SCENARIO-BASED EVALUATION OF THE SKILLS OF NEWLY-CERTIFICATED INSTRUMENT PILOTS

By

MARK UHLMAN

Bachelor of Science in Bible
Oklahoma Christian University of Arts and Science
Oklahoma City, Oklahoma
1986

Master of Science in Applied Educational Studies
Oklahoma State University
Stillwater, Oklahoma
2003

Submitted to the Faculty of the
Graduate College of the
Oklahoma State University
in partial fulfillment of
the requirements for
the Degree of
DOCTOR OF EDUCATION
May, 2010

SCENARIO-BASED EVALUATION OF THE SKILLS OF NEWLY-CERTIFICATED INSTRUMENT PILOTS

Dissertation Approved:

Dr. Steven Marks

Dissertation Adviser

Dr. Timm Bliss

Dr. A. Gordon Emslie

Dr. Mary Kutz

Dr. A. Gordon Emslie

Dean of the Graduate College

ACKNOWLEDGMENTS

This study was conducted to provide information that would be helpful in improving airman instrument rating training. It is offered as partial thanks to the many flight students who have learned about instrument flying under my tutelage, and who have taught me how much there is still to learn about it.

I would like to further express appreciation to the following people:

My doctoral committee: Drs. Steven Marks (Chair), A. Gordon Emslie, Timothy Bliss, and Mary Kutz.

My wife and best friend, Sheila Uhlman, who believes I am not done writing.

My friend and mentor, A. Gordon Emslie, who both challenged and empowered me to grow with this project.

Oklahoma State University Flight Center personnel past and present: Terry Hunt, Glen Nemechek, John Burton, Steven Roberts, Rick Mangrum, Virginia Lowry, and Debbie McAuliff.

Several “generations” of Oklahoma State University flight instructors, who perfected their instrument flying skills by practicing them daily, even while mine grew rusty studying the academics.

I also thank my parents, Virgil and Joy Uhlman, who instilled in me the value of higher education and made me believe in the promise that it holds; and my children, Anne, Janie, and Breck, for continuing the tradition of educational excellence.

TABLE OF CONTENTS

Chapter Page

LIST OF TABLES

Table Page

CHAPTER I

INTRODUCTION

Pilots who earn an instrument rating must learn a lot. They must also demonstrate that knowledge during a practical test, which is the last major hurdle en route to certification. This test - the instrument rating “checkride” - is commonly considered one of the most difficult flight tests in airman training. In fact it should be, as instrument flying can be quite difficult, and the breadth of required theoretical knowledge and applied skill, along with the complexity of the modern air traffic control and airspace system, has grown incrementally over many years. During those same years, however, some testing procedures (and certification requirements) have remained mostly unchanged and may be somewhat artificial. A possible result is that some training for the instrument rating has devolved into preparing students for the difficult practical test in and of itself, instead of preparing them for actual operations under instrument flight rules (FAA-Industry, 2003). Indeed, Federal Aviation Administration pilot examiners sometimes refer to a new certificate as a “license to learn.” This light-hearted admonition from examiners may suggest that there is *much* more to learn, and many experienced instrument pilots would likely agree.

Background

For many years, the Federal Aviation Administration has served as the overseer of airman certification in the United States. The FAA's congressional mandate (in Section 44701 of Title 49 of the Federal Aviation Act of 1958) to do so stems from the awkward requirement to differentiate between air transportation and "other air commerce." The modern codified authority of the FAA to do so by issuing "rules regarding safety" is found in Title 49 of the United States Code. Section I, item 106 of Title 49 describes the authority of the FAA to issue, rescind, and revise these rules. Subtitle VII, Aviation Programs, describes in more detail the scope of the agency's authority. Included within this authority, and codified in Subtitle VII, Part A, Chapter 447, is the FAA's authority to "issue an airman certificate to an individual when found, after investigation, to be qualified for, and physically able, to perform the duties related to the position authorized by the certificate."

Obviously, the FAA does more than just test airmen. Indeed, the FAA has established a "safety oversight system" for airman certification and regulation based upon "regulations, certification, inspection, surveillance, and enforcement" (FAA-Industry, 2003). Most of the various components of this FAA oversight are codified in publications called Advisory Circulars, handbooks, Title 14 of the Code of Federal Regulations Parts 61, 91, and 141, and other materials. Elements of airman certification oversight include knowledge and practical tests, the certification and delegation of pilot examiners, and publication of Practical Test Standards. Various elements of the FAA's certification process are sometimes called into question within the flight training industry.

The intent of this study is to call the instrument rating into question, and the question that will be asked is this: are new instrument pilots really ready to use their new rating?

Statement of the Problem

A concern within the airman certification process, and one that will receive considerable attention in this study, is the possible "artificiality" of some flight training and airman certification practical tests. General aviation training and certification has traditionally been predicated upon pilot applicants meeting specific aeronautical knowledge, flight proficiency, and aeronautical experience requirements, a successful training paradigm with roots that can be traced back to the "Bingham Plan" of World War I (Durden, 1998). Current airman trainees must demonstrate their knowledge and skill on "written" (actually computer based) tests and practical tests, frequently called "checkrides." Unfortunately, the training and testing process still contains vestiges of WWII era training, including maneuvers that are rarely or never performed during routine flights (Blickensderfer, Summers, and Schumacher, 2005). At least a few researchers question whether or not time spent teaching these maneuvers, to be conducted only on the checkride, might not be better spent in teaching actual flight operations. Perhaps even more significantly, some of the operations that *are* routinely performed by holders of advanced airman ratings are discouraged from being performed during the practical test *at all.*

The Instrument rating is a good example of a level of airman certification that involves skills and knowledge that may be difficult to measure during the practical test. During every flight conducted under Instrument Flight Rules (IFR), the pilot must file an

IFR flight plan, contact the appropriate ATC facility to get an IFR clearance, restate the clearance back to ATC, and then comply with (or seek modification of) all elements of the clearance throughout the flight. Compliance may require the interpretation of complex (and cryptic) aeronautical charts, ongoing communication with the appropriate (and changing) ATC facility, and an "on-the-fly" application of a host of rules and regulations. Further, any element of the clearance may change en route, requiring a change in routing, altitude, type of approach, necessity to "hold," or other surprises, all of which must be received and implemented while flying the airplane. Despite (or because of) the weighty responsibility that the instrument pilot assumes, "filing IFR" is prohibited for the not-yet-certified airman and thus is not allowed on the practical test (14 CFR 61.3 **(e)**). Without actually filing an IFR flight plan, there is no *real* clearance to receive, copy, read back, execute, or amend. Thus, many of the above tasks are frequently only *simulated* during the Instrument rating practical test (Flight Standards Service, 2004), and the simulation of them may involve oral questioning only. Further, many instrument rating practical tests never leave the vicinity of the airport at which they begin. Without an actual en route portion of the flight, some en route tasks and procedures are likewise simulated only.

It should be noted that generally few of the above tasks, by themselves, are particularly difficult. However, most of the tasks are done *in flight,* while the pilot is dividing his or her attention between other things, not the least of which is controlling the aircraft! As most instrument rated pilots know, it is frequently the *sum* of cumulative tasks that makes IFR difficult. Further, experienced instrument pilots know that all of the tasks are definitely *not* of equal importance; experience teaches pilots that some tasks may be deferred to a low-workload phase of flight or may be simplified by savvy dialogue with Air Traffic Control. *New* instrument pilots may not know how or when to juggle tasks, and this may cause them to prioritize the wrong ones, do all of them poorly, or commit other errors. Therefore, evaluating a pilot's knowledge of tasks through oral questioning before or after flight may not accurately reflect a pilot's ability, since this "task juggling" is rarely required in a question-answer session. Again, it is often the required *cumulative* skill and applied knowledge that makes instrument flying difficult.

It should be noted that the administrator of the practical test (the FAA Designated Examiner or FAA Safety Inspector) *may* file IFR on behalf of the applicant, and thus require all IFR procedures to be executed. However, this practice is expressly discouraged by the FAA (Federal Aviation Administration, 2004). It should also be noted that the FAA is sensitive to the need to administer a realistic, rigorous test. In a section of the PTS entitled "Use of the Practical Test Standards," the FAA mandates the use of a written "plan of action" (for the administration of the test) that includes one or more "scenarios." The FAA further requires examiners to "include as many of the TASKs into the scenario portion of the test as possible," with the intent being that the execution of the flight be more "real" than the performance of stand-alone tasks. Further still, the examiner is required by the PTS to evaluate applicants' "ability to use good aeronautical decision making procedures," and suggestions to incorporate scenarios requiring "weather decisions and performance planning" are provided (Flight Standards Service, 2004). In other words, the FAA wants the test to simulate a real IFR flight. Still, the fidelity of simulated IFR flight to the real thing is questionable.

Anecdotal evidence at a flight school may be evidence that the training and testing for the instrument rating are insufficient. Having served as a Chief and/or Assistant Chief Flight Instructor at an FAA Certified school for several years, the principal investigator of this study has administered literally hundreds of End-of-Course flight tests. An end-of-course test is a practical test administered at an FAA approved flight school to document that all elements of the skill and knowledge within a course of training have been assimilated by a student. Usually, the test result reveals that they have been. However, experimentation with that same student in a non-testing environment, or in an unpredicted phase of the test, frequently suggests otherwise, leading to interest in this study. Others have observed the same thing. Consider the following anecdotal evidence from a popular aviation periodical. The article, which deals mostly with creating meaningful "practice challenges" during routine flights to maintain proficiency, suggests that many pilots lack basic skills, particularly in regard to instrument flying. Even some instrument instructors, the article contends, have not developed basic *real world* instrument skills and are thus in no position to pass them on. As evidence, the article's author relates his own experience of overseeing an intercollegiate flying competition in which instrument rated pilots and instructors were first required to perform difficult instrument pilot tasks in VFR weather under simulated IFR conditions. "The kids," the author concluded, "were astonishingly good at every kind of simulated IFR procedure that we could think of and had clearly been practicing a lot under the hood…" However, when the weather deteriorated and the competitors had to actually file IFR and operate in the IFR system, things changed. The narrative continues:

> We decided to ask the participants to file a flight plan to a nearby airport and we would get a regular IFR clearance and make the trip in the system. The results were amazing. More than half of the pilots, including the instrument instructors, were totally befuddled. They demanded to know in advance the route they would fly and altitudes, and what approach would be at the destination. We told them we had no idea, but to file a flight plan that looks logical and see what clearance the controllers issued. When the controllers read something different than what the contestants filed, they were indignant, and some even insisted that ATC couldn't do that. We assured them that ATC can offer any clearance that works for it, and the option remaining for a pilot is to reject the offer and stay on the ground. In flight most had trouble copying ATC instructions and were constantly surprised by what they were asked to do, such as change altitude. Even vectors to final proved to be a challenge to some pilots who could fly a DME arc on their own to perfection. What became clear is that the students had mastered the textbook world of IFR flying, but had little or no real-world experience in the system (McClellan, 2008).

A casual reader might be surprised that both instrument rated pilots and instrument *instructors* mentioned in the article exhibited the same problems, as it would be logically assumed that the latter would be much more experienced. In reality, there is sometimes little difference in knowledge or experience between the two. Indeed, a flight instructor need only pass a written test and a flight test to add an instrument rating (and hence the authorization to *teach* the instrument rating) to an existing instructor certificate; there are no requirements to build experience under IFR before doing so (14 CFR 61.183 **(a-h),** 61.191 **(a)**). Further, the written test comes from the same bank of FAA questions that the applicant studied during the training for his own initial instrument rating (to hold an instructor certificate with an airplane category requires a prior instrument rating as per 14CFR 61.183 **(c)**), and the instrument instructor practical test commonly involves similar tasks that the applicant performed during his own instrument checkride. Indeed, since both the instructor certificate and the instrument instructor rating are often earned during a "time building" phase of a pilot's career, the instructor may earn both within a brief period of time, at the same airport, conducting the same approaches, studying the same body of knowledge. Exposure to real-world IFR flying for both instrument-rated pilots *and their teachers* may be very limited!

Purpose of the Study

The purpose of this study is to provide information that will assist in evaluating the efficacy of airman instrument rating training and testing. Specifically, the study is designed to determine if there is a significant performance difference between experienced and inexperienced instrument pilots and whether the null hypothesis that there *is not* should be retained or rejected. Stated more succinctly, the null hypothesis for this study is this: there is *no difference* between the experienced pre-test group pilots and the less experienced test group pilots in regard to basic instrument pilot competencies. Note that wording of the null hypothesis is very deliberate; it does *not* suggest that there is no difference between experienced and inexperienced pilots. It states that in regard to *basic instrument pilot competencies* (the tasks extracted from the FAA Practical Test Standards which are the “learning objectives” noted below) there is no difference between the aforementioned groups of pilots. Indeed, all have passed the FAA practical test by demonstrating these competencies and hold an instrument rating as proof.

More specifically, information gathered during this study will help determine the degree to which a newly rated instrument pilot’s training has equipped him/her to:

- Acquire, copy, understand, execute, and amend, if appropriate, an IFR route clearance.
- Control an aircraft using instrument references only while performing other tasks required during single-pilot IFR operations.
- Copy and execute a holding clearance using correct entry, timing, and reporting procedures.
- Tune, identify, interpret, intercept, and track ground-based navigational systems and use information gleaned from them to attain and maintain adequate situational awareness.
- Execute a precision instrument approach, applying charted courses and minimums, as well as stated clearances and procedures.
- Plan for, initiate, and execute a missed approach.
- Select an alternate destination with consideration given to legalities, weather, and practicality.

Objectives of the Study

To accomplish the purpose state above, the following objectives must be met:

- To establish the historical background and subsequent evolution of the airman instrument rating.
- To provide an overview of the knowledge, skill, aeronautical experience, and testing required to earn an airman instrument rating.
- To test a sample of newly rated instrument pilots on the conduct of an accurately simulated IFR flight requiring all of the above tasks.
- To answer the following research questions:
    - Does the newly rated instrument pilot, having demonstrated the ability to pass the FAA instrument rating practical test as described in the practical test standards and applied by a FAA designated pilot examiner, really have the skills and knowledge necessary to successfully complete a simulated, non-training, point-to-point, IFR flight?
    - Did the training of the newly rated instrument pilot adequately prepare him or her to apply the skill and knowledge required by 14 CFR FAR 61.65 **(b)** and **(c)** to successfully surmount common challenges during a real-world IFR flight?
- To offer recommendations to improve the effectiveness of airman instrument rating training and testing.

Definition of Terms and Acronyms

Aviation terminology is laden with acronyms, abbreviations, and technical language, making their use unavoidable in this study. Appendix L provides definitions for all of the specialized language used in this report.

Assumptions

For the purpose of this study, the following assumptions have been made:

- The intent of instrument rating training is to equip pilots to operate in instrument meteorological conditions in the modern airspace system under instrument flight rules. The intent of instrument rating testing is to confirm that all required knowledge and skills required for doing so have been assimilated by the instrument rating applicant.
- Pilots who have earned an instrument rating *should be able* to operate under instrument flight rules safely and competently without further training or experience.

Limitations of the Study

The potential artificiality of the research flight, the available sample size and population, and potential participant skill erosion impose certain limitations on this study. The reader should understand that:

- This study was limited to students at one university, all of whom followed the same training syllabus. Since the FAA allows certified flight schools to create and submit their own syllabi for approval (within limits as defined by FAR 141 Appendix C), the sequence and content of instrument training or testing at other training providers could be somewhat different.
- The number of eligible participants during the data collection phase of this project was relatively small. Therefore, the generalizability of findings from this project may be limited.

- Initial instrument currency lasts for six calendar months. Therefore, "newly certificated instrument pilots" as defined by this study (certificated within previous six calendar months and therefore current) actually includes pilots whose training is not that "new" or recent. The effect of skill erosion over the six months of currency is not addressed in this study. Future research may be needed to determine or describe this effect.
- It is impossible to exactly duplicate the flight environment without actually being *in* it. Certain tasks in the flight simulator may therefore be somewhat different than the same tasks performed during actual IFR flight. Also, certain pilot actions or decisions - since the potential of an actual crash is eliminated in the simulator - could be artificially influenced by simulated flight. Further research may be needed to determine the psychological impact of simulated flight on pilot decision making and/or pilot actions.

Significance of the Study

This research was designed to provide information to assist in evaluating the effectiveness of airman instrument rating training and testing. Earlier in Chapter I the Principal Investigator (along with the literature) expressed doubts about some current instrument training paradigms. However, the findings from the study suggest that even those assumptions may have been underestimated! As the study progressed, it became clear that several of the newly certificated instrument pilots clearly lacked certain fundamental competencies. If these findings accurately represent the greater population of new instrument pilots, the significance of this study may be greater than originally assumed and certain instrument pilot training and testing paradigms, as well new instrument pilot privileges, may need to be fundamentally changed. The “if” in the foregoing sentence, however, is not just academic; the small sample size in this study severely limits the generizability of the findings therein. In fact, had the sample size been twice as large and the performance relationship of new and experienced instrument pilots been mathematically identical, the null hypothesis noted above could be rejected at virtually the 100% confidence level. The rationale for doing so will be developed in subsequent chapters noted below and in Appendix K.

Following this introductory chapter, Chapter II reviews related literature in the evolution of, and research regarding, airman instrument rating certification, including: the contemporary instrument rating, scenario based training, the need of realism in training, and investigation of published testing procedures. Chapter III discusses the procedures used to collect the data. Attention is given to the population, the selection process and criteria, sample size, and experiment realism. Chapter IV reports the data collected during the study, and Chapter V provides observations, examples, and commentary that help explain the data. Chapter VI summarizes the major findings and conclusions, and provides recommendations based on them. To begin, however, the development and evolution of the airman instrument rating must be considered, which is where the next Chapter of this report begins.

