RECURRENT FLIGHT TRAINING TRENDS: A DELPHI STUDY TO EXAMINE POSSIBLE LOSS OF PILOTING SKILLS

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NOMENCLATURE

14 CFR	Code of Federal Regulations. Title 14 covers the Department of Transportation which includes the Federal Aviation Administration.
AFCS	A system which includes all equipment to automatically control the flight of an aircraft by reference to either internal or external data.
APU	Auxiliary Power Unit. A small, self contained generator used in aircraft to start the main engines, provide electrical power, hydraulic pressure and air conditioning while the aircraft is on the ground.
ATP	Airline Transport Pilot. The highest level of aircraft pilot certification.
EFIS	Electronic Flight Information System. A system where primary flight and navigational data are displayed on an electronic display. EFIS is designed to present all information required for the current phase of a flight in a compact display. The EFIS is the central part of the glass cockpit. The system usually consists of a Primary Flight Display (PFD), Multi-Function Display (MFD), and an Engine Indication and Crew Alerting System (EICAS) display.
EICAS	Engine Indicating and Crew Alerting System. Displays information about the aircraft’s systems, including its fuel, electrical and engine data, allowing the pilots to view data in a graphical format and also alerting the crew to abnormal conditions.
FAR	Federal Aviation Regulation. A portion of Title 14 CFR dealing with the control and regulation of civil air operations in the United States.

FD	Flight Director. A device that displays visual cues on the attitude indicator or PFD to the pilot directing control inputs to meet the requirements for the phase of flight.
FGC	Flight Guidance Computer. The central part of the Flight Management System. It computes real-time navigational data and constantly updates performance data.
FMS	Flight Management System. A computerized avionics system computing flight planning, navigation, and aircraft control functions. The FMS consists of the FMC, AFCS, EFIS, and the navigation system.
GPS	Global Positioning System. A satellite navigation system operated by the United States. A constellation of satellites provides positional data to a GPS receiver allowing it to determine its location anywhere on Earth. It is a major component of most navigational suites.
ICAO	International Civil Aviation Organization. A United Nations Agency that coordinates techniques and principles of international aviation procedures and regulations.
INS	Inertial Navigation System. A navigation system that determines position by measuring lateral and vertical accelerations placed on a reference platform prior to takeoff. This system uses no outside references such as GPS or ground based radio signals.
JAA	Joint Aviation Authorities. An associated body of the European Civil Aviation Conference who have agreed to develop common aviation safety regulations and procedures.
LORAN-C	LOng RAnge Navigation. A low frequency radio navigational system used by both aviation and maritime users. A precursor to GPS.
MFD	Multi-Function Display. Displays navigational and weather information from multiple systems. The MFD can also be used to display aircraft systems information.

NMUSAF	National Museum of the United States Air Force.
PFD	Primary Flight Display. The PFD displays all information critical to flight, including airspeed, altitude, attitude, heading, vertical velocity and yaw. The PFD is designed to increase the pilot's situational awareness by combining this information onto one instrument instead of the six analog instruments it was previously necessary to scan.
PTS	Practical Test Standards. The FAA document which specifies the knowledge and skills that must be demonstrated by an applicant before the issuance of an airline transport certificate and/or a type rating in airplanes.
SA	Situational Awareness. A recognition and understanding of your aircraft surroundings and being able to predict how the aircraft fits into that picture and how things will develop.
TCAS	Traffic alert and Collision Avoidance System. A computerized avionics system designed to reduce the danger of mid-air collisions between aircraft. It operates on signals generated by the aircraft's transponder, and other aircraft in its presence.
UPT	Undergraduate Pilot Training. The U.S Air Force basic flying training program lasting approximately 52 weeks. Graduates are then rated as military pilots.

CHAPTER I

INTRODUCTION, RATIONALE, AND STATEMENT OF THE PROBLEM

Introduction

In the one hundred three years man has been flying heavier-than-air machines, the complexity of the aircraft and the systems with which they fly has increased exponentially. This increase in technology has dictated a change from single-pilot operation to multi-pilot operation and from little or no formal training to extensive initial training, with formally scheduled recurrent training in those systems and an accompanying shift from "seat of the pants" flying to monitoring computer-generated systems displays as the airplane flies itself on autopilot. Is this shift creating problems?

Rationale

The Wright Flyer of 1903 had three recording instruments installed: an anemometer to measure distance traveled, a stopwatch to time the flight, and a tachometer to record engine revolutions and propeller speed (Kelly, 1989). The engine had two speeds: On and Off.

The period between 1910 and the end of World War I saw significant increases in technology. Engines became more reliable; and with the addition of supercharging, were able to reach altitudes exceeding the physiological capabilities of their pilots (Miller, 1968). Multiengine airplanes were proven to be feasible as engine size and power increased. Cockpit complexity increased with airplane size, and for the most part, these aircraft were still flown by a single pilot.

The “Golden Years” between World War I and World War II were marked by rapid increases in technology, including the introduction of variable pitch propellers, instrument development allowing flight at night and in poor weather, and the shift from wood and fabric covered airplanes to all metal construction. The Air Commerce Act of 1926 was signed into law, establishing licensing procedures for both aircraft and airmen. As aircraft grew in size and complexity, the instrument panel became more crowded and potentially confusing for the pilot (Bilstein, 1994).

World War II accelerated the technological development of the airplane. Innovations such as cabin pressurization were put into production as soon as engines were developed capable of providing the required power necessary to operate the systems.

The complexity of the four-engine airplane grew so rapidly that two pilots could no longer manage the cockpit without additional crewmembers. Flight controls were now pneumatically or hydraulically actuated and amplified as direct cable and pushrod controls were abandoned. A flight engineer was added to the crew specifically to manage the powerplants and ancillary systems, thus freeing the pilots to fly the airplane instead of having to divert their attention to managing the health and operation of the highly complex engines and sub-systems (Brooks, 1961). The cockpit now was even more complex and crowded. Instrumentation differed from airplane to airplane, which added to the pilots’ workload. Standardization and automation were on the horizon, but not yet available.

The end of the Second World War introduced the first of the pressurized intercontinental propeller-driven transports developed from the experience derived from long-range bomber production and operations (Brooks, 1961, Miller and Sawers, 1968). Industry standardization was reinforced by the establishment of the International Civil Aviation Organization (ICAO) in 1947, setting common levels of training and experience for the licensing of pilots. Airborne communications and electronics were also experiencing rapid changes. Vacuum tube electronics evolved into transistor electronics, which were soon replaced by integrated circuitry. Electronic miniaturization reduced the size and weight of airborne equipment, which led to an exponential growth in both availability and practical capability. Autopilot and navigational technologies were refined to the point they could now be coupled to the airplane after takeoff. Cockpit automation was beginning to be developed, further increasing the pilot's workload (Brooks, 1961).

Gradually, from the late sixties and at an ever-increasing rate, electronics started to fulfill functions previously performed by electromechanical, hydraulic, or pneumatic systems. Each new aircraft had more on-board electronics for communication, navigation and other functions. Weather radar became standard on transport category aircraft. An Electronic Flight Instruments System (EFIS) and an Engine Indicating and Crew Alerting System (EICAS) replaced cockpit instruments that had been electromechanical since the 1930s. Electronic systems were no longer limited to communication and navigation only. Electronic Engine Control Systems, Inertial Navigation Systems (INS), Automatic Flight Control Systems (AFCS), Traffic alert and

Collision Avoidance Systems (TCAS) were all developed as a result of the rapid growth and development of digital electronics and the availability of modern airborne computer technology with its associated airborne software packages. By the 1970s, cockpits were becoming more and more automated and pilots were charged with the dual responsibilities of managing the systems as well as flying the airplane (Weiner, Kanki, Helmreich, 1993) (Stewart, 1992).

Pilot certification by the Federal Aviation Authority was changing as well. Heretofore, pilot certification was based on the pilot's ability to fly the airplane under varying conditions. An Airline Transport Pilot (ATP) of the 1930s was required to demonstrate his ability to maintain control of the airplane with one or more engines shut down, electrical system malfunctions, and other distractions as selected by the examiner. The primary emphasis, however, was always on flying skills and aircraft control (DOC, 1937). The ATP of the 1940s was required to perform the same tasks with the addition of hydraulic systems and radio navigation. As ground based navigational systems matured, the testing requirements evolved to match the increased aircraft and avionics capabilities available to the aircrew, but still the primary emphasis was on the ability of the pilot to demonstrate flying skills and positive aircraft control (DOC, 1951). The ATP Practical Test Standards (PTS) for the year 1967 listed 31 items the candidate would be tested over, but "smoothness and coordination" were the primary criteria for rating the candidate's flying skills (FAA, 1957). Between 1988 and 2001, emphasis moved from "use of available automation" to demonstrating competency in Flight Management Systems (FMS) procedures and "effective use of all available resources" (FAA, 2001). The current ATP flight check does include basic airwork: steep turns, approach to stalls, and unusual attitude recoveries, but the primary emphasis is on the effective use of all available resources and the effective use of automation (FAA, 2001).

Statement of the Problem

The constantly increasing automation in modern aircraft may have resulted in basic and fundamental piloting skills being lost or degraded due to over-reliance on automation. The problem is exacerbated by the requirement to demonstrate proficiency in operating all installed equipment and automation during initial and recurrent flight checks, leading to the tendency of a pilot's trying to program his way out of a problem rather than reverting to basic flying skills to resolve the situation.

Purpose of the Study

The purpose of this study was to ask aviation experts to explore the extent of the problem and examine how the required flying skills necessary to basic flying safety are being relegated to secondary importance due to over-reliance on, and the testing requirement to show effective use of, automation.

Objective of the Study

To achieve the purpose of the study, aviation training experts were asked to explore to what extent basic piloting skills are being relegated to secondary importance in crew-served aircraft, by asking the aviation training experts, "How does the requirement in the Special Emphasis Areas of the Airline Transport Pilot (ATP) Practical Test Standard (PTS) to demonstrate proficiency in operating all installed equipment and automation during initial and recurrent flight checks lead to over-reliance on automation, and what actions can be taken by the training community to correct this possible trend?"

Assumptions of the Study

To achieve the purpose of the study, the following assumptions were made:

1. Respondents provided thoughtful insights during each round of the study from the viewpoint of their experience as experts in aviation training and testing.
2. Respondents' views represented the views of other aviation specialists in their areas and provided a rich source of data.
3. Respondents provided their best individual professional opinions to each question and not a statement that reflected current practices within their organizations.

Scope and Limitations of the Study

This study was conducted from April 25, 2006, when the question was first sent to the respondents, through August 11, 2006, when the final responses were received.

The scope of this study was limited to select respondents who were in instructional and/or evaluation positions within the business aviation industry.

The study was limited to those business class aircraft usually referred to as "corporate," requiring a type rating by the Federal Aviation Administration.

The study was further limited by the Delphi Study factor that consensus is neither expected, nor necessarily desirable (Linstone and Turoff, 1975).

An additional limitation of the Delphi method was that the researcher had no control over the commitment of the respondents to participate in the complete study.

Significance of the Study

In late 1982 when the Boeing 757/767 series aircraft first entered service with industry, a significant item of interest and concern was the two-place cockpit. Previously, all aircraft of this size and weight category had included a flight engineer as an integral member of the flight deck, but now the position was conspicuous by its absence (Buck, 1994, Wiener and Nagel, 1988). The state of the art in microprocessing and software development had reached the stage where automation was capable of monitoring aircraft systems in addition to other functions of navigation and flight management. The technological capability that allowed Boeing to build this series of aircraft was also available to the manufacturers of corporate aircraft, and the first series of "glass cockpit" business jets entered the market.

Cockpit automation has generally been well received by the aviation community; however, some have expressed concern that the aircrews could put too much faith in automation to the detriment of primary flying skills. Several studies have been accomplished to this end with airline and military crews. This study, however, will be focused on the business aviation (corporate) crew force operating under Parts 91, and/or 135, of the Federal Aviation Regulations (FARs).

CHAPTER II

REVIEW OF LITERATURE

Overview

In the one hundred three years man has been flying heavier-than-air machines, the complexity of the aircraft and the systems with which they fly has increased exponentially. This increase in technology has dictated a change from single-pilot operation to multi-pilot operation and from little or no formal training to extensive initial training with formally scheduled recurrent training in those systems and an accompanying shift from “seat of the pants” flying to monitoring computer-generated systems displays as the airplane flies itself on autopilot. Is this shift creating problems?

In the one hundred three years the airplane has been a part of civilized society, its technology has continually grown and matured. As with any growth and maturation process, the airplane has become a more complex machine.

Development of Aerial Technology

The first philosophies of flight training emphasized manually controlling the aircraft. Initially, the first changes were mechanical improvements to existing technology such as the use of a pulley to reduce friction, or a bell crank to increase mechanical advantage to a flight control surface. Pilots had little trouble adapting to these changes as they were easily incorporated into the already familiar tasks required to safely pilot the aircraft. Practical limitations to the airplane's utility were readily identified. Aircraft instrumentation was, at best, primitive. The 1903 Wright Flyer had three recording instruments installed — the most important of which was an anemometer to measure the distance traveled through the air, the second was a stopwatch to measure the time airborne, and the third was a tachometer to record propeller speed (Kelly, 1989).

