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Degradation of Piloting Skills

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DEGRADATION OF PILOTING SKILLS

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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

ABSTRACT

With the advent of advanced, highly automated cockpits that are found in modern jet transport category aircraft, most of the tedious work of flying the aircraft solely by reference to raw data information from the airplane's instruments is becoming a thing of the past. Pilots are no longer required to use their basic instrument skills on a daily basis and as a result, their basic instrument flying skills may diminish over time due to lack of use.

The purpose of this study was to gain an assessment of professional pilots' basic instrument skills. The study used both qualitative and quantitative measures to accomplish this task.

The hypothesis for this study was that with the advent of advanced aircraft, a pilot's basic instrument flying skills will diminish over time, and will no longer be at the level required when they received their ATP license. The two research questions were to what extent degradation in basic instrument pilot skills occurs, and can this degradation be statistically proven?

The study used two groups of pilots (wide-body and narrow body) flying five basic instrument maneuvers. The maneuvers were flown without the use of any automation. Each maneuver was flown 30 times. Statistical analysis was conducted on the pilots groups looking for significant differences between groups.

In addition to the quantitative portion of the study, the pilots were surveyed to gauge their individual perceptions of their instrument skill level. The survey results were compared and correlated to the data from the maneuvers flown by the pilots.

When analyzed, using a t-test, all of the maneuvers showed a significant degradation below what is required for Airline Transport Pilot (ATP) certification. In each case the mean maneuver grade was close to the basic instrument certification standard as defined by the Federal Aviation Administration (FAA). There was no statistical significance between different groups of pilots that participated in the study.

The survey portion of the study revealed that most professional pilots agree that their basic instrument skills have declined over time. However the pilots in the study also believed that they could still fly the airplane by reference to raw data with a high degree of skill. Maneuver grades and survey responses indicate that the pilots overestimated their basic instrument skills.

This study did not seek to investigate professional pilot's overall flying skills which remain both safe and highly competent. It only intended to investigate a small segment of overall piloting skills. By increasing a pilot's basic instrument skills, overall flying skills can be enhanced as well as the ability to cope with instrumentation failures that degrade the fidelity of the modern glass aircraft. The problem of decreased instrument skills will continue into the future as more older-generation aircraft are retired. Additional training and practice should be sufficient to retain these skills.

CHAPTER 1

DEDRADATON OF PILOTING SKILLS

Introduction

With the advent of advanced, highly-automated cockpits found in modern jet transport category aircraft, most of the tedious work of flying the aircraft solely by reference to raw data information from the airplane's instruments is becoming a thing of the past. In fact, many of the airlines now suggest that pilots not hand fly the aircraft with the automation turned off (United, 2006). In years past, with older style aircraft, commercial pilots were required to do a majority of instrument flying by reference to raw data instrumentation. Although flight directors were installed on these aircraft, they were seldom used and often unreliable. The net result of this type of flying produced highly competent instrument pilots. With the increased use of automation, basic instrument skills flight may be declining. It is the purpose of this study to determine if the average jet transport pilot's basic instrument flying skills have diminished as a function of the time spent flying technologically advanced aircraft. Research on adult literacy skills does show a decline over periods of non-use (Wagner, 1995).

Problem

The piloting style of highly automated jet transport category aircraft may cause a commercial airline pilots' basic instrument flying skills to diminish over time. In fact, a recent research study asked pilots to evaluate their own instrument skills (Advanced Aircraft Technology Safety Survey Report, 1998). A majority of pilots responded that they believed their skills have diminished. In the survey 85% of respondents stated that they preferred to hand-fly part of every trip to retain their pilots skills. In addition, 43% pilots considered that their manual flying skills had declined since they started flying advanced technology aircraft. Most major airlines encourage the use of automation thus adding to the problem of possible skill degradation (United Airlines, 2006).

Purpose

The purpose of this study was to gain professional pilots' self assessment of their basic instrument flying skills. In addition, the study attempted to quantify if a statistically significant degradation of a professional pilot's instrument flying skills occurs over time while flying highly automated aircraft.

Significance

Certain failures in highly automated aircraft can cause complete loss of the auto-throttles, flight director, and moving map display, thus forcing the pilots to revert to their basic instrument flying skills. If a significant decline in basic instrument flying skills is observed as a function of time spent flying technologically advanced aircraft, then a potential safety risk exists. If any degradation of skills can be empirically documented and proven, then the airlines can use this study to develop specific training programs and guidelines to improve basic instrument flying skills. In addition, guidance can be derived and given to professional flight crews on how to maintain their instrument skills during regular line operations.

Hypothesis

With the advent of advanced aircraft with modern auto-throttles, flight director, and FMC/map, a pilot's basic instrument flying skills will diminish over time and will no longer be at the level required when they received their ATP license. The null hypothesis is that even after flying advanced aircraft, professional pilots still met the minimum skills as defined by the FAA to pass an ATP check.

Research Questions

1. Do basic instrument piloting skills decline in pilots of advanced modern jet transport aircraft?
2. If basic instrument piloting skills decline in pilots of advanced modern jet transport aircraft, then does the decline depend upon time spent flying technologically advanced aircraft?
3. Does a professional pilot's perception of their instrument skills reflect their actual skill level?
4. Can this degradation be statistically proven by comparing these pilots against the Federal Aviation Administration's (FAA) standard for professional pilots (Airline Transport Pilot – ATP – standard).

Framework

This study was a mixed methodology study focusing on two aspects of basic instrument flying. First a qualitative survey was given to pilots to gauge their perception of their own instrument skills. The second part of the study required the use of first look data (data from maneuvers flown without pre-briefing or practice) from participating airlines and was quantitative in nature. Each pilot of the flight crew flew five basic instrument maneuvers (in the simulator) without any prior practice or briefing. The captain and first officer each started with a different maneuver (starting maneuver was based on the day of the week). The maneuvers were evaluated in accordance with standard airline industry grading criteria and were represented as a numerical rating. The data was completely de-identified and the maneuvers were non-jeopardy to the flight crew. The independent variable for the quantitative part of the study was the type of aircraft that pilots were flying, and the dependent variable was their basic instrument skill level. Each maneuver was flown 30 times by each of the following categories of pilots:

a. Pilots of long-haul wide-body aircraft (B777, B747-400 A330, A340).
b. Pilot of narrow-body short haul aircraft (B737-300, A320, B757)

The two pilot groups were each chosen due to the fact that they should show significantly different results. Narrow body pilots have a greater frequency of takeoffs and landings than those of wide-body aircraft. This frequency may add to a pilot flying proficiency. In addition, most wide-body aircraft rely heavily on automation due to the long duration of their flights. The study took both type of aircraft and frequency of flying into account.

There were 30 total pilots from a variety of backgrounds in the study. The number of pilots was chosen in order to gain a statistically significant sample approximating the skill level of the general professional pilot population. Each pilot group was compared using an independent samples t-test against the FAA proficiency standard with specific emphasis placed on the comparison between narrow-body and wide-body aircraft. This was done in an attempt to prove that there is a statistical difference between these pilots. Post hoc tests were performed on the different maneuvers sets to determine if the complexity of the maneuver affected the pilot's ability to successfully fly them. If the study hypothesis is correct the pilots of the modern aircraft should show a significant statistical difference as compared to the standard pilot performance as defined by the FAA. A summary of perceived instrument skills in each category was compared to the actual first look data results to see if there was any correlation between perceived piloting skills and actual performance.

Assumptions

1. Each participant was a qualified FAR pt 121 jet transport pilot employed by a US carrier (passenger or cargo).
2. Each participant has spent at least one year in the specific seat and type of aircraft. It is assumed that after one year of experience on a particular aircraft, that the pilot will be both comfortable and accustomed to flying that particular aircraft (the aircraft will not be "new" to them).
3. Each pilot was current and qualified in the respective aircraft.
4. Each pilot was considered a line pilot.
5. The pilots had no prior knowledge or practice of the maneuver that was flown and was given no opportunity to practice it beforehand.

6. Each pilot was assumed to fly to the best of their ability during the maneuver.
7. Each Check Airman rated the maneuvers on a consistent basis after receiving specific rater reliability training.

Limits

1. The study could be subject to inter-rater reliability errors of the individual instructors who evaluated the maneuvers.
2. The study did account for pilots who fly additional aircraft outside of their respective company which in many cases would be traditional style aircraft. The study asked in the survey if the pilot is flying outside of his/her professional employment.
3. This study was not designed to specify what, if any, additional training would be required to maintain these instrument flying skills (that will be a follow on study). The study recorded how long it has been since a pilot has flown in a professional capacity using “raw data”, and this in turn may lead to some insight as to how long these skills remain active.
4. The study tested only five maneuvers to determine the level of piloting skills and is only representative of a pilot’s basic instrument skills, and not their overall piloting skills.
5. This study is applicable to jet transport pilots of US carriers only.
6. The study does not account for the fact that most of the pilots of widebody glass aircraft spent many years flying traditional aircraft, and conversely the junior first officers of narrow body aircraft may have mainly flown

advanced aircraft. Some studies do indicate that skills learned and extensively practiced will be maintained and recalled at a higher rate than those skills briefly learned and utilized. (Argote, 1998).

Literature Review

A literature review was conducted of pertinent articles related to this study. Although there were no direct articles on this particular problem, there were many articles concerning professional flight crews and automation. The review begins with a broad overview of learning theory especially related to skill acquisition, retention, and declination. In addition to reviewing only automation related issues, skill retention issues in the other fields were reviewed. Finally, an anecdotal study on the reliance on GPS was reviewed to add some additional perspective to the problem of negative learning transfer with related system reliance problems. The automation articles were from a wide range of government and private bodies that are considered experts in the field of automation.