CHAPTER II

REVIEW OF RELATED LITERATURE

Introduction

Instrument rated pilots are allowed to fly without outside visual references. This one fact mandates an entirely new set of skills and knowledge that a pilot must master before earning the instrument rating and the privilege to "fly blind." The Instrument rating dates back to 1933, when the Bureau of Air Commerce (a predecessor to the FAA) first acknowledged that certain competencies were required for pilots to fly without outside visual references (Milbrooke, 2000). But the realization that flying without these references presented unique challenges came long before. Indeed, flying in (or avoiding) instrument meteorological conditions parallels the evolution of airman certification. The fundamental problem, as early airmen noted, was the inability of the human "balance" system to remain oriented without a visible horizon.

Physiologically, humans spatially orient themselves by means of vision, kinesthetic, and vestibular senses. The Kinesthetic senses refer to the muscles, sinews, and related nervous system that "feel" which way is up or down by reference to gravity and inertia. The vestibular system functions by reference to the same forces, but is far more sensitive and balance-specific. It is comprised of multiple channels in the inner ear that sense the movement of fluid. This fluid, also driven by gravitational or inertial forces, ultimately triggers a message to the brain that muscle movement around one or more axis is required to remain upright. And, as long as the forces acting on that fluid are *predictable* gravity and inertia, humans easily keep track of up and down. But in an airplane moving around three axes, all at constantly varying amounts and duration, the kinesthetic and vestibular systems simply cannot keep up. Without external visual references, the hapless human will, sometimes within seconds, become completely disoriented (Jeppesen Guided Flight Discovery Team, Advanced Human Factors, 2006). Modern aircraft have instruments that artificially provide these necessary visual references, but most early ones did not. Tragically, many airmen learned that flying into clouds or reduced visibility could be deadly. Not surprisingly then, once aircraft performance made flying in clouds a possibility, regulations were imposed to make sure pilots were properly trained, equipped, and certified before they did so. The first task, then, is to understand the evolution of Federal airman certification, and know what it entails.

History

When the Wright Brothers flew in 1903, there were few restrictions on aircraft or airmen, and none regarding weather. This was soon to change, however, as the burgeoning field of aeronautics grew at a fantastic rate in both complexity and capability. Within a few years of the Wrights' first flight, many in local, state, and federal government argued that the growing number of pilots and aircraft (and crashes) dictated the need to regulate pilots and operating procedures. Thus began a continuing discussion of who should do the regulating, and what the regulations should include. Indeed, by the 1920's, several states had already created aeronautical legislation, some of it dealing with airman certification. It soon became clear, however, that the boundary-crossing nature of flight was unsuited to a "patchwork" style of local legislation, and that centralized control was required. Indeed, much of the state and local aeronautical legislation that evolved during this period would need to be reviewed and re-codified to create uniform federal law, a task that was undertaken by the Aeronautics branch and published in a non-binding "Aeronautical Bulletin" on Aug. 1st, 1928 (Federal Aviation Administration Historical Chronology, 1996). By then, the federal codification and control of airman certification was well underway.

The very first "Air Commerce Regulations" were created by the Aeronautics Branch of the Department of Commerce under the provisions of the Air Commerce Act of 1926 (FAA Historical Chronology, 1996). These regulations were created from the pooled recommendations of many stakeholders including pilots, manufacturers, the Post Office Department, and the Military. And, while these rules impacted many different aspects of aviation, the licensing of aircraft (at least those engaged in interstate or "foreign" commerce) and airmen figured prominently into the final draft of codified rules. The new regulations required the pilots of all licensed aircraft (again, only those involved in commerce) to hold at least private or commercial licenses. Further, holders of commercial licenses were classed as either industrial or transport, presumably to differentiate between the carriage of freight and people. Aircraft mechanics were required to hold the appropriate level of certification as well, and all pilots, mechanics, owners, and operators had until July, 1927 to comply with the newly binding rules. Even before July, however, the rules began to evolve, with the addition of the "limited commercial pilot license" classification to allow certain short-range flights to be conducted by aspiring commercial pilots for the purpose of building flight time and experience. As might be guessed, this limitation dealt indirectly with weather flying as it represented a crude means of avoiding it. In 1929 the rules would be further amended so that transport pilots could only carry persons or property for hire in aircraft types that were "specified on the license," and again in 1930 to limit them to the carriage of passengers only with "special authority from the Department of Commerce" (FAA Historical Chronology).

It was, then, in 1927 that Private pilot license #1 was issued to William P. MacCracken, Jr., the Assistant Secretary of Commerce for Aeronautics (though during World War I, the military had issued pilot licenses to civilians under the exigencies of wartime demand). MacCracken became the first person to be issued a civilian pilot license by the U.S. Government, though to his credit he attempted to defer the honor to Orville Wright, who declined. With the precedent of federal airman certification in place, there were many to follow. By October 1928, there were 3,695 civilian pilots holding active licenses, with 66% of them being transport pilots, 10% commercial pilots, 2% industrial pilots, and nearly 22% private pilots, with a definite trend developing in the increase of private flying (FAA Historical Chronology, 1996). In response to this trend, the Air Commerce Act was amended in 1929 to provide for the licensing of "flying schools" and flight instructors. Both required that certain experience and competency benchmarks be met, and both a ground and "flying" instructor rating were created, a paradigm that still exists.

Other advances within the growing field of aeronautics would drive changes in airman certification. Of these, few had greater significance than the flight of James H. Doolittle on Sep. 24, 1929. On this flight, Lt. Doolittle used gyro-powered and pressure-sensitive flight instruments, ground-based radio range and maker beacons, and a safety pilot with unobstructed vision and access to dual controls, to fly (from takeoff to landing!) a pre-determined course with no outside visual references (Bilstein, 1994). Doolittle made the flight as part of research being conducted by the Aeronautics Branch of the Department of Commerce, the Bureau of Standards, and private organizations, all anxious to develop the means to fly through clouds and demonstrate the feasibility of doing so. And, as all understood, without the ability to fly in clouds all-weather capability and scheduled service would forever remain impractical (Bilstein). Doolittle's flight showed that weather flying was possible, and that the technology was evolving to make it safe. It was followed by a similar flight by Capt. A. F. Hegenberger in 1932 in which a similar course was flown without outside visual references and *without any safety pilot (*National Museum of the USAF)! The science of "blind flying" was indeed advancing.

While Doolittle's and Hegenberger's flights showed that the technology existed to overcome the problem of weather, they also showed that specific and advanced pilot skills, as well as specialized equipment, were required for all-weather flying. Along with the advancement of radio ranges and beacons for en-route operations, the first instrument landing by a system incorporating a glide path was demonstrated at College Park, MD in

1931 (FAA Historical Chronology, 1996). On March 1, 1933, the Aeronautics Branch demonstrated a radio system that it had developed for the "blind landing of aircraft," and significantly, made the system available for service testing by all aircraft equipped with the necessary radio receivers. During that same month, James L. Kinney, an Aeronautics Branch pilot, completed the first instrument-only cross country flight from College Park, Md. to Newark, N. J. (FAA Historical Chronology, 1996). Thus, the elements of en-route and approach guidance were being incorporated into weather flying, and the promise that they held for all operators was clear.

By 1932 yet another new rating for transport pilots, entitled "scheduled air transport pilot" was published in the Air Commerce Bulletin. By Jan. 1, 1933, the rating was required for all pilots on scheduled interstate passenger service (FAA Historical Chronology, 1996). To earn it, pilots had to demonstrate the ability to use airway navigation aids and to fly specified maneuvers guided entirely by instruments. The era of the "Instrument Rating," by function if not by name, had begun.

Also during this time, the FAA Historical Chronology notes that the regulation of all pilot ratings and privileges came under firmer federal control. From 1933 through 1940 there were a great many changes regarding pilot certification, including:

- The increase of solo flight time for a private license from 10 to 50 hours (which would change in ensuing years).
- Abolishment of the grade of "industrial pilot," and its replacement with the new grade of "solo pilot," which required 10 hours of flying time and successful completion of a practical test.

- Abolishment of the grade of "solo pilot," and the transfer of solo flying privileges to "student pilots."
- Minimum age of 21 or consent of parents before qualifying for any type of pilot license. Later, minimum age (with consent of parents) for a Private license was set at 16 and still later increased to 18, due to the lobbying of a parent whose child was killed in a plane crash. All of these changes would evolve in the ensuing years, with the 21 minimum certification age, and the parental consent for student pilots finally dropped in 1967.
- Creation of the new "amateur pilot license," requiring 25 hours of solo flying time (compared to 50 hours for a private license) in an attempt to encourage recreational flying.
- The announcement of an experimental "Civilian Pilot Training Program" involving 330 pilots and 13 colleges. The intent of the program was to use federal funds to create new pilots so that a reserve pilot corps might be in place should they be needed for military service. This program was greatly expanded as war in Europe loomed, eventually becoming a military program. Due mostly to the CPTP, the number of pilots in the U.S. had increased to over 100,000 by 1941 and continued to grow during the war years. The "CPT" was an important step in the evolution of instrument flying because of the large number of pilots that it created, and because military pilots generally had exposure to flight simulators and "weather flying."

By Nov. 1937, a complete re-coding of the old Air Commerce Regulations went into effect under the new title "Civil Air Regulations," or "CAR's." The new regulations featured the now-familiar parts and sections, along with the expansible decimal system to provide for inevitable future intrusions and revisions. Most of the work of re-coding was done by two consultants from Northwestern University: Fred D. Fagg, Jr. and John H. Wigmore. Wigmore was the Dean Emeritus of Northwestern's School of Law, and Fagg became Director of Air Commerce midway through the project, requiring his replacement by Howard C. Knotts, Editor in Chief of the Journal of Air Law. Not surprisingly, some of the re-coded regulations dealt with flyable and non-flyable weather (FAA Historical Chronology, 1996). Among the driving forces behind the project was the need to standardize the confusing array of rules that had been promulgated by individuals within the Aeronautics Branch, the Bureau of Air Commerce, and the Department of Commerce. Without a system for clearance through a central office, many rules were unknown (published only in Department of Bureau correspondence) or potentially unenforceable, since they were issued by persons other than the Secretary of Commerce, the official designated in the Air Commerce Act. Understandably, the recoding was a major step forward in the promulgation of federal aviation regulation.

In May, 1944, the jurisdiction of federal aviation authority would be tested. In the U. S. District Court case United States v. Drumm, Andrew Drumm, Jr. had been charged by the authority of repeatedly violating those parts of the Civil Air Regulations requiring a pilot to have an airman certificate (as well as other violations). Drum contended that the regulations did not apply to him since he did not fly on civil airways or other restricted areas, and that the Civil Aeronautics Authority had exceeded its jurisdiction promulgating Parts 60.30 and 60.31. The Federal judge disagreed, and federal authority to certify airmen and U. S. airspace was upheld (FAA Historical Chronology, 1996).

In 1964, the FAA would again re-code the Federal Regulations into the appropriately named “Federal Aviation Regulations,” or “FAR’s.” The major thrust of this re-coding was to eliminate duplicate, obsolete, and unnecessary provisions of multiple regulatory systems inherited from the Civil Aeronautics Board and the Civil Aeronautics Administration. Further, the FAA sought to streamline all of the current and binding rules into a single body. This revision of the FARs consolidated and simplified the former Civil Air Regulations, Civil Aeronautics Manuals, and the Regulations of the Administrator, and also introduced many of the now familiar “Parts” (and related content) of the current Chapter 14 of the Code of Federal Regulations, or “14 CFR.” By 1971, the “Parts” relevant to airmen were available in separate volumes.

Even before the recoding of 1937, the regulations governing instrument flight received major modification. By August 1936, all civilian pilots who flew by instrument reference on a civil airway were required to have an instrument rating and a licensed aircraft equipped with two-way radio and approved instrument flying equipment. Further, pilots flying on instruments, or on a civil airway with visibility less than one mile, were required to file a flight plan. These rules, however, were designed more to *inhibit* than to *regulate* civilian air traffic on airways, since at that time virtually no civilian aircraft or airmen had instrument ratings or equipment. The new rules had the desired effect of keeping traffic off of the airways used by the growing fleet of air carriers (FAA Historical Chronology, 1996).

By 1940, the first Pilot and Written Test Examiners were designated. Under this CAA order, appropriately qualified "private persons" were authorized to conduct flight and written exams. The intent of this program was to free full-time CAA Inspectors to do other tasks besides flight tests, though they still retained authority (and responsibility) to "spot check" certified pilots. This program started a trend, and the use of designees would be greatly expanded over the years, with aircraft inspectors, pilot examiners, and (previously authorized) medical examiners doing many tasks for the agency. Indeed, by 1945 Private pilot examiners were added to the pool of "DPE's," and by 1946 there were 6,222 airman rating examiners in the pool (FAA Historical Chronology, 1996).

Further, starting in 1946 CAA regional offices (rather than Washington headquarters) became the approving authority for flight schools, making flight training even more accessible. This change was followed in 1950 by an amendment to the Civil Aeronautics Act that greatly expanded the Secretary of Commerce and the CAA Administrator's authority to delegate to "private persons" the authority to perform examinations and issue certificates. This change was driven by the vast increase in civil aircraft and pilots in the postwar years, and continues with the current FAA's authority to delegate examiners. Indeed, the FAA envisions delegating even more authority in the future, with the outsourcing of rulemaking and training requirements possible (FAA-Industry Training Standards Program Plan, 2003).

In 1960, there was a renewed focus on instrument flying skills, driven in part by the proliferation of gyroscopic instruments and the instrument flying opportunities that they provided. Presumably, accident statistics were also a cause of the focus on instrument skills, as there was a growing realization that the single greatest cause of fatal general aviation accidents was continued flight into instrument meteorological conditions by non-instrument rated pilots (National Transportation Safety Board, 2005). Understandably then, the instrument rating did not undergo major change, but instrument *skills* at other grades of pilot certification did. New pilots (though the rules were not made retroactive to previously certificated pilots) receiving commercial certificates without an instrument rating were required to receive 10 hours of instrument flight instruction and demonstrate basic attitude instrument flight skills on the practical test. Similarly, new private pilot trainees were now required to receive dual instruction in basic attitude instrument flying, and were required to demonstrate "manual capability in attitude control" in simulated "loss of outside reference" emergencies. Also, by 1966 an instrument rating for helicopter pilots flying in IMC was required (FAA Historical Chronology, 1996).

In 1967, in the wake of these changes, came a high-profile "instrument accident." In September of that year, a Cessna 310 was involved in a mid-air accident with a Boeing 727, killing Secretary-designate of the Navy John T. McNaughton and 81 others. The National Transportation Safety Board listed the probable cause of the accident as the Cessna's deviation from its IFR clearance, but implicated the air traffic control system and lax requirements for instrument pilots as contributory factors. As a result, the Board made recommendations regarding more stringent requirements for IFR pilots (Flight Safety Foundation, 2006). Among the resulting changes were new standards for instrument currency, and required proficiency checks. Although evolved in the years since, currency and proficiency checks remain significant considerations (and legal requirements) in instrument training and flying.

More changes came in 1974. These changes were not the result of any major accidents, but were part of a move toward tougher new rules in most areas of pilot and flight school training, testing, and certification. The FAA Chronology notes the following changes affecting instrument training and certification:

- All Flight Instructors in airplanes were now required to hold an instrument rating. With the advent of this rule, the ATC functions related to both IFR and VFR were generally better understood and explained to all pilots in training.
- Commercial pilots were required to have an instrument rating to qualify for unrestricted privileges. Additionally, the total flight time requirement for new Commercial pilots was raised from 200 to 250 hours, and 50 of these could be acquired in a ground trainer. Since ground trainers are generally more useful in teaching instrument skills than visual flight skills, the effect of this rule was the exposure of many new commercial pilots to increased instrument training.
- More and different skills now had to be demonstrated for an Instrument Rating; roughly the same ones that will be discussed later in this report. Also, new currency requirements for instrument pilots with experience lapses took effect.

By 1985, the total flight hours required for a pilot to be eligible to obtain an instrument rating was dropped from 200 to 125, and a few years later (when the regulations were yet again substantially revised) the total time requirement was dropped. This had the effect of making instrument training available to more pilots, and would encourage them to acquire the rating earlier. Both of these results directly addressed general aviation safety, since many fatal GA accidents involve non-instrument rated pilots attempting to fly in instrument meteorological conditions (National Transportation Safety Board, 2005).

Current Instrument Rating Requirements and Privileges

The currently required flight times and mandated competencies reveal the breadth and complexity of instrument pilot certification. The Federal Aviation Administration requires airmen who wish to add an instrument rating to a previously earned Private or Commercial certificate (with airplane category privileges) to have at least 50 hours of pilot-in-command cross country experience (14 CFR 61.65 (d) (1) Federal Aviation Regulations). Considering that only three hours of dual cross country training and five hours of solo cross country training are required for Private Pilot certification (less in approved training curricula), the 50 hour PIC requirement makes it clear that the FAA still deems significant pilot experience a prerequisite for an instrument rating. Indeed, many of the mandated *Private* Pilot competencies, such as radio communications, recognition and interpretation of critical weather situations, preflight procedures, navigation and navigation systems, and other skills must be deeply ingrained in a pilot prior to instrument rating eligibility. By necessity, all are practiced during the accumulation of 50 hours of PIC cross country. Even many FAA certified schools that are exempted from the “50 hour PIC cross country rule” voluntarily retain an equivalent amount and type of training within their syllabi, in part so that the necessary airman “skill assimilation” may occur before or during initial instrument training (Jeppesen Instrument Commercial Syllabus, Spartan School of Aeronautics, et. al.). Specialized and specifically mandated skills required for the Instrument rating, as described by 14 CFR 61.187 (Federal Aviation Regulations) include:

- Attitude instrument aircraft control and operation.
- IFR weather information and interpretation.
- Instrument-specific chart interpretation and cross-country flight planning.
- Aircraft instrument and instrument system knowledge.
- Air Traffic Control procedures, phraseology, and compliance, including procedures related to holding, en route, departure, arrival and approach.
- Navigation and associated navigation instrument interpretation and manipulation.
- Applied regulatory and procedural decision making skills.