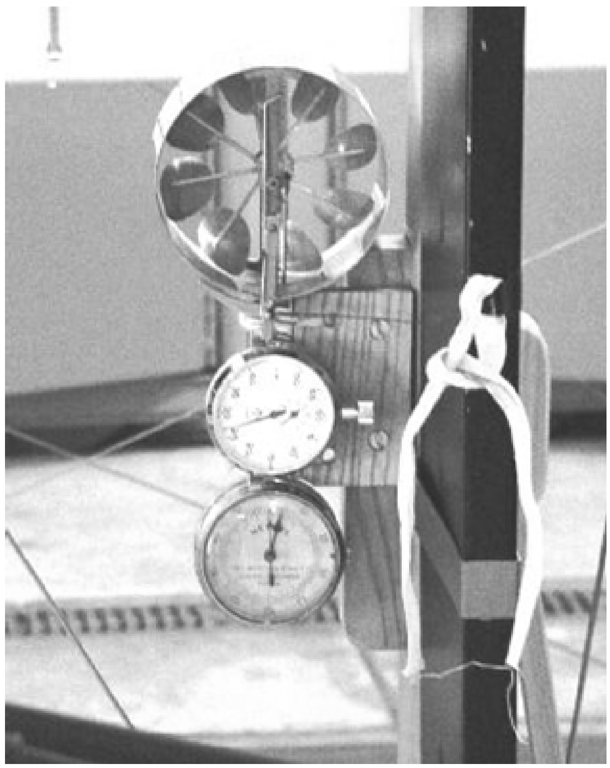


Figure 1. Wright Flyer Instrumentation
(Courtesy The Wright Experience)

The need for improved engine capability and reliability was quickly realized and significant efforts were expended in producing more powerful and reliable powerplants. Kelly (1989) recorded that the engine on the 1903 Flyer had two speeds: On and Off. By the summer of 1908 when Wilbur Wright was demonstrating the Flyer A to the Europeans in France, engine capabilities had improved enough to provide variable throttle positions. However, reliability was still a matter of major concern. Two engine types were in use during this period. The first was the in-line, which took its origins from the automotive industry (Figure 2).

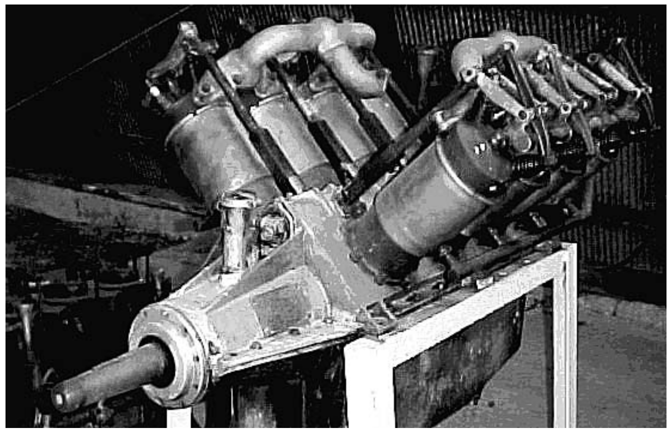


Figure 2. Curtiss water cooled engine, 1904 (Courtesy NMUSAF)

The second type in use was the radial engine (Figure 3) which had been developed specifically as an aircraft powerplant. The radial engine was developed to provide a higher power-to-weight ratio than was possible with the in-line engine. It relied on air flow to provide cooling and was generally 35% lighter than its in-line competition.

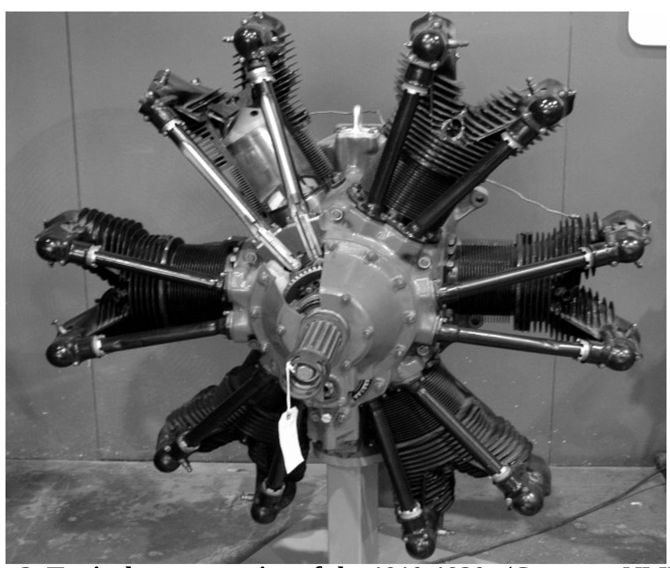


Figure 3. Typical rotary engine of the 1910-1920s (Courtesy NMUSAF)

By 1914, the cockpit of the well equipped trainer, such as the Curtis JN-4D Jenny (Figure 4) included a recording tachometer, magnetic compass, oil temperature and pressure gauge, and a coolant temperature gauge (Jordanoff, 1936). Airspeed was determined by the sound of the slipstream passing through the wing struts and bracing wires. Cockpit complexity had increased slightly, but not significantly, as most pilots had no problem understanding additions to primary engine instrumentation.

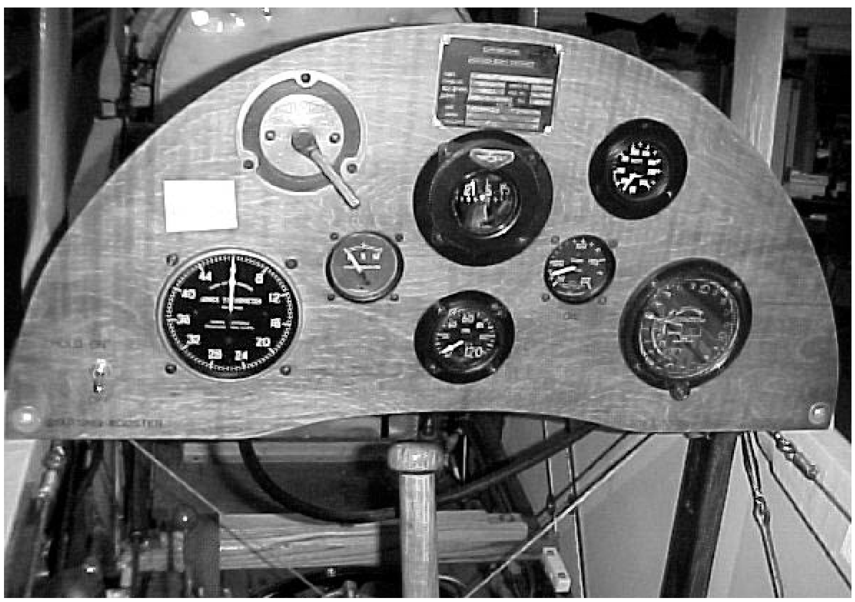


Figure 4. JN-4 Aircraft Cockpit (Courtesy NMUSAF)

The period between 1910 and the end of World War I saw significant increases in technology. Engines became more reliable and with the addition of supercharging, were able to reach altitudes exceeding the physiological capabilities of the pilots to remain conscious. One significant advance was the introduction of multiengine aircraft. The majority of these machines were twin engine, but examples of three-, four- , and even eight engine aircraft were flying. Cockpit complexity increased with aircraft size, and, for the most part, these aircraft were still flown by a single pilot (Christy & Wells, 1987).

In August of 1918 the U.S. Post Office took over airmail service from the United States Army Air Service (Jackson, 1982). The postal service was largely equipped with World War I surplus deHavilland DH-4 aircraft, built for combat, not long-haul freight operations. The requirement to maintain a regular schedule regardless of the weather conditions illustrated one of the most serious limitations of the airplane: the inability to safely fly at night or in inclement weather conditions when the pilot had no visible horizon to maintain attitudinal orientation (Christy & Wells, 1987). Ground navigational aids were being developed and installed as early as late 1921, when ten ground radio stations were placed along the San Francisco-New York route which lead to transcontinental airmail service by mid 1924 (Leary, 1985).

The Golden Age of Technology

The period between World Wars One and Two is often referred to by many historians as "The Golden Age of Aviation" (Bilstein, 1994). Barnstorming, air races, military long distance flights, and polar exploration were frequent news stories. Many individual acts of courage were attempted: some succeeded, others did not and lives were lost (Bilstein, 1994). Behind all these efforts, aviation was the driving force pushing technology to the limit. The Ford Trimotor A-4T aircraft was introduced in June 1926. It was the first successful American built metal skinned aircraft and carried up to eight passengers in an enclosed cabin even though the two pilots were in an open cockpit. Later versions incorporated closed cockpits and increased passenger-carrying capability. By 1927 the introduction of the Sperry gyroscopic horizon added to the available instruments a pilot could include in the cockpit, along with the directional gyro. By

1929, instrument flying had become practical: The cockpit of a well-equipped mail or passenger airplane would have the “basic six” flight instruments: two or three navigational instruments, and at least six engine instruments (Jordanoff, 1936).

The two-position variable pitch propeller was introduced by Hamilton-Standard in 1930 and was in common use by 1932. Curtiss-Wright introduced the electric variable-pitch propeller in 1930 and marketed it first to the military before offering it to commercial aviation in 1932 (Miller & Sawers, 1968). The cockpit was becoming a more complex environment for the pilot. As aircraft increased in size and capability, the instrument panel grew in complexity and number of instruments until space to install them became a true challenge for the engineer designing the cockpit (Wiener and Nagel, 1988). Multiengine aircraft being designed for passenger service were now being designed with two pilots in the cockpit to combat the fatigue of long flights, even though only one might have flight instruments on the panel in front of him. The right seat pilot often had only the engine instruments on his side of the aircraft.

On May 20, 1926, President Calvin Coolidge signed the Air Commerce Act of 1926 into law. The law required, among other things, the government to license pilots and to issue airworthiness certificates for aircraft and major aircraft components. Additionally, the Act prescribed safety rules for air traffic and to investigate accidents. The first of these regulations became effective on December 31. A significant provision of the law was that all pilots engaging in interstate commerce were required to obtain either an air transport or industrial pilot license, or both (Wells, 1984). The industrial license was a category of commercial license. Until this time, there were no formal licensing procedures. The military had in place a formal training program and designated individuals as rated pilots upon completion of flying training. There were civilian flying schools that, upon graduation, would award a title of "pilot," but there was no formal standardization. It was also possible to be self-taught since many who acquired war surplus airplanes after the World War I had taught themselves (Christy & Wells, 1987). The Aero Club of America had been issuing licenses as an adjunct arm of the Federation Aeronautique Internationale, but this was not federally recognized. The Act established the Bureau of Air Commerce to enforce the regulations and established the Government's role in commercial aviation.

In February 1931, the Department of Commerce mandated that all passenger flights in excess of five hours or carrying eight or more passengers would require a co-pilot. Initial pilot licenses were classed according to aircraft weight. Class 1 was for aircraft not more than 3,500 pounds maximum weight. Class 2 was for aircraft between 3,500 and 7,000 pounds gross weight. Class 3 was designated for aircraft over 7,000 pounds gross weight. Each class was further subdivided into four sections, based on single or multi-engines, and open cockpit or enclosed cabin. A Class 3D license entitled the pilot to operate a multi-engine, cabin class airplane over 7,000 pounds gross weight (DOC, 1929). Aircraft certification standards for passenger airplanes in 1936 required, as set forth by Aeronautical Bulletin 7 – J,

> … (1) A bank and turn indicator, (2) An instrument that will indicate degree of bank and pitch . . . (3) An instrument that will indicate the amount of turn, (4) A compass, properly damped and compensated, (5) An airspeed indicator, with electrically heated pitot tube or equivalent, (6) A climb indicator, (7) A sensitive altimeter . . . adjustable for barometric pressure, (8) A free air thermometer . . . with an indicating dial in the cockpit, (9) A clock, (10) A complete set of engine instruments (DOC, Air Commerce Regulation 7-J, 1936, pp. 3,4).

Additionally, the Bulletin called for separate power sources for the instruments as well as lighting requirements for night operations.

As airplanes grew more complex and pilot workloads increased, manufacturers began to make provisions for a copilot to provide support to the pilot, to reduce workload and reduce the probability of errors. The original concept of the two-place cockpit of 1932 was to place the directional gyro and the artificial horizon in the center of the instrument panel where it was visible to both the pilot and copilot. The pilot was provided with a turn and bank indicator as the primary instrument on his panel, supported by an altimeter, vertical velocity indicator, airspeed indicator altimeter, and radio compass. The magnetic compass was generally located above the instrument panel visible to both pilot and copilot. The Boeing Model 247 airliner and early models of the B-17 used this format, as did Douglas and Consolidated (Boeing, 1985, Cameron, 1999).