Learning a Complex Skill

In the study, *Knowledge Structures and the Acquisition of a Complex Skill*, the researchers examined the viability of knowledge structures as an operationalization of learning in the context of a task that required a high degree of skill (Day, 2001). During a period of three days, 86 men participated in nine training sessions on learning to play a complex video game. After a four day non-practice period, the participants completed tests of skill retention and skill transfer. The findings of the study indicated that the similarity of trainees' knowledge structures to an expert structure correlated with skill acquisition and was predictive of skill retention and skill transfer (Day, 2001). In addition, knowledge structures mediated the relationship between general cognitive ability and skill based performance.

Knowledge structures are based on the premise that people organize information into patterns that reflect the relationships that exist between concepts and the features that define them (Johnson-Laird, 1983). These structures represent the organization of knowledge. Declarative knowledge reflects the amount of knowledge or facts that are learned. Memory organization enables individuals with a means for organizing and retrieving information for long term storage. The study used a technique called structural assessment (SA) to measure knowledge structures (Johnson-Laird, 1983). In a training context, knowledge structures reflect the degree to which trainees have organized and comprehended the content of training. SA can be used to identify knowledge structures that differentiate between experts and novices.

The study (Knowledge Structures) expected to find that the accuracy of trainees' knowledge structures to have a positive correlation with skill acquisition, retention, and transfer (Day, 2001). As individuals gain knowledge of a concept or task, their knowledge structures converge toward a true representation of that task. The researchers in the study assumed that an expert's organization and comprehension of a domain of knowledge are a close approximation of the true representation of that domain, and that this expert structure can be considered an indicator of skill development.

The results of the study showed that trainees whose knowledge structures were more similar to an expert structure performed substantially better on mastering the video game. General cognitive ability was correlated with the accuracy of trainees' knowledge structures, and had a strong relationship with a mechanically combined referent structure (CM) (expert memory organization). CM was related to skill acquisition. The structure of the highly skilled trainee reflected functional similarities (to an expert), whereas the structure of the poorly skilled trainee reflected superficial similarities (Day, 2001). Finally, the study found that trainees with a higher cognitive ability have knowledge structures that are more similar to an expert in nature (Day, 2001).

Learning Degradation

Argote (1990) examined the persistence and transfer of learning using production rates and transfer of knowledge of producing Liberty War ships (during World War II). During a review of the most prevalent research, the study found that little evidence about the extent to which learning persists (Argote, 1990). The study also concurred with the fact that the time required to perform a task declined at a decreasing rate as experience with the task increased. However, previous studies also found that if practicing of a task was interrupted; forgetting occurs (Ebbinghaus 1885). While interference from other tasks causes forgetting, forgetting occurs when performance is delayed even if there is no interference (Anderson 1985). When performance is resumed, it is typically inferior to when it was interrupted (Kolers, 1976). The study found that the "conventional measure of learning, cumulative output, significantly overstates the persistence of learning" (Argote, 1990 page 145). Results from the study indicated a rapid rate of learning depreciation, in some cases as much as 97% over a one year period. It must be noted that all data for the study was gathered from shipyards in the 1940s.

The opportunity for pilots to practice and maintain their skills has decreased significantly over time (Advanced Aircraft Technology Safety Survey Report, 1998). Airline polices, advanced automation, and increased long haul flying has all added to this decreased opportunity to manually fly the airplane. To combat this problem, some airlines have added simulator sessions to allow pilots to practice hand flying skills. A recent survey of pilot perceptions indicated that 85% of respondents prefer to hand-fly part of every trip to retain their skills. A statistically significant difference was noted between the responses of captains and first officers, with first officers more likely to prefer to "hand-fly part of every trip than captains." (Advanced Aircraft Technology Safety Survey Report, 1998, page 28). "Forty-three per cent of pilots considered that their manual flying skills had declined since they started flying advanced technology aircraft." (Advanced Aircraft Technology Safety Survey Report, 1998, page 29). Most pilots hand-fly their aircraft at some stages of each flight to maintain an acceptable skill level. Anecdotal evidence indicates that the main reasons for this are a pilot's natural satisfaction in performing manual flying tasks, the requirement to perform manual flying exercises during simulator sessions (including recurrent training and license renewal) and the need to be able to manually fly the aircraft should the automated systems fail to function as expected.

It would appear that the attempts of both the pilots and their airlines have not succeeded in maintaining a perceived level of manual skills. Of concern are pilots who continue to manually control an aircraft with a diminishing level of skill. This has been recognized by some airlines who have implemented supplementary simulator programs to compensate for a perceived loss of manual flying skills. Some airlines have required pilots to demonstrate their manual flying skills during simulator exercises to fulfill the requirements set down by regulatory authorities (Advanced Aircraft technology Safety Survey Report, 1998). These requirements (for example, manually flown instrument approaches or emergency descents) are often outdated and thus not appropriate for the current level of technology. Further research is needed to determine how pilots can best maintain their manual flying skills, the reliability of autopilot systems, and the appropriateness of license renewal procedures. The Bureau of Air Safety Investigation recommends that the Civil Aviation Safety Authority (Australia) ensure that all recurrent and rating renewal simulator exercises are appropriate considering the level of automation fitted to the aircraft type. Such exercises should reflect the level of serviceability which the pilot may be expected to encounter during line operations. (Advanced Aircraft Technology Safety Survey Report, 1998)

Stefanidis (2006) examined the proficiency of highly complex skills over a period of time if those skills are not used. Specifically, the study found that laparoroscopic surgery skills declined by 40% in residents after 15 months of non-use. The study developed a hypothesis that a complex laparoscopic skill (suturing) acquired by novices using a proficiency-based curriculum would be better maintained with ongoing training compared with a control group. The study's specific aims were also to measure long term retention by novice learners and to identify the time interval at which skill deterioration initially becomes detectable, so that maintenance training interventions can be appropriately timed during future curricula (Stefanidis, 2006). To assess retention, both groups performed three repetitions of laparoscopic suturing at 2 weeks and at 1, 3, and 6 months post training completion without any instruction. The ongoing training group continued training after the first three repetitions at each follow up interval (starting at the first month) until the proficiency level was achieved on two consecutive plus five additional attempts. The study found that both groups had excellent retention at the six month period, but the ongoing training group retained a greater portion of their skill. Maintenance training reduced the skill loss to that of half of the control group. At 15 months, a similar group of surgeons demonstrated a 40% skill loss in spite of on the job training (unpublished data). The study went on to state that notable differences between the groups were detected and that ongoing training enhances skill retention. Finally, the study found that despite excellent initial training, in the absence of routine clinical use, complex skills diminish.

Another study on adult literacy skills titled Use it or Lose it, The Problem of Adult Literacy Skill Retention, published by the National Center for Adult Literacy, reported several key findings as they relate to skills retention. The study found that adult literacy skill retention varied dramatically from adult to adult depending on the individual learner, prior knowledge of the skill, and the type and duration of instruction (Wagner, 1995). It also found that extensive retraining of a skill is necessary after regular practice of that skill ceased (Wagner, 1995).

Automation Training

The Flight Safety Foundation published an article focusing on pilots transitioning to glass airplanes. In the article, the author (Wiener, 1999) made many recommendations on how to successfully train pilots on the operation of advanced aircraft. He suggested that there must only be one standard, and it must be taught and checked constantly. He also recommended that flight management should formulate a policy on maintaining manual flying (hand flying) skills and convey this to the pilots (Wiener, 1999). He also suggested that companies allow for the practice of non-automation-based problem solving skills. A similar study commissioned by the FAA reported similar findings.

As a result of a crash of an Airbus A300 in Nagoya Japan, the FAA chartered a human factors (HF) team to address automaton related issues. They were concerned that incidents and accidents such as what happed in Nagoya appeared to highlight difficulties in flight crews interacting with increasing flight deck automation. The HF team determined from its findings that vulnerabilities in flight crew management of automation and situation awareness exist. Among their findings were the pilots understanding of the automations' capabilities, limitations, modes, and operating principles and techniques (Abbott, 1992). The team also found differing pilot decisions about whether to turn the automation on or off during non-normal situations. In addition, the HF team made a specific recommendation to the FAA, that it should require operators' manuals and training programs to provide clear guidance on circumstances in which the autopilot should be engaged, disengaged, or used in a mode with greater or lesser authority.

Automation and Communication / Decision Making

In the study <u>Impact of Automation of Aircrew Communication and Decision-Making Performance</u>, the researchers' attempted to clarify the relationship between automation, crew communication, and effective decision making. The study involved 48 pilots flying predetermined simulator missions in either automated or manual conditions. The scenario was designed to require crewmembers to arrive at a collective decision based on information obtained about an evolving simulated disaster. The study found that the introduction of automation was not associated with better performance (Bowers, 1995). There were however, significant differences in the communications of crews flying in the automated versus manual conditions. Harmful consequences as a result of automation have been hypothesized that include increased complacency and decreased vigilance (Wiener, 1987) Results from the study indicated that communication rates measured in spoken works tended to decrease as the level of automation increased even though activity rates of piloting duties and problem solving remained equally high. The introduction of automation did not appear to result in improved crew performance. In fact, the data suggested a mild advantage for crews in traditional cockpits (Bowers, 1995). Further data suggested that automation resulted in a slight reduction in workload; however, this reduction was not associated with improved flight performance. The crews in the automated flight condition displayed worse performance on a decision-making task (Bowers, 1995). This study along with others on this topic indicates that a consequence of automation is the redistribution of workload and alteration of the crew process.