Further, an airman applying for an instrument rating must be prepared to demonstrate competency on certain *tasks* (Flight Standards Service, Instrument Rating For Airplane Practical Test Standards, 2004). A listing and explanation of required tasks is fairly comprehensive, and includes:

- Obtaining, interpreting, and analyzing weather reports and forecasts. The instrument rating applicant must be able to make regulatory and procedural decisions based on the weather forecast, such as determining and designating an appropriate (and legally eligible) alternate destination.
- Planning an IFR cross-country flight. During the planning process, the applicant must demonstrate due consideration of real-time weather conditions, aircraft performance, appropriate departure, en route, arrival, and approach charts, NOTAM information, and related regulatory and procedural decision making.
- Knowledge and operation of aircraft deicing systems.

- Knowledge of, preflight considerations of, and operation/interpretation of aircraft instruments and navigation equipment (as appropriate to the aircraft flown). Specific equipment listed in the PTS includes: pitot-static system, pitot heat, altimeter, airspeed indicator, vertical speed indicator, attitude indicator, horizontal situation indicator, magnetic compass, turn and-slip/turn coordinator, heading indicator, electrical systems, vacuum systems, electronic flight instrument display, VOR, DME, ILS, marker beacon receiver/indicator, transponder, ADF, GPS, FMS, communications equipment, and traffic and terrain awareness/avoidance systems.
- Knowledge and demonstrated mastery of air traffic control clearances, including (at least) these clearance elements: copying, understanding and reading back the clearance, verifying compliance capability, and executing clearance "set up" tasks, such as tuning frequencies and setting transponder codes. It should be noted (though the PTS does not specify) that "mastery" should also include knowing how to amend or modify clearances if needed, as well as finding frequencies and the correct ATC facility and phraseology to *request* the clearance.
- The ability to execute the above clearance, with consideration given to failed communication or navigation equipment, and the related regulatory and procedural knowledge.
- Knowledge and demonstrated mastery of holding procedures, including appropriate speeds, holding pattern entry procedures, holding fix identification, and operation within the protected airspace.

- Basic instrument flight maneuvers, which includes turns, climbs, descents, unusual attitudes, and various combinations of all of these. Demonstrated knowledge of correct power settings and configuration during these maneuvers is also required.
- Demonstrated mastery of intercepting and tracking VOR, NDB, or GPS radials, bearings, or routes, including DME arcs, and the identification and correct orientation of each.
- Knowledge and demonstrated mastery of instrument approach procedures, including two nonprecision approaches (NDB, VOR, LOC, LDA, GPS, RNAV, SDF) and one precision approach (ILS or MLS). Many of the operations specified in other tasks (communication, regulatory knowledge and resulting implications, clearance compliance, etc.) are integral to the completion of these approaches, and are listed in the PTS as specific skills to be evaluated during this phase of the practical test. Also, missed approaches, circling approaches, a "partial panel" approach accomplished with loss of one instrument system (usually the vacuum driven gyros), and a landing from a straight-in approach all represent specific tasks with their own sets of required skill and knowledge, but are noted here under "approaches" for reasons of brevity.
- Knowledge of emergency procedures, dealing mostly with loss of communication capability.

It should be noted that many of these tasks require *applied* knowledge, which the FAA calls "knowledge correlation," and it is at the top of the FAA's "Levels of Learning" (Federal Aviation Administration, Aviation Instructor's Handbook, 1999).

The FAA defines this level as “associating what has been learned, understood, and applied with previous or subsequent learning,” and this is an apt description of the knowledge and skill required to perform many of the noted instrument pilot skills. Acquiring this required knowledge can be quite daunting to the beginning instrument student, and some pilots may not learn it well. Instead, they may learn only enough to earn the rating. This is easier than it sounds, since the FAA’s Practical Test Standards book not only outlines the required skill and knowledge, but may also provide a template for how the skill and knowledge will be tested (though the FAA warns against using it as such in the Airplane Flying Handbook). The tendency for students to prepare for the test, not the real-world application, is ever present (Blickensderfer, Summers, and Schumacher, 2005). Indeed, FAA designated Pilot Examiners sometimes construct a test that incorporates the most PTS tasks in the least time, and routinely employ this test on successive applicants. Instrument rating trainees (and their instructors) may prepare for the practical test, in part, by “networking” with peers who have taken the same test with the same examiner. If the test is too predictable, less actual applied knowledge is required, since anticipated tasks and procedures can be memorized and demonstrated through rote understanding (a lower level of the FAA’s hierarchy of learning).

Once an instrument rating is earned, as noted, a pilot may operate an aircraft without outside visual references. He or she may do so in practically any phase of flight, from departure, through en route and approach to landing. The tasks related to these different phases of flight differ greatly in difficulty. Some require little more than the ability to control the aircraft solely by reference to instruments, while others combine aircraft control skills with navigation, communication, chart interpretation, and situational and procedural awareness skills. Unlike in some other countries, there is no "entry level instrument rating." An airman who holds the FAA instrument rating (and complies with certain currency, aircraft type, and weather requirements) may attempt virtually any of the tasks noted above.

The broad range of privileges granted by the FAA instrument rating stands in contrast to the limitations imposed on the holders of instrument ratings granted by other counties' aviation administrators. In Canada and the UK, for instance, there are graduated instrument "ratings." In Canada, a not-yet-instrument rated pilot may earn a VFR-Over the-Top rating by demonstrating his knowledge of the required subject matter to a qualified flight instructor (Canadian Aviation Regulations 602.116). This rating allows the holder to fly without visual contact with the ground and over or between cloud layers, but not without at least *some* outside visual references. The flight must originate in, maintain, and terminate in visual meteorological conditions. While a similar *privilege* is granted in American airspace to non-instrument rated pilots, the Canadian VFR-Over-The-Top rating is not a transitional step in American airman certification, as it may be in Canada. Indeed, the FAA's "VFR-On-Top" *clearance*, may *only* be granted to pilots who have earned an Instrument rating and are instrument current. In the UK, non-instrument pilots are similarly prohibited from flying without visual contact with the surface, while instrument rated pilots (who meet the appropriate currency and aircraft type requirements) have broad privileges to fly in instrument meteorological conditions, much like American pilots. Between these two extremes, however, lies the U.K.'s "IMC Rating," which requires considerably less training and demonstrated skill to earn, and authorizes pilots to fly in IMC only in certain classes of airspace and with restrictions on conditions for take-off and landing (LASORS, 2008). The IMC rating, interestingly, is considered a "national rating" only, and is generally not recognized outside of the UK. It does, however, enable UK pilots to incrementally gain experience in instrument meteorological conditions while insulating them from the worst IFR weather.

It should also be noted that the training and certification philosophy of the Federal Aviation Administration is different than that of its European counterpart, the Joint Aviation Authorities, an organization which represents several European member states. Within the FAA, practical tests have historically been emphasized. This is due to the traditional "building block" philosophy of training whereby modular "tasks" are contained within certificate and rating-specific flight time and knowledge requirements. Many of these same tasks are then grouped within "Areas of Operation" and published in the "Practical Test Standards," or "PTS." The PTS serves as a template for how the practical test is to be conducted and what will be included in it. The PTS will figure prominently in this research project, as we will see, and a later section of this chapter is dedicated to it. A PTS is published for each of the various airman ratings and grades of certification, and each of the levels of certification may be a stand-alone endeavor (though previous levels of certification are frequently prerequisites). Aircraft type-specific training, when required, is done the same way. Only in certain FAA approved experimental syllabi (to be discussed later) are the various privileges of the higher ratings learned and practiced throughout an airman's training.

Within the JAA, however, the airman training structure has historically embraced "integrated training" more than the FAA's task-based training and testing philosophy (General Philosophies Behind FAA and JAA Pilot Licensing Systems, 2008). Certain

JAA-approved flight training organizations offer the JAR-FCL professional license and the ARP-L (which correspond roughly to the FAA's Commercial and ATP certificates, respectively) that include training in multi-pilot and, sometimes, type-specific operations.

Regardless of training philosophies, the need for realistic instrument training in any setting has made the use of flight simulators very desirable. Indeed, the capability of modern simulators has made possible training situations that involve realistic IFR scenarios that cannot be legally or safely duplicated in actual flight. Called "Scenario Based Training" (or just "SBT"), this training paradigm is used more and more frequently in flight training and testing, and appears to hold great promise for aviation education.

Scenario Based Airman Training

Scenario Based Training may represent a major paradigm shift in flight training. Traditionally, aviation training has involved the learning of facts and procedures through memorization, correlation, and duplication, both in the classroom and the cockpit. Once learned, the mastery of facts, procedures and "maneuvers" are then demonstrated on written and/or practical tests. Unfortunately, many of the facts and maneuvers are "stand alone" items; some do not relate directly to realistic airman competencies (Blickensderfer et al., 2005). Actual point-to-point operation of an aircraft, involving information gathering/interpreting/application skills, is not easily tested on flight and written tests, and the training and preparation for those tests has therefore not been incentivized to include them.

Scenario based training, on the other hand, was developed to integrate real-world operator competencies. SBT is a "training system that uses a highly structured script of real-world experiences to address flight training objectives in an operational environment" (FAA-Industry Training Standards, 2003). In fact, SBT has been used to train operators in diverse environments including nuclear power plants, military team exercises, and others. The concept acknowledges the need for operators in complex and dynamic environments to "continuously adapt their operational strategies to cope with emergent demands" (Oser, 1999). Specific characteristics of SBT include: a focus on the development of practice and feedback, an emphasis on the acquisition of complex (i.e., often non-proceduralized or novel) tasks, team (rather than individual) training, and the use of simulation in training (Oser). Interestingly, all of these elements are assuming greater importance in primary flight training with the aforementioned emphasis on integrated training, the greater role of the team (ATC, weather briefer, etc.) even in single pilot operations, and the proliferation of low-cost flight simulators.

Notably, Line-Oriented Flight Training, or "LOFT," has been used in airline training for years. LOFT makes use of "realistic full mission situations" in contrast to the isolated "tasks" common to general aviation training (Lauber and Foushee, 1981). Loft training includes both routine operations and non-routine emergency operations, some of which are reconstructed from actual accident reports. LOFT has proven to be so successful in airline training that it has replaced semi-annual proficiency checks under certain conditions.

Recently, the FAA has endorsed the concept of Scenario Based Training for general aviation with a program called FAA/Industry Training Standards, or "FITS." FITS was originally envisioned by the FAA as an initiative to improve and modernize training for the new generation of Technically Advanced Aircraft without mandating the training process through regulations. Technically Advanced Aircraft, as the name implies, employ highly sophisticated instruments and avionics to provide pilots with a great deal of information. Specifically, Technically Advanced Aircraft (TAA) are defined as “general aviation aircraft that contain a GPS navigator with a moving map display, plus any additional systems” (FAA-Industry, 2003). Traditional systems such as autopilots when combined with GPS navigators are included, but the term “TAA” is commonly used to mean “glass cockpit.” An aircraft so equipped has little cockpit similarity to traditional training aircraft; virtually all of the traditional instruments are replaced with “TV screens” (primary and multi-function displays). A pilot with no glass cockpit training or experience would be unequipped to operate one to its full capability, regardless of his previous “traditional” flight experience (General Aviation TAA Safety Study, 2003).

As might be expected, this infusion of technology into the General Aviation Fleet has created major training headaches for the FAA. Aware that TAA were continuing to evolve, and that TAA were representing an increasing percentage of the fleet, the FAA in 1995 sought outside guidance to juggle the conflicting issues of rapid industry growth, changing technology, and declining resources (FAA-Industry, 2003). As part of Challenge 2000 - the name of the FAA’s initiative to prepare for the necessary changes in general aviation oversight - the Administration commissioned a national consulting firm to advise them on how to proceed. The consulting firm’s final report contained a section entitled “Empower Rulemaking and Evolve To Performance Based Regulation,” which encouraged the FAA to do just that. Further, the report noted that “the current rulemaking process and the prescriptive nature of most of the FARs are neither responsive to the pace of change in the aviation environment, nor to granting industry the operational flexibility [to evolve towards performance based regulations]" (FAA-Industry). In response, the FAA has created and fully endorsed FITS. As noted, an integral part of FITS is to incorporate scenario based training into primary (and advanced) flight training. Another characteristic of FITS is the direct input that manufacturers and users have on training requirements. Indeed, the FAA has stated that they are deliberately "confining the scope of FITS to technical standards, rather than regulatory and policy issues" (FAA-Industry). Suppliers and trainers are encouraged to submit syllabi to the FAA for approval, and the FAA publishes multiple approved syllabi to serve as templates (Federal Aviation Administration, n.d.). The FAA's role is "primarily in the areas of technical review and as repository for the standards" (FAA-Industry). Once FAA approval is granted, training and standardization with FITS syllabi may be conducted. This provides several benefits for both trainers and trainees, including reduced training time, possible insurance cost reduction, and of course, more realistic flight training. Of course, the FAA will retain statutory oversight responsibility. Along with simply "approving" FITS syllabi submitted by industry stakeholders, a specially formed FAA workgroup will be trained and knowledgeable in FITS standards and will critically evaluate and make recommendations for approved syllabi and provide guidance to Aviation Safety Inspectors and Designated Pilot Examiners (FAA-Industry).

Initial research into the efficacy of FITS-style SBT shows promise both in the reduction of training time and the integration of multiple airman competencies. As noted, integrating real-world pilot skills into the training and testing mandated by the regulations can be problematic. This is particularly true in modern TAA aircraft, since the major technological advances of these aircraft (synthetic course depiction, moving maps, depicted weather and limitation information) are not fully utilized unless a pilot is operating under (or training for) instrument flight rules and/or conducting course-specific, point-to-point operations. As already noted, traditional flight training - with its bias towards stick-and-rudder, task-based training - does not fully take advantage of these technological advances. To determine, in part, whether modern aircraft and airmanship had advanced beyond the traditional training paradigm, researchers at Middle Tennessee State University devised a study involving TAA aircraft, a training paradigm that involved no minimum flight times, and a scenario based curriculum. The scenarios were "real-world" based; the student's very first flight using the syllabus involved a trip to a nearby airport. And, while the syllabus still required basic stick-and-rudder skills, they were encompassed in a "mission" scenario. Notably, the MTSU study involved the seamless training of student pilots from "zero time" up through the instrument rating, which is only now being considered for codification into the Federal Aviation Regulations through the FAA's proposed rule making process (Pilot In Command Proficiency Check And Other Changes, 2009). We should remember that combining certificates and ratings is definitely *not* the norm, as the FAA's modular training philosophy has traditionally required Private pilot certification first, and then the addition of an instrument rating (General Philosophies, 2008). Traditionally, both of these levels of airman certification have required distinct flight time requirements, skill sets, and training regimens. Indeed, MTSU researchers had pioneered combined Private and Instrument training, having previously (2004) developed the first experimental combined private/instrument TAA Private *and* Instrument course to receive FAA approval at a certificated flight school. Even so, the FAA was not entirely willing to combine the training and testing of the two levels of certification for the study, and granted the researchers a conditional exemption from the standard training paradigm that still included "…many drill-and-practice type maneuvers that do no match well with [the study's] scenario based syllabus" (Craig, Bertrand, Dornan, Gossett, and Thorsby, 2005). Indeed, researchers noted that elements of the FAA's incomplete approval to forego Private pilot certification en route to the instrument rating "lengthens the time of training and pushes instructors to 'teach the test' rather than 'teach for the real world'" (Craig et al.). Understandably, some of the "bottlenecks" of traditional flight training remained, particularly the difficulty of (and repetition of lessons to prepare for) first solo flight. However as training progressed, students involved in the study reaped major rewards as more advanced airman tasks such as cross country planning, navigation, and instrument approaches - all of which had been practiced since early in the curriculum - were performed with relative ease. Indeed, student pilots involved in the study earned private and instrument ratings in an average time of 88.7 flight hours. This compares favorably to the average of 134.3 hours for control group students who followed the traditional training paradigm (Craig et al.).

It should not be assumed that the move away from traditional "maneuvers based training" is applicable only to TAA. In fact, the FAA and various flight training stakeholders encourage the use of scenario based training for all levels of airman certification and for all types of aircraft. One notable example is Jeppesen, a well known provider of aviation training materials and aeronautical charts. Jeppesen impacts much of the aviation training community through their popular Flight Instructor Refresher Course (all flight instructors are required to renew their certification biannually) so much of the Jeppesen curriculum “trickles down” to all pilots. A core component of this curriculum is a lengthy section entitled “Systems Safety,” which includes the following subtopics: Risk Management, Decision making, Single-pilot Resource Management, and Scenario-based instruction. The section begins with a statement that encourages a shift away from isolated maneuvers-based training towards more realistic “scenario” style training:

> Your students will learn how to perform dozens of individual maneuvers and procedures throughout the course of their training…[but] when you incorporate system safety concepts into your instruction, you teach your student to look at the life cycle of each flight as a system that depends on the working relationships of a wide variety of elements (Jeppesen CFI Renewal).

The Jeppesen text acknowledges that students are “…more anxious to learn to land, fly an approach, or handle a simulated emergency … than to manage risk and hone their decision-making abilities.” But the text supports the necessity to do the latter with sobering facts and statistics, including:

- “The Nall Report lists the pilot as the major cause in over 70 percent of all accidents.”
- “Continuing VFR flight into IFR conditions result in the greatest number of fatal weather accidents.”
- “Maneuvering flight is one of the largest single producers of fatal accidents. Many of these accidents are caused by loss of control during low, slow flight; or striking wires, trees, or terrain when flying at low altitudes.”