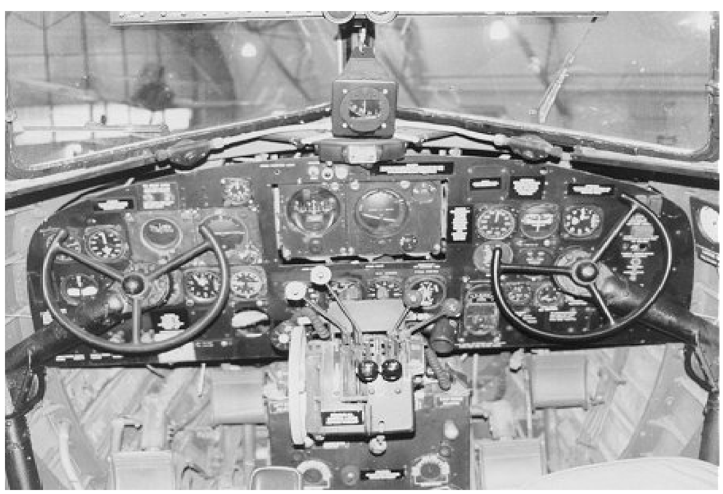


Figure 5. Douglas DC-3, 1937 (Courtesy NMUSAF)

The Effect of World War Two on Technology

World War Two accelerated advancements in aviation technology and the design of new aircraft. Range, speed, maneuverability and load carrying capabilities were improved. as new designs went into production By the end of 1947, all the basic technology for modern aviation had been developed (Wells, 1984). The fallout of military research and development in jet engine technology, high-speed aerodynamics, and radio and radar technologies was decisive in the growth of commercial aviation. With all the new and varied technologies developed, airliners were larger, faster, pressurized and even more complex for the crews to operate. The Flight Engineer was now an integral part of the crew, charged with the responsibility of operating the engines at peak efficiency throughout the flight. Additionally, he was responsible for the oversight and operation of the hydraulic and electrical systems. In this cockpit, the pilots had a set of throttle levers for power adjustment, but all else was managed by the Flight Engineer. (Figure 6)

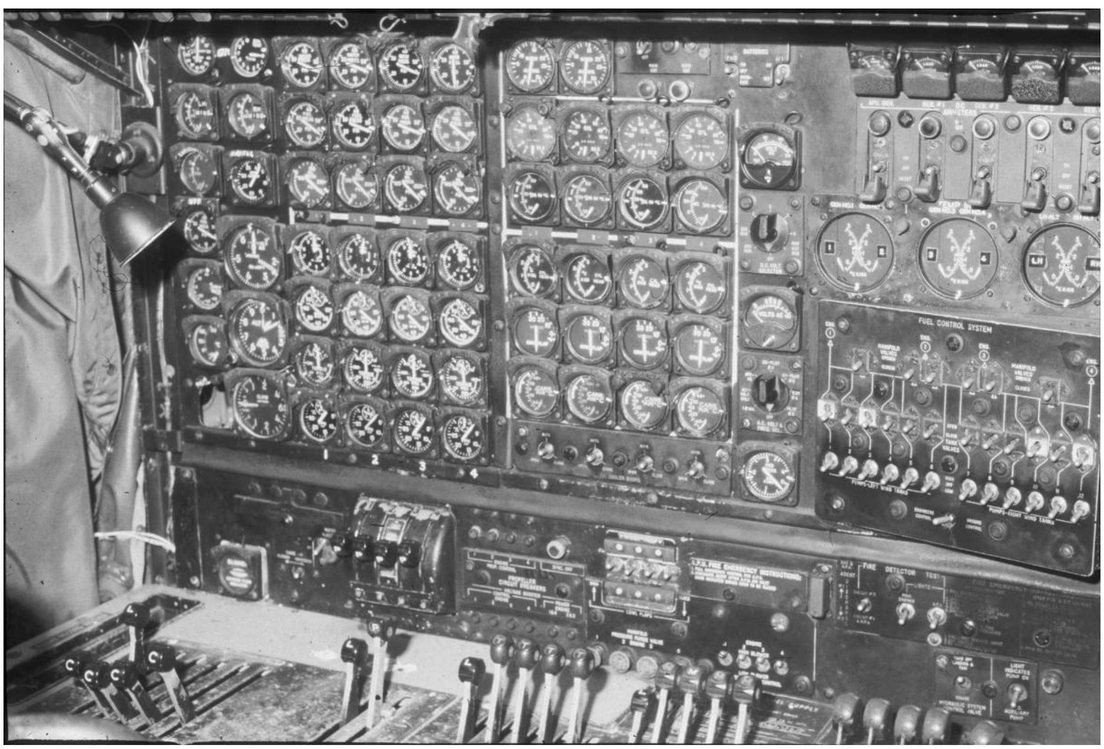
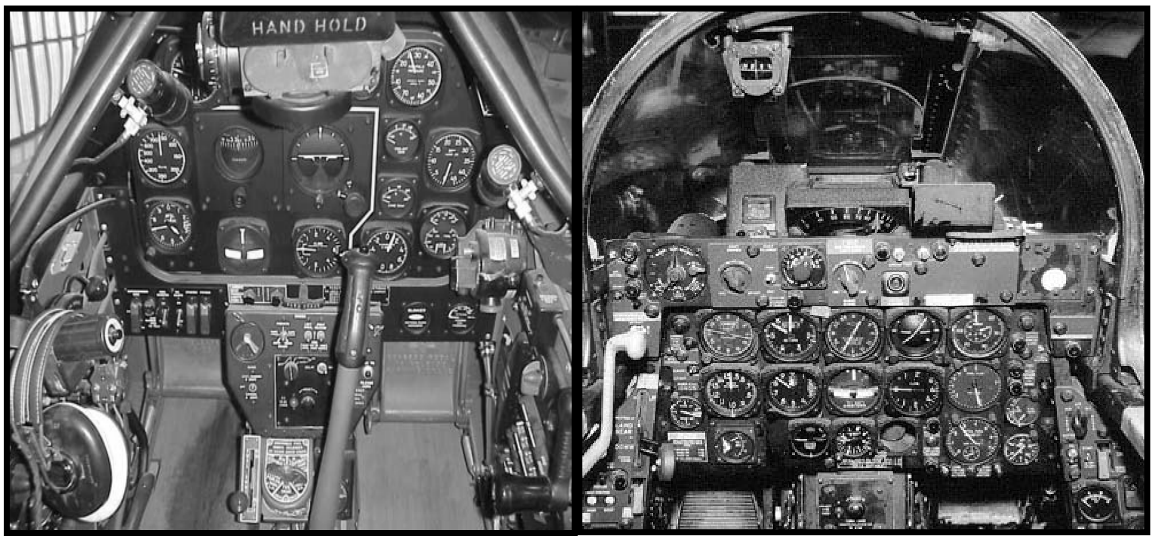


Figure 6. Douglas C-124, 1950 (Courtesy NMUSAF)

Chuck Yeager notes that his fighter aircraft of World War Two carried approximately 50 pounds of electronics but the new jet (of 1950) carried 1,500 pounds of sophisticated electronics and the cockpit of this era was "straight out of *Buck Rogers*" (Yeager, 1986). Figure 7 illustrates Yeager's 1945 cockpit of the North American P-51 compared to the cockpit of the 1950 North American F-86, the "*Buck Rogers*" airplane.



P-51, 1945 (Courtesy NMUSAF) F-86, 1950

Figure 7. Cockpit Comparison

Perhaps the best example of military-civilian technology transfer was the Boeing KC135, developed in 1955 as an aerial tanker to refuel jet bombers in flight Redesigned and introduced in 1958 as the Boeing 707 airliner, it became the first U.S. passenger jet and was widely considered the mainstay of jet transportation until the B727 was introduced in 1963. Boeing introduced the B747 in 1970 and McDonnell-Douglas the DC-10 in 1971— both aircraft commercial outgrowths of the competition for military contracts. All four of these aircraft required a flight engineer as well as two pilots to form the basic flight crew.

Just as the mechanical aspects of aviation were evolving, the electronic side was experiencing rapid growth. Analog computers were replacing some electro-mechanical functions on the aircraft. Basic automation was beginning to enter the cockpit: autopilot functions were coupled to early digital computers. The small size of the read-only memory units of the early computers resulted in limited capability; however, as miniaturization and programming technologies advanced, so did the capability. In the late 1970s, the LORAN-C navigational system became fully operational for overland use between the East and West coasts of the United States. It was then possible to program a course by entering waypoints via latitude and longitude coordinates into the control unit and provide this information to the autopilot (Clausing, 1992).

Early automated cockpits had simple electromechanical flight and navigation instruments with a basic autopilot and Flight Director (FD). Aircraft information was presented on several individual instruments. The pilot had the primary responsibility of manually controlling the aircraft while monitoring the flight progress with rudimentary computer support. The next generation aircraft integrated the basic autopilot and rudimentary computer-based navigational support with the FD. This became the concept behind the Flight Management System (FMS) (Clausing, 1992). With increased computer memory and processing speeds, the next generation aircraft realized a major evolutionary step in automation. Systems that were previously independent were integrated with the autopilot to form the FMS. Aircraft operating parameters were programmed into the Flight Management Computer (FMC) along with an updateable navigational database. Using accurate positional information from a combination of long and short-range navigational sources, and integrated performance parameters, the data are presented to the pilot on the Primary Flight Display (PFD), an Electronic Flight Information System (EFIS) system and a Multi-Function Display (MFD) showing positional information, terrain data and weather radar displays. System automation information is displayed on an Engine Indicating and, Crew Alerting System (EICAS) to complete the cockpit display. As the FMS capabilities increased, the flight and navigational instruments were also being computerized. Using inputs from the FMC and other sources, the individual attitude indicator and directional gyro were melded into a single PFD and presented on a single cathode ray tube. Flight control inputs were entered on a Flight Guidance Controller (FGC) to command the FD to follow desired flight profiles. The glass cockpit had arrived: flight instruments were displayed on the PFD: engine, fuel and systems status on the EICAS: and navigational data on the MFD. All of this data is generated by one or more computers onboard the aircraft. Even though the pilot and copilot systems are separate and required to be able to stand alone, the Federal Aviation Administration requires a mechanical or battery powered backup attitude direction indicator, airspeed indicator and altimeter in all glass cockpits (FAR/AIM, 2006).

Pilot Training Requirements to Meet the Glass Cockpit

The trend toward the automated cockpit flight decks – “the glass cockpit” – has had a major impact on commercial aviation. Generally, the reception has been positive and has provided several significant benefits such as fuel efficiency, increased navigational accuracy and precision, and the more efficient use of limited cockpit “real estate” (Wiener, 1999). Current training philosophies stress the efficient use of automation to control flight path and aircraft energy. For the purposes of this study, we define the automated cockpit as an integrated system consisting of a FMS, a FGC, and an

EICAS. Considerable training is required to become proficient in the operation of an automated cockpit (Weiner, 1989).

Pilot or Manager

The use of automation may have come, however, with an unintended price. Crews may be trying to program their way out of trouble when the best course of action would be to disregard the automation and hand fly the aircraft out of the situation (Cooper, et al, 1980). A classic example of this occurrence is the crash of American Airlines Flight 965 in December, 1995, when the crew, after a missed approach and apparent loss of situational awareness, failed "to revert to basic radio navigation at the time when the FMS-assisted navigation became confusing and demanded an excessive workload in a critical phase of flight"(NTSB, 1966). The airplane flew into the side of a mountain, killing 156 of the 160 souls on board. The 1983 loss of an Eastern Air Lines L-1011 in the Florida swamps was caused by the autopilot becoming disconnected while the crew was distracted troubleshooting a possible landing gear malfunction (NTSB, 1984). Other instances of mismanagement include the Air New Zealand DC-10 flight into Mount Erebus, Antarctica, in November, 1979. The crew disconnected the altitude hold function of the autopilot to descend below an undercast, and then manually put the aircraft on a heading directly towards the mountain not realizing the waypoint selected would take them directly to the mountain instead of along side as they expected (Maurino et al, 1998).

Increased automation has raised concern among some pilots, safety officials and training professionals due to the considerable complexity of the modern glass cockpit. Design-related errors are also a large area of concern.

Design Deficiencies

Design deficiencies leading to pilot error accidents have been a major concern ever since World War Two. A number of bomber accidents were traced to the fact that the landing gear handle and flap handle were placed side by side and were similar in looks and touch, resulting in crews who raised the gear on landing roll instead of the flaps. The end results were the same: a shortened landing roll — but the procedure clearly needed refinement (Cameron, 1999).

In recent years, a series of pilot-error accidents have focused on the requirement for a review of the FMS operability capabilities by both the human factor and aircrew training specialists (Wiener and Nagel, 1988). Both Boeing and FAA data show human error as a significant factor in aircraft accidents. Boeing data shows that 56% of the hull-loss accidents between 1959 and 2005 involved aircrew mistakes. Design-related error is a component of this factor (Boeing, 2006). The FAA states that the majority of aircraft accidents are due to human error (NTSB, 2004).

Over the past three decades, avionics advancements introduced increasingly sophisticated technology into the cockpit. These advancements were made on the premise of increasing safety and providing the operator with improved economic benefits (Stewart, 1992).

First, automation would accomplish the routine monitoring functions of aircraft operations, thus freeing the crew for the tasks of monitoring flight progress, problem solving and decision making, and thereby increasing safety. Decision-making would be improved by ensuring that the crew had the best relevant flight and systems data available to make the required decision (Weiner and Nagel, 1988).

Economic benefits were to be achieved from several factors. Crew size could be reduced by automation of some crew tasking. Additionally, solid state avionics and display systems would provide economic returns by improved reliability and reduced maintenance. Finally, automation would provide trend monitoring of high value systems such as engines and auxiliary power units (APUs) (Weiner et al, 1993).