Automation Bias

A study titled Automation Bias: Decision Making and Performance in High-Tech Cockpits sought to quantify the effects of automation over-reliance in modern cockpits. This study pointed out the need for pilots to be able to fly the airplane when the automation does not function correctly. Automated aid and decision support tools are becoming the norm in today's' modern jet aircraft. Automation is assuming increasing control of cognitive flights tasks, such as calculating fuel-efficient routes, navigating, or detecting and diagnosing system malfunctions and abnormalities (Mosier, 1998). The term automation bias refers to omission and commission errors resulting from the use of automated cues as a heuristic replacement for vigilant information seeking and processing (Mosier, 1998). Highly automated cockpits tend to change the way pilots perform tasks and make decisions. Researchers have documented problems in the use of advanced automated systems, including mode misunderstanding, failures to understand automated behavior, confusion or lack of awareness concerning what automated systems are doing and why, and difficulty tracing the functioning or reasoning process of automated agent (Billings, 1996; Sarter and Woods, 1993).

In traditional aircraft, crewmembers are trained and develop their skills assessment through the use of both system and environmental cues (cross checking of information). In most situations, processing is facilitated by inter-correlations among cues (Wickerns and Flach, 1998). In the cross checking environment, which related to older technology aircraft, pilots often looked for many clues in determining if a problem existed. Pilots know and look for patterns or combination of cues that are most ecologically valid, reliable, or relevant for diagnosing particular situations, and they are able to incorporate contextual information to formulate a workable action plan based on their assessment of these cues (Kaempf and Klein, 1994).

When automated aids are introduced, the pattern of cue utilization is disrupted. Automated aids present powerful and usually highly accurate cues. In fact, computational system diagnostic capabilities are advertised as being more accurate than pilots. This leads to the overall attitude that the automated cues are not just another cue, but the most powerful and important cue. These automated decision aids feeds into the general human tendency to travel the road of least cognitive effort. Typically people try to engage in the least amount of cognitive work they can get away with (Fiske and Taylor, 1994). People will generally utilize heuristics (cognitive shortcuts) to reduce effort and information load.

It must be noted that automation does greatly aid in high-tech environments. These systems are designed to decrease pilot workload by performing many cognitive tasks. However indiscriminate use may have the effect of increasing errors. Inappropriate usage of automation in decision making may result in automation bias.

The study described two types of automation errors; omission errors and commission errors. Automation omission errors result when decision makers do not take appropriate action because they are not informed of an imminent problem or situation by automated aids (Moiser, 1998).

> China Airlines B747-SP, flying at 41,000 ft., lost power in its #4 engine. The autopilot, which was set for pitch guidance and altitude hold, attempted to correct for the loss by holding the left wing down, masking the approaching loss of control of the airplane. The crew did not realize that there was a problem with the engine and took no action to deal with it. When the captain disengaged the autopilot, the airplane rolled to the right, yawed, then entered a steep descent in clouds. Extensive damage occurred during descent and recovery (NTSB Report AAR-86-03, in Billings, 1996).

In a non-random sample of 166 events, the study found that the most likely phase of flight for omission errors to occur was the cruise phase. Automation commission errors are errors made when decision makers inappropriately follow automated information or directives (when other information in the environment contradicts or is inconsistent with the automated cue) (Moiser, 1998,).

> Experimental evidence of automation-induced commission errors was provided by a full-mission simulation in the NASA Ames Advanced Concepts Flight Simulator (ACFS; Mosier, Palmer, & Degani, 1992). During takeoff, crews received contradictory fire indications. An auto-sensing electronic checklist suggested that the crew shut down the #1 engine, which was supposedly on fire.
>
> Traditional engine parameters indicated that the #1 engine was recovering and that the #2 engine was actually more severely damaged. Seventy-five percent of the crews in the auto-sensing condition incorrectly shut down the #1 engine, whereas only 25% with the traditional paper checklist did likewise (Moiser, 1998).

The use of automated cues as a shortcut in decision making may result in omission or commission errors. Participants in this study were 25 commercial glass-cockpit pilots (i.e., pilots of automated aircraft, including Boeing 737-300,757,747,747-400, MD-11). The average age of the pilots was 47, mean total flight experience was 12,370 hr, and the average career flying time was 23 years (Moiser, 1998).

The participants were divided into two groups and given profiles to fly and their errors were recorded. Descriptive analysis of the results of the study revealed overall omission rates for flight-related events of approximately 55%. The results of the study found that automation bias is a significant factor in pilot interaction with automated aids. The study also found that most pilots are not utilizing all of their available information when performing tasks and making decisions. Experience and expertise, which might be predicted to make pilots more vigilant and less susceptible to automation bias, are related to a greater tendency to use only automated cues (Moiser, 1998)

Automation Over Reliance

The final portion of this literature review compares an anecdotal study of GPS usage vs. traditional navigation. A study in 2005 by Casner demonstrated that pilots who navigate solely with a GPS and moving map displays have significantly less situational awareness than those pilots flying with a traditional map. It was hypothesized that this drop in navigational awareness was due to the passive role assumed by pilots when using equipment that automates the navigational task.

In the first study two groups of pilots were given the task to navigate over three predetermined points. Pilot group one used only a current aviation map (sectional chart), whereas group 2 used only a GPS with a moving map display. Both pilot groups were again asked to navigate over the same circuit without the use of any navigational aids. The results were measured in deviation from the circuit points in nautical miles. Pilot group two performed significantly ($P \leq .05$) worse than pilot group one (Casner, 2005). In fact two pilots in the GPS group could not even find their way to the starting point of the circuit. The study then sought to find a way to keep pilots using GPS more aware of their surroundings. A third group of pilots was tasked to fly the same circuit as the first two groups.

Group three was permitted to use a GPS/moving map, however they were instructed to point out geological features along the circuit. The study used the hypothesis of deep vs. shallow processing in hopes that pilot group 3 would perform better than pilot group 2 while flying the circuit a second time. “In fact, performance of pilot group 3 was significantly better than group 2 during the second circuit (1.53 mean deviation vs. 4.92).” (Casner, 2005 page 8). The study concluded that the more pilot is active in a navigation task, the greater their navigational awareness.

This literature review sought to give a broad overview of the related issues involving professional pilot instrument skill degradation. The review touched on learning and retention theory as well as automation related issues. It also discussed similar issues in related fields.

CHAPTER II

METHODS

Introduction

With the widespread use of highly automated jet aircraft, will a professional pilot's basic instrument skills deteriorate over time? Twenty-five years ago, the only glass aircraft in production was the Boeing 767/757. At that time, pilots were required to do a majority of instrument flying by reference to raw data instrumentation. Today, however, a majority of US airlines fly highly automated glass aircraft. The tedious work of flying the aircraft solely by reference to raw data is becoming a thing of the past. It was the purpose of this study to determine if pilots are losing their basic instrument flying skills. In this chapter, the study population, sample, and design are discussed in detail.

Population

The population for this study was professional pilots of FAR 121 commercial carriers. More specifically, the study focused on pilots of major and/or global (in terms of revenue) US airlines. The aircraft that these pilots operate are termed transport category by the FAA. Furthermore, the study focused on the pilots of scheduled passenger airlines.

Sample

The study used data from airline pilots employed by US carriers during their recurrent training cycle. Each subject flew all five of the basic maneuvers.

Thirty pilots participated in the study. All of the subjects were active pilots employed by a major US air carrier (the carriers are not identified). Each pilot was either a Captain or First Officer and had flown their particular aircraft for at least one year. The average experience level was 7.1 years with a range from 2-16 years. There were 17 Captains and 13 First Officers, in addition, there were 18 narrow-body and 12 wide-body pilots. Pilots were also separated by the type of aircraft that they were assigned to, either wide-body (B747, B777, DC-10) or narrow-body (B737, A320, MD-80). The pilots were separated in order to determine if there were any statistical differences between these groups.

Study Design

This study utilized a mixed methodology study focusing on two aspects of basic instrument flying. First a qualitative survey was given to pilots to gauge their perception of their own instrument skills. The second part of the study required the use of first look data (data gained from pilot flying a maneuver without any warning or pre-briefing) from participating airlines and was quantitative in nature. The quantitative portion of the study was a quasi-experimental design with no formal control group. The first look data was obtained from a maneuver set comprised of: a takeoff, ILS approach, holding, missed approach, and an engine failure at V1. These maneuvers were flown without the use of auto-throttles, a flight director, or the FMC/map. They were flown solely be reference to raw data (heading, airspeed, attitude, and vertical speed instruments only). The first maneuver flown first was based on the day of the week.

Data Collection Methods/Procedures

Data collection for this study was focused on two parts. The qualitative portion was completed via survey, and the quantitative portion was done by a check pilot. The survey consisted of 13 multiple choice questions regarding the individual pilot's perception of their own instrument skills. Questions focused on how much basic instrument flying a pilot does on a regular basis, any flying outside of their professional employment, and their assessment of their instrument skills overall that specifically related to raw data flying. The only identification on this survey for was the aircraft, date, and seat position.

For the maneuvers, the study used the airline's check pilots who certify maneuvers for the FAA during recurrent training. The check pilots (check airmen) rated each maneuver based upon the observed performance of the pilot. The rating scale was as follows:

Table 1. Grading Scale

Five Point Grade Scale	5	The pilot remained well within airline standards and performance was exemplary.
	4	The pilot remained within airline standards. Pilot flew to ATP instrument standards
	3	The pilot committed minor deviations from airline standards that were promptly corrected. Basic instrument level.
	2	Major deviations (full scale deflection) for greater than 10 seconds
	1	The pilot committed major deviations from airline standards that were not promptly corrected and/or were unsafe; or was unable to perform the maneuver/task without assistance. Crash or loss of aircraft control.

On the data collection form, the aircraft type, date, and seat position was recorded only in order to match the pilot groups' objective performance with their subjective survey. In addition, a question asked how much experience the pilots had flying in their particular aircraft (at least one year to be included in the study).