- "Personal flying averages about 50 percent of all GA flying, but is responsible for approximately 70 percent of all accidents and at least 75 percent of fatal accidents. The Nall Report has stated: "Reasons for the high accident rate in personal flying include lack of experience, proficiency issues, pilots exceeding personal limitations, showing off, and just plain poor judgment."
- "Studies have shown a strong link between errors in decision making and the severity of accidents: simple problems with skills can produce minor injuries and damage, while faulty decision making often results in accidents with serious injuries and fatalities."

The Jeppesen text also supplies tools and subject matter designed to help teach students to see the "big picture" when conducting a flight. One of these, as noted, is Aeronautical Decision Making, which borrows strongly from the scenario-based concept. Aeronautical Decision Making, or "ADM," is a training philosophy that leads students into simulated non-emergency situations that require "on-the-fly" decision making and applied actions. In short, the carefully planned maneuvers or tasks of a lesson may *not* happen, but are instead replaced by the necessity to adapt with applied knowledge of resources and procedures. Indeed, the acronym ADAPT (Acknowledge a change, Define the problem, Analyze your options, Perform an action, and Think ahead) is one of the tools that Jeppesen encourages all pilots to learn. As noted, the FAA has heartily endorsed the ADM concept, and requires ADM principles to be applied during all practical tests. In fact, ADM appears in the special Emphasis section in the Private, Commercial, Instrument, and Flight Instructor Practical Test Standards (Flight Standards Service, 2002, 2004).

The Need for Realistic Instrument Training

As noted, bad weather has always been the nemesis of safe flight. Even in the modern era, with weather information easily obtainable and knowledge of adverse weather required of all pilots, weather related accidents still occur. In fact, while the total number of general aviation accidents per year has declined over the past two decades, the proportion of general aviation accidents that occur during instrument meteorological conditions has remained fairly constant, ranging from 5 to 9 per cent (NTSB Risk Factors, 2005). Further, weather-related accidents that occur in IMC are much more likely to be fatal than accidents that take place in visual meteorological conditions. This is due to the common causes of both. VMC weather-related accidents are most likely to be relatively low-speed takeoff or landing mishaps, often caused by gusty wind. Conversely, IMC accidents are more likely to involve loss of control at altitude and uncontrolled descent to the ground with a correspondingly high speed (Price & Groff). Indeed, over the past 20 years about two-thirds of all IMC general aviation accidents have been fatal. This represents a rate about three times higher than the fatality rate of all GA accidents (NTSB Risk Factors)!

Not surprisingly, much research has been conducted regarding IMC accidents. Researchers within the National Transportation Safety Board published reports on weather- or visibility-related GA accidents in 1968, 1974, 1976, and 1989. A total of 82 recommendations resulted from these reports, with most directed at the FAA. Other recommendations were addressed to the Environmental Science Services Administration or the National Oceanic and Atmospheric Administration. The Board's recommendations fall into three broad categories: the collection and dissemination of weather information, air traffic control, and pilot training and operation. Obviously, the category of “pilot training and operation” is most relevant to this project, and within it the Board’s recommendations have included:

- Revise the regulations to disallow takeoffs or flight beyond the final approach fix of instrument approaches unless the latest weather report for that airport reports the visibility to be equal to or greater than the prescribed visibility minimums. (1983)
- Require all holders of airman certificates with instrument and multiengine ratings to demonstrate “ability to operate a multiengine aircraft under normal and emergency conditions by reference to flight instruments.” (1985)
- Incrementally increasing requirements for airman meteorological knowledge at various grades of certification. (1975, 1977)
- Issue an advisory circular stressing to all instrument-rated pilots the need for continuous surveillance of flight instruments when operating in IMC (!). (1973)
- Revised limits on minimum approach altitudes and visibility. (1969, 1973)

The NTSB’s research on GA weather accidents have not specifically focused on the level of pilot certification, probably because a general assumption is that it is non-instrument rated pilots who are the hapless victims of VFR flight into IMC. Indeed, the majority of the accidents studied involved relatively low-time, non-instrument rated pilots (NTSB Risk Factors, 2005). The annual Nall report does correlate level of pilot certification and accident trends, but tracks *grade* of pilot certification rather than pilot *ratings*. It may be that the role of instrument rating training and testing, and the impact of both on the weather accidents remains under-researched.

One recent study did make at least some assumptions about the efficacy of the instrument rating. This NTSB study, entitled *Risk Factors Associated With Weather-Related General Aviation Accidents* compared GA weather accident flights to flights on the same day and location that did *not* result in an accident. Among the Board's findings was that of the 72 accidents studied, 68 percent of the accident pilots were rated for instrument flight. This statistic, of course, does *not* mean that instrument rated pilots are less skilled than non-instrument rated pilots at flying in adverse weather. Rather, it more likely reflects the obvious increased exposure of instrument rated pilots to IMC. Indeed, another of the Board's findings was that "not having an instrument rating was associated with significantly higher accident risk… pilots who did not hold an instrument rating were found to be 4.8 times more likely than instrument-rated pilots to be involved in a weather-related accident" (NTSB). Also, the 2007 Nall Report (AOPA Air Safety Foundation, 2007) noted that if all general aviation flight hours are lumped together, flight in IMC actually has a *lower* per-hour accident rate than does flight in VMC (5.7 vs. 7.2 accidents per 100,000 hours).

Still, the fact that 68 percent of the studied weather-related accidents involved instrument rated pilots suggests that the instrument rating is no panacea for bad weather. In fact, it *may* suggest that some pilots who have earned an instrument rating are not able to use it. Anecdotal comments within the literature seem to agree, as noted aviation columnist Richard Collins observes:

> Some years ago, VFR weather-related accidents outnumbered IFR weather-related accidents by a lot. That has now reversed and many more weather accidents are found in IFR flying. Maybe there is more

> IFR flying, or maybe VFR pilots are doing a better job of risk management. Whatever the reason, the potentially high level of risk is something to think about before taking the IFR plunge (Collins, 2008).

Within the NTSB's database of aviation accidents, certain accident reports cast some doubt on the efficacy of instrument training. Some of these same accidents, however, may also reveal a very real element of instrument training's value: it teaches the inherent difficulty of instrument flying! A fatal accident on July 6, 2007 is one example. On this date, an instrument-rated commercial pilot anxiously watched the weather and debated attempting an IFR flight from Waco to Lufkin, Texas. As an area of low ceilings and reduced visibility moved through the region, the pilot called the Flight Service Station no fewer than six times to receive standard briefings and updates. During the conversations the pilot revealed that he was instrument-rated but "did not want to take any chances," and that his flight instructor told him not to take off if he "didn't feel comfortable." But, with the desire to get home building, the pilot did finally file an IFR flight plan and take off into the clouds.

It was a fatal decision, as the pilot was unable to intercept and track a course or even maintain aircraft control. The pilot departed normally and transitioned from Low Radar (Control Tower) to Approach Control High Radar, but then evidently broke out of the clouds and began discussing with ATC the feasibility of changing his clearance to "VFR on Top," possibly implying that he was uncomfortable in IMC. Before any change in his clearance was made, however, he reported that he was "back in the clouds now," and would remain IFR "unless something happens." A few minutes later, the pilot drifted about 2 miles left of course and asked ATC if he "was on the correct course," and that he didn't know what was wrong with his Global Positioning System. With ATC assistance, the pilot was turned back towards the course line to Lufkin. However, within a few more minutes the pilot overshot the course to the right but then corrected back to the left. Then, for unexplained reasons, the aircraft entered a shallow turn to the right. Soon after, a routine frequency hand-off prompted a 1,000 feet per minute descent. Noting the heading and altitude deviations, the ATC controller queried the pilot and assigned a new heading and altitude. Within seconds the pilot reported that he was "lost and going to descend." The right turn continued and the rate of descent increased (up to 3,600 feet per minute) before the aircraft contacted terrain in an uncontrolled spiral dive. The post-accident investigation revealed no mechanical anomalies with the aircraft, and the NTSB ultimately determined the probable cause to be "loss of control due to spatial disorientation," with a contributing factor being "lack of flight experience in actual instrument meteorological conditions" (NTSB Accident Report DFW07). In fact the pilot *was* inexperienced with only 456.7 hours total time, 105.7 hours of simulated instrument time, and *2.5 hours of actual instrument time*.

Of course, care should be taken that too much significance is not read into isolated accident reports. However, the similarities between the preceding report and observations made during the research flights to be discussed later are unmistakable. The pilot in the accident report cited above knew that the flight he was undertaking was risky, and he did so only under considerable, self-imposed duress. The pilot's hesitancy to embark on the flight may emphasize an unintended value of instrument training: the breadth and depth of the required knowledge reveals just how much is demanded of the instrument pilot! In fact, casual conversations with many instrument course graduates is that single pilot IFR is something that they are “not really ready for,” and some pilot examiners award successful instrument applicants a new certificate while semi-jokingly referring to it as “a license to learn.” Indeed, the accident rate of instrument-rated pilots does decrease considerably with experience *after* the rating is earned. Jeppesen reports that “pilots with less than 50 hours of instrument time were involved in 58% of all weather accidents, and 47% of fatal weather accidents. As pilots gain more experience (50 to 100 hours of instrument flying time) their risk decreases by more than 80% to a level slightly below 9% of all accidents” (Jeppesen Guided Flight Discovery Team, Advanced Human Factors, 2006). Newly rated instrument pilots may be insulated from IMC accidents simply because they have learned first-hand how difficult it is and opt to not try it.

Another accident in the NTSB’s database (NTSB Accident Report MIA07) may suggest the difficulty of single-pilot IFR for an inexperienced pilot. The accident, which occurred on September 21, 2007, involved a flight from Conway, South Carolina to Culpeper, Virginia. The pilot, who died in the crash, took off into solid IFR weather; ceilings in the vicinity were between 200’ and 500’ AGL, and visibility at an airport 11 miles away (ceiling and visibility were not reported at the airport of departure) was reported as ½ mile. Evidently, the pilot’s plan was to “scud run,” which is a slang term meaning to stay below clouds and maintain visual contact with the surface for navigation and obstacle clearance. The pilot managed to do just that for approximately 45 minutes, though the weather continued to worsen and terrain elevation was gradually rising along his route. Radar data reflects that the flight was never higher than about 600’AGL, and that the pilot had descended to 265’ AGL when two obstacles (an antenna tower at 215’

AGL and a water tower at 215’ AGL) prompted an aggressive maneuver and ultimate loss of control. Sadly, “scud running” is a common cause of accidents for non-instrument rated pilots and is frequently associated with the “VFR into IMC” accident category. Usually, it is done because the pilot has no other options besides staying on the ground, e.g. the weather is IFR and the pilot is VFR only. The accident described above is therefore notable for at least one very good reason: the pilot was instrument rated.

Indeed, the pilot had earned his instrument rating some 23 months earlier and had logged three simulated instrument flights since, totaling 8.5 simulated instrument hours. Notably, however, he had no logged time in actual instrument conditions. Why he did not elect to use his instrument rating on the accident flight to climb to a safe altitude, particularly as ceiling and visibility decreased, is unknown. Possible answers, as suggested by Goh and Wiegmann (2001), are that the pilot’s decision making was flawed by poor “situation assessment” and/or poor “risk perception.” That is, the pilot may have simply underestimated the worsening weather conditions and overestimated his ability to compensate for them, and therefore concluded that operation under IFR was unnecessary. Another possible answer, however, and one that may be under-researched, is that he was less intimidated by the rising terrain than by the difficulty of acquiring and executing an IFR clearance! Indeed, other instrument rated pilots have possibly made the same decision. As noted, the NTSB reports that 68% of pilots involved in weather related GA accidents from August 2003 through April 2004 were instrument rated, though only about 56% of these accidents were operating on an instrument flight plan (NTSB Risk Factors, 2005).

Investigating the Practical Test Standards

Within the flight training industry, other researchers have given thought to the current airman certification training and testing paradigm. A study conducted jointly by faculty at the University of North Dakota and Embry-Riddle Aeronautical University proposes “development of a methodology for justifying the inclusion or removal of maneuvers from the Practical Test Standards.” This study was published in four reports between April and October 2005. Not surprisingly, the first report is an analysis of how the current Practical Test Standards were originally created and subsequently evolved. Researchers’ telephone interviews with members of AFS 630 (the FAA branch tasked with oversight of the PTS) revealed that “…many maneuvers [in the PTS] had been ‘Grandfathered in’ based on original work by the Army Air Corps.” Further, the FAA acknowledged that the intent of some PTS maneuvers were designed to “teach eye-hand coordination, division of attention, and basic aircraft control,” and were admittedly “not tasks that a pilot encounters on real flights” (Blickensderfer et al., 2005). This “disconnect” between PTS maneuvers and “real flights” has become even more apparent with the advent of FITS, as discussed earlier. Researchers creating FITS-style syllabi have noted a “mismatch” between FITS training and the final Practical Test. Researchers argued that the “FITS approach to pilot training trains the same knowledge and skills but in a different manner” (Blickensderfer et al.). As evidence, they offer the traditional PTS task of “turns around a point,” a maneuver designed to acquaint the student with wind drift corrections and the necessary division of attention inside and outside of the cockpit. These same skills, researchers contend, are already developed via the accomplishment of real-life maneuvers such as VFR traffic patterns. Indeed, Craig et al. (2005) argue that, at times, the flight instructor must take the student's focus off of the "big picture" and teach with the "sole purpose of passing the PTS-mandated test instead of teaching the skills necessary for actual flights." Further research into the efficacy of traditional maneuvers-based flight training led to a series of surveys in which other flight maneuvers were evaluated. Flight instructors from the two aeronautical universities were asked about the relevance of "tasks" in the Private and Commercial PTS. The questions were designed to elicit an "expert" opinion on (1) how *frequently* the task was required for actual flight, (2) how *important* the task was perceived to be for an actual point-to-point flight, (3) how "*real*" the task used in training was perceived to be, and (4) how *redundantly* the task was evaluated in other, but similar training tasks (Blickensderfer et al, 2005.) As might be expected, many of the traditional training tasks were scored quite low in all areas, with ground-reference maneuvers generally fairing the worst (Blickensderfer et al.).

Researchers from UND and ERAU note that the issues confronting practical test creation and application are *content validity* and *criterion validity*, and while considerable research exists on both topics, a simple definition of each will suffice here. In this context, "Content Validity" refers to the relationship between what knowledge or skill is *tested*, and what knowledge or skill is *required* for the performance of the actual task or procedure. Criterion validity, in this context, relates to the *measurement* of knowledge and skills, and how this measurement gleaned from the test accurately gauges actual performance of the task in the real world. Blickensderfer et al. note a reported "mismatch" in what the PTS requires, and what is actually required in certain operations, particularly the operation of TAA aircraft and the training outlined in certain FITS syllabi. If the pilots of TAA are indeed unlikely (or less likely) to use the skills required by the PTS, content validity issues are certainly called into question. She further notes that Craig et al. (2005) contends that artificial PTS requirements, such as the formerly noted “turns around a point,” are not a valid measure of an airman’s ability to conduct “real” ground-reference operations (such as a traffic pattern), and that grading the former as a gauge of the latter represents questionable criterion validity. This is compounded by the knowledge that considerable time and energy is spent training the student to perform turns around a point, when both the student and instructor know that the maneuver will *only* be performed on the practical test, and *rarely or never* in real life. Anecdotal comments from the flight instructors who completed the UND/ERAU survey made repeated references to “wasting” training time while teaching certain maneuvers. The comments include: “This maneuver in no way relates to any skill required in flight. It’s time consuming and frustrating for students to train [to] standards in these maneuvers,” “Never used for normal flight,” “Never performed one or needed to other than on the check ride,” and “Only thing I get out of this is patience!”

It should be noted that Blickensderfer’s work dealt exclusively with the Private and Commercial Practical Test Standards and their respective levels of airman certification. Likewise, Craig et al’s work deals with Private pilot operations. And while their findings have great relevance to all airman certification, they may have even more profound implications for the instrument rating. Indeed, content and criterion validity could have serious implications for instrument training since actual IFR operations routinely involve weather, complex ATC interaction, and decision making scenarios that are difficult to reproduce in the training and testing environment. Indeed, content validity on the Instrument rating test may be highly suspect, since certain items may never be tested at all!

In fairness, it should be noted that the PTS is not a static document, and AFS 630 does not ignore changes within the flight training industry. In fact, each PTS (a separate PTS exists for each airman certificate and rating) is reviewed and updated on a 5-year cycle, with incremental changes occurring as needed. The update process involves the solicitation of input from industry stakeholders including FAA designated examiners, active pilots and FAA administrators, and the general public (Blickensderfer et al., 2005). Indeed, the PTS is published with an introduction that solicits input from the field, and provides an address for interested parties to forward comments to the FAA. Further, the PTS contains a section entitled “Special Emphasis Areas,” which frequently represent the very latest issues relevant to aviation safety, and as previously noted, makes reference to scenario-implied Aeronautical Decision Making principles.

It should also be noted that scenarios, rather than tasks only, figure prominently in the FAA Practical Test Standards. For instance, in an introductory section entitled “Use of the Practical Test Standards” in the Instrument Rating PTS, the examiner is required to develop a written “plan of action” that includes “one or more scenarios that will be used during the test.” The examiner is further encouraged to include as many tasks as possible within the scenarios, but also to “maintain the flexibility to change due to unexpected situations,” presumably to accurately model real-world operations (Flight Standards, 2004). The PTS has also codified the need to evaluate “basic instrument flight maneuvers throughout the test instead of being treated as separate tasks” in a section entitled “Major Enhancements [to the current PTS]”. Further, some specifics are offered for developing scenarios that require an applicant to apply Aeronautical Decision Making principles, with weather decisions and performance planning being noted. Finally, in a preliminary section of the Instrument Rating PTS entitled “Examiner Responsibility,” it is clearly stated that “Examiners shall test to the greatest extent practicable the applicant’s correlative abilities rather than mere rote enumeration of facts throughout the test.” How effectively the corps of instrument examiners are integrating these recommendations into airman practical tests is open to debate, and could be the basis for further study.