Modern avionics have accomplished most, if not all, of these economic goals, but their safety effectiveness is a subject for dispute. It is generally accepted that the automated features of flight control systems can improve a crew's situational awareness by reducing workload. However, the same systems that compensate for equipment malfunctions or for unusual flight conditions can seriously reduce situational awareness if the automated system masks the occurrence or does not clearly notify the crew as to what actions are being taken in response to the malfunction (FAA, 1996). Aircraft design must be such that the aircrew can expect easily recognizable data to facilitate decision making for all aspects of the flight. Additionally, this design must assist the flight crew under emergency or abnormal situations when things are not as expected and safety depends on quick and correct actions by the crew (FAA, 1996).

CHAPTER III

METHODOLOGY

Introduction

In the one hundred three years man has been flying heavier-than-air vehicles, the complexity of the aircraft and the systems with which they fly has increased exponentially. This increase in technology has dictated a change from single-pilot operation to multi-pilot operation and from little or no formal training to extensive initial training with formally scheduled recurrent training in those systems, and an accompanying shift from "seat of the pants" flying to monitoring computer-generated systems displays as the airplane flies itself on autopilot. Is this shift creating problems with flying safety?

Overview

The purpose of this study was to explore the possibility that the Federal Aviation Administration Practical Test Standard (FAA, 2001) requirement for a pilot to demonstrate the ability to use all installed avionics equipment during a type certification examination or during mandatory recurrent training may have a detrimental effect on basic flying skills.

Intuitively, the logical source for this information would be the pilot community flying aircraft that require type ratings. However, in this case, the question, if asked of the users, might result in unclear and ambiguous responses due to the wide spectrum of operations: i.e., contract freight, charter, corporate, fractional, or owner operated. In order to capture an over-arching view of the question, it was considered necessary to move the question to the instructional and evaluation levels where the bias of operation could be neutralized.

A Delphi technique was used to explore the issues for this study.

Rationale for Delphi

The Delphi technique was developed in the late 1940s by the RAND Corporation as a method to forecast the application of advancing military technologies (Dalkey, 1967). Norman Dalkey and Olaf Helmer postulated that if a panel of experts were asked to give their opinions of what the future of a specific subject might hold, then a reasonable idea might be formed by their consensus. Buckley (1995, p. 17) quotes Cary and Salmon's definition of the Delphi technique from their July 1976 Agricultural Extension Research report as a "tool for discovering agreement, and discovering differences rather than forcing consensus." According to Kaynak, Bloom, and Leibold (1994), "The Delphi technique attempts to make constructive and systematic use of informed intuitive judgment" (p.19). Despite its original purpose, Adams (1980) reports that an early use of the system was to check the reliability of horse racing handicappers. The more serious use, to postulate the number of atomic weapons the Soviet Union would require to cripple the industrial capability of the United States was reported by

Andranovich (1995) and Baker (1988). The technique was further refined during the 1950s by adding the additional feature of controlled feedback (Jones and Twiss, 1978). Dalkey and Helmer (1993) elaborated on this addition in their article in the April issue of Management Science. Buckley (1995) states that the Delphi technique as modified is used to garner judgments and information from experts to facilitate decision-making, planning and problem solving. The primary purpose of the technique is the reliable and creative discovery of ideas or the collection of sufficient information for decision making or policy determination. The Delphi technique is used to "… identify problems, define needs, establish priorities, and evaluate solutions" (Borg and Gall, 1979). It utilizes written answers collected from a group of participating subject matter experts and is characterized by several iterations with feedback to the participants. According to Winzenried (1977), the Delphi technique would be selected to investigate the subjective situation of an individual's reaction to a changing work situation. It is designed to collect expert opinions as independent individual ideas on a debated topic, offering structure and validity without an oppressive formal framework that would not allow for personal subjective considerations. Hinks and McNay (1999) view the Delphi as being used when one or more of the following situations may exist: (a) the situation is emotionally charged, (b) when a decision is opinion-based, (c) when there is need for expert opinion and the experts are not centrally located, and/or (d) when better results might be achieved if the experts did not meet face to face. The simplest method to work around an emotionally charged situation is to keep the emotionally involved parties separated. The same application is viable when the decision will be opinion based. Any time a group of experts convenes for a meeting, the possibility of personality conflicts is present. The Delphi addresses this issue by insuring the anonymity of the respondents.

The primary characteristic of the technique that will facilitate this investigation is that the individually generated ideas of the respondents will produce a high quantity of ideas as follows:

1. The process of writing responses to the question requires the respondents to submit well-reasoned, specific ideas.
2. Behavior is proactive because the respondents cannot react to others' verbal ideas.
3. The isolation and anonymity of the respondents provide insulation from pressures to conform.
4. Pooling of individual ideas and judgments aids the equality of the participants.
5. The Delphi process tends to conclude with a sense of accomplishment and closure.
6. The Delphi technique is valuable for obtaining ideas from geographically separated experts (Delbecq, Van de Ven and Gustafson, 1986).

The Delphi Panel

Selecting the panel of experts is critical to the validity and reliability of the study (Williams and Webb, 1994). Goodman (1987) as well as Walker and Selfe (1996) point out that the validity of a Delphi study is measured by the accuracy of the panel selection.

Weatherman and Swenson (1974) said that the panel must be representative, appropriate, competent, and committed. Sumsion (1998) states that "it is important to recruit individuals who have knowledge of the topic and are willing to dedicate the time to this discussion."

The database for potential respondents was constructed by cross-referencing recommendations from the chief training officers of four nationally recognized aviation training facilities (Leedy, 1974). Each was asked to nominate ten of their instructors and/or evaluators as potential members of the Delphi Panel. These individuals were required to be current in at least one aircraft; and currently be or have previously been qualified as an instructor, standardization or check pilot, or evaluator in a business class airplane requiring a type rating to operate. Each facility provided a minimum of ten names and these individuals were contacted to determine their willingness to participate in the study (Appendix B). However, one training center withdrew its participation prior to the start of the study.

Pilot Testing

The study was designed to be emergent throughout all iterations and the respondents were unaware of the identities of the other panel members. Sellitz, Wrightman, and Cook (1981) pointed out the difficulty of developing questionnaires and rating scales. Since this Delphi study required expertise in both airmanship and examination requirements, the field of potentially available experts and respondents was somewhat limited in number. The three major training facilities nominated ten instructors or evaluators for consideration as panel members. Once the question for the study was developed, 10 of the 30 recommended individuals were randomly selected to validate the appropriateness of the question (Helmar, 1966). These individuals were then removed from the pool of potential respondents. Each of the remaining candidates was then contacted and invited to participate in the study. Minor changes in wording suggested by the validation process were incorporated into the final version of the question presented to the panel.

Population of the Panel

Research by Ulschak (1983) and Delbecq, Van de Ven and Gustafsen (1975), suggest a range of 10 to 20 Delphi participants as the ideal size of the panel. Potential participants were identified and invitations extended, soliciting participation until a suitable panel was assembled. All selected members met the requirements detailed in the sub-section "The Delphi Panel."

Qualifications of Respondents

Respondents were selected on the basis of their position in the aviation training industry and their extensive background in business and corporate aviation as well as their recognized expertise in aircrew training and evaluation. Additionally, all of them met the four criteria as outlined by Delbecq, Van de Ven, and Gustafson (1986) of:

1. Personal involvement,
2. Pertinent information to share,
3. Motivation to complete the study, and
4. Belief they will gain from the experience.

The classic Delphi requires expertise in the diverse areas of the subject under scrutiny in order to seek clarification of the elements of the research question. The respondents selected were all experienced practitioners of the industry and recognized as known experts in their aircraft.

All respondents were ATP-rated pilots. Eight were initially taught to fly by the military; eight were trained through the civilian process. Three of the eight military pilots remained on active service until eligible for retirement with at least twenty years experience before beginning their career in business aviation. Those three all had extensive experience as military flight instructors and examiners. The other five served their mandatory commitment (usually five years) and then joined the civil aviation workforce. Two members enjoyed full careers with major U. S airlines. Two had experience with regional airlines.

The lowest number of flight hours logged by any respondent was between 4,000 and 5,000 hours. Three had over 10,000 hours. The junior member of the group had over 11 years experience while the most experienced checked in with over 50 years. Averaging both the years experience and flight hours logged resulted in an average of 29 years and 9,975 flight hours. Table 1 summarizes the respondents' qualifications.

TABLE I

SUMMARY OF RESPONDENTS' QUALIFICATIONS

Categories of Qualifications	n = 16	Percent
Background Experience (some respondents have multiple areas of experience)		
Civilian (no military experience)	8	50.00
Major Airline	2	12.50
Regional Airline	2	12.50
Military	8	50.00
Charter/Fractional	7	43.75
Current Position		
Instructor Qualified	16	100.00
Training Center Evaluator (FAA)	16	100.00
Type Rating Examiner (JAA)	8	50.00
Flight Hours		
1,200 – 5,000	1	6.25
5,001 – 10,000	8	50.00
10,001 – 15,000	5	31.25
15,001 -	2	12.50
Type Ratings Held		
1 – 4	3	18.75
5 – 10	11	68.75
11 – 15	2	12.50
16 -	1	6.25
Years in Aviation		
10 – 20	6	37.50
21 – 30	3	18.75
31 – 40	5	31.25
41 -	4	25.00
Published	5	31.25
Formal Education Level		
Associate Degree	3	18.75
Bachelor's Degree	10	62.50
Advanced Degree	3	18.75

Twenty potential respondents were invited to participate in the study. All 20 had been previously contacted by telephone (Appendix B) and had expressed interest in the study. After contacting the potential respondents by telephone, the consent form (Appendix C) was e-mailed to each individual. Sixteen positive responses were returned and became the panel.

One day prior to the start of the study, the notification to expect the question was e-mailed to each of the 16 positively responding respondents (Appendix D). The purposes of this notification were to alert the respondents to expect the Delphi question and to provide instruction concerning their responses. Additionally, encouragement to become fully involved in the study from start to completion was enclosed in the message. Specifically, these points were included:

- Respondents were asked to take a moment and review the question from their individual perspectives as soon as possible after receipt. They were asked to send their ideas back to the researcher as a reply to the basic message or as a new e-mail.
- They were instructed to remember there was no required format for answering the question. Their answers could be as long or short as they wished, using any format such as talking points, phrases, sentences, or paragraphs. Getting the discovery process started was the primary focus of round one. "When you consider the question, what are your thoughts?" was the basic guidance.
- They were reminded that they were anonymous, and so were free to express their thoughts as they wished. They were told that for round two they could

expect to receive a compilation of the responses returned from round one for their consideration.

- They were reminded that there would be an approximate two-week period between the closing of round one and round two, and once again, thanked for their participation.

Conduct of the Study

The study was conducted along the traditional lines of the Policy Delphi technique, remembering that the goal in this function was not so much to obtain a consensus as to expose differing positions and pro and con arguments for these positions (Linstone and Turoff, 1975). The basic method as described by Delbecq, et al (1986) is:

1. The Principal Investigator develops the initial question and delivers it to the panel.
2. Panelists will generate, and respond with, independent ideas to answer the question.
3. The Principal Investigator will summarize the responses and develop a feedback report along with a second set of questions for the panelists.
4. Upon receiving the feedback report, the panelists will individually evaluate earlier responses and independently generate and rate comments to the second round.
5. The Principal Investigator will summarize the second round and ask the respondents to rate their findings.
6. The Respondents will rate their summarized findings.
7. The Principal Investigator will develop a final summary and report the ratings.

Validity and Reliability

Linstone and Turoff (1975) propose that while no one method of inquiry completely satisfies every requirement for truth content, the Delphi technique of data gathering fosters validity. Wiersma states that increasing the panel size does not counter bias, but only increases the quantity of data. He goes on to say that it is necessary to capture the perceptions of those involved in the study in order to achieve the accurate measure of reality that the research seeks (Wiersma, 2000).

Turoff states that the objective of the study may not be consensus, but to elicit diverse points of view and potential aspects of the issue, given that the respondents are broader in scope than the background that any one individual possesses (Linstone and Turoff, 1975).

According to Linstone and Turoff (1975) the premise of reliability of the Delphi study lies in the inference that a larger group, using consistent methods with other experts, would develop the same results.

CHAPTER IV

FINDINGS

Introduction

In the one hundred three years man has been flying heavier-than-air machines, the complexity of the aircraft and the systems with which they fly has increased exponentially. This increase in technology has dictated a change from single pilot operation to multi-pilot operation and from little or no formal training to extensive initial training, with formally scheduled recurrent training in those systems and an accompanying shift from "seat of the pants" flying to monitoring computer generated systems displays as the airplane flies itself on autopilot. Is this shift creating problems?

Rationale

The purpose of this study was to identify the possibility that current FAA pilot testing policy for type rated airplanes might lead to a loss of basic flying skills by the pilots, and, if this policy did lead to a loss of skills, to suggest steps that the training community might take to prevent this further degradation of skills from continuing to happen.

The results of the study were separated into two sections and were structured to correlate with the two sides of the question: (A) "Does the policy create a problem" and,

(B) “What corrective actions can be taken by the training community to prevent, or at a minimum, to minimize the effects.” This purpose was achieved by the use of the Policy Delphi technique.