Instrument Reliability and Validity

In order to ensure the success and content validity of the survey, it was evaluated by a panel of five experts to include; industry, union, and associated collegiate experts. The experts reviewed the survey for both content and structure.

The instrument for the maneuvers rating was a certified check airman. These pilots are certified by the FAA to evaluate maneuvers during recurrent training. They must attain a certain level of knowledge and experience before the FAA certifies them. In addition, these pilots must pass a practical exam administered by the FAA in order to be certified to examine maneuvers. In order to gain an accurate maneuver rating, each check airman completed a rater reliability training (RRT).   The check airman completed this requirement by reviewing a detailed instruction sheet on how the maneuvers were to be scored, examples of valid ratings, and examples of both correct and incorrect scoring. In addition a specific maneuver deviation sheet was included in each survey/maneuvers packet to further aid the check airman in scoring the maneuver.

Proposed Data Analysis

The survey portion of the study attempted to correlate the pilot's perceptions and attitudes towards their actual performance (in the pilot groups and not as individuals).

The maneuver scores were recorded and set in tables according to what group the pilot fell into. A descriptive analysis using SPSS was conducted on the maneuver data. In addition a series of independent t-tests were conducted comparing the two pilot groups for each maneuver. The alpha level for the entire study was .05.

Protection of Human Subjects

Pilots who participated in this study did so at no jeopardy to themselves in regards to their employment status at their respective airline. Participation in the study did not count towards successfully completing the required recurrent training program.. The research study received assurances in writing from the respective airline before the study began and made this point clear to the pilots before the maneuvers were flown via a written consent form. In addition, the participating airline gave its consent to be part of the study. The pilot's union was also notified of the study before data collection began. Pilots' survey responses and actual performance on the maneuvers was completely de-identified to protect both the pilots and their respective company. When the data material was received, it was also completely stripped of the company identification. This was done to prevent the results from any one company being compared to any other company or ending up published in the media.

CHAPTER III

RESULTS

This study consisted of two parts a qualitative survey and a quantative analysis of basic instrument maneuvers flown in the simulator. Maneuvers were graded against a set standard and compared to the FAA standard for Airline Transport Pilots. The survey was conducted in order to gain a perspective into both how pilots at major airlines fly their aircraft during normal operations, and how they perceive their own flying skills.

The quantative analysis of the study involved observing pilots flying five basic instrument maneuvers in an FAA certified level D simulator. The five maneuvers consisted of flying a takeoff, holding, ILS approach, missed approach, and a V1 cut. The order of the maneuvers flown was based on the day of the week. The maneuvers were rated by an FAA certified check airman and were graded 1-5 based on both a major airline's and FAA standards.

The type of aircraft the pilots flew was used in comparing both survey responses and maneuver performance. This comparison was done due to the fact that these two pilot groups fly similar hours per month, but have vastly different frequencies (number of takeoffs and landings). During a typical 20 hour trip a narrow body pilot may have as many as 12-15 takeoffs and landings, whereas a wide-body pilot would typically have only two. Due to a higher frequency of cycles, narrow-body pilots would perform better on the maneuvers than the wide-body pilots.

The certification standard for all airline pilots is defined by the FAA in "ATP Practical Test Standards". Airline standards are generally in line but never less than the FAA standards. The airline usually adds elements of time for deviations. When pilots are certified they must attain a standard of four as defined by Table 1 above (page 23).

Experience

The first tests that were performed were a series of independent samples t-tests that compared self-reported experience with glass and non-glass aircraft along with the time since flying a non-glass aircraft as a function of type of aircraft flown. Therefore, as previous stated, pilots were divided into either narrow-body or wide-body pilots. The results of the t-tests are summarized in the table below.

Table 2. Experience Independent Samples t-test Results

	Type of aircraft	N	Mean	Std. Deviation	t	Sig. –(2 tailed)
Years since flying a non-glass aircraft	Narrow-body	18	3.50	.857	.301	.765
	Wide-body	12	3.42	.515		
Years flying a non-glass aircraft	Narrow-body	18	2.33	1.328	.903	.374
	Wide-body	12	1.92	1.084		
Years flying a glass aircraft	Narrow-body	18	3.89	.323	2.591	.015
	Wide-body	12	3.42	.669		

The analysis revealed no significant difference in the years since flying a non-glass aircraft or in the years of experience flying a non-glass aircraft between narrow body and wide body pilots. However, the analysis indicated that Narrow-Body Pilots reported flying glass aircraft significantly longer than wide body pilots. These results were further analyzed by the specific survey responses relating to pilot experience. In the case of years since pilots had flown a non-glass aircraft there were very few pilots with recent experience. A further examination of the survey question pertaining to experience with glass and non-glass aircraft is presented below.

The first experience survey question asked the pilot how long it had been since they had flown a non-glass aircraft. The results are presented in figure 1.

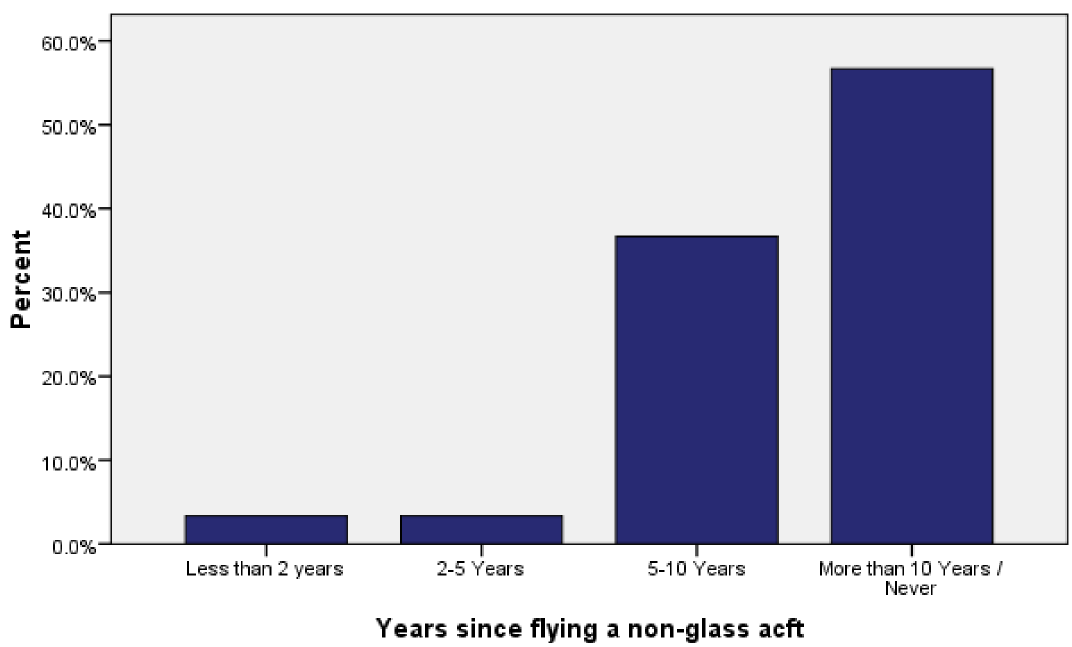

Figure 1. Years Since Flying a Non-glass Aircraft

A majority of these types of aircraft are being retired, and as a result, the survey indicated that over 56% of the pilots had either never flown a non-glass aircraft or it had been greater than 10 years since they had done so. The next category 5-10 years held 36 % of the pilots with 3% each for less than two years and 2-5 years.

The next survey question sought to quantify how much experience pilots had flying non-glass aircraft in airline operations. The results are presented in figure 2. The scale was the same as for the first question. The highest percentage of pilots (46%) indicated that they had two years or less flying non-glass aircraft. Pilots with 5-10 years experience were 23% of the sample, with 20% having more than 10 years.

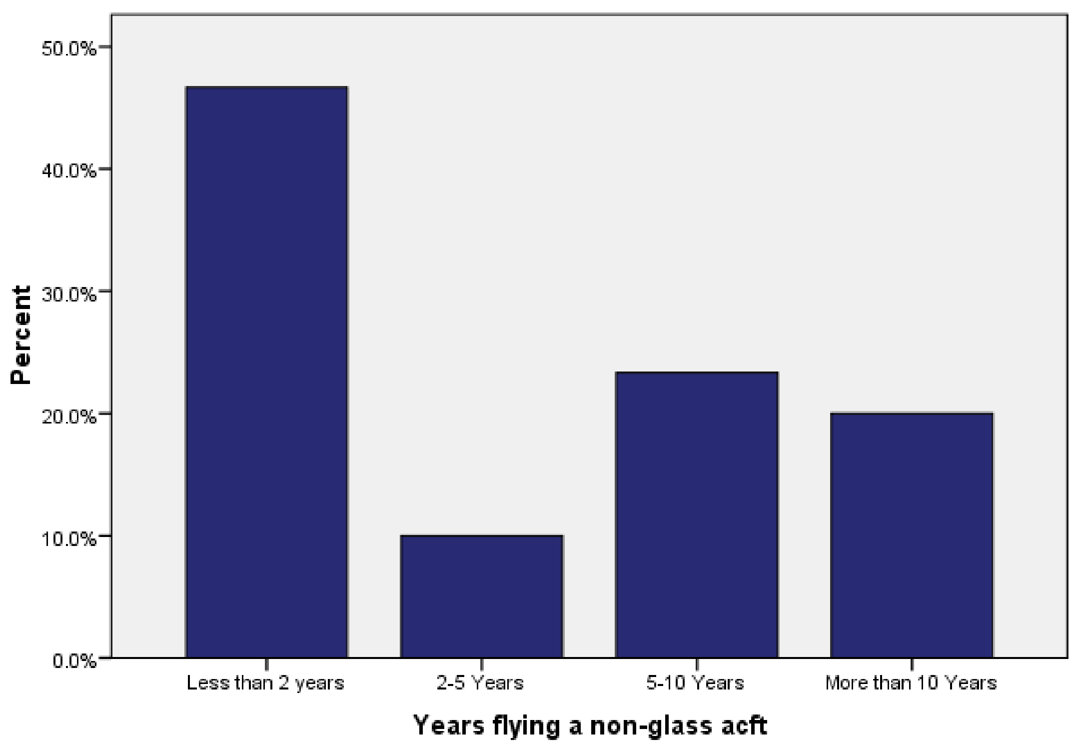

Figure 2. Non-glass Experience

Pilots were then asked how may years they have been flying glass aircraft. In this question, 73% of the pilots indicated that have 10 or more years flying these types of aircraft. The next highest response was 5-10 years which accounted for 23% of the responses. There were no pilots in the survey that indicated that they had two years or less flying glass aircraft.