Summary

The prospect of change to flight training is nothing new. Indeed, changes to knowledge, experience, equipment, and certificate requirements have accompanied the instrument rating since its inception in 1933. What has *not* changed is the need to keep flight training current with contemporary educational philosophy and technology, and the time may be right for a major infusion of modernity. The burgeoning fields of scenario based training, sophisticated, low-cost flight simulation, and blended-rating syllabi may together be poised to significantly change flight training. Certainly, cause exists to critically examine the present training paradigm, and see if it might be improved by an unflinching evaluation of current training practices. As discussed in this chapter, current instrument rating test standards, and the way in which they are employed in practical tests, may not clearly discriminate between applicants who have adequate instrument pilot skills and those who may have merely mastered the test tasks. Indeed, perhaps only a real IFR flight, with real-time application of instrument pilot skill, can provide satisfactory answers to the following research questions:

1. Does the newly rated instrument pilot, having demonstrated the ability to pass the FAA instrument rating practical test as described in the practical test standards and applied by a FAA designated pilot examiner, really have the skills and knowledge necessary to successfully complete a simulated, non-training, point-to-point, IFR flight?

2. Did the training of the newly rated instrument pilot adequately prepare him or her to apply the skill and knowledge required by 14 CFR FAR 61.65 **(b)** and **(c)** to successfully surmount common challenges during a real-world IFR flight?

The following chapter will describe how, in this study, a “real” flight under instrument flight rules, with real-world ATC interaction and common IFR procedures, has been engineered to attempt to answer these questions.

CHAPTER III

METHODOLOGY

Introduction

This study proposes collection of data to answer questions concerning the effectiveness of airman instrument rating training; specifically, is an airman who has *earned* an instrument rating able to successfully *use* it? The information may be useful in evaluating the efficacy of instrument rating training and potentially improving it, and will also be used to address the research questions that appeared at the end of the last chapter and will be repeated later in this one. Specifically, this chapter will describe in detail how the experiment used to answer these questions was constructed.

In this self-reported study, data was collected using human subjects conducting a simulated IFR, point-to-point, flight in a flight simulator. The volunteer research participants in this study, all of whom were newly certified instrument rated pilots, were tasked with conducting an IFR flight with moderate, but common, “challenges” occurring en route. None of the challenges were designed to constitute an emergency, but all were designed to represent fairly common tasks that are not easily duplicated, and possibly under-practiced, in instrument training. Participant performance was measured against required instrument pilot competencies (referenced in this study as both “tasks” and “learning objectives”) with representative letter grades assigned for each required competency. The relative importance of each task was assessed as well, with each being assigned a numeric value from 1 (least important) to 5 (most important). The rationale for the foregoing task valuation assessment is discussed in the task headings in Chapter IV and sometimes in the text in Chapter V. Finally, the performance of the research participants was measured against the performance of more experienced instrument pilots, and the Fisher exact test was employed to determine if a measurable performance difference could be detected between the two groups.

This chapter will explain the methodology of the study and will describe the population represented by the sample, including its size and major characteristics, and a definition and justification for the term “newly certificated instrument pilot.” The development of the instrument will be explained in some detail, as it is multi-faceted. Additionally, definition and justification for the “common challenges” will be provided. Documentation and explanation of “instrument pilot competencies” will also be provided, and an explanation of the grading process and criteria will be clarified and correlated with an FAA certification standard. Finally, certain procedural details will be explained.

Development of the Instrument

The instrument in this study is a “real” IFR flight. The use of the word “real” in this context does not mean “actual,” but is designed to imply that the flight may be more “real” than many instrument training flights, as will be discussed later. Indeed, the flight that represents the instrument of this study is not real at all, but was conducted in a flight simulator that meets AATD (Advanced Aircraft Training Device) criteria. Simulated flights are common within airman training as they provide efficiency of time and cost, as well as allow potentially hazardous routine and non-routine operations to be conducted safely (Flexman, Matheny, and Brown, 1993). The efficacy of simulated flight for training purposes has been documented as far back as 1950 by Lintern & McMillan. Since then, the sophistication of simulated flight and its fidelity to real flight has been enhanced greatly. Simulated flights are not only commonly used in airman training, but are even used for elements of airman certification tests if the "simulator" meets required criteria (14 CFR Part 61.65 (e) (2). The simulator used in this study does. It is a Fidelity Flight Simulation MOTUS 622i, which can be configured for multiple aircraft types and training scenarios. For this project, it was configured with the permanent fixtures (yoke, knobs, instruments, etc.) and visual cues (computer generated instrument and terrain graphics) of a Cessna 172, which is the make and model of instrument trainer used at Oklahoma State University, the source for all participants in this study. The simulator and its installation have been approved by the Federal Aviation Administration for instrument training and limited testing as noted in the approval letter in Appendix H.

Enhancing the realism of the simulated flight were non-emergency "challenges." Stated more simply, the flight did not go exactly as the pilots planned. Instead, they were required to apply skill and knowledge to modify the route, enter a hold, and perform a missed approach at the destination. The pilots then had to decide what to do next, and be able to (or at least *begin* to) implement this plan. All of these "challenges" were *applications* of the required competencies of instrument rated pilots. All are tested on these competencies during the instrument rating certification test. This test, called the

“Practical Test,” or more commonly “checkride,” is conducted in strict compliance with a published test guide, called the *Instrument Rating Practical Test Standards*. The Practical Test Standards, or “PTS,” is published by the FAA. As noted in Chapter II, it contains a very specific outline of the required skills and knowledge of an instrument rated pilot, and provides guidance on how these skills are to be tested. The structure of the PTS breaks these skills down into “Areas of Operations,” “Tasks,” and “Elements.” The PTS ensures that all aspiring instrument pilots (and their instructors) are informed of the body of knowledge over which they may be tested and serves to standardize the base knowledge threshold required to pass the test. It stands to reason, then, that all instrument rated pilots have demonstrated competency in the various tasks and elements of the PTS or they would otherwise not hold the rating. Of course, no single test can fully measure a pilot’s ability to apply the twenty-one tasks of the PTS to all conceivable in-flight situations. Thus, the *challenges* of the proposed research flight are simple, stated elements of the PTS applied to a “real” flight. They may be elements, however, that were under-practiced or under-tested during the airman’s training. The intent of this study, simply stated, is to determine if the newly rated pilot can successfully meet the challenge of moderate “real world” IFR problems in a “real world” IFR flight. The pilot’s new rating says that he can. The “real” flight in the simulator was designed to challenge this assertion.

It should be noted that none of the “challenges” confronting participants in the simulated flight were emergencies. That is, none of the challenges, by themselves, met the FAA’s definition of “emergency” as published in the FAA’s Pilot /Controller

Glossary, even if the pilot's possible inability to cope with the challenge *did* constitute an emergency. The challenges for this flight were limited to:

- Route change (PTS Area of Operation III, Task B, Objective 1, 3, 6).
- Clearance amendment (PTS Area of Operation III, Task A, Objective 1, 2, 3, 4, 7).
- Unsuccessful approach due to terminal area weather and execution of missed approach (PTS Area of Operation VI, Task C, Objective 1, 2, 4, 5).
- Holding clearance/entry and execution of a hold (PTS Area of Operation III, Task C, Objectives 1, 3, 4, 6).
- Necessity to select an alternate destination, and make sound decisions regarding fuel, weather, and route in order to get there (PTS Area of Operation I, Task A, Objective 2 and 5).

As noted, enhancing the realism of the flight was its point-to-point nature. Most instrument training flights depart and return to the same airport. For instance, the Jeppesen Instrument Syllabus, which is a commercially produced syllabus in use at many collegiate flight training institutions, requires only three of the twenty-nine lessons to have departure and arrival points that are different, along with two other flights where cross-country "procedures" are to be practiced (Instrument Commercial Syllabus, 2002). Thus, most instrument training flights are "local" flights. By definition, local flights generally do not expose students to the structure of the IFR departure, en route, and arrival system. Also, local flights do not normally require en route decision making and amending, since there is not an en route portion of the flight. By contrast, a *simulated* flight does allow an en route portion of a flight to be conducted, with the associated ATC and operational requirements. Indeed, modification to routes, clearances, and terminal weather may be easily incorporated both visually and operationally in the simulator. The actual conduct of the flight, including dialogue with ATC, specific routing and clearances, and the relationship of all of these to their respective learning objectives is published in appendix A. Multiple documents necessary for the completion of the flight were presented to participants and are also published as appendices. These include: a standardized pre-flight briefing issued to all participants (Appendix B), a near-complete flight plan form (Appendix C), Terminal Area Forecasts for weather at area airports (Appendix D), and applicable approach (Appendix M) and en route (Appendix N) charts.

Sample and Its Relationship to Population

The control group participants in this study were instrument rated pilots with less than 25 hours of PIC (pilot in command) flight time under IFR. Flight time was verified by a logbook audit before the "flight." All of the participants were students in the Oklahoma State University aviation program, an FAA approved Part 141 flight training provider. The participants were recruited by use of flyers posted at the OSU Flight Center (Appendix D), as well as personal appeals made to certain aviation-related classes at OSU and to individuals. All qualified volunteers were accepted up to a maximum of 25. Indeed, the randomness of participant selection was assured by the fact that *all* eligible participants who were willing to participate were included in the test group; there was no picking and choosing of participants! To eliminate certain variables relating to (lack of) recent experience, all participants were instrument current as per FAR 61.57 (b)

(1)[1]. The only inducement offered to volunteers was loggable "flight" time that they would acquire during the project.

All of the participants were "newly certified," in that they had acquired less than 25 hours as PIC under IFR. Statistically, it could be argued that any instrument pilot with less than 100 hours of "instrument time" is a "new" instrument pilot, since the accident rates show that "as pilots gain more experience (50 to 100 hours of instrument time) their risk [of a weather related accident] decreases by more than 80%" (Jeppesen Guided Flight Discovery Team, Advanced Human Factors, 2006). The 25 hour limit, therefore, was somewhat arbitrary, but was helpful in defining an available sample of the population.

Required Instrument Pilot Competencies

The required competencies that this study sought to measure are also learning "Objectives" stated in the PTS. Or, as the research question asks, "Did the recently certified instrument pilot have the skill and knowledge required by 14 CFR FAR 61.65 **(b)** and **(c)** to successfully surmount common challenges during a real-world IFR flight?" The learning objectives for this research project were supplied by the "elements," "tasks," and "objectives" within the "Areas of Operation" published in the instrument rating Practical Test Standards. As noted in the PTS, "*The Objective lists the important elements that must be satisfactorily performed to demonstrate competency in a TASK.*"

---

[1] It should be noted that one participant was not legally current, but was only *4 days* out of currency. Since getting this participant current would have required five approaches, a hold, and other tasks which would allow enough practice to potentially skew research results, he was allowed to participate without meeting currency requirements. It should also be noted that this participant had made a similar dual flight in actual instrument conditions only the day before, and had actually performed (coincidentally) the Tulsa ILS 36R approach. The principal investigator deemed that this practice somewhat offset the participant's lack of currency, strengthening the decision to include him in the project.

And, while there are many tasks listed in the PTS relevant to the single engine instrument pilot, only eight of these objectives were selected for this research project. The objective selection process was based upon relevance of the objective to the flight and time required to evaluate it. It should be noted that specific elements within the objectives - such as allowed divergence criteria or irrelevant requirements - were sometimes omitted from the objectives or modified for this research project. This was done to more accurately gauge a "real" flight, since the success of a flight is measured by its correct - not perfect - conduct. For instance, a minor altitude divergence that could technically be grounds for failure of the practical test would likely receive no more than a reminder to "check altitude" from ATC during a real flight. The eight objectives, thus excerpted from the PTS, are:

Learning Objective 1: AIR TRAFFIC CONTROL CLEARANCES

REFERENCES: 14 CFR parts 61, 91; FAA-H-8083-15; AIM

Objective. To determine that the applicant:

1. Exhibits adequate knowledge of the elements related to ATC clearances and pilot/controller responsibilities (…).
2. Copies correctly, in a timely manner, the ATC clearance as issued.
3. Determines that it is possible to comply with ATC clearance.
4. Interprets correctly the ATC clearance received and, when necessary, requests clarification, verification, or change.
5. Reads back correctly, in a timely manner, the ATC clearance in the sequence received.

6. Uses standard phraseology when reading back clearance.

7. Sets the appropriate communication and navigation systems and transponder codes in compliance with the ATC clearance.

Learning Objective 2: COMPLIANCE WITH DEPARTURE, EN ROUTE, AND ARRIVAL PROCEDURES AND CLEARANCES

REFERENCES: 14 CFR parts 61, 91; FAA-H-8083-15; DPs; En Route Low Altitude Charts; STARs.

Objective. To determine that the applicant:

1. Exhibits adequate knowledge of the elements related to ATC routes, and related pilot/controller responsibilities.

2. Uses the current and appropriate navigation publication for the proposed flight.

3. Selects and uses the appropriate communication facilities; selects and identifies the navigation aids associated with the proposed flight.

4. Performs the appropriate aircraft checklist items relative to the phase of flight.

5. Establishes two-way communications with the proper controlling agency, using proper phraseology.

6. Complies, in a timely manner, with all ATC instructions and airspace restrictions.

8. Intercepts, in a timely manner, all courses, radials, and bearings appropriate to the procedure, route, or clearance.

Learning Objective 3: BASIC INSTRUMENT FLIGHT MANEUVERS

REFERENCES: 14 CFR PART 61; FAA-H-8083-15.

Objective. To determine the applicant can perform basic flight maneuvers.

1. Exhibits adequate knowledge of the elements related to attitude instrument flying during straight-and-level, climbs, turns, and descents while conducting various instrument flight procedures.
2. Maintains altitude within +/- 200 feet during level flight, headings within +/- 20°, and bank angles within 10° during turns.
3. Uses proper instrument crosscheck and interpretation, and applies the appropriate pitch, bank, power, and trim corrections when applicable.

Learning Objective 4: HOLDING PROCEDURES

REFERENCES: 14 CFR parts 61, 91; FAA-H-8083-15; AIM

Objective: To determine that the applicant:

1. Exhibits adequate knowledge of the elements related to holding procedures.
3. Explains and uses an entry procedure that ensure the aircraft remains within the holding pattern airspace for a standard, nonstandard, published, or nonpublished holding pattern.
4. Recognizes arrival at the holding fix and initiates prompt entry into the holding pattern.

5. Complies with ATC reporting requirements.

6. Uses the proper timing criteria, where applicable, as required by altitude or ATC instructions.

Learning Objective 5: INTERCECPTING AND TRACKING NAVIGATIONAL SYSTEMS

REFERENCES: 14 CFR parts 61, 91; FAA-H-8083-15; AIM

Objective: To determine that the applicant:

1. Exhibits adequate knowledge of the elements related to intercepting and tracking navigational systems (…).
2. Tunes and correctly identifies the navigation facility.
3. Sets and correctly orients the course to be intercepted into the course Selector.
4. Intercepts the specified course at a predetermined angle, inbound or outbound from a navigational facility.
7. Determines the aircraft position relative to the navigational facility.

Learning Objective 6: PRECISION APPROACH

REFERENCES: 14 CFR parts 61, 91; FAA-H-8083-15; IAP; AIM

Objective: To determine that the applicant:

1. Exhibits adequate knowledge of the precision instrument approach procedures.
2. Accomplishes the appropriate precision instrument approaches as

selected by the examiner.

3. Establishes two-way communications with ATC using the proper communications phraseology and techniques, as required for the phase of flight or approach segment.

4. Complies, in a timely manner, with all clearances, instructions, and procedures.

5. Advises ATC anytime that the applicant is unable to comply with a clearance.

9. Selects, tunes, identifies, and monitors the operational status of ground and airplane navigation equipment used for the approach.

12. Maintains a stabilized final approach, from the Final Approach Fix to DA/DH allowing no more than three-quarter scale deflection of either the glide slope or localizer indications.

14. Initiates immediately the missed approach when at the DA/DH, and the required visual references for the runway are not unmistakably visible and identifiable.

Learning Objective 7: MISSED APPROACH

REFERENCES: 14 CFR parts 61, 91; FAA-H-8083-15, IAP, AIM.

Objectives: To determine that the applicant

1. Exhibits adequate knowledge of the elements related to missed approach procedures associated with standard instrument approaches.

2. Initiates the missed approach promptly by applying power, establishing a climb attitude, and reducing drag in accordance with the aircraft manufacturer's recommendations.

3. Reports to ATC beginning the missed approach procedure.

4. Complies with the published or alternate missed approach procedure.

5. Advises ATC anytime that the aircraft is unable to comply with a clearance, restriction, or climb gradient.

Learning Objective 8: "PREFLIGHT" PREPARATION (DETERMINATION OF/PROCEEDING TO ALTERNATE)

REFERENCES: 14 CFR parts 61, 91; FAA-H-8083-15

Objectives: To determine that the applicant

1. Correctly analyzes the weather information pertaining to the route of flight and destination airport, and selects alternate destination as appropriate.

2. Correctly analyzes weather information (in flight), and determines suitable alternate destination.

3. Determines the calculated performance is within the aircraft's capability and operating limitations.

4. Correctly interprets (and applies) charts (and procedures) to proceed to suitable alternate destination.

Grading Criteria

For each “flight,” each of the 40 tasks within the 8 learning objectives was assigned a task value. These assigned values, ranging from 1-5, reflect the relevance of each task to the safe, efficient completion of an IFR flight, and are reported in Chapter IV and the matrix in Appendix E. The participants in the pre-test were asked to assess the accuracy of the task values, and final values reflect input from these subject matter experts. Approximate definitions of the assigned task values are as follows:

1- Task/knowledge that likely would not affect safe completion of flight and/or facilitate its skillful completion.