The Classic Delphi was developed by the RAND Corporation in the 1950s. The Policy Delphi evolved and was first introduced in 1969 and reported on in 1970 (Turoff & Linstone, 1975). The original concept of the Delphi as introduced and utilized, was designed to seek consensus from a group of experts on a technical topic of interest. The Policy Delphi seeks to generate ideas on the potential resolutions of an issue. The Policy Delphi also rests on the premise that the respondents will present options and supporting evidence toward the question and that consensus is not a major objective of the study. Turoff (1970) notes that the structure of the process may make consensus unlikely.

As the study moved through the discovery process, comments from the respondents were grouped and categorized and made available via e-mail for the next round. The final ratings from round three came after the study had stabilized following round two, and indicated an emergent understanding of the problem.

The Question

The Delphi question sent to each respondent was: “The FAA requires the demonstrated use of automation during type and recurrent flight checks. (A) How does this requirement lead to over-reliance on automation? and, (B) What actions can be taken by the training community to correct this possible trend?”

Because of the researcher’s professional experience in the field of study, every effort was taken to avoid biasing the question with the researcher's ideas or opinions.

Round one consisted of the preamble "The FAA requires the demonstrated use of automation during type and recurrent flight checks." Followed by the question "How does this requirement lead to an over-reliance on automation, and what actions can be taken by the training community to correct this possible trend?" Round one was sent to 16 respondents on May 23, 2006, with all 16 returning the questionnaire (Appendix E). The responses generated a total of 16 areas of discovery for the first part of the question and 13 areas for the second part.

Synopsis of Round One

In response to the first part of the question, regarding testing policy developing an over-reliance on automation, the respondents identified 15 areas of interest during discovery. Embedded in the areas of discovery were insights into training philosophies, ab-initio training, the capabilities of aging pilots, and computer literacy. The second part of the question generated 13 areas of discovery with imbedded issues of regulations that needed to be written or changed, recertification of instructors, and industry-wide training requirements made mandatory by the FAA. In most cases, the comments showed a great concern for the situation as it currently exists.

Selected Quotes, Round One

"Create scenarios to demonstrate the limitations of automation."

"The use of automation . . . is a skill that should be and must be evaluated."

"I reject the notion that over-reliance exists."

“Automation makes us safer and more efficient pilots.”

“Pilots with poor flying skills are most likely to use automation as a crutch and are at highest risk for over-reliance.”

“Automation is a powerful tool, but only as good as the skill and knowledge of the operator.”

“Develop flight lessons specifically for automation skills.”

“Emphasize the techniques of ‘de-layering’ automation during training.”

“Limit automation to those who can demonstrate manual skills.”

Round Two

The second round e-mail was sent to all 16 participants (Appendix F) on June 19, 2006. It provided the respondents with a compiled list of the thoughts of both sides of the question unveiled during the first round of discovery as well as the quotes listed above. The accompanying letter thanked them for their insights and encouraged additional discovery as they reviewed and commented on their efforts of round one. They were challenged to re-think their ideas, challenge the thinking of other respondents as they thought necessary, and add new thoughts triggered by other comments or ideas. Several new ideas emerged from the first round. It was pointed out that the PTS defines the minimum standards for success and that the panel must remember that in their thoughts and comments. It was also noted that the current testing standards are of another time: “Evaluations are currently based on aging theories developed during the ‘jet’ age and are rapidly becoming outdated.” Well said. Regarding the issue of industry-wide standardization, we were reminded that marketing, not flying safety is the driving force behind which manufacturer uses what equipment, and as a consequence, there will never be industry-wide standardization without a direct FAA direction.

Synopsis of Round Two

Round two had a 100 % return rate. Added discovery came as amplification to previous comments by other respondents. In each case, it was intended to clarify and further define a previous input. Individual bias was evident in several comments, and comments ranged from whimsical to brute force and direct, challenges. The discussions around the infallibility of newer automated equipment and the acceptability of placing complete trust in it drew the more pointed comments. “Wow! I hear dead pilots telling me how good this idea was.” “How many more crews will we have to lose to show the stupidity of this comment?” There was a noticeable difference of opinion between the pilots trained before the level of cockpit sophistication reached today’s level, and those who have always had some form of automated assistance in the cockpit.

Selected Quotes, Round Two

“I think we have to realize that automation is a two-edged sword and that over-reliance can definitely be a problem.”

“Over-reliance is only a problem if the automation quits and your basic airman skills are not proficient.”

“As manufacturers’ representatives, we must make sure clients are taught how it works.”

"Mastery of the airplane should be first priority. Second priority should be a reasonably useful familiarity with the automation."

"In any case, there's no such thing as 'pilot proof'."

"No one properly trained in the proper use of the turn and slip indicator and the airspeed indicator will ever be over-reliant on automation."

"Who is in charge, the pilot or the machine?"

From the received inputs it was obvious that no clear consensus would develop. This outcome was not unexpected, and was mentioned as a possibility by Turoff (1970). The comments were, however diverse, grouped closely enough to form 15 possible reasons a problem existed and 13 possible methods to correct or prevent the problem. Two of the ideas for correcting or preventing the problem through training were combined into a single entry reducing the solutions to 13. The two items of discovery generating the highest level of interest were dealing with the idea of training doctrine being forced by the regulation, and that of placing full confidence in the automation equipment. Individual comment on these two topics of discovery was spirited.

Round Three

As in round two, the e-mail sent to the respondents was a compilation of their earlier responses and comments (Appendix G). They were commended for their thoughts and insightful responses to the areas of interest and once again reminded of their anonymous relationship to one another. In this round, however, the areas of interest were converted into statements and the respondents were asked to review both halves of the question and then rate each item on a Likert-like 0 to 7 scale with 0 having the lowest rating and therefore, having little or no merit to determining the existence of a problem or a solution. A rating of 7 would indicate the statement had significant merit pertaining to the existence of a problem or the solution. The panel was again reminded that additional comments or discovery were appropriate.

Synopsis of Round Three

Round three was sent on July 17^{th}, 2006, at the peak of the summer vacation schedule, and, as it turned out, the busiest time for all the training centers as well. All three training centers were operating at full capacity and, in addition to regular classroom and simulator schedules, the members of the panel actively flying were also spending an unusual amount of time out of the office and away from their normal communication channels. Respondents holding cockpit positions with Part 135 and fractional operators were equally busy. Consequently, the turn around time for receiving the final data was, by necessity, extended until the second week in August. All 16 respondents eventually completed the round three ratings. There was no new discovery during round three but several respondents did choose to amplify their reasons for scoring some of the items as they did. Using the scale of 0 to 7, with 0 being the lowest score and having no potential to determine either the existence of a problem or a possible solution, and 7 having a very high potential to determine the existence of a problem or a possible solution, the respondents were asked to consider each item in light of both parts of the question "Does the FAA requirement to use automation on a checkride lead to over-reliance on automation, and, what actions can be taken by the training community to correct this possible trend?"

With a maximum mean of 7, ten of the items concerning the possible over-reliance on automation were considered as having some potential for addressing the problem. One item had a neutral mean of four; and three items with means less than neutral were assessed as having no potential for addressing the problem. Following are the ten items the panel found to have some potential to address the problem:

First Item: The proper use of automation to fly modern aircraft is a skill just like hand flying. It needs to be, and should continue to be, evaluated (M= 6.31).

Second Item: The complexities of installed automation may require additional training to use and master the equipment (M=6.06).

Third Item: Training doctrine puts a high priority on automation (M= 5.25).

Fourth Item: Over-reliance is generally dependent on pilot experience. It appears to be inversely proportional to experience (M= 5.25).

Fifth Item: Pilots with poor flying skills are most likely to use automation as a crutch and are at highest risk for over-reliance (M= 5.12).

Sixth Item: The lack of industry-wide standardization is a causal factor to the problem (M= 4.93).

Seventh Item: Over-reliance on automation may lead to a feeling of invulnerability and infallibility (M= 4.75).

Eighth Item: Over-reliance results in a loss of situational awareness (SA) (M= 4.56).

Ninth Item: There is insufficient syllabus time to properly train crews in the proper use of automation (M= 4.50).

Tenth Item: What is perceived as over-reliance may be a lack of skill in utilizing automation (M= 4.18).

With a maximum mean of 7, eleven possible solutions were identified as having potential to address the problem. Two items fell below the neutral mean and were assessed as having no potential to address the problem. For clarity, responses to the second half of the question will be referred to as ‘solutions’.

Solution One: Training should include specific techniques to handle automation (M= 6.50).

Solution Two: The instructor and examiner must ensure that the automation is used as a tool, not a crutch (M= 6.06).

Solution Three: The evaluator must create a balanced level during the checkride to ensure manual skills are demonstrated to balance the use of automation (M= 5.81).

Solution Four: Recurrent and subsequent training should include incrementally more difficult and complex scenarios, teaching more efficient and appropriate uses of automation (M= 5.75).

Solution Five: Definable minimum levels of training must be established (M= 5.68).

Solution Six: Increase training time without sacrificing systems integration (M= 5.62).

Solution Seven: Intensify training in failure mode management. Automation should be used as a supplement to the primary tools in the aircraft, never as a substitute (M= 5.56).

Solution Eight: Trainers must be trained to teach the specific automation installed in the aircraft to include the conceptual fundamentals of how the system software determines courses of action in specific situations (M=5.18).

Solution Nine: There must be satisfactory demonstration of manual skills before allowing the use of automation (M= 5.00).

Solution Ten: Courseware development must be upgraded to allow for maximized training (M= 4.93).

Solution Eleven: The training community must develop internet-based interactive training modules to prepare the student prior to his arrival at the training site (M= 4.25).

Table II lists the ideas and solutions, shows the actual scores posted by the respondents in the order they were received, and the mean for each idea and solution.

TABLE II
ROUND THREE RANKING OF DOMINANT IDEAS BY THE DELPHI PANEL

Idea	Ideas and Solutions n=16	Total	Mean
1.	Over-reliance is not a problem at this time	39	2.4375
2.	Perceived over-reliance may be lack of knowledge	67	4.1875
3.	Training doctrine puts a high priority on automation	84	5.2500
4.	Total reliance acceptable based on system design	30	1.8750
5.	Proper use of automation a skill to be evaluated	101	6.3125
6.	Pilots with poor flying skills highest risk for over-reliance	82	5.1250
7.	Complexities of equipment require additional training	97	6.0625
8.	Over-reliance dependent on pilot experience	84	5.2500
9.	No pilot trained on needle, ball and airspeed has a problem	40	2.5000
10.	Lack of industry-wide standardization a causal factor	79	4.9375
11.	Insufficient syllabus time to properly train crews	72	4.5000
12.	Over-reliance causes loss of Situational Awareness	73	4.5625
13.	Over-reliance leads to feeling invulnerable and invincible	76	4.7500
14.	The PTS forces over-reliance on automation to be taught	64	4.0000
Solution			
1.	Increase training time without sacrificing systems integration	90	5.6250
2.	Training should include specific techniques for automaton	104	6.5000
3.	Definable minimum levels of training must be established	91	5.6875
4.	Evaluator must establish balance to ensure proper use	93	5.8125
5.	Demonstrate manual skills before allowing automation	80	5.0000
6.	Require use of manual skills after automation mastered	81	3.8125
7.	Instructor and evaluator must ensure used as tool, not crutch	97	6.0625
8.	Automation training separated from aircraft specific training	23	1.4375
9.	Recurrent training should introduce complex automation skills	92	5.7500
10.	Trainers need specific and detailed training on equipment	83	5.1875
11	Teach failure mode management	89	5.5625
12.	Upgrade courseware development to maximize training	79	4.9375
13.	Training Community develop interactive training modules	68	4.2500

Table III displays the mean scores for each idea and solution in rank order as reported by the respondents. Calculating the means without the outliers made no significant difference in rankings.

TABLE III

RESULTS OF RESPONDENTS' RATING OF FINDINGS

Idea	n=16	Mean	Rank Order
5.	Proper of automation use a skill to be evaluated	6.3125	1
7.	Complexities of equipment require additional training	6.0625	2
3.	Training doctrine puts a high priority on automation	5.2500	3
8.	Over-reliance dependant on pilot experience	5.2500	4
6.	Pilots with poor flying skills highest risk for over-reliance	5.1250	5
10.	Lack of industry-wide standardization a causal factor	4.9375	6
13.	Over-reliance leads to feeling invulnerable and invincible	4.7500	7
12.	Over-reliance causes loss of Situational Awareness	4.5625	8
11.	Insufficient syllabus time to properly train crews	4.5000	9
2.	Perceived over-reliance may be lack of knowledge	4.1875	10
11.	Insufficient syllabus time to properly train crews	4.5000	11
12.	Over-reliance causes loss of Situational Awareness	4.5625	12
1.	Over-reliance is not a problem at this time	2.4375	13
4.	Total reliance acceptable based on system design	1.8750	14
Solution			
2.	Training should include specific techniques for automaton	6.5000	1
7.	Instructor and evaluator must ensure used as tool, not crutch	6.0625	2
4.	Evaluator must establish balance to ensure proper use	5.8125	3
9.	Recurrent training should introduce complex automation skills	5.7500	4
3.	Definable minimum levels of training must be established	5.6875	5
1.	Increase training time without sacrificing systems integration	5.6250	6
11.	Teach failure mode management	5.5625	7
10.	Trainers need specific and detailed training on equipment	5.1875	8
5.	Demonstrate manual skills before allowing automation	5.0000	9
12.	Upgrade courseware development to maximize training	4.9375	10
13.	Training Community develop interactive training modules	4.2500	11
6.	Require use of manual skills after automation mastered	3.8125	12
8.	Automation training separated from aircraft specific training	1.4375	13

Throughout the three rounds of the Delphi, the respondents were quite clear and forthright in voicing their input to the questions asked. No one ever cited 'chapter and verse' of any part of 14 CFR Part 61, the federal regulation governing flight training, or

Part 91, the regulation governing general flight rules and operations, but it was evident from the comments that those regulations as well as those pertaining to formal training were never far from their minds. This was especially evident in the second part of the question dealing with prevention.