Figure 3. Experience Flying Glass Aircraft

Self Assessment

The next section of the survey asked the pilots to asses their basic instrument skills. Self assessment of flying skills as a function of aircraft type flown was also analyzed using a series independent samples t-tests. The results are summarized in the table below.

Table 3. Self Assessment Independent Samples t-test Results

	Type of aircraft	N	Mean	Std. Dev.	t	Sig. (2-tailed)
Hand flying below 10,000 feet	Narrow-body	18	1.28	.575	.585	.563
	Wide-body	12	1.17	.389		
Ability to fly maneuvers	Narrow-body	18	1.56	.511	1.183	.247
	Wide-body	12	1.33	.492		
Skills have declined over time	Narrow-body	18	2.06	.873	.774	.445
	Wide-body	12	1.83	.577		
Comfort flying raw rata	Narrow-body	18	2.11	.676	-.233	.817
	Wide-body	12	2.17	.577		
Often practice raw data skills	Narrow-body	18	1.89	.758	.201	.842
	Wide-body	12	1.83	.718		
Company encourages hand flying	Narrow-body	18	2.00	.767	-.831	.413
	Wide-body	12	2.25	.866		

This test again revealed no significant difference between narrow body and wide body pilots in how they assessed their flying skill.

A further presentation of the survey results in graphic form is below. Survey questions were presented in the form of a statement to which the pilot responded in terms of; strongly agree, somewhat agree, somewhat disagree, and strongly disagree. The first statement was “I usually hand fly the aircraft below 10,000 feet.” This statement was used in order to gain a perspective of how many pilots were actively flying the aircraft. A great majority of aircraft maneuvering for both takeoff and landing occur below 10,000 feet. Above this altitude most of the flying is in the cruise phase of flight with little maneuvering. As such, a pilot will retain a maximum amount of skill by routinely hand flying below this altitude. The survey responses (Figure 4) indicated that 80% of the pilots strongly agreed that they usually hand flew the airplane below 10,000 feet.

In addition 16% of pilots somewhat agreed with the statement. This indicates that a majority of pilots are hand flying the airplane in the maneuver intensive phases of flight. It does not however indicate if they are using all of the aircraft's advanced capabilities or flying by "raw data".

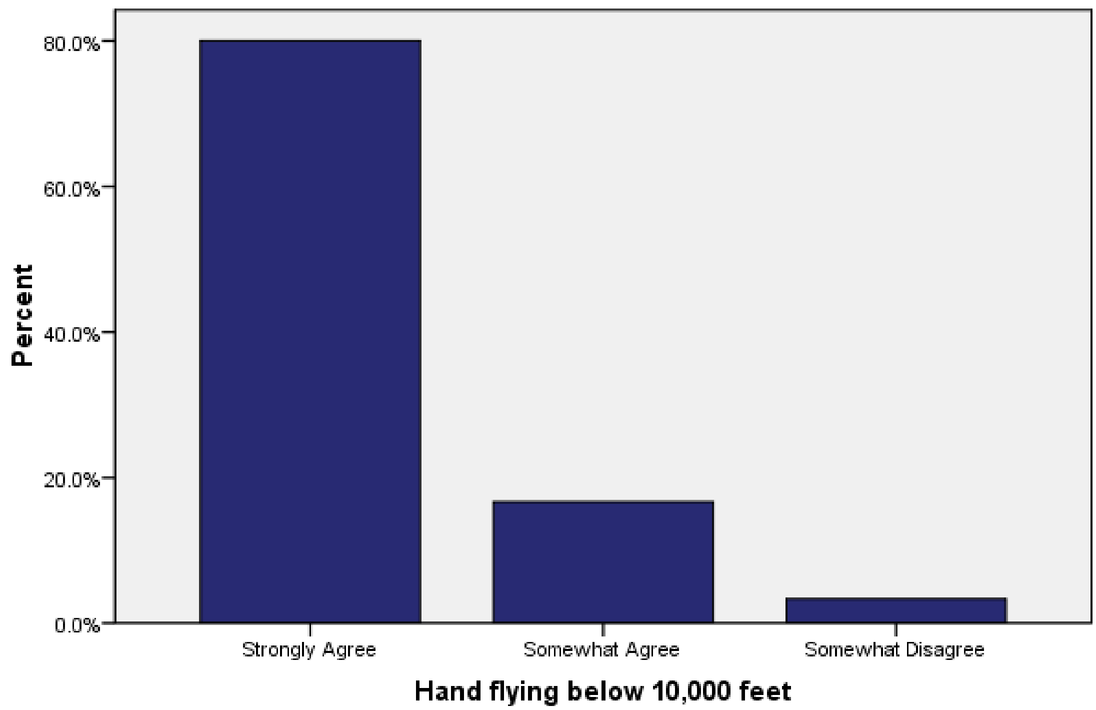

Figure 4. Hand Flying

The next statement asked pilots if they felt confident flying by raw data alone.   The results presented in Figure 5 indicated that pilots strongly agreed with this statement only 13% of the time with 60% stating that they somewhat agreed. A total of 26% of the pilots somewhat disagreed with the statement. These responses indicate that a majority of pilots (86%) have some reservations about flying solely by raw data as indicated by the lack of "strongly agree" responses.

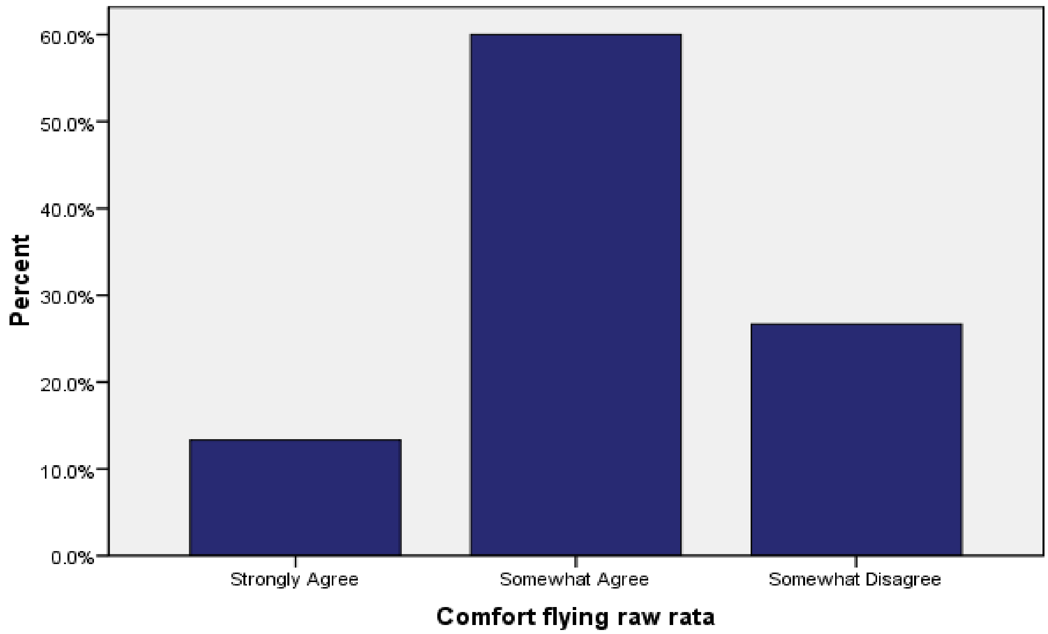

Figure 5. Raw Data

In response to the statement “I could fly a takeoff, V1 cut, ILS, and a missed approach using only raw data,” 53% of pilots strongly agreed and 47% somewhat agreed (see figure 6).

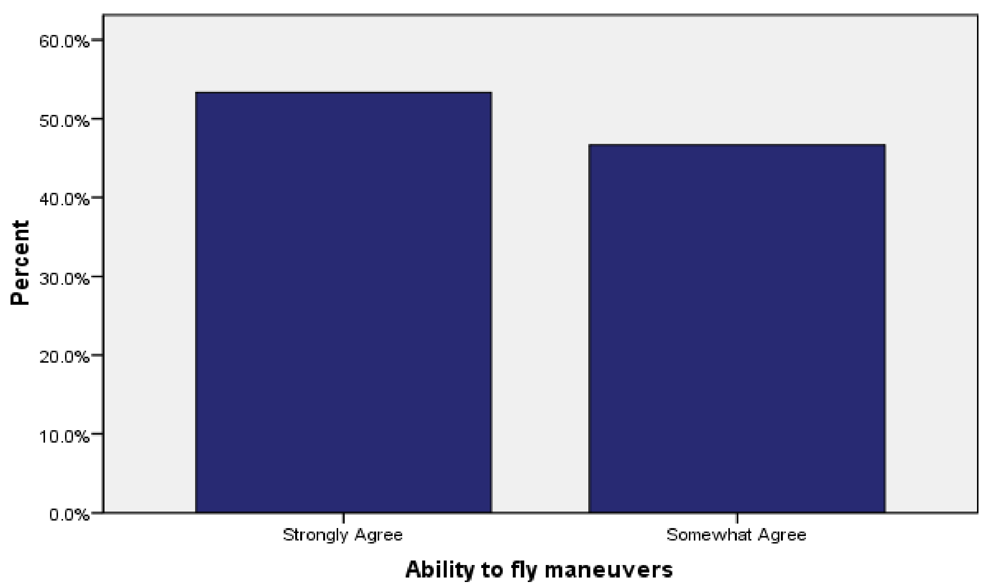

Figure 6. Ability to Fly Maneuvers

This indicates that the pilots believed that they could fly these maneuvers although not perfectly as indicated by the somewhat agree response. There were no pilots who disagreed with the statement.