2- Task/knowledge that probably would not affect safe completion of flight, but could hinder its skillful completion.

3- Task/knowledge that could affect safe completion of flight, and/or *could* hinder its skillful completion.

4- Task/knowledge that could affect safe completion of flight, and/or is *likely* to hinder its skillful completion.

5- Task that is likely to affect and/or hinder safe completion of the flight.

Throughout the exercise, participants were assigned letter grades based on their performance of each task. An approximate definition of these grades follows:

A- Task easily completed or knowledge easily demonstrated.

B- Task fully completed and/or knowledge demonstrated, but at least one extra attempt/clarification/query required.

C- Task completed and/or knowledge demonstrated, but multiple attempts/clarification.

D- Task partially completed and/or knowledge partially demonstrated, but elements of task not done or done incorrectly and/or gaps in knowledge observed or suspected.

F- Task never completed, or knowledge never demonstrated.

As previously noted, certain minor pilot errors were ignored during the exercise. This was done so that procedural conduct of the entire flight itself could be emphasized over minor deviations along the way. For instance, minor altitude deviations due to poor control technique might have earned the participant a "B" on learning objective #3 (Basic Instrument Flight Maneuvers). But *not knowing, misinterpreting, or ignoring* published, assigned or minimum altitudes was grounds for an "F" grade on Learning Objective #6 (Precision Approach). Technically, the PTS is to be applied the same way, as the published grounds for failure includes the phrase, "*consistently* exceeding tolerances." Further, the PTS includes the following statement:

> The tolerances [in the PTS] represent the performance expected in good flying conditions… **[they] are intended to be used as a measurement of the applicant's ability to operate in the instrument environment. They provide guidance for examiners to use in judging the applicant's qualifications…** (emphasis added).

In other words, the PTS tolerances were designed to grade applicant performance during practical tests just as they were applied during this project. Again, grades reflected both task mastery and task importance, with both described in the text accompanying summaries of pilot performance. Each participant had one letter grade assigned for each of the 40 tasks. At the completion of the data collection phase, the assigned task grades were tabulated and published in Chapter IV of this report, along with an accompanying pass/fail assessment. Summaries of participant performance on entire Areas of Operation are reported in chapter VI. A statistical analysis of the data collected from the exercise was conducted using the Fisher exact test, which is explained in some detail in appendix F. Using results from this test, certain conclusions are drawn regarding new instrument pilot abilities, along with the confidence level at which these conclusions may be asserted. These conclusions, along with recommendations are published in chapter VI. Finally, relevant observations of pilot actions or inactions, apparent knowledge or skill gaps, examples, etc. are included in chapter V. These observations and comments are important, because pilot actions or omissions (and thus grades) may have been influenced by factors not readily apparent to the reader of this report.

Pre-Test

Clearly, it is important that task importance was assessed correctly. Also, it is important that the flight truly represented what it was designed to represent: a moderately challenging IFR flight. Obviously, a flight test in the simulator could be created that is so difficult that virtually no one could pass! Conversely, a flight could be created that is too easy. To make sure that this flight avoided both extremes, and to establish a performance standard, a pre-test was conducted. Four subject matter experts completed the proposed flight and were graded exactly like the test group participants. Their comments after the flight were recorded as noted, and their suggestions were used to modify the task values, grading rigor, and elements of the flight. Originally, to qualify as subject matter experts each of the pre-test group members was required to have at least 500 logged hours under IFR, be certificated at the Airline Transport Pilot level, and be an active pilot, examiner, or flight instructor. Since not enough pilots were available that met this criteria, the requirements were relaxed for one subject matter expert. This “second tier” pre-test participant was an active flight instructor with over 900 hours total time, and more than 200 hours under IFR.

Research Design and Procedure

This study was designed to answer the research questions developed from the Review of Literature in Chapter II. These questions include:

1. Did the recently certified instrument pilot have the skills and knowledge required to successfully complete a simulated, non-training, point-to-point, IFR flight?
2. Did the training that the recently certified instrument pilot receive adequately prepare him/her to apply the skill and knowledge required by 14 CFR FAR 61.65 **(b)** and **(c)** to successfully surmount common challenges during a real-world IFR flight?

The answers to these questions will provide information that may assist in evaluating and possibly modifying airman instrument rating training. Further, answers to these questions may be used to modify the Standard Operating Procedures in effect at the university where the project was conducted to allow or disallow IFR flight under certain conditions by newly certified instrument pilots.

Permission to perform research involving OSU flight students was granted by the Institutional Review Board at Oklahoma State University, Stillwater, Oklahoma, where the study was conducted (Appendix G). The research was conducted between May and August, 2009.

Analysis of Data

Upon completion of the 15 “flights” (4 pre-test flights and 11 test group flights) the data collected from all participants was analyzed. Specifically, the performance of the test group pilots on each task was compared to the performance of the pre-test group pilots, and the Fisher exact test was employed to detect statistically significant differences between them. As previously noted, findings from this comparison, as well as an explanation of the Fisher test are published in the appropriate sections of this report.

Summary

In summary, this chapter has given a description of the design of the study. Major areas discussed were a description of the purpose of the study, research questions, sampling of test and pre-test participants, and development, validity, and application of the instrument. Also discussed were grading procedures, pretest, and method and criteria for analyzing data.

CHAPTER IV

RESULTS OF THE STUDY

Introduction

This chapter presents the findings from the participants' "flights" in the simulator. The data will be presented in multiple forms. First, the grade earned by each participant for each task will be presented in a table. Since the data analysis tool used in this experiment requires a pass/fail assessment of pilot performance, this assessment will also be noted in the table. Another table will show the pass/fail data condensed into totals to make rapid assessment easier for the reader, and to show the relationship of data in the assessment tool. A rationale for the assignment of these grades will also be provided in the text accompanying each task, along with relevant explanations. The grade will be analyzed within the context of its importance, and the importance value will be noted in the task heading and accompanied by a rationale of how it was determined. When appropriate, task importance will also be discussed in the supporting text. A much fuller explanation of participant performance, including possible explanations and examples of participant errors, will be provided in Chapter V. The reader will sometimes be encouraged to refer to the appropriate section of that chapter to better understand this one. Finally, Fisher's exact test will be employed on all tasks to determine if a statistically significant performance difference exists between the experienced pilots in the pre-test group and the less experienced test group pilots. The *relevance* of the statistical significance will be further analyzed by reference to a confidence threshold gradient, which is explained in Appendix K. The cumulative *p*-value for each task will be noted in the task heading and again in the text. Finally, an explanation of the Fisher exact test and the rationale used to determine its suitability for this project is provided in Appendix F.

We now turn to the data collected during this project.

Area of Operation 1: ATC Clearance

Task 1.a. Adequate knowledge of the elements related to ATC clearances and pilot/controller responsibilities.

Task Importance: 4

Rationale: The high importance value for this task is due to the foundational significance of the pilot's knowledge of his/her role in acquiring, understanding, and implementing an IFR clearance.

Participant Number	1	2	3	4	5	6	7	8	9	10	11
Pre-Test Group	A (Pass)	A (Pass)	A (Pass)	A (Pass)							
Test Group	A (Pass)	B (Pass)	A (Pass)	A (Pass)	D (Fail)	D (Fail)	A (Pass)	D (Fail)	A (Pass)	A (Pass)	B (Pass)

Fisher Test Contingency Table:

	Pre-test Group	Test Group
Pass	4	8
Fail	0	3

***p*=.363**

As shown by the grade table, all but three pilots demonstrated adequate knowledge of the pilot's role in acquiring and implementing an IFR clearance. The *p*-value, obtained using Fisher's exact test, is *p*=.363 so there is a 36% chance that any difference between the pass/fail ratios between the two groups is simply due to random chance. Consequently, the "null hypothesis" (that the two group of pilots have similar skill/knowledge levels) cannot be rejected.

It should be understood that this task deals only with the overall "knowledge of the elements related to IFR clearances." The *execution* of these elements was sometimes problematic, and grades for specific tasks will frequently be lower. Specifically, six of the test group pilots did not set one or both navigation radios to the correct frequency before takeoff, eight did not pre-set navigation instruments entirely in accordance with clearance, six required multiple "repeats" of the clearance and/or corrections from ATC, and one requested the clearance on the wrong communication frequency. None of these items alone necessarily demonstrates a lack of pilot knowledge regarding IFR clearances, thus the relatively high grade assignments for this task. All of the pilot errors referenced above will be more accurately graded under the relevant task headings in this chapter, and will be more fully discussed in Chapter V.

Task 1.b. Copies ATC Clearance

Task Importance: 4

Rationale: The high importance value for this task is due to the essential accuracy of the pilot's transcription of the verbally communicated clearance.

Participant Number	1	2	3	4	5	6	7	8	9	10	11
Pre-Test Group	A (Pass)	A (Pass)	A (Pass)	A (Pass)							
Test Group	A (Pass)	A (Pass)	A (Pass)	A (Pass)	C	D (Fail)	B (Pass)	C	B (Pass)	A (Pass)	B (Pass)

Fisher Test Contingency Table:

	Pre-test Group	Test Group
Pass	4	8
Fail	0	1

***p*=.692**

All but one test group pilot demonstrated adequate ability on this important task. Still, the grades show that six pilots were less than perfect, with two being marginal and four others making mistakes of varying degrees of frequency and severity. One pilot required the clearance to be read no less than 3 times, three required at least 2 complete readbacks, and several of the pilots had one or more corrections from ATC. At least some of this difficulty should be attributed to the fact that the route described in the ATC clearance was not the route that the pilot had requested in his/her flight plan, which will be discussed more fully in Chapter V. The *p*-value for this task is .692, so there is roughly a 70% chance that any differences between the performances of the two groups may be due only to chance. Therefore, the null hypothesis is not rejected.

Task 1.c. Determines Ability to Comply

Task Importance: 3

Rationale: The moderate task value of this task is due to the subjectivity of self-assessment during a simulated flight, as discussed below.

Participant Number	1	2	3	4	5	6	7	8	9	10	11
Pre-Test Group	A (Pass)	A (Pass)	A (Pass)	A (Pass)							
Test Group	A (Pass)	C	A (Pass)	A (Pass)	D (Fail)	C	A (Pass)	D (Fail)	A (Pass)	A (Pass)	B (Pass)

Fisher Test Contingency Table:

	Pre-test Group	Test Group
Pass	4	7
Fail	0	2

***p*=.462**

This task was somewhat difficult to grade, since the clearance assigned by ATC required nothing with which the pilots technically would be unable to comply. Therefore, to provide a meaningful grade a subjective assessment was made regarding the *ability to comply given the pilot's individual skill level*. In other words, the question was whether the pilot - not the airplane or equipment - had the ability to comply with the ATC assignment and self-assessed this ability accurately. Only two pilots clearly overestimated their ability to comply with the clearance. However, multiple pilots struggled with elements of it. Again, these elements will be more fully explained under the relevant tasks in this section and in the relevant sections of Chapter V.

The *p*-value obtained for this task using the Fisher Exact Test is *p*=.462, meaning that there is a 46% chance that random chance may have determined the outcome. Therefore, the null hypothesis is not rejected.

Task 1.d. Correctly Interprets/Requests Clarification of Clearance.

Task Importance: 4

Rationale: The high task value for this task is due to the logical requirement for the pilot to understand the clearance, as well as the legal requirement to clarify any part of it that is not understood.

Participant Number	1	2	3	4	5	6	7	8	9	10	11
Pre-Test Group	A (Pass)	A (Pass)	A (Pass)	A (Pass)							
Test Group	A (Pass)	D (Fail)	A (Pass)	A (Pass)	F (Fail)	C	A (Pass)	F (Fail)	A (Pass)	A (Pass)	A (Pass)

Fisher Test Contingency Table:

	Pre-test Group	Test Group
Pass	4	7
Fail	0	3

***p*=.330**

As shown by the table, three pilots failed this important task. All three took off with navigation radios set incorrectly (as did others, but less egregiously) and never adequately demonstrated en route that they understood the routing in the clearance or that they were able to execute it. Further, they did not adequately seek timely clarification.

The *p*-value for this task, again calculated using the Fisher exact test, is *p*=.330 and the null hypothesis is not rejected.

Task 1.e. Reads Back Clearance

Task Importance: 3

Rationale: This task received only a moderate value since reading back the clearance is only one part of the clearance confirmation process; an accuracy check by ATC is still pending

Participant Number	1	2	3	4	5	6	7	8	9	10	11
Pre-Test Group	A (Pass)	A (Pass)	A (Pass)	A (Pass)							
Test Group	A (Pass)	A (Pass)	A (Pass)	A (Pass)	C	D (Fail)	B (Pass)	C	B (Pass)	B (Pass)	A (Pass)

Fisher Test Contingency Table:

	Pre-test Group	Test Group
Pass	4	8
Fail	0	1

***p*=.692**

Grades for this task necessarily reflect the grades for task 1.b., “Copies ATC Clearance” due to the interrelationship of both. Only one test group pilot failed this moderately important task. It was the same pilot who failed task 1.b., and for the same reasons.

The *p*-value for this task is *p*=.692 and the null hypothesis is not rejected.

Task 1.f. Standard Phraseology

Task Importance: 1

Rationale: The low task value for this task reflects the fact that even non-standard phraseology may adequately communicate the clearance and/or ATC instructions.

Participant Number	1	2	3	4	5	6	7	8	9	10	11
Pre-Test Group	A (Pass)	A (Pass)	A (Pass)	A (Pass)							
Test Group	A (Pass)	A (Pass)	A (Pass)	A (Pass)	B (Pass)	D (Fail)	A (Pass)	B (Pass)	A (Pass)	A (Pass)	A (Pass)

Fisher Test Contingency Table:

	Pre-test Group	Test Group
Pass	4	10
Fail	0	1

***p*=.733**

As reflected by the grades, few pilots had trouble with this relatively unimportant task, and only one received a failing grade. The *p*-value for this task is *p*=.733 and the null hypothesis is not rejected.

Task 1.g. Sets Communication/Navigation Systems & Transponder in Compliance With Clearance

Task Importance: 4

Rationale: The high task value of this task is due to the fundamental importance of understanding and correctly employing VHF navigation instruments and systems.

Participant Number	1	2	3	4	5	6	7	8	9	10	11
Pre-Test Group	A (Pass)	A (Pass)	A (Pass)	A (Pass)							
Test Group	C	F (Fail)	A (Pass)	A (Pass)	F (Fail)	D (Fail)	A (Pass)	F (Fail)	A (Pass)	B (Pass)	C

Fisher Test Contingency Table:

	Pre-test Group	Test Group
Pass	4	5
Fail	0	4

***p*=.176**

As can be seen in the accompanying grade table, several test group pilots made errors setting navigation instruments in compliance with the clearance. No less than seven of the test group pilots took off with navigation instruments set incorrectly, six took off with navigation radios set incorrectly, and one pilot never set the transponder code. It should be understood that the severity of these errors varied widely, as some were noticed and corrected almost immediately and others simply did not affect the outcome or progress of the flight. Other “set up” errors were quite serious, and were compounded en route, leading to major course deviations and/or ATC intervention. The grades in the table above reflect the disparity of these errors. In any event, setting the navigation instruments and radios incorrectly (and while still on the ground!) is an important instrument pilot skill, and general lack of pilot expertise in doing so was notable.

The *p*-value for this task is *p*=.176, which means that the null hypothesis can be rejected at the 82.4% confidence level. Although this is a large number, it still falls short of the required confidence level. However, incorrect navigation technique frequently had a significant impact on the completion of the flight, and the reader is encouraged to peruse Chapter V, section 2.c to better understand these errors and learn more about their possible cause.

Area of Operation 2: Compliance With Clearance/Procedures

Task 2.a. Adequate knowledge of elements of departure, en route, & arrival clearance and pilot/controller responsibility

Task Importance: 4

Rationale: The high task value of this task reflects the importance, once again, of the pilot's overall knowledge of navigation fundamentals and his/her responsibility regarding them.

Participant Number	1	2	3	4	5	6	7	8	9	10	11
Pre-Test Group	A (Pass)	A (Pass)	A (Pass)	A (Pass)							
Test Group	A (Pass)	B (Pass)	A (Pass)	A (Pass)	F (Fail)	B (Pass)	A (Pass)	D (Fail)	A (Pass)	A (Pass)	A (Pass)

Fisher Test Contingency Table:

	Pre-test Group	Test Group
Pass	4	9
Fail	0	2

***p*=.524**

As can be readily seen by the grades in the table, most pilots received a passing grade for this important task. The task itself, however, is quite broad and as also noted in

Chapter V, an effort was made to evaluate only the pilots' *knowledge* of it rather than their skill in implementing the clearance.

Two pilots appeared to not understand the departure, en route, or amended clearances, as the compliance errors that began immediately after takeoff and continued throughout the flight confirmed. Later in the flight, as the route clearance was amended, one of these pilots was unable to comply with the change and wound up receiving radar vectors from ATC as a last resort.

Two pilots of the test group received less than passing grades for this task and the *p*-value for this task is *p*=.524, thus the null hypothesis is not rejected.

Task 2.b. Uses correct publication

Task Importance: 2

Rationale: The relatively low task importance reflects the ease of the task, and the fact that nominally incorrect publications (e.g., non-current) rarely affect the flight.