The rank ordered listing of the respondents returns are presumed to be their final quantitative positions on the question. Statistician Richard Shavelson (1996) notes that the mean is the most basic and frequently used measure of central tendency (p 92). As only one ranking was accomplished, there was no requirement to weight the means obtained.

Using the scale of 0 to 7, only those items scoring above the median score of 4 were considered to be relevant to the question. This resulted in 12 items on the first half of the question that the respondents saw as having the greatest impact for addressing the question of a problem existing. The highest level of concern was over the need to properly evaluate the use of automation. The complexity of training along with the priority placed on automation by training doctrine closely followed. Finally, pilot experience and skill was addressed. They found 11 items of interest in the second half of the question concerning possible solutions. All items in the second half of the question had an impact on training. The highest ranking of comments was on equipment specific training and instructor requirements to ensure proper utilization of the equipment. Examination requirements and future courseware development were also interest items.

Chapter V will draw conclusions and make recommendations based on this study.

CHAPTER V

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

Introduction

The purpose of this study was to investigate the possibility that the current FAA testing policy of directing the use of all available automation during initial type certification flight checks leads to over-reliance on automation, and to ask what actions could be taken by the training community to correct this possible trend. The study was divided into two sections. The first section addressed the Delphi panel's discoveries concerning the possibility that the current flight testing policy does, in fact, lead to an over-reliance on automation with a concurrent loss of basic flying skills. The second section addressed possible actions the training community might take to correct this degradation of skills if it were determined the problem of over-reliance on automation did exist.

Summary of Findings

This study sought to answer the following research question: "The FAA requires the demonstrated use of automation during flight and recurrent flight checks. (A) How does this requirement lead to over-reliance on automation, and (B) What actions can be taken by the training community to correct this possible trend?"

Findings of the Review of Literature

The review of literature described the development of the airplane and the concurrent growth of technology beginning with the Wrights' first Flyer and progressing to the present. The growth of technology and its incorporation into the modern cockpit was traced. In a parallel manner, the requirements to be certified as a pilot were followed with the emphasis being put on the requirements to obtain an Airline Transport Pilot rating, after the establishment of the rating in 1926.

The review of literature showed that, as the airplane matured, the complexities and benefits of cockpit automation were integrated, and how, as technological capabilities increased, machines assumed responsibility for the management of engine performance monitoring as well as navigational duties.

Findings of the Delphi Committee

To achieve the purpose of the study, aviation training experts were asked to determine if the current FAA policy of mandating the use of all automation during recurrent and type checks might lead to an over-reliance on automation, and, if it were determined to be the case, what actions could be taken by the training community to correct this possible trend. The study took the form of a three-round Policy Delphi to seek clarification of the issue (Dalkey, et al. 1963). The first two rounds were for discovery, and the final round called for a Likert-type rating scale to determine the position of each expert respondent regarding the potential of each of the dominant items generated by the two rounds of discovery to address the question.

Twenty experts were invited – and agreed – to participate. Only 16 respondents, however, returned the initial questionnaire and, thus, became the expert panel for the study.

Round One Findings

In the first round of discovery, the respondents identified 15 dominant items of interest pertaining to the first half of the question regarding the testing policy, and 13 items regarding the second half of the question for training concerns. Sixteen respondents participated in round one.

Round Two Findings

During round two of the study, the 16 respondents were asked to review their first round comments, and to amplify or clarify any input made by themselves or any other member of the panel. They were also asked to note the strengths and weaknesses of the items as they were presented to them in this round. Several respondents modified their original comments and several added clarifying comments to their original positions. The conclusion of round two resulted in two of the original 15 policy items being consolidated into one, leaving 14 to be considered. The 13 training items were refined by amplification, but there were no additions or deletions to the list.

Round Three Findings

In round three of the study, all the respondents were asked to rate each of the items on a Likert-like scale. Rating was necessary in order to gain the perspective of each expert regarding the merits of each of the panel-generated dominant items, to answer both sides of the question.

Conclusions

The conclusions are divided into two sections. The first section concerns the problem of over-reliance on automation. The second section concerns possible actions by the training community to correct the problems of over-reliance.

The panel responded to the first part of the question by affirming their belief that over-reliance on automation does, in fact, exist. This belief was evident in the manner the panel worded their discoveries: “The proper use of automation . . . is a skill . . . and should continue to be evaluated,” and, “Training doctrine puts a high priority on automation.” Two of the top three ideas acknowledge the problem is present; one by recognizing the need for evaluation, the other by confirming that training doctrine has migrated from aircraft control to systems management. There was general agreement concerning levels of experience with dependency on the use of automation, but not necessarily with age being directly proportional to experience. Respondents likewise agreed that training philosophy should incorporate automation, but not to the exclusion of “hands on” flying capabilities. In regard to the wording of the Special Emphasis Section of the Practical Test Standard (PTS) concerning the required use of automation, there was no consensus on whether or not it was a factor, although it was acknowledged that it might possibly encourage over-reliance. Company training policies and Standard Operating Procedures (SOPs) requiring the use of the autopilot at all times other than take off and landing also were cited as major factors.

The panel responded to the second half of the question with near unanimity in changes to the training program. Only once was it suggested that the PTS should be changed. That lone suggestion was lost in the second round and never resurfaced. The other solutions were well reasoned and supported in both rounds. In round one, most solutions were presented in complete sentence form and clearly understood. Round two clarification was generally an expansion of the first sentence, and in most cases, not by the original respondent. Comments on strengths and weaknesses of the solutions were likewise well thought out. The most prevalent solution called for training to include specific techniques to handle automation. Some initially considered that to mean brand name specific training, but that suggestion was clarified during round two. Brand name specific instruction was listed as solution eight. Solutions two and three called for the instructor and examiner to be certain the automation was being properly utilized and not being used as a crutch. It was agreed that from an instructor's viewpoint, there is never enough time in the syllabus. That being the case, it was also agreed that more time isn't always the answer. They felt more effective use of the available time would always yield enhanced results. The panel noted that the earliest training philosophies utilized a systematic approach correlating visual conditions to instrument indications. They noted that integration of advanced automation should begin at the outset of training and continue throughout in the same manner. Further, they felt that this building block approach has proven too effective to abandon.

Recommendations

Based on the findings of this study, the following recommendations are offered as related to the findings. The panel agreed that there was an over-reliance on automation, quite possibly encouraged by the FAA requirement mandating its use during type and recurrent checks. Internal company policy was also cited as a causal factor.

With the panel's findings in mind, the recommendations of this study must include:

1. Adding additional syllabus time to both initial and recurrent classroom instruction to increase the students' understanding of the automation features of their aircraft. This can be accomplished by adding hours to the syllabus, or by re-aligning times allocated to other systems.
2. Initial type rating simulator lessons should include instruction on the proper use of aircraft automation as an adjunct means of aircraft control.
3. Recurrent simulator lessons should require a mix of automation failures as well as en route programming tasks to evaluate and train the more experienced crews on system capabilities.
4. Type rating examinations must include automation failures to properly evaluate the applicant's ability to recognize the failure and safely fly the aircraft in a manual mode of operation.
5. The FAA should mandate a level of commonality in respect to systems operations much the same way they instituted the commonality of the 'basic six' instrument panel arrangement.
6. Training providers should examine their courseware to maximize training opportunities.
7. Flight departments must allow flight crews to hand fly the aircraft without automation when feasible, such as on repositioning legs.

Concluding Remarks

Changing the standards for issuing an initial type rating or for satisfying the requirements for recurrent training is a difficult task. If the change is directed downward from the FAA, the industry will, by necessity, comply - perhaps not without resistance, but compliance will eventually be required. The procedures are defined in the Code of Federal Regulations and are very structured and measured in their protocols. This procedure has resulted in a relatively stable set of regulations with changes being reviewed at several levels before implementation. Usually, the aviation community has the opportunity to comment on a new regulation and prepare for its implementation.

Five of the seven recommendations call for changes to be made by the training community. Without industry-wide recognition that change is required, there is considerable risk involved for a training provider to implement changes on an individual basis. Some changes, such as restructuring classroom hours, can be made without too much impact on the training provider. Other changes, such as adding training material and hours to an established course, will be much more difficult to implement. First, the internal cost of developing and producing the courseware must be considered. Secondly, the revisions must be approved by the training facility's FAA Primary Operations Inspector before they can be put into the syllabus. Finally, the production expense will have to be factored into the quoted cost to the consumer for the particular course of instruction. The aircrew training business is a very costly business. Decisions to change existing training contracts are often made by the accounting division, not the aviation department or the chief pilot. The cost of an initial type rating in a business class jet already exceeds several thousands of dollars, depending on the airplane. If a training provider adds two days to the length of a course, along with a cost increase, the provider will have to convince the client base that the increase in time and expense is good value for money, or run the risk of losing clients strictly on the economic issue.

This researcher recommends that the major training providers meet under the auspices of an aviation-oriented organization such as the Aircraft Owners and Pilots Association or the National Business Aircraft Association to develop an agreed plan to organize the use of automation. The problem of over-reliance on automation is no longer limited to the business aircraft segment of the industry: glass cockpit technology is now available and being offered to the single-engine community by the major aircraft manufacturers, and is rapidly becoming the preferred choice for new airplane deliveries.

As this technology becomes more readily affordable, the problems inherent with the technology will continue to increase until fully addressed by regulation.

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APPENDIXES

APPENDIX A

INSTITUTIONAL REVIEW BOARD

APPROVAL LETTER

Oklahoma State University Institutional Review Board

Date:	Thursday, April 13, 2006
IRB Application No	ED06127
Proposal Title:	Recurrent Flight Training Trends: A Delphi Study to Examine Possible Loss of Piloting Skills
Reviewed and Processed as:	Exempt

Status Recommended by Reviewer(s): Approved Protocol Expires: 4/12/2007

Principal
Investigator(s

Charles R. Sullivan
1733 Vinewood Street
Fort Worth, TX 76112

Steven Marks
300 Cordell North
Stillwater, OK 74078

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

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

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

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

Please note that approved protocols are subject to monitoring by the IRB and that the IRB office has the authority to inspect research records associated with this protocol at any time. If you have questions about the IRB procedures or need any assistance from the Board, please contact Beth McTernan in 415 Whitehurst (phone: 405-744-5700, beth.mcternan@okstate.edu).

Sincerely,

Sue C Jacobs

Sue C. Jacobs, Chair
Institutional Review Board

APPENDIX B

SOLICITATION SCRIPT

DELPHI STUDY: PARTICIPATION SOLICITATION SCRIPT (VERBAL)

(Greeting) I am a doctoral candidate through Oklahoma State University, the College of Education in Aviation and Space Education.

Because of your expertise in aviation training, I am requesting your voluntary participation as a Delphi panel respondent in my research study. Your participation will be completely anonymous — i.e., your name and identifying characteristics will never be used — and there is no benefit to you, other than the satisfaction of speaking freely from your area of expertise in an interesting, and important, study. Your participation will be enormously appreciated, and entirely voluntary, with no consequences for withdrawal before the study is completed.

My research study will be conducted as a classic Delphi study.

- In the first round, I will send a single question to respondents, and ask them to respond, through e-mail, with their interpretations of the essential components in the question. Responses will be separated from the senders' identities upon receipt.
- For the second round, I will correlate, rank, and condense the first-round responses of all participants into common themes and new issues to be considered. Second-round responses will, again, be separated from respondents' identities, and correlated, ranked and condensed.
- Third-round responses (if required) will seek clarification, from each respondent, of the identified issues and will ask respondents to rate the correlated responses.

Consensus is not a goal of the Delphi technique process.

Again, every precaution to maintain confidentiality and privacy will be taken. The Delphi format encourages complete freedom to discuss the issues, because of the anonymity of panel respondents to each other.

Your time involvement will be whatever you choose to put into any round in which you participate. Prompt responses are encouraged, because there will be only 10 days between rounds, once the question is released to the respondents. The question will be sent to all respondents on the same day.

If you verbally agree to participate, I will e-mail you an implied, informed consent form, before sending you the research question. An e-mail reply to the form will constitute your consent to participate.

May I count on you to be one of the respondents?

Thank you!

Chuck Sullivan

APPENDIX C

CONSENT FORM

CONSENT FORM for Delphi Study

Dear Delphi panel respondent: To consent to participate, please read this document, then click on reply. Your reply will give me your implied, informed consent. Thank you. Charles (Chuck) Sullivan

AUTHORIZATION

I, (respondent) , hereby authorize Charles Sullivan to include my input in his research study.

