consider making the FITS program (SBT based) mandatory and modify the final certification or practical test to be scenario based as well. Training curriculums governed by FAR 142.39 should specifically address the training associated with the technology and automation installed in training center aircraft. The training curriculums should include elements of CRM and in particular risk management. Hubbard proposed methods to observe/measure student pilot behaviors including the use of behavior markers and event probes (2007). Further, the training center should adopt a risk management program with a formal system safety process to reduce accident and incident rates (Hansen, 2005).

Significance of the Study

The significance of this study is clear. If pilots are not properly prepared to operate the high-tech TAA and ADT aircraft, then the opportunity for a mishap/accident is increased. Krey reports, there is true concern within the industry, that the new automation may negatively affect safety and create new hazards (Krey, 1992). This would likely result in: increased regulation by the FAA, higher aircraft insurance premiums, and increased litigation.

Future Research

The interview portion of this research with DPEs has identified pockets of excellence in the training of pilots in the advanced technology. Future research should consider benchmarking these successful advanced technology training programs and others yet to be identified in order to formulate standard curriculum(s).

There are numerous manufactures of Advanced Display Technology with new entrants into the marketplace occurring routinely. There is no requirement in TSO-C113C for standardization in display or functionality. According to the survey, 72% of examiners perceive more standardization is necessary and the interviews uncovered a concern with the digital representation of certain flight information. Future research could investigation standardized representations.

Summary

This researcher is grateful to the examiners that participated in this research. From the high survey response rate and the willingness of examiners to participate in the follow-up interviews, it is apparent that the topic of advanced technology in the pilot certification process is of high interest to the community. This research has identified areas of excellence and areas requiring attention. The good news is, we have a way forward to create a cadre of safer pilots and maximize the benefits that the technology offers.

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APPENDICES

Appendix A

Random Numbers

(see attachment)

Appendix B

Survey Packet

(see attachment)

Appendix C

Survey Response Summary

(see attachment)

Appendix D

Interview Guide

(see attachment)

Appendix E

Interview Transcription

(see attachment)

Appendix F

Interview Coding

(see attachment)

Appendix G

Institutional Review Board (IRB) Protocol Approvals

(see attachment)

VITA

Michael A. Friday

Candidate for the Degree of

Doctorate in Education

Thesis: A MIXED METHODS STUDY OF FLIGHT EXAMINERS EXPERIENCES WITH PILOT CERTIFICATION IN TECHNOLOGY ADVANCED AIRCRAFT

Major Field: Applied Aviation Studies

Biographical:

Personal Data:

Born 03 December, 1956 in Homestead, Florida

Education:

Completed the requirements for the Doctorate in Education in Applied Behavioral Studies (Aviation) at Oklahoma State University, Stillwater, Oklahoma in December, 2010.

Masters in Business Administration at University of Central Oklahoma, Edmond, Oklahoma in December, 2004.

Bachelor of Science in Electrical Engineering at University of Miami, Coral Gables, Florida in August, 1979.

Experience:

Electronics Engineer, U.S. Air Force, Tinker AFB, Oklahoma, 1984 – present.

Engineer, Halifax Engineering, Midwest City, Oklahoma, 1982 – 1984.

Senior Field Engineer, Schlumberger, Pharr, Texas, 1979 - 1982.

Professional Memberships:

Delta Mu Delta , National Honor Society (Inducted in 2003)

Phi Kappa Phi , National Honor Society (Inducted in 2007)

Name: Michael A. Friday Date of Degree: May, 2011

Institution: Oklahoma State University Location: Stillwater, Oklahoma

Title of Study: A MIXED METHODS STUDY OF FLIGHT EXAMINERS EXPERIENCES WITH PILOT CERTIFICATION IN TECHNOLOGY ADVANCED AIRCRAFT

Pages in Study: 95 Candidate for the Degree of Doctorate in Education

Major Field: Applied Educational Studies

Scope and Method of Study: This study is a mixed methods investigation into the experiences of FAA Designated Pilot Examiners (DPEs) with the certification of private pilots in technology advanced general aviation aircraft. A survey was sent to 100 randomly selected examiners to obtain information on their experiences with advance technology. From the survey respondents, 10 examiners were selected and interviewed to determine the safety, training, and testing impacts of advanced technology in general aviation aircraft equipped with new private pilots.

Findings and Conclusions: This research into the perception of examiners experiences with Advanced Display Technology indicates there are incidents where safety has been negatively impacted as a result of the current certification process for new airmen. Surprisingly, the DPEs perceived little need for changes to the FAA's rules and regulations with the exception of a pilot technology endorsement. Rather, the greatest need is for more structure and standardization in the pilot training curriculums with advanced technology and the monitoring/enforcement of training objectives. To that end, instructors and examiners must be proficient in the technology that they are teaching and certifying pilots in. This research re-enforces the findings in the NTSB 2010 study of glass cockpits in light aircraft.

ADVISER'S APPROVAL: Dr. Fredrick Hansen