Participant Number	1	2	3	4	5	6	7	8	9	10	11
Pre-Test Group	A (Pass)	A (Pass)	A (Pass)	A (Pass)							
Test Group	A (Pass)	F (Fail)	A (Pass)	A (Pass)	A (Pass)	A (Pass)	A (Pass)	A (Pass)	A (Pass)	A (Pass)	A (Pass)

Fisher Test Contingency Table:

	Pre-test Group	Test Group
Pass	4	10
Fail	0	1

***p*=.733**

Only one pilot failed this task, and simply because he set up for one approach and referenced the chart for another. The reader is encouraged to review section 2.b. in Chapter V for more information on this error. All other pilots received a passing grade for this task and the task itself was quite simple. Pilots were *supplied* the one en route chart necessary, and a large photocopy of the one needed approach chart. To pass, pilots had only to *not* go to the extra trouble of finding and using a *wrong* chart.

The *p*-value for this task is *p*=.733 and the null hypothesis is not rejected.

Task 2.c. Uses and identifies correct communication and navigation facilities

Task Importance: 4

Rationale: The high task value of this task is due, once again, to the fundamental importance of understanding and correctly employing VHF navigation instruments and systems.

Participant Number	1	2	3	4	5	6	7	8	9	10	11
Pre-Test Group	A (Pass)	A (Pass)	A (Pass)	A (Pass)							
Test Group	A (Pass)	F (Fail)	A (Pass)	C	F (Fail)	F (Fail)	B (Pass)	F (Fail)	A (Pass)	A (Pass)	C

Fisher Test Contingency Table:

	Pre-test Group	Test Group
Pass	4	5
Fail	0	4

***p*=.176**

As can be seen in the accompanying table, four pilots failed this important task. The specific task “uses… correct navigation facilities” represented a recurring problem for several of the test group pilots, and references to it, as well as similar grades will be noted in task 1.g. and 5.b. It should be noted that two additional test group pilots made only marginally passing grades on this task.

The most common errors involved setting incorrect frequencies in navigation radios. Sometimes, this was simply a case of missing a digit in the frequency setting, but other times it was a result of misreading the chart and simply setting the wrong frequency, or setting the frequency for the wrong ground-based navaid. Compounding the problem for some pilots was the availability of the GPS. The VFR-only GPS was usable for situational awareness only, and using it for primary navigation was illegal. However, some pilots did just that, and went where the GPS guided them despite what the VHF navigation instruments indicated, or for that matter, how they were set. Conversely, some pilots made excellent (and legal) use of the GPS by setting it in conjunction with VHF navigation instruments so that both supplemented each other. The reader is encouraged to review section 2.c. in Chapter V for more information and examples of pilot errors.

The *p*-value for this task is *p*=.176, which means that the null hypothesis can be rejected at the 82.4% confidence level. Although this is a large number, it still falls short of the required level of confidence.

Task 2.d. Performs appropriate checklist

Task Importance: 2

Rationale: The value for this task is low due to the fact that most checklist items are airplane, not IFR, specific and did not significantly affect the flight.

Participant Number	1	2	3	4	5	6	7	8	9	10	11
Pre-Test Group	A (Pass)	A (Pass)	A (Pass)	A (Pass)							
Test Group	A (Pass)	B (Pass)	A (Pass)	A (Pass)	B (Pass)	A (Pass)	A (Pass)	B (Pass)	A (Pass)	A (Pass)	A (Pass)

Fisher Test Contingency Table:

	Pre-test Group	Test Group
Pass	4	11
Fail	0	0

This relatively unimportant task presented little difficulty to participants. Airplane checklist errors (omissions) were of minimal interest to the PI, as they had little impact on the IFR pilot skills of interest in this study. Therefore, minor checklist errors were mostly ignored.

Obviously, the null hypothesis for this task is not rejected.

Task 2.e. Establishes communication with proper ATC facility

Task Importance: 2

Rationale: Establishing communication with *any* ATC facility is usually sufficient (ATC assigns another as required) and safety of flight is rarely affected, thus the low task value.

Participant Number	1	2	3	4	5	6	7	8	9	10	11
Pre-Test Group	A (Pass)	A (Pass)	A (Pass)	A (Pass)							
Test Group	A (Pass)	A (Pass)	A (Pass)	A (Pass)	A (Pass)	A (Pass)	A (Pass)	B (Pass)	A (Pass)	A (Pass)	A (Pass)

Fisher Test Contingency Table:

	Pre-test Group	Test Group
Pass	4	11
Fail	0	0

This was another relatively unimportant task that presented little difficulty. Since the simulated flight took place in a geographic area common to all participants, frequencies were already known and well rehearsed. Further, ATC assigned frequencies as needed, and pilots had little trouble keeping up with the assigned frequencies.

No pilots failed this task and the null hypothesis is not rejected.

Task 2.f. Complies with ATC instructions and airspace restrictions

Task Importance: 5

Rationale: Non-compliance with ATC and/or divergence into uncleared airspace can be dangerous and may lead to FAA enforcement action, thus the very high task value.

Participant Number	1	2	3	4	5	6	7	8	9	10	11
Pre-Test Group	A (Pass)	A (Pass)	A (Pass)	A (Pass)							
Test Group	A (Pass)	D (Fail)	A (Pass)	A (Pass)	D (Fail)	D (Fail)	A (Pass)	F (Fail)	A (Pass)	D (Fail)	B (Pass)

Fisher Test Contingency Table:

	Pre-test Group	Test Group
Pass	4	6
Fail	0	5

***p*=.154**

As noted in the table above, five test group pilots failed this important task. Most of these failures were related to non-compliance with ATC instructions, as there was no Restricted or otherwise "off limit" airspace along the route, neither of which is particularly relevant to IFR flight anyway (since controllers, not pilots, are tasked with avoiding off-limit airspace). There were, however, excursions into uncleared airspace, and these are reflected in the grades. It should be understood that technically, even minor en route navigation errors or altitude deviations can put a pilot in "uncleared" airspace and constitute "noncompliance with ATC," but since those tasks are more specifically addressed elsewhere in this report, only significant non-compliance with ATC errors are addressed here.

With a *p*-value of .154, the null hypothesis of a difference between the pre-test and test group pilots CAN be rejected at roughly the 85% confidence level. Our willingness to reject the null hypothesis at this reduced level of confidence is directly related to this task's very high importance value as discussed in Appendix K. The reader is strongly encouraged to read that appendix for a fuller explanation of the graduated confidence level, and how it affects the data analysis of this project.

Task 2.g. Intercepts appropriate radials and bearings as published in procedures

Task Importance: 4

Rationale: The high task value of this task is due, once again, to the fundamental importance of understanding and correctly employing VHF navigation instruments and systems.

Participant Number	1	2	3	4	5	6	7	8	9	10	11
Pre-Test Group	A (Pass)	A (Pass)	A (Pass)	A (Pass)							
Test Group	A (Pass)	F (Fail)	A (Pass)	A (Pass)	F (Fail)	D (Fail)	B (Pass)	F (Fail)	A (Pass)	B (Pass)	C

Fisher Test Contingency Table:

	Pre-test Group	Test Group
Pass	4	6
Fail	0	4

***p*=.210**

Four test group pilots received failing grades on this task, and radial intercept errors were common. Usually, these errors were related to radio/indicator set-up errors and distinguishing between set-up and intercept errors was not always easy. For this flight, published (charted) departure or arrival procedures were not assigned, so the only “radials as published in procedures” were those on en route and approach charts. Comments related to pilot performance on these tasks are fully developed in Chapter V, sections 1.g. and 2.c. Readers are encouraged to reference those sections of this report to read more about errors in intercepting radials, and to read first-hand researcher observations made during the research flights. As already noted, setting navigation radios/indicators correctly and using them for radial interception was a problematic part of the flight, and errors in doing so ranged from minor set-up deviations to apparent lack of understanding of instrument functionality.

The *p*-value for this task is *p*=.210, which means that the null hypothesis can be rejected at the 79% confidence level. And although, once again, the confidence level is a relatively large number, it still falls significantly short of the required level of confidence.

Area Of Operation 3: Basic Instrument Maneuvers

Task 3.a. Adequate knowledge and skill related to attitude instrument flight

Task Importance: 5

Rationale: Maintaining normal and appropriately controlled aircraft attitude is of primary importance, thus the extremely high task value.

Participant Number	1	2	3	4	5	6	7	8	9	10	11
Pre-Test Group	A (Pass)	A (Pass)	A (Pass)	B (Pass)							
Test Group	A (Pass)	D (Fail)	A (Pass)	A (Pass)	D (Fail)	D (Fail)	A (Pass)	A (Pass)	A (Pass)	A (Pass)	A (Pass)

Fisher Test Contingency Table:

	Pre-test Group	Test Group
Pass	4	8
Fail	0	3

***p*=.363**

Three test group pilots received less than passing grades on this task, though all were able to maintain aircraft control. For many pilots, minor heading and altitude deviations were common throughout the research flight. However, since the objective of this research project was to re-create a “real” IFR flight, the criteria for a passing grade for this task required only that pilots not routinely exceed heading or altitude deviations that would be excessive for the real IFR flight environment. Three pilots exceeded these tolerances due to excessive and recurrent heading and altitude deviations, but not due to inability to maintain a normal flight attitude.

The p-value for this task is *p*=.363 and the null hypothesis is not rejected.

Task 3.b. Maintains altitude +/- 200 feet, heading +/- 20°, and airspeed +/- 20 knots.

Task Importance: 4

Rationale: The very high task value reflects the necessity (and difficulty) of incorporating multiple tasks into the IFR pilot’s workload while prioritizing accurate aircraft control.

Participant Number	1	2	3	4	5	6	7	8	9	10	11
Pre-Test Group	A (Pass)	A (Pass)	A (Pass)	C							
Test Group	B (Pass)	D (Fail)	A (Pass)	B (Pass)	F (Fail)	F (Fail)	A (Pass)	A (Fail)	A (Pass)	A (Pass)	C

Fisher Test Contingency Table:

	Pre-test Group	Test Group
Pass	3	7
Fail	0	3

***p*=.420**

As discussed above, there were multiple heading and altitude deviations throughout the flights. In fact, nearly all of the pilots had brief heading or altitude deviations at or near the limits as stated above, and these were mostly ignored as they likely would be by ATC (particularly if corrected rapidly). However, one test group pilot and one pre-test group pilot had altitude deviations that were as much as 500' and/or heading deviations as much as 70°. Both of these pilots noted and corrected their errors without assistance, though some persisted longer than others. Three other pilots simply did not demonstrate adequate aircraft control, leading to grossly errant altitudes or headings. These pilots wound up cruising at the wrong altitude, climbing in an unchecked manner, or widely diverging from the correct heading.

The *p*-value for this task is *p*=.420 and the null hypothesis is not rejected.

.

Area Of Operation 4: Holding Procedures

Task 4.a. Adequate knowledge and skill related to holding procedures

Task Importance: 3

Rationale: The task value for holding procedures is moderate for dichotomous reasons: while holds may be difficult to learn and execute, they are usually conducted in large, protected areas where even poorly executed holds are separated from terrain or other traffic. Safety of flight is rarely affected.

Participant Number	1	2	3	4	5	6	7	8	9	10	11
Pre-Test Group	A (Pass)	A (Pass)	A (Pass)	B (Pass)							
Test Group	C	F (Fail)	B (Pass)	F (Fail)	F (Fail)	F (Fail)	F (Fail)	D (Fail)	B (Pass)	A (Pass)	D (Fail)

Fisher Test Contingency Table:

	Pre-test Group	Test Group
Pass	4	3
Fail	0	7

***p*=.035**

Holding procedures proved to be a problematic part of the flight. And, as discussed in Chapter V, a knowledge deficiency was sometimes evident in pilots who were quite skilled in other instrument pilot tasks.

It should be noted that the task importance assigned to holds is only moderate. This is due to the fact that holds contribute little to the completion of a flight, and are usually assigned by ATC as a delaying function. Additionally, even poorly executed holds rarely represent a significant safety concern as they are usually assigned well away from terrain or conflicting traffic.

Still, holding procedures can be difficult, and this was evident in pilot performance. A multitude of errors were committed during holds, including: visualizing the hold incorrectly (as explained by pilots after the flight), confusing inbound and outbound holding legs, incorrectly identifying the holding fix (or not at all), incorrect timing procedures, and others.

It should be noted that two of the test group pilots were *never assigned* holds, or at least were never required to conduct them, as their abilities were already taxed to the limit and increasing their mental workload with holding clearances/procedures was impractical. As discussed in the methodology, these test group pilots received failing grades on the relevant tasks of this Area of Operation.

The *p*-value for this task is *p*=.035, and since there is a statistically dependable (96.5%) difference between the levels of performance of the two different groups on this task, we reject the null hypothesis with confidence. Also, from an observational standpoint, there appeared to be a clear performance difference between the pre-test group pilots and the test group pilots.

Task 4.b. Remains within holding airspace

Task Importance: 3

Rationale: Protected holding areas are relatively large, and even poorly executed holding procedures are generally contained within them. Task importance remains moderate only because deviation from protected airspace *can* create collision hazard or need for ATC intervention.

Participant Number	1	2	3	4	5	6	7	8	9	10	11
Pre-Test Group	A (Pass)	A (Pass)	A (Pass)	B (Pass)							
Test Group	C	F (Fail)	A (Pass)	F (Fail)	F (Fail)	C	D (Fail)	F (Fail)	A (Pass)	A (Pass)	D (Fail)

Fisher Test Contingency Table:

	Pre-test Group	Test Group
Pass	4	3
Fail	0	6

***p*=.049**

Grades for this task are similar to grades for task 4.a. There are some differences, however, as this task reflects only the pilots' ability to remain within protected holding airspace. Unfortunately, "protected holding airspace" is not as easily defined as might be expected, and only those pilots who egregiously strayed from it received failing grades. As noted in the grade table above, 6 test group pilots did so. It might be noted that other pilots sometimes made minor deviations from established holding patterns and/or holding pattern entry procedures. However, these were generally ignored since actual "protected" holding airspace can be significantly greater than "assigned" holding airspace, and because established holding pattern entry procedures are recommendations only. The reader is encouraged to see Chapter V, section 4.b. for more on protected airspace and grading procedures for this task.

The pilots who received failing grades for this task were generally the same pilots who demonstrated a lack of knowledge regarding holding procedures (task 6.a.). The *p*-value for this task is *p*=.049 and the null hypothesis IS, once again, rejected at the 95% confidence level.

Task 4.c. Recognizes arrival at holding fix

Task Importance: 2

Rationale: The task value for this task is low due to the relatively low priority of all *individual* holding tasks.

Participant Number	1	2	3	4	5	6	7	8	9	10	11
Pre-Test Group	A (Pass)	A (Pass)	A (Pass)	A (Pass)							
Test Group	A (Pass)	B (Pass)	A (Pass)	B (Pass)	F (Fail)	D (Fail)	B (Pass)	D (Fail)	A (Pass)	A (Pass)	C

Fisher Test Contingency Table:

	Pre-test Group	Test Group
Pass	4	7
Fail	0	3

***p*=.330**

Three test group pilots received a failing grade for this relatively unimportant task. The task itself, however, was sometimes difficult to distinguish from other holding procedure errors, as maneuvering and other pilot actions that occurred around the holding fix were not always easy for the observer/grader to interpret. In the three failures noted above, the fix identification that is a fundamental part of holding procedures was verifiably missing.

The *p*-value for this very specific task is *p*=.330 and the null hypothesis is not rejected.

Task 4.d. Complies with ATC reporting requirements

Task Importance: 1

Rationale: Reporting requirements are generally designed to inform ATC of the progress of the flight. In the radar equipped area of this simulated flight, ATC was not dependent on pilot reports for this information, thus the very low task value.

Participant Number	1	2	3	4	5	6	7	8	9	10	11
Pre-Test Group	A (Pass)	A (Pass)	A (Pass)	A (Pass)							
Test Group	A (Pass)	C	A (Pass)	B (Pass)	F (Fail)	B (Pass)	B (Pass)	D (Fail)	A (Pass)	B (Pass)	B (Pass)

Fisher Test Contingency Table:

	Pre-test Group	Test Group
Pass	4	8
Fail	0	2

***p*=.495**

Only two test group pilots received failing grades on this unimportant task, and most pilots reported as required. It should be remembered, however, that there were a multitude of holding procedure errors, and some pilots were never in a position *to* report, so the lack of identifiable reporting errors may be somewhat misleading.

The *p*-value for this task is *p*=.495 and the null hypothesis is not rejected.

Task 4.e. Times holds correctly

Task Importance: 1

Rationale: The task value for this task is low due to the relatively low priority of all *individual* holding tasks.

Participant Number	1	2	3	4	5	6	7	8	9	10	11
Pre-Test Group	A (Pass)	A (Pass)	A (Pass)	A (Pass)							
Test Group	D (Fail)	F (Fail)	A (Pass)	C	F (Fail)	A (Pass)	B (Pass)	D (Fail)	A (Pass)	A (Pass)	C

Fisher Test Contingency Table:

	Pre-test Group	Test Group
Pass	4	5
Fail	0	4

***p*=.176**

Four pilots received failing grades on this relatively unimportant holding task. As noted previously, however, holding errors were common and some timing errors (particularly omissions) may have gone unobserved. Even so, four pilots made identifiable timing errors. The *p*-value for this task is *p*=.176 and the null hypothesis is not rejected. Once again, however, only statistical constraints keep us from doing so, as the confidence level of a difference between the groups is 82.4%, near the required level of confidence.

Area Of Operation 5: Intercepting and Tracking Navigational Systems

Task 5.a. Adequate knowledge of the elements of intercepting and tracking navigational systems

Task Importance: 4

Rationale: The high task value of this task is due, once again, to the fundamental importance of understanding and correctly employing VHF navigation instruments and systems.