DESCRIPTION OF RESEARCH AND ASSOCIATED RISKS/BENEFITS.

- ***Name of research project***: RECURRENT FLIGHT TRAINING TRENDS: A DELPHI STUDY TO EXAMINE A POSSIBLE LOSS OF PILOTING SKILLS
-
- ***Statement of affiliation:*** The study involves participating in research conducted by **Principal Investigator (PI) Charles Sullivan**, a doctoral candidate through Oklahoma State University, Stillwater, OK. ***Explanation of the purposes of the research and expected duration:*** The purpose of the research is to ask aviation training experts to explore the possibility that FAA training requirements may have a detrimental effect on basic flying skills. The problem is that due to the special emphasis on "use of available automation," the pilot may try to program his way out of a problem rather than revert to basic flying skills to correct the situation. Respondents' participation is expected to occur on three occasions spanning less than 45 days, total.
- ***Description of the procedures to be utilized:*** The research will be conducted as a three-round Delphi technique in which respondents will be asked to respond to a single question in the first round, then to comment on issues brought out by all respondents in the first round.
- ***Description of any benefits to the respondents…*** None, to the respondent, other than the satisfaction of speaking freely on the subject. By defining the issues, there will be some benefits to the industry and to society.
- ***Statement describing the extent …to which confidentiality will be maintained:*** Respondents' identifying information will be separated from their responses upon receipt (except for consent form). Respondents' names and other identifying information will not be used. PI is only person having access to the email account being used.
- ***Explanation of how and whom to contact about:***

  The research: PI, Charles Sullivan; 817- 492 - 8060; charles.r.sullivan@att.net

  Research respondents' rights: the IRB office at 405 - 744 - 5700

Additional contact: Dr. Carol Olson, IRB Chair, Oklahoma State University, 415 Whitehurst, Stillwater, Oklahoma 74078; or Dr. Steven Marks, 308 Cordell North, Stillwater, OK, 74087 or steve.marks@aesp.nasa.okstste.edu.

VOLUNTARY PARTICIPATION

I understand that participation is voluntary and that I will not be penalized if I choose not to participate. I also understand that I am free to withdraw my consent and end my participation in this project at any time without penalty after I notify the project director, Charles Sullivan at

817-492-8060 or charles.r.sullivan@att.net

CONSENT DOCUMENTATION

I have read and fully understand this consent form. I consent freely and voluntarily. My reply to this document constitutes my consent.

(Consent by clicking "REPLY")

PI'S STATEMENT

I certify that this document explains all required elements of the research study to the respondent, and that I am available to answer any additional questions that may arise through email (charles.r.sullivan@att.net) or by phone (817-492-8060). Asking the respondent to click on "REPLY" is equivalent to asking the respondent to sign the form.

APPENDIX D

NOTIFICATION TO EXPECT THE DELPHI QUESTION

22 May 2006

Dear Delphi Respondent,

Thank you for agreeing to participate in this study. I believe the study addresses an important issue in the training community.

On Tuesday, 23 May, I will start the Delphi process by sending the question to each of you to discover your thoughts and comments, in the first of three rounds.

Please take a moment as soon as possible to look at the question and put down your thoughts about the issues involved in the question from your standpoint as an IP and/or evaluator. You can return your responses either as a reply to the question itself or as a new email to charles.r.sullivan@att.net.

The question will have instructions. **The important thing for round one is to get started. *What do you think when you consider the question?***

Remember that you will never be identified -- so you may say anything you wish!

For Round Two (early June), you will receive a compilation of all the respondents' comments from Round One, for your further consideration.

After I send the question, you won't hear from me for about two weeks. **Time is critical! Each round should be returned within ten days.**

Thank you, again, for your participation.

Chuck Sullivan (PI)
817-492-8060

APPENDIX E

DELPHI QUESTION: ROUND 1

23 May 2006

Round 1

The FAA requires the demonstrated use of automation during type and recurrent flight checks. (A) How does this requirement lead to over-reliance on automation, and, (B) What actions can be taken by the training community to correct this possible trend?

Please engage in individual brainstorming so as to generate as many ideas as possible for dealing with this issue. Please list each idea in a brief, concise manner and e-mail your response to me. Your ideas need not be fully developed. It is preferable to have each idea expressed in one brief sentence or phrase. No attempt should be made to evaluate or justify these ideas at this time. Treat each half of the question as a standalone part. Your ideas will be anonymously included in the next questionnaire.

Idea # 1A:

Idea # 2A:

Idea # 3A:

Idea # 4A:

Idea # 5A:

Idea # 6A:

Idea # 7A:

Idea # 8A:

Idea # 9A:

Idea # 10A:

Idea # 1B:

Idea # 2B:

Idea # 3B:

Idea # 4B:

Idea # 5B:

Idea # 6B:

Idea # 7B:

Idea # 8B:

Idea # 9B:

Idea # 10B:

APPENDIX F

DELPHI QUESTION: ROUND 2

19 June 2006

Round Two

Thank you all for your responses to Round 1 (of 3). Your answers were thoughtful and insightful from the perspective of your areas of expertise and years of experience, and fell between a terse statement that there are no problems with either the Special Emphasis section of the PTS or the way ATP initial and recurrent checks are administered, to dire warnings that we are doomed to creating a generation of accidents just waiting to occur if we don't make some significant changes to the system in short order. There were levels of both humor and bitterness in some of the responses, and that is good, for it signifies that you are taking the question seriously, whichever side you happen to be on.

Sixteen of 20 potential respondents replied positively to my initial request for assistance. Each of you were carefully chosen based on your unique experiences and qualifications in the aviation community as well as being qualified instructor pilots, and in some cases, examiners. The diversity in your backgrounds will bring an insightful view of the question.

In this round, you will be asked to comment on the discoveries of Round 1. Please feel free to consider, reconsider, rebut, challenge the other opinions represented, and/or modify or update your own ideas/opinions as you see fit. Remember that you are transparent to one another and your identities will never be divulged, so you are free to voice your opinions.

INSTRUCTIONS
This is a busy season for us all. The effective date of transmission for Round 2 is Tuesday, 20 June. In order to process the data and have round 3 available for you the week of 9 July, **it is imperative that I have your responses not later than Friday, 30 June.**
You may make your comments as long or short as you like. **Please use "reply" and make your comments adjacent to the area you wish to reply to. Additional comments may be added if you wish: New discovery is appropriate and will be cheerfully accepted.**

The question is unchanged:
The FAA requires the demonstrated use of automation during type and recurrent flight checks. (A) How does this requirement lead to over-reliance on automation, and, (B) What actions can be taken by the training community to correct this possible trend?

Synopsis of Round 1

As PI, I have collected the many responses and grouped them into general categories of discovery. Each category has a representative sampling of the comments received. There are direct as well as indirect quotes included throughout for flavor and color. Some colors had to be modified a little. Keep in mind that the question is not limited to your immediate workplace, but is directed toward the universal pilot certification question. Discovery to date is applicable to both levels.

Please refine the ideas below by clarifying them if desired and by listing the strengths and weaknesses you associate with each. Please list any new ideas at the bottom of the questionnaire. Your ideas will be anonymously included in the next questionnaire.

The FAA requires the demonstrated use of automation during type and recurrent flight checks.

Part A

How does this requirement lead to over-reliance on automation?

Idea 1. Over-reliance on automation does not seem to be a problem at this time.

-Over-reliance does not appear to be a problem, SOPs are.
-“Why would over-reliance be a problem?”
-“I reject the notion that over-reliance exists.”

- ♦ Your clarification (if any)
- ♦ Strengths
- ♦ Weaknesses

Idea 2. Lack of skills in using available automation may be the problem.

- The lack of skills in using available automation results in being unable to manage the system.
-“Pilots lacking an understanding of the automation technology tend to use it improperly and poorly.”
-A pilot’s computer skills may impact his ability to pass a flight check, for example, “older pilots may find automation such as a glass cockpit more of a deterrent than a benefit.”

- ♦ Your clarification (if any)
- ♦ Strengths
- ♦ Weaknesses

Idea 3. Training doctrine puts a high priority on automation.

- Should mastering the automation be the greatest concern?

♦ Your clarification (if any)

♦ Strengths

♦ Weaknesses

Idea 4. Total reliance on automation is all right because the equipment is "Pilot Proof."

-"Flight training is easier with the autopilot than hand flying."
"I believe it is engineered to be pilot proof and won't accept obviously wrong stuff."

- Given the safeguards and redundancy, it's all right to be reliant on the automation.

♦ Your clarification (if any)

♦ Strengths

♦ Weaknesses

Idea 5. Problems with total reliance.

- A little knowledge is a dangerous thing. When "the box" breaks, the crew is lost. Crews must be taught how to get back to basics when the fancy stuff fails.
- "There is a vast majority of pro pilots out there that do not break out the enroute charts when outside the terminal areas. If things did go black, there would be a substantial spool time required to regain SA and revert to basics (green data)."

♦ Your clarification (if any)

♦ Strengths

♦ Weaknesses

Idea 6. Necessity to evaluate skill in automation use.

- “The proper use of automation to fly modern aircraft is a skill just like hand flying. It needs to and should continue to be evaluated.”
- Based on the current reliability and multiple levels of automation, we should be to demonstrate proper use.
- How do we define, and then measure over-reliance?
- Who is in the best position to make that determination?

♦ Your clarification (if any)

♦ Strengths

♦ Weaknesses

Idea 7. Problems with poor skills:

Pilots with poor flying skills are most likely to use automation as a crutch and are at highest risk for over-reliance.

“Reliance on a Flight Director for manual flying shrinks the instrument scan to the FD and the airspeed indicator.” This can lead to uncoordinated flight under abnormal flight situations.

“Over-reliance implies a balance between automation and manual skills has not been maintained.” Due to company policy on autopilot use.

♦ Your clarification (if any)

♦ Strengths

♦ Weaknesses

Idea 8. Need for additional training

The complexities of installed automation may require additional training to use and master the equipment.

Not understanding the capabilities of the system can result in information overload.

♦ Your clarification (if any)

♦ Strengths

♦ Weaknesses

Idea 9. Automation is on the aircraft; therefore I MUST use it.

> “Automation is like getting a new toy. The tendency is to play with the new toy to the exclusion of the old one. This can lead to less use of manual control and a loss of basic proficiency.”
>
> The flight department directs use above 400 ft

- Your clarification (if any)
- Strengths
- Weaknesses

Idea 10. Over-Reliance is based on pilot experience.

> “The older pilot has a broad background of experience to fall back upon. A younger pilot lacks this experience, therefore would be more apt to rely on automation. The tendency to become over-reliant appears then to be inversely proportional to experience and would also appear to inversely generational as well.”
> What may seem to be over-reliance for one pilot skill (experience) level may not necessarily be over-reliance for another.
> “Over-reliance should not occur for an experienced, competent and well-trained pilot.”

- Your clarification (if any)
- Strengths
- Weaknesses

Idea 11. The lack of industry-wide standardization contributes to the problem.

> “The absence of intuitive interfaces and standardization across all manufacturers creates a cumbersome and time consuming training requirement.”

- Your clarification (if any)
- Strengths
- Weaknesses

Idea 12. Insufficient syllabus time to properly train crews.

"As trainers, we don't have the (syllabus) time to emphasize and practice reverting back to a primitive level of aircraft control."

- "The time allocated for training is set at the lowest level in order to maximize throughput."
- "Time required training a pilot to understand and properly use automation implies that precise utilization of automation supersedes efficient operation of the aircraft."

♦ Your clarification (if any)

♦ Strengths

♦ Weaknesses

Idea 13. Over-reliance results in loss of Situational Awareness (SA).

Pilots become so reliant on automation they lose Situational Awareness (SA).

Over-reliance doesn't just happen on its own.

"A pilot allows himself to become over-reliant over time and lose SA"

♦ Your clarification (if any)

♦ Strengths

♦ Weaknesses

Idea 14. The use of automation may lead to a feeling of invulnerability and infallibility.

- "Automation is a powerful tool, but only as good as the skill and knowledge of the operator."

♦ Your clarification (if any)

♦ Strengths

♦ Weaknesses

Idea 15. The Special Emphasis direction in the PTS forces over-reliance to be taught.

"The Special Emphasis section of the PTS may lead instructors to focus more on automation and less on systems knowledge. We sometimes teach that automation cures the problem."

- Your clarification (if any)
- Strengths
- Weaknesses

The FAA requires the demonstrated use of automation during type and recurrent flight checks. How does this requirement lead to over-reliance on automation, and,

Part B

What actions can be taken by the training community to correct this possible trend?

Solution 1. Increase training time without sacrificing systems integration.

"GA (and airline) training courses are dangerously too short to give comprehensive training on the use of all systems and equipment installed on the aircraft for a majority of pilots. Courses need to be longer and not so compressed in order to allow this type of training."
Increase training time to cover both automation and redundancy to the next level of flight management.
Develop flight lessons specifically for automation skills.
Set training requirements for "hands on" skill demonstration.

- Your clarification (if any)
- Strengths
- Weaknesses

Solution 2. Change training to teach specific techniques to handle automation.

"Emphasize techniques of "de-layering" automation during training."
Crew must be taught to regress to less automation when there is an apparent discrepancy.
"Require pilots to define the differences between levels of automation."
Pilots must recognize abnormalities and apply necessary and appropriate resources.
Create scenarios to demonstrate limitations of automation.