Pilots were asked if they believe that their basic instrument skills have declined over time and the results are presented in figure 7. Pilots agreed with this statement 26% of the time and somewhat agreed 53% of the time. Only one pilot strongly disagreed with the statement, however 16% of the pilots somewhat disagreed with the statement. This indicates that a majority of the pilots feel that their skills have somewhat diminished over time.

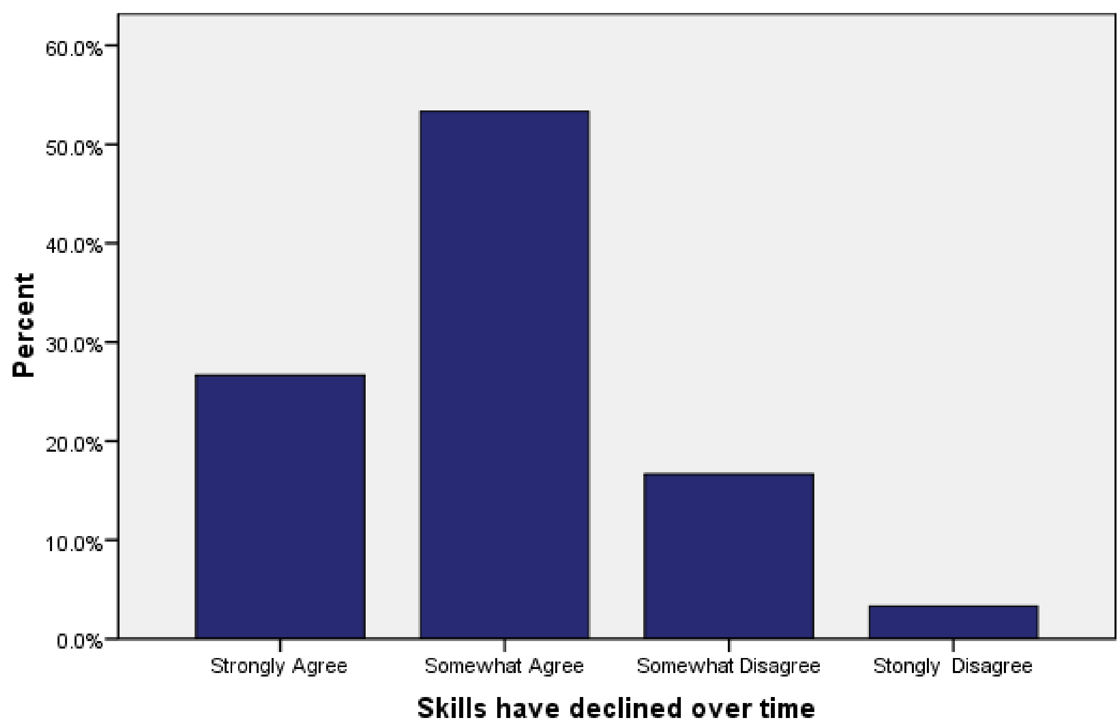

Figure 7. Skills Over Time

Pilots were asked if they often practice their basic instrument skills. The results are presented in figure 8. Of the pilots surveyed 33% strongly agreed and 46% somewhat agreed. Pilots somewhat disagreed with the statement 20% of the time. This statement indicates that a majority of pilots are doing at least some basic instrument flying.

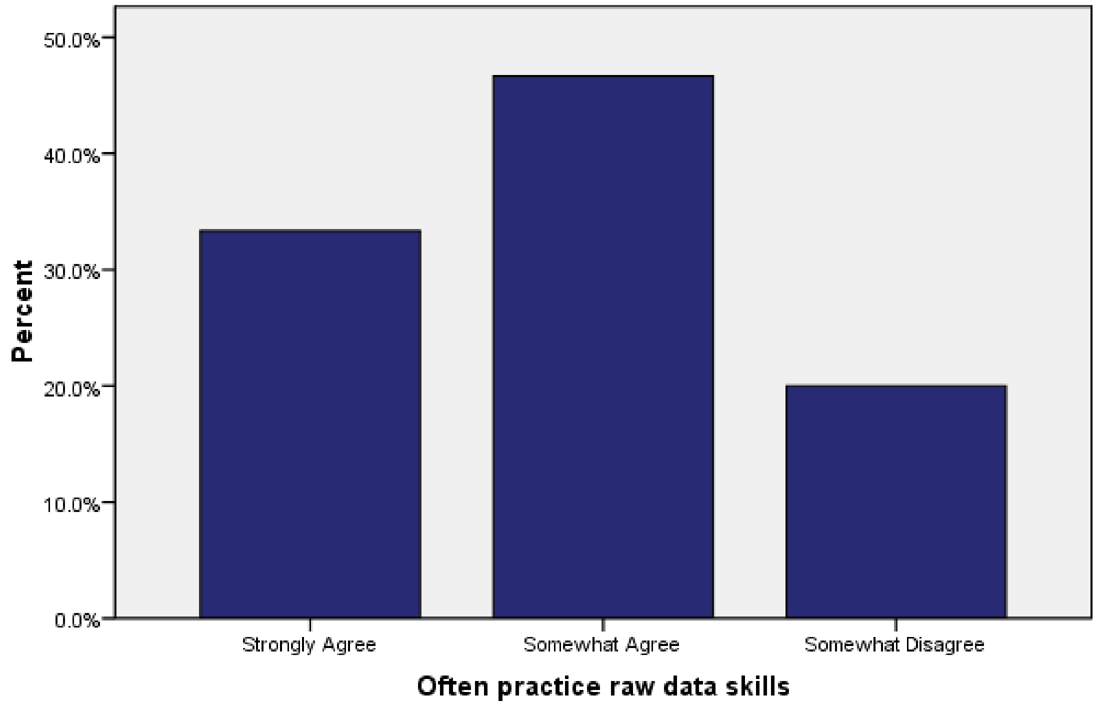

Figure 8. Skills Practice

The final survey statement asked whether pilots believed that their company encourages hand flying. This statement saw a wide range of opinions and the results are presented in figure 9. It is the author's experience and and anecdotal opinion that companies who encourage hand flying generally have pilots who choose to hand fly more often. Pilots agreed with this statement 20% of the time and somewhat agreed 57% of the time. Pilots somewhat disagreed 16% of the time and strongly disagreed 7% of the time.

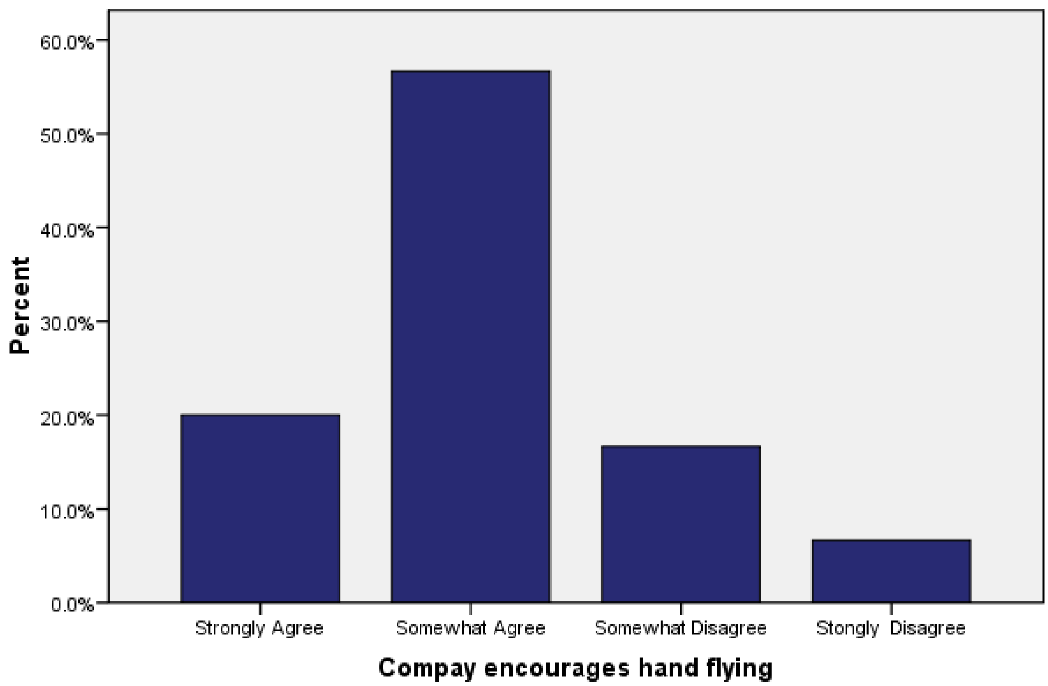

Figure 9. Company Policy

An independent t-test was also performed on the maneuver rating as a function of aircraft type flown. This was done to determine if any significant differences were noted between the two different pilot groups. The results are presented in Table 4.