- Your clarification (if any)
- Strengths
- Weaknesses

Solution 3. Establish a definable minimum level of training.

There is an "obligation to determine a 'norm' for adequate training time and evaluation. "Past practices are suspect."

"Identify the minimum skill level and train to that rudimentary level. (Especially pilots new to the aircraft or systems.)"

- Your clarification (if any)
- Strengths
- Weaknesses

Solution 4. Instructor/evaluator must create balanced levels.

During checkrides make sure manual skills are demonstrated to balance the use of automation.

"The use of automation may require a new approach to training to include establishing new skillsets as well as new flow patterns."

- Your clarification (if any)
- Strengths
- Weaknesses

Solution 5. Require demonstration of manual skills before allowing automation.

Require the pilot to perform high difficulty tasking without automation during recurrent training.

Require raw data approaches to proficiency before allowing FD coupled operations.

Limit automation to those who can demonstrate manual skills.

Train pilots on instrument flight without the FD.

"Measure manual proficiency before introducing automation."

- Your clarification (if any)

- Strengths

- Weaknesses

Solution 6. Require use of manual operations **<u>after</u>** automation mastered.
Emphasize proficiency in non-automated environment.

- Your clarification (if any)

- Strengths

- Weaknesses

Solution 7. Ensure proper usage of automation.
"Ensure automation is used as a tool, not a crutch."
"Clearly define the use of flight guidance modes."

- Your clarification (if any)

- Strengths

- Weaknesses

Solution 8. "Training in cockpit automation should be separated from aircraft specific training and introduced at some later point in training."

- Your clarification (if any)

- Strengths

- Weaknesses

Solution 9. Recurrent and subsequent training should include incrementally more difficult and complex scenarios teaching more effective and appropriate uses of automation.

- Your clarification (if any)
- Strengths
- Weaknesses

Solution 10. "Trainers must be trained to teach specific automation installed in the aircraft to include conceptual fundamentals of the level of automation to be utilized in specific situations and features that may be inappropriate."

- Your clarification (if any)
- Strengths
- Weaknesses

Solution 11. Intensify training on failure mode management.

- The automation should be used as a supplement to the primary tools in the aircraft, never as a substitute or sole source (unless trans-oceanic).

- Your clarification (if any)
- Strengths
- Weaknesses

Solution 12. Courseware development must be upgraded to allow for maximized training.

- Classrooms need interactive computer generated presentations.
- Laptop training courseware needs to be developed end implemented.

- Your clarification (if any)
- Strengths
- Weaknesses

Solution 13. The training community must develop internet-based interactive training modules to prepare the pilot **prior** to his arrival at the training site.

- ♦ Your clarification (if any)
- ♦ Strengths
- ♦ Weaknesses

As one of your colleagues said, “My head hurts from all this thinking. I am going to start the spell checker, push the send button, engage the autopilot, and go get some coffee.”

Thank you for your time and efforts!

APPENDIX G

DELPHI QUESTION: ROUND 3

19 June 2006

DELPHI ROUND 3

The purpose of this round is to rate the ideas and solutions developed during the first two rounds of the Delphi study dealing with the issue:

> The FAA requires the demonstrated use of automation during type and recurrent flight checks. (A) How does this requirement lead to over-reliance on automation? and, (B) What actions can be taken by the training community to correct this possible trend?

The following are a summation of the ideas and solutions developed by the participants during Rounds 1 and 2. In this round you are asked to rate each idea and solution. With your rating, I will be able to determine which of the ideas and solutions you consider to have the greatest merit for dealing with the question.

Please review the entire list of ideas and solutions. Then use the 'reply' function and rate each idea and solution on a scale of 0 to 7, ***with 0 being the lowest rating and 7 the highest. 0, being the lowest rating, will indicate the statement has little or no merit to either determining the existence of a problem or a solution. 7, as the highest rating, will indicate the statement has significant merit pertaining to the existence of a problem or the solution.*** If you have additional comments, feel free to add them next to the appropriate idea or solution.

Thank you for your efforts, your time and patience. You have been forthright and thoughtful in your participation. I gratefully appreciate the time and effort you have devoted to this project.

IDEAS (Part A)

___1. Over-reliance on automation does not seem to be a problem at this time.

___2. What is perceived as over-reliance may be a lack of skill in utilizing available automation.

____3. Training doctrine puts a high priority on automation.

____4. Total reliance on automation is acceptable based on system design and redundancy.

____5. The proper use of automation to fly modern aircraft is a skill just like hand flying. It needs to and should continue to be evaluated.

____6. Pilots with poor flying skills are most likely to use automation as a crutch and are at highest risk for over-reliance.

____7. The complexities of installed automation may require additional training to use and master the equipment.

____8. Over-reliance is generally dependent on pilot experience. It appears to be inversely proportional to experience.

____9. No pilot trained on " …needle, ball and airspeed …" will become over-reliant.

____10. The lack of industry-wide standardization is a causal factor to the problem.

____11. There is insufficient syllabus time to properly train crews in the proper use of automation.

____12. Over-reliance on automation results in a loss of situational awareness (SA).

____13. Over-reliance on automation may lead to a feeling of invulnerability and infallibility.

____14. The Special Emphasis section in the Practical Test Standards (PTS) forces over-reliance to be taught.

SOLUTIONS (Part B)

____1. Increase training time without sacrificing systems integration.

____2. Training should include specific techniques to handle automation.

____3. Definable minimum levels of training must be established.

____4. The evaluator must create a balanced level during the checkride to ensure manual skills are demonstrated to balance the use of automation.

____5. There must be satisfactory demonstration of manual skills before allowing the use of automation.

____6. Require the use of manual skills after automation has been mastered.

____7. The instructor and examiner must ensure the automation is used as a tool, not a crutch.

____8. Training in cockpit automation should be separated from aircraft specific training and introduced at some later point in training.

____9. Recurrent and subsequent training should include incrementally more difficult and complex scenarios, teaching more efficient and appropriate uses of automation.

____10. Trainers must be trained to teach the specific automation installed in the aircraft to include the conceptual fundamentals of how the system software determines courses of action in specific situations.

____11. Intensify training in failure mode management. Automation should be used as a supplement to the primary tools in the aircraft, never as a substitute.

____12. Courseware development must be upgraded to allow for maximized training.

____13. The training community must develop internet based interactive training modules to prepare the student prior to his arrival at the training site.

APPENDIX H

TABLE II

ROUND 3 RANKING OF DOMINANT IDEAS BY THE

DELPHI PANEL

NUMERICAL DATA

TABLE II

ROUND 3 RANKING OF DOMINANT IDEAS BY THE DELPHI PANEL

Idea	Scores Received	Total	Mean
Idea	Scores Received	Total	Mean
1.	0,5,0,3,1,1,0,2,5,0,5,4,2,2,6,3	39	2.4375
2.	5,4,4,0,3,2,3,4,6,7,7,6,2,6,2,6	67	4.1875
3.	6,3,7,3,6,6,6,4,7,4,3,6,6,7,6,4	84	5.2500
4.	0,0,0,3,1,5,0,0,0,2,2,5,1,6,2,3	30	1.8750
5.	7,6,5,7,6,5,6,6,7,7,6,7,7,6,7,6	101	6.3125
6.	7,6,1,5,6,6,6,6,6,2,4,5,5,6,5,6	82	5.1250
7.	7,7,5,7,7,7,7,6,6,7,3,5,5,6,5,6	97	6.0625
8.	3,6,7,4,6,6,6,5,6,4,5,5,3,6,7,5	84	5.2500
9.	1,2,3,0,4,7,0,1,6,1,1,0,5,2,3,2	40	2.5000
10.	5,6,7,7,5,5,5,5,2,5,3,3,4,6.7,4	79	4.9375
11.	6,3,3,7,6,0,7,4,3,7,6,4,5,2,6,3	72	4.5000
12.	7,4,7,0,7,6,5,5,6,7,0,1,3,6,3,6	73	4.5625
13.	7,2,4,5,7,6,7,4,6,5,0,3,5,3,6,6	76	4.7500
14.	5,3,7,0,6,5,4,4,3,4,0,4,5,6,5,3	64	4.0000
Solution			
1.	5,4,6,7,5,7,7,4,6,6,7,4,4,4,7,7	90	5.6250
2.	6,6,7,7,7,7,6,6,7,7,7,7,7,4,7,6	104	6.5000
3.	4,5,7,7,7,6,6,4,7,7,7,5,4,6,2,7	91	5.6875
4.	7,7,7,7,6,6,7,7,7,4,7,5,3,6,2,5	93	5.8125
5.	4,7,7,3,5,6,5,5,5,4,7,6,6,2,3,5	80	5.0000
6.	0,5,5,4,1,4,1,2,7,7,1,6,2,6,6,4	81	3.8125
7.	7,6,7,7,7,7,6,6,7,3,7,5,7,2,7,6	97	6.0625
8.	1,2,0,0,1,1,0,1,2,2,0,1,7,2,1,2	23	1.4375
9.	7,5,7,7,6,6,5,6,6,5,7,5,3,6,5,6	92	5.7500
10.	7,3,6,7,5,6,6,4,6,7,0,4,7,2,7,6	83	5.1875
11	7,6,7,7,6,6,6,6,7,5,7,4,1,6,5,3	89	5.5625
12.	0,4,7,7,6,6,3,2,7,7,7,6,4,6,6,1	79	4.9375
13.	3,4,7,3,5,6,5,3,7,3,0,5,5,3,6,3	68	4.2500

APPENDIX I

TABLE III

RESULTS OF RESPONDENTS’ RATING OF FINDINGS

NUMERICAL DATA

TABLE III

RESULTS OF RESPONDENTS' RATING OF FINDINGS

Idea	Mean	Rank Order
5.	6.3125	1
7.	6.0625	2
3.	5.2500	3
8.	5.250	4
6.	5.125	5
10.	4.9375	6
13.	4.7500	7
12.	4.5625	8
11.	4.5000	9
2.	4.1875	10
14.	4.0000	11
9.	2.5000	12
1.	2.4375	13
4.	1.875	14
Solution		
2	6.5000	1
7	6.0625	2
4	5.8125	3
9	5.7500	4
3	5.6875	5
1	5.6250	6
11	5.5625	7
10	5.1875	8
5	5.0000	9
12	4.9375	10
13	4.2500	11
6	3.8125	12
8	1.4375	13

VITA

Charles Richard Sullivan II

Candidate for the Degree of

Doctor of Education

Thesis: RECURRENT FLIGHT TRAINING TRENDS: A DELPHI STUDY TO DETERMINE POSSIBLE LOSS OF PILOTING SKILLS

Major Field: Applied Educational Studies

Biographical:

Personal Data: Born in San Angelo, Texas, August 9, 1942, the son of Frank E. and Helen S. Sullivan.

Education: Graduated from Rancho High School, North Las Vegas, Nevada in May 1960. Received Bachelor of Science in Industrial Management degree from the University of Nebraska, January 1972; received Master of Science degree in Natural and Applied Sciences from Oklahoma State University in December 1997; completed the requirements for the Doctor of Education degree from Oklahoma State University in December 2006.

Experience: Twenty four years experience as an Air Force pilot. Fifteen years working with the Airborne Warning and Control (AWACS) program in the U. S. and Europe. Served as Chief of Training for Airborne Early Warning on staff at Supreme Headquarters Allied Powers Europe (SHAPE) for four years, responsible for flight training activities for 16 separate crew specialties. Retired from the Air Force and entered civilian aviation. Certificated Flight Instructor since 1976. Senior ground school instructor for the University of Oklahoma, 1991-1998, adjunct instructor for Oklahoma State University; 1997-1998. Chief Flight Instructor at Delta State University1998-2001. Instructor Pilot and Training Center Evaluator for Bombardier Aerospace 2001 to present.

Charles Richard Sullivan II Date of Degree: December 2006

Institution: Oklahoma State University Location: Stillwater, Oklahoma

Title of Study: RECURRENT FLIGHT TRAINING TRENDS: A DELPHI STUDY TO EXAMINE POSSIBLE LOSS OF PILOTING SKILLS

Pages in Study: 92 Candidate for the Degree of Doctor of Education

Major Field: Applied Educational Studies

Scope and Method of Study: The purpose of this study was to ask aviation training experts to explore to what extent basic and fundamental piloting skills could be lost or degraded due to over-reliance on automation, and, what corrective action could the training community take to correct the problem. A Policy Delphi was conducted using a panel of 16 respondents drawn from three major aviation training facilities in north Texas. The study was limited to corporate level aircraft requiring a type rating to operate.

Findings and Conclusions: The respondents agreed that over-reliance on automation does exist. The migration of training doctrine from aircraft control to systems management was cited as a causal factor. Company training policies and Standard Operating Procedures driven by FAA testing philosophies were also cited as a factor. Respondents agreed that training philosophy should include automation, but not to the exclusion of hands-on flying requirements. They believed that training centers must improve the content of both initial and recurrent class syllabi to better present the capabilities and limitations of installed automation. Finally, they stated that the FAA should direct a common presentation of automated data similar to the basic six flight instrument presentation.

ADVISER'S APPROVAL _______STEVEN K. MARKS____________________