Table 4. Mean Maneuver Ratings

	Type of aircraft	N	Mean	Std. Deviation	t	Sig. (2-tailed)
Takeoff Maneuver	Narrow-body	18	3.2222	.94281	.158	.875
	Wide-body	12	3.1667	.93744		
V1 Cut Maneuver	Narrow-body	18	3.0556	.72536	.204	.840
	Wide-body	12	3.0000	.73855		
Holding Maneuver	Narrow-body	18	2.4444	.85559	.607	.549
	Wide-body	12	2.2500	.86603		

Table 4. Continued						
ILS Maneuver	Narrow-body	18	3.0556	.80237	.731	.471
	Wide-body	12	2.8333	.83485		
Missed Approach	Narrow-body	18	3.1667	.70711	1.157	.257
	Wide-body	12	2.9167	.28868		
Mean of Maneuvers	Narrow-body	18	2.9889	.46259	.900	.376
	Wide-body	12	2.8333	.46580		

The analysis of the above data revealed no significant differences between wide-body and narrow body pilots in their performance on the individual maneuvers or on a composite measure.

A final set of analyses were computed to test whether the maneuver ratings (ignoring aircraft type) were significantly different from the FAA standard of 4. The results are presented in Table 5.

Table 5. Maneuver Means

	N	Mean	Std. Deviation	Std. Error Mean
Takeoff Maneuver	30	3.2000	.92476	.16884
V1 Cut Maneuver	30	3.0333	.71840	.13116
Holding Maneuver	30	2.3667	.85029	.15524
ILD Maneuver	30	2.9667	.80872	.14765
Missed Approach	30	3.0667	.58329	.10649

A t-test reveled that the pilots in the study flew the five basic instrument maneuvers well below the FAA standards. Significant t scores were noted for all maneuvers. The t-test results are in Table 6.

Table 6. One-Sample Test

	Test Value = 4 (FAA Standard)					
	t	df	Sig. (2-tailed)	Mean Difference	95% Confidence Interval of the Difference	
					Lower	Upper
Takeoff Maneuver	-4.738	29	.000	-.80000	-1.1453	-.4547
V1 Cut Maneuver	-7.370	29	.000	-.96667	-1.2349	-.6984
Holding Maneuver	-10.521	29	.000	-1.63333	-1.9508	-1.3158
ILS Maneuver	-6.998	29	.000	-1.03333	-1.3353	-.7314
Missed Approach	-8.764	29	.000	-.93333	-1.1511	-.7155

The results indicate that the study pilots flew the maneuvers closer to a basic instrument level instead of the FAA standard for Airline Transport Pilots (ATP). The holding maneuver received the lowest grade 2.4 and the takeoff had the highest at 3.2. Takeoffs are largely performed by reference to raw data instrumentation whereas holding is rarely if ever performed in such a manner.

Correlations

The responses to the survey were correlated with the maneuver ratings using a bivariate Pearson correlation with a significant correlation at .05 (2-tailed). All of the individual maneuvers means were analyzed in addition to the mean of all of the maneuvers. The mean of all maneuvers should be the most stable of the analyzed means. The only significant correlation existed between the holding maneuver and the survey question pertaining to company policy regarding hand flying. No other correlations existed. The results are summarized in Table 7.

Table 7. Correlations

		Takeoff	V1 Cut	Holding	ILS	Missed	Mean
Type of aircraft	Pearson Correlation	-.030	-.039	-.114	-.137	-.214	-.168
	Sig. (2-tailed)	.875	.840	.549	.471	.257	.376
	N	30	30	30	30	30	30
Years since flying a non-glass aircraft	Pearson Correlation	.163	.101	-.285	-.148	.086	-.038
	Sig. (2-tailed)	.388	.596	.127	.435	.650	.841
	N	30	30	30	30	30	30
Years flying a non-glass aircraft	Pearson Correlation	.000	.227	.367*	.317	-.016	.312
	Sig. (2-tailed)	1.000	.228	.046	.088	.933	.093
	N	30	30	30	30	30	30
Years flying a glass aircraft	Pearson Correlation	-.084	.206	-.053	.135	.066	.075
	Sig. (2-tailed)	.660	.274	.781	.475	.728	.693
	N	30	30	30	30	30	30
Hand flying below 10,000 feet	Pearson Correlation	.118	.073	-.046	.274	.297	.224
	Sig. (2-tailed)	.533	.701	.811	.144	.111	.234
	N	30	30	30	30	30	30
Ability to fly maneuvers	Pearson Correlation	-.353	.145	-.011	.123	.124	-.025
	Sig. (2-tailed)	.056	.444	.955	.516	.513	.894
	N	30	30	30	30	30	30
Skills have declined over time	Pearson Correlation	.010	.065	.125	.333	.160	.227
	Sig. (2-tailed)	.959	.734	.509	.073	.399	.228
	N	30	30	30	30	30	30
Comfort flying raw rata	Pearson Correlation	.071	.142	-.095	.280	-.025	.130
	Sig. (2-tailed)	.709	.453	.619	.134	.895	.495
	N	30	30	30	30	30	30
Often practice raw data skills	Pearson Correlation	-.010	.009	-.141	-.008	.103	-.030
	Sig. (2-tailed)	.957	.963	.458	.967	.590	.875
	N	30	30	30	30	30	30
Company encourages hand flying	Pearson Correlation	.251	.114	.399*	-.048	.059	.281
	Sig. (2-tailed)	.181	.550	.029	.802	.757	.133
	N	30	30	30	30	30	30

*. Correlation is significant at the 0.05 level (2-tailed).

Data Summary

Analysis of the above data strongly suggests that pilots of advanced glass aircraft have experienced a significant decline in their basic instrument skills. All of the maneuvers that were sampled were graded below the FAA certification standard for an Airline Transport Pilot. In addition, the survey indicates that pilots are aware that their skills have declines, but still believe that they could successfully fly these maneuvers. Lack of recent basic instrument flying experience is very high in flying glass aircraft which has lead to the decline in raw data skills. Further discussion of these findings will be discussed in the next chapter.

CHAPTER IV

DISCUSSION

Findings

The study found that professional pilots have a significant decline in their basic instrument skills. The mean for each maneuver was compared to the FAA certification standards for both the Airline Transport Pilot (ATP) certificate and the Instrument rating. An ATP certificate is required to be a Captain for a major airline. The certification standards are defined in the FAA's *Practical Test Standards*. All of the maneuvers were graded below the FAA certification standard for an ATP certificate (4) and in fact a majority of the maneuvers were rated at or below what is required for basic instrument certification (3). The lowest rated maneuver was holding that was graded at 2.4. This is well below the basic instrument certification grade (3). The highest rated maneuver was the takeoff, graded at 3.2. There were two maneuvers graded below three and three maneuvers graded above three.

The study also found through survey responses that the pilots who volunteered had an average of over seven years of experience flying their particular aircraft. In addition, the study found that 73% of the pilots have over 10 years of experience flying newer-generation glass aircraft. The majority of pilots, 47%, had two years or less flying a non-glass aircraft in commercial service.

The survey also found that 80% of the pilots surveyed agreed that their basic instrument skills have declined over time. However, when asked if they could fly the basic instrument maneuvers with reference to raw data only, 100% of the pilots surveyed stated that they could. In addition, 60% of the pilots agreed with the statement that they feel comfortable flying by reference to raw data only. Pilots (80%) also indicated that they often practice their raw data skills.

Narrow-body and wide-body pilots were examined to see if there was any significance between maneuver means for these two groups. There was no statistical difference between these two groups for the basic instrument maneuvers.

Significance

The data clearly indicates that professional pilots have seen their basic instrument skills decline over time. The study recognizes, however, that these same pilots are highly competent in the aircraft that they fly. All of the pilots in the study continually meet the FAA certification standards for an ATP. The study only observes one segment of instrument flying and thus only comments on this segment. The study makes no assessment of professional pilots overall flying skills, which data suggests are at a very high level.

Certain technical failures in advanced glass aircraft can significantly degrade cockpit instrumentation. These failures have occurred at the major airline that participated in this study. When these failures occur, pilots are required to use their basic instrument skills to safely land the airplane.

Pilots who are competent in basic instrument flying enhance their overall flying skills. They can devote less attention to physically flying the airplane and more time managing their environment.

Although most pilots in the study agreed that their instrument skills have declined over time, their survey responses indicated that they felt they could still fly the basic instrument maneuvers. The survey responses related to skills do not correlate with the actual maneuver grades. This leads to the conclusion that pilots in the study believed that they could fly the maneuvers better than they actually could, leading to a false sense of confidence.

Correlation

The maneuver grades generally fit with what the literature review revealed in other related studies. Earlier studies indicated that skills, when not used, decline over time. This was observed throughout the study in the mean maneuver grades. Earlier studies also suggest that pilots who fly advanced glass aircraft see a general decline in their basic instrument skills as a result of using the instrumentation features of these aircraft.

Survey responses, although candid about skills declining over time, did not correlate with maneuver grades or responses to earlier surveys on the same subject. It would seem as though the pilots who participated in the study believed that their skills had not declined as much as indicated by the maneuver grades.

The suggestion by earlier studies that once a skill set was learned and practiced over a long period of time it would be retained longer than if the skills were practiced over a shorter period of time. This was not seen in the wide-body / narrow-body within groups comparison. Pilots of the wide-body aircraft had more experience flying older-generation aircraft than the narrow-body pilots, but had very similar maneuver grades. In fact there was no statistical difference between maneuver grades for these two groups. This is most likely due to the fact that although narrow-body pilots fly similar monthly hours, they fly far more cycles than wide-body pilots. This leads in a significant increase in maneuvering the aircraft and thus increased flying skills.

Weaknesses

This study only observed five maneuvers. The maneuvers were selected due to both their complexity and their relevance to typical line flying. These maneuvers are trained and practiced by every pilot at least every nine months at the major airline that participated in the study. Although these maneuvers are very common, they represent only a very small portion of the total flight maneuver envelope.

The study involved pilots at a major US airline. This particular airline retired all of it's non-glass aircraft in the fall of 2001. As a result, most of the pilots in the study had not flown an older generation aircraft in the past 5-10 years. Other major US airlines still operate these types of aircraft although they too are in the process of removing them from active service. The results might have been different if pilots from these other carriers were included in the study.

Legal barriers kept these other airlines from participating. Since most major carriers are retiring older generation aircraft, the results that were seen in this study would likely apply to these other carrier at a later date due to their pilots becoming less familiar with basic instrument flying. Although including pilots who are currently flying older generation aircraft would make a slightly better within groups analysis possible, it would be valid for this point in time only. In the next five years, all major carriers will be flying newer generation aircraft hence these results would be valid for most other major airline in the future. Since only one major airline participated in the study, the corporate culture, policies, procedures, and training program curriculum could have affected the results of the study. The airline that participated has an advanced qualification program (AQP) for both initial and recurrently training cycles. This training philosophy is targeted for crew training. Pilots train and check together throughout all phases of training. Training consists of critiquing both how the pilots physically flew the aircraft and how they interacted with each other. In this type of training program less time is spent on flying maneuvers than a traditional training program. It must be noted however, that the certification standards are identical for both programs. Traditional training programs focus on flying specific maneuver sets with little or no input from the other pilot.

The survey attempted to garner both the pilots' experience and the way that they flew their aircraft and generally had four responses to the questions. In addition, the survey consisted of a total of 13 questions. The responses in the survey pertaining to pilots' assessment of their own skills did not correlate with their actual performance. If the survey were somewhat more robust with regards to response choices, a better picture of the pilots' self assessment may have been able to be gained. In addition, only three pilots indicated that they flew outside of their current professional employment. As a result, very little was inferred from how these pilots were rated on the actual maneuvers.

Future

There is little doubt that based on the results of the maneuvers, professional pilot's basic instrument skills have declined over time. This is linked to non-use of these skills in routine line flying. In addition, newer-generation aircraft generally do not lend themselves to basic instrument flying, nor do most companies train or promote this type of flying. Although it is rare, some failures in advanced glass aircraft can degrade the aircraft instrumentation to a state that would require a pilot to fly the aircraft based on raw data alone. During the past 10 years, two such failures have occurred at the airline that participated in the study. In both cases the pilots landed safely.

The key to retaining these skills is practice. Each professional pilot was highly competent in these skills at one time during their career. A follow on study to determine how much practice is needed to retain these skills would be required. In addition each airline would have to not only train and practice these skills, but encourage their use while line flying.

The results of this study will be forwarded to the airline that participated as well as the Airline Pilots Association (ALPA) in hopes that airlines will realize that basic instrument skills have declined in their pilots but also stress the need for training and practicing these maneuvers.

Airline safety can be improved by having pilots that are competent not only in flying the airplane with all of the advanced instrumentation working, but with degraded systems as well. Pilots possessed these basic instrument skills at one time. These skills can be increased through both training and practice thus making the pilot better to handle problems that degrade aircraft instrumentation.

APPENDICES

APPENDIX A

Survey and Maneuvers

Piloting Skills Thesis

Piloting Skills Survey

☐ ***By checking this box, I agree that I have volunteered for this study and have felt no undue pressure from the Airline, the University of North Dakota, or the principle investigator to participate.***

Date (mm/yy)	Years on Current Aircraft.				
/	☐ Captain	☐ First Officer			
Airplane	☐ A319/A320	☐ B737	☐ B747	☐ B757/B767	☐ B777

1.	How long has it been since you flew a non-glass aircraft for an airline?	2 years or less	2-5 years	5-10 years	10+ / Never
2.	How much experience do you have flying non-glass aircraft for an airline	2 years or less	2-5 years	5-10 years	More than 10 years
3.	How much experience do you have flying "glass aircraft"	2 years or less	2-5 years	5-10 years	More than 10 years
4.	Do you fly outside of your current job? (If yes please answer the next question).			Yes	No
5.	If you fly outside of your current job, do you fly under instrument flight rules?			Yes	No
6.	If you fly IFR outside of your current employment, how many hours a year do you fly?	Less than 25	25-75	75-100	More than 100
	In this section, please rate the following statements:	Strongly agree	Somewhat agree	Somewhat disagree	Strongly disagree
9.	I often hand fly the airplane during departure and approach below 10,000 feet.	1	2	3	4
10.	I could fly a takeoff, V1 cut, ILS, missed approach or engine out approach using raw data alone.	1	2	3	4
11.	I believe that my basic instrument skills have diminished over time.	1	2	3	4
12.	I feel comfortable flying the aircraft without the use of the F/D, autothrottles and map mode..	1	2	3	4

University of North Dakota Michael Gillen

13.	I routinely practice my basic instrument skills.	1	2	3	4
14.	My company encourages hand flying.	1	2	3	4
	Please list any additional comments that you feel are important to this study.				

I would like to personally thank you for your time in participating in this study. The information collected will help to increase airline safety by identifying where professional pilots require additional practice to maintain their flying skills. Please be assured that no personal information has been collected in this study. In addition the study does not even collect information on which airlines the data originated from. If you have any questions or comments pertaining to this study, please feel free to contact me.

Captain Michael Gillen – geebee1932@gmail.com

PILOTING SKILLS GRADESHEET PACKET

GRADESHEET INSTRUCTIONS AND KEY

INSTRUCTIONS FOR PILOT INSTRUCTORS AND STANDARDS CAPTAINS

Evaluate crew using criteria below. Please return to DENTK – Michael Gillen.

GRADESHEET KEY

Technical Performance Grading Criteria

Five Point Grade Scale	5	The pilot remained well within UA standards and performance was exemplary.
	4	The pilot remained within UA standards. Pilot flew to ATP instrument standards
	3	The pilot committed minor deviations from UA standards that were promptly corrected. Basic instrument level.
	2	Major deviations (full scale deflection) for greater than 10 seconds
	1	The pilot committed major deviations from UA standards that were not promptly corrected and/or were unsafe; or was unable to perform the maneuver/task without assistance. Crash or loss of aircraft control.

	Maneuver	Days to begin with maneuver					
Maneuver to be flown for CAPTAIN	Normal Takeoff	1	6	11	16	21	26
	Engine Failure on Takeoff	2	7	12	17	22	27
	Holding	3	8	13	18	23	28
	ILS Approach	4	9	14	19	24	29
	Missed Approach	5	10	15	20	25	30/31

	Maneuver	Days to begin with maneuver					
Maneuver to be flown for FIRST OFFICER	Missed Approach	1	6	11	16	21	26
	Holding	2	7	12	17	22	27
	ILS Approach	3	8	13	18	23	28
	Engine Failure on Takeoff	4	9	14	19	24	29
	Normal Takeoff	5	10	15	20	25	30/31

MANEUVER GRADESHEET

	MANEUVER	GRADE				
A	Normal Takeoff	1	2	3	4	5
B	Engine Failure on Takeoff	1	2	3	4	5
C	Holding	1	2	3	4	5
D	ILS	1	2	3	4	5
E	Missed Approach	1	2	3	4	5

GRADESHEET COMMENTS

Maneuver	Comments (Required for 1 or 2).

APPENDIX B

Definitions

.AC Advisory circular

ACO Aircraft certification office

AD Airworthiness directive

AEG Aircraft Evaluation Group

ALPA Airline Pilots Association

APA Allied Pilots Association

AQP Advanced Qualification Program

ARAC Aviation Rulemaking Advisory Committee

ASAP Aviation Safety/Accident Prevention

ASRS Aviation Safety Reporting System

ATA Air Transport Association of America

ATC Air Traffic Control

ATIS Automatic Terminal Information Service

ATP: Airline Transport Pilot

ATS Air Traffic Services

AWO All weather operations

BIS Basic Instrument Skills: The ability to fly the aircraft solely by reference to the raw data without the use of auto-throttles, flight director, or map mode.

CFIT Controlled flight into terrain

CMO Certificate Management Office

CNS Communication, Navigation, and Surveillance

CRM Crew resource management

FAA Federal Aviation Administration

FAR Federal Aviation Regulations

FCOM Flightcrew operating manual

FCU Flight control unit

FMS Flight management system

FOEB Flight Operations Evaluation Board

FSB Flight Standardization Board

FSDO Flight Standards District Office

GPS Global Positioning System

GPWS Ground Proximity Warning System

HF Human factors

HFStG Human factors steering group (JAA)

HWG Harmonization working group

ICAO International Civil Aviation Organization

IFR Instrument Flight Rules

IOE Initial Operational Experience

ILS Instrument Landing System

JAA Joint Aviation Authorities

JAR Joint Aviation Requirements

LNAV Lateral navigation

LOFT Line Oriented Flight Training

LOS Line Operational Simulations

Modern Aircraft/Glass Aircraft: Aircraft that have advanced automation to include: CAT III capability, auto-throttles, flight director, FMC, and CRT displays instead of actual instruments, the ability to LNAV and VNAV

NASA National Aeronautics and Space Administration

NOAA National Oceanic and Atmospheric Administration

NOTAM Notice to Airmen

NTSB National Transportation Safety Board

Old Style Aircraft: Aircraft that have standard cockpit instrumentation to include an attitude indicator and HIS. These aircraft may have Lnav and CAT III capability but they do not have any CRT displays

PDC Pre-departure clearance

PFD Primary flight display

PTS: Practical Test Standards defined by the FAA pilot qualification.

RNP Required Navigation Performance

SAE Society of Automotive Engineers

STC Supplemental type certificate

TAD Transport Airplane Directorate

TC Type certificate

TCAS Traffic Alert and Collision Avoidance System

VNAV Vertical navigation

VOR Very High Frequency Omnidirectional Radio Range

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