Participant Number	1	2	3	4	5	6	7	8	9	10	11
Pre-Test Group	A (Pass)	A (Pass)	A (Pass)	A (Pass)							
Test Group	B (Pass)	D (Fail)	A (Pass)	A (Pass)	F (Fail)	D (Fail)	A (Pass)	F (Fail)	A (Pass)	A (Pass)	B (Pass)

Fisher Test Contingency Table:

	Pre-test Group	Test Group
Pass	4	7
Fail	0	4

***p*=.242**

Pilot performance regarding “Intercepting and Tracking Navigational Systems” is thoroughly discussed in tasks 1.g. (sets communication/navigation systems), 2.c. (uses and identifies correct communication and navigation facilities), and 2.g. (interprets appropriate radials and bearings as published in procedure). Grades for tasks within this area of operation will by necessity reflect the grade assignments for similar tasks within the sections noted above, and for the same reasons. In the interest of brevity, the reader is referred to the task narratives for tasks 1.g., 2.c., and 2.g. for the three similar tasks of Area of Operation 5. Only grade assignments will be reported for the tasks within this section.

Once again, 4 test group pilots received failing grades on this important task. The *p*-value for this task is *p*=.242 and the null hypothesis is not rejected.

Task 5.b. Tunes and identifies navigational facility and sets & intercepts course to be intercepted

Task Importance: 4

Rationale: Fundamental importance of understanding and correctly employing VHF navigation instruments and systems.

Participant Number	1	2	3	4	5	6	7	8	9	10	11
Pre-Test Group	A (Pass)	A (Pass)	A (Pass)	A (Pass)							
Test Group	A (Pass)	F (Fail)	A (Pass)	A (Pass)	F (Fail)	D (Fail)	A (Pass)	F (Fail)	A (Pass)	A (Pass)	C

Fisher Test Contingency Table:

	Pre-test Group	Test Group
Pass	4	6
Fail	0	4

***p*=.210**

Four test group pilots received failing grades for this task. The probability value for this task is *p*= .210 and the null hypothesis is not rejected.

Task 5.c. Intercepts course at correct angle, inbound or outbound

Task Importance: 2

Rationale: The course may be intercepted and maintained even with application of incorrect intercept angles, particularly at the speeds common during the research flight. Thus, task value is relatively low.

Participant Number	1	2	3	4	5	6	7	8	9	10	11
Pre-Test Group	A (Pass)	A (Pass)	A (Pass)	A (Pass)							
Test Group	A (Pass)	D (Fail)	A (Pass)	A (Pass)	F (Fail)	D (Fail)	A (Pass)	F (Fail)	A (Pass)	A (Pass)	B (Pass)

Fisher Test Contingency Table:

	Pre-test Group	Test Group
Pass	4	7
Fail	0	4

***p*=.242**

Four test group pilots received failing grades for this task. The probability value for this task is *p*= .242 and the null hypothesis is not rejected.

Area Of Operation 6: Precision Approach

Task 6.a. Adequate knowledge of precision instrument approach procedures

Task Importance: 4

Rationale: Most approach tasks have high importance value due to proximity of terrain and required skill. This task, involving adequate knowledge of procedures, is fundamental to all and valued accordingly.

Participant Number	1	2	3	4	5	6	7	8	9	10	11
Pre-Test Group	A (Pass)	A (Pass)	A (Pass)	A (Pass)							
Test Group	B (Pass)	D (Fail)	A (Pass)	A (Pass)	F (Fail)	D (Fail)	A (Pass)	C	A (Pass)	A (Pass)	B (Pass)

Fisher Test Contingency Table:

	Pre-test Group	Test Group
Pass	4	7
Fail	0	3

***p*=.330**

Most participants received a passing grade on this task, though certain *elements* of the precision approach proved to among the most troublesome tasks of the entire flight. The relatively high grades on this task reflect the fact that most participants had "adequate knowledge of precision instrument approach procedures." That is, nearly all understood that they were receiving radar vectors to the final approach course, which they would intercept via instrument indications, and would then descend to a position from which they would expect to see the runway and continue visually. Participants who received a failing grade on this task appeared to have a fundamental misunderstanding of some part of this process.

The *p*-value for this task is p=.330 and the null hypothesis is not rejected.

Task 6.b. Establishes and uses correct ATC facility & correct phraseology for approach

Task Importance: 2

Rationale: Establishing communication with *any* ATC facility is usually sufficient (ATC assigns another as required) and safety of flight is rarely affected. Also, incorrect phraseology, as long as it is understood by both ATC and the pilot, is usually equally sufficient.

Participant Number	1	2	3	4	5	6	7	8	9	10	11
Pre-Test Group	A (Pass)	A (Pass)	A (Pass)	A (Pass)							
Test Group	A (Pass)	F (Fail)	A (Pass)	A (Pass)	F (Fail)	C	A (Pass)	B (Pass)	A (Pass)	A (Pass)	A (Pass)

Fisher Test Contingency Table:

	Pre-test Group	Test Group
Pass	4	8
Fail	0	2

***p*=.495**

This task was a relatively easy one for nearly all participants, as “using the correct ATC facility” is fundamental to the approach in Class C Airspace; under normal circumstances a pilot would likely be *unable* to continue without direction from the correct ATC facility. “Using correct phraseology,” however, was more challenging since approach clearances tend to be lengthy and somewhat complicated. Still, only two pilots received failing grades on this task, due either to repeated muddling of clearance “readbacks” or simply reading back the wrong clearance.

The *p*-value for the task is *p*=.495. The null hypothesis is not rejected.

Task 6.c. Complies with clearance instructions and procedures

Task Importance: 4

Rationale: Clearance instructions and procedures are generally specific and conducted in a high workload phase of flight, potentially in close proximity to terrain. The high task value reflects these criteria.

Participant Number	1	2	3	4	5	6	7	8	9	10	11
Pre-Test Group	A (Pass)	A (Pass)	A (Pass)	B (Pass)							
Test Group	C	F (Fail)	A (Pass)	A (Pass)	F (Fail)	D (Fail)	A (Pass)	D (Fail)	A (Pass)	A (Pass)	D (Fail)

Fisher Test Contingency Table:

	Pre-test Group	Test Group
Pass	4	5
Fail	0	5

***p*=.126**

Approach procedures are so well scripted that virtually any error is technically "noncompliance with procedure," so an effort was made to identify systemic procedural errors, not just "mistakes." For this reason, "descent below minimums" was a major and recurring mistake that is *not* reflected in the grades above. Instead, it will be assessed in task 6.g.

Procedural errors that did affect grades within this task included grossly incorrect set-up or interpretation of approach instruments, or incorrect response to instrument indications. Both were fairly common approach errors, as noted by the 5 failing grades. It should be noted, however, that other test group pilots flew the approach very well procedurally (though a few of these pilots also went below minimums), and excellent grades within this task are as prevalent as failing ones.

The *p*-value for this task is *p*=.126 and the null hypothesis can be rejected only at the 87.4% level, near but still short of the required confidence level.

Task 6.d. Advises ATC if unable to comply

Task Importance: 5

Rationale: Due to the proximity of terrain and specificity of procedures, the pilot must continually determine that the approach is progressing safely and within established limits. Exercising PIC authority to advise ATC of inability to continue an errant approach is a potentially critical PIC responsibility, thus the very high task value.

Participant Number	1	2	3	4	5	6	7	8	9	10	11
Pre-Test Group	A (Pass)	A (Pass)	A (Pass)	D (Fail)							
Test Group	B (Pass)	F (Fail)	A (Pass)	A (Pass)	F (Fail)	D (Fail)	A (Pass)	D (Fail)	A (Pass)	A (Pass)	D (Fail)

Fisher Test Contingency Table:

	Pre-test Group	Test Group
Pass	3	6
Fail	1	5

***p*=.462**

There are certain flight parameters that must be met during an instrument approach. If they are not, a notification of ATC is required. During the research flights, several instrument indications or course deviations should have triggered a call to ATC but did not. Five test group pilots and one pre-test group pilot opted to press on and “fix” the problem without notifying ATC or seeking assistance.

The *p*-value for this task is again *p*=.462 and the null hypothesis is not rejected.

Task 6.e. Selects, tunes, and identifies correct approach facilities

Task Importance: 5

Rationale: Again, the proximity of terrain, as well as specificity and potential difficulty of approach procedures, requires a very high task value in relation to similar tasks during departure or en route. This task, using correct approach facilities, is fundamental to executing, or even *initiating*, a precision approach.

Participant Number	1	2	3	4	5	6	7	8	9	10	11
Pre-Test Group	A (Pass)	A (Pass)	A (Pass)	A (Pass)							
Test Group	C	F (Fail)	A (Pass)	A (Pass)	F (Fail)	D (Fail)	A (Pass)	D (Fail)	A (Pass)	A (Pass)	D (Fail)

Fisher Test Contingency Table:

	Pre-test Group	Test Group
Pass	4	5
Fail	0	5

***p*=.126**

The reader should refer to task Chapter V, section 6.c. for more information on (and examples of) participants "selecting, tuning, and identifying correct approach facilities." As noted in that section of the report, there were four instances of pilots not tuning in the LOM (OILER), and five instances of pilots not tuning in the localizer frequency and/or not setting the correct radial in the instrument display (with some pilots committing both errors). Note that these errors can have differing levels of significance, since an incorrectly tuned indicator may still provide correct indications and an untuned LOM may be entirely insignificant. Conversely, correctly tuning the localizer frequency is imperative, which is reflected in the grade importance of this task. All of the errors noted above had some effect on the flight, though they did not always lead to a failing grade.

The *p*-value for this task is *p*=.126, and due to the high importance value for this task, the null hypothesis CAN be rejected at roughly the 87% confidence level. The reader is encouraged to see Appendix K for an explanation of how task importance affects the decision to reject the null hypothesis.

Task 6.f. Stabilized approach with no more than ¾ scale deflection on both localizer and glideslope

Task Importance: 4

Rationale: Precision during the conduct of the final approach segment is critical to the correct conduct of approach, thus the high value of this task.

Participant Number	1	2	3	4	5	6	7	8	9	10	11
Pre-Test Group	A (Pass)	A (Pass)	A (Pass)	D (Fail)							
Test Group	D (Fail)	C	A (Pass)	B (Pass)	F (Fail)	F (Fail)	A (Pass)	C	A (Pass)	A (Pass)	D (Fail)

Fisher Test Contingency Table:

	Pre-test Group	Test Group
Pass	3	5
Fail	1	4

***p*=.490 or .255**

To differentiate this task from tasks 6.g. (Missed approach at DH if visibility not met) and 7.e (Initiates missed approach at full scale), only the pilots' ability to *intercept* and *track* the localizer and glideslope have been considered for this task. Some pilots who kept the needles centered went below minimums, and any who lingered at or below minimums without initiating a missed approach had, by necessity, a full scale needle deflection on the glideslope. Therefore, pilots may receive passing grades on this task but failing grades on similar ones that better describe what they did wrong. In any event, 4 test group pilots and 1 pre-test group pilot did not keep the glideslope and/or localizer needles adequately centered, though the pre-test group pilot's performance may have been aggravated by a controller error. The reader is encouraged to see Chapter V, section 6.f. for more on this error.

The p-value for this task is *p*=.490 (or *p*=.255 if the pre-test group failing grade is omitted) and the null hypothesis is not rejected.

Task 6.g. Missed approach at DH if visibility requirements not met

Task Importance: 4

Rationale: This task has both legal and safety of flight ramifications, thus the high task value.

Participant Number	1	2	3	4	5	6	7	8	9	10	11
Pre-Test Group	A (Pass)	A (Pass)	A (Pass)	C							
Test Group	D (Fail)	F (Fail)	A (Pass)	F (Fail)	F (Fail)	F (Fail)	A (Pass)	F (Fail)	A (Pass)	F (Fail)	F (Fail)

Fisher Test Contingency Table:

	Pre-test Group	Test Group
Pass	3	3
Fail	0	8

***p*=.055**

No less than eight pilots continued their descent below the minimum approach altitude without meeting visual reference requirements. Additionally, some pilots who descended below minimums appeared to do so quite deliberately. Observations from the research flight are quite enlightening, and the reader is encouraged to see Chapter V, section 6.g. for examples and commentary on pilot performance.

The *p*-value for this important task (4) is *p*=.055 and the null hypothesis IS rejected at roughly the 95% confidence level, as this is well above the graduated confidence level of high-value tasks discussed in Appendix K. Indeed, pilot performance on this task was one of the more striking findings of the entire project.

Area Of Operation 7: Missed Approach

Task 7.a. Adequate knowledge of missed approach procedures and prepares for missed approach

Task Importance: 3

Rationale: Required missed approach precision is less than that required for the actual approach, as the aircraft is from this point continually moving *away* from terrain. The moderate task value reflects the significance of knowledge and preparation required.

Participant Number	1	2	3	4	5	6	7	8	9	10	11
Pre-Test Group	A (Pass)	A (Pass)	A (Pass)	B (Pass)							
Test Group	B (Pass)	F (Fail)	A (Pass)	D (Fail)	F (Fail)	D (Fail)	A (Pass)	F (Fail)	A (Pass)	D (Fail)	D (Fail)

Fisher Test Contingency Table:

	Pre-test Group	Test Group
Pass	4	4
Fail	0	7

***p*=.051**

Few test group pilots adequately prepared for the missed approach. And, as was noted in the previous task, several pilots were hesitant to abandon the attempt to land and transition to the missed approach procedure. Since the judgment required to initiate the missed approach at the proper time is an integral part of "adequate knowledge of missed approach procedures," doing so was necessary for a passing grade on this task.

As previously reported, two pilots crashed while conducting the approach. Since both crashes reset the simulator computers, the missed approach could not be conducted. As per methodology, these two pilots received failing grades on this task. Other pilots did not seem to understand the integral relationship of the missed approach to the ILS approach and received less than passing grades. Finally, one pilot flew a course that was completely different than the published missed approach procedure.

It should be noted that the hold included in the published missed approach procedure did *not* affect the grading of this task, as participant performance on that particular task element is better described and graded in task 4.a. The reader is referred to that section for more information on holds.

The *p*-value for this task is *p*=.051 and the null hypothesis CAN once again be rejected at the 95% confidence level.

Task 7.b. Initiates missed approach with correct control inputs

Task Importance: 3

Rationale: Required missed approach precision is less than that required for the actual approach, as the aircraft is from this point continually moving *away* from

terrain. The moderate task value reflects the significance of knowledge and preparation required.

Participant Number	1	2	3	4	5	6	7	8	9	10	11
Pre-Test Group	A (Pass)	A (Pass)	A (Pass)	B (Pass)							
Test Group	A (Pass)	F (Fail)	A (Pass)	A (Pass)	F (Fail)	C	A (Pass)	F (Fail)	A (Pass)	A (Pass)	D (Fail)

Fisher Test Contingency Table:

	Pre-test Group	Test Group
Pass	4	6
Fail	0	4

***p*=.210**

This PTS task is likely intended to capture an examiner assessment of pilot control skill at the initiation of the missed approach. This is logical, as a grossly errant control input at this low altitude could be disastrous. As can be seen in the table above, most pilots employed appropriate control inputs. However, one test group pilot turned in an unchecked manner and another simply did not initiate a climb. Two other test group pilots received failing grades for this task by crashing during the approach, and as per methodology, subsequent ungradable tasks were considered failed. None of the pilots grossly over-controlled the airplane, but the examples noted above are deemed identifiable "incorrect missed approach control inputs."

The *p*-value for this task is *p*=.210 and the null hypothesis is not rejected.

Task 7.c. Reports to ATC

Task Importance: 1

Rationale: This pilot action provides little information to ATC (in the simulated Class C airspace) and contributes nothing to progression of flight, thus the very low task value.

Participant Number	1	2	3	4	5	6	7	8	9	10	11
Pre-Test Group	A (Pass)	A (Pass)	A (Pass)	A (Pass)							
Test Group	A (Pass)	F (Fail)	A (Pass)	B (Pass)	F (Fail)	D (Fail)	A (Pass)	F (Fail)	A (Pass)	C	D (Fail)

Fisher Test Contingency Table:

	Pre-test Group	Test Group
Pass	4	5
Fail	0	5

***p*=.126**

The initiation of a missed approach is a mandatory reporting point (Jeppesen Guided Flight Discovery Team, ATC Clearances, 2006). This required pilot action must be known and remembered by the pilot at this busy phase of flight, as he/she is not prompted by ACT to report and other flight tasks likely occupy the pilot's immediate attention at this time. Further, the pilot may be unintentionally conditioned by ATC during the approach process to *respond* to communications rather than initiate them. Perhaps not surprisingly then, three pilots simply did not report at the missed approach point and had to be contacted by ATC. Two other pilots, as previously noted, crashed before initiating the missed approach.

The Fisher score for this task is *p*=.126 and the null hypothesis is not rejected, though once again, the *p*-value is close to the required confidence level threshold to do so.

Task 7.d. Complies with missed approach clearance and procedures

Task Importance: 4

Rationale: The task value for this task is relatively high, as fully executing the missed approach clearance/procedure occurs during a high workload phase of flight and compliance involves multiple chart interpretation and implementation skills.

Participant Number	1	2	3	4	5	6	7	8	9	10	11
Pre-Test Group	A (Pass)	A (Pass)	A (Pass)	A (Pass)							
Test Group	C	F (Fail)	A (Pass)	D (Fail)	F (Fail)	C	A (Pass)	F (Fail)	A (Pass)	A (Pass)	C

Fisher Test Contingency Table:

	Pre-test Group	Test Group
Pass	4	4
Fail	0	4

***p*=.141**

As already noted in task in task 7.b, two pilots did not comply with published missed approach procedures: one pilot turned indiscriminately, and another delayed the initial climb. The other two pilots who received failing grades on this task, once again, crashed before getting to it. Other pilots made lesser errors that did not affect the successful completion of the missed approach (such as holding pattern entry errors), and received a C grade.

The *p*-value for this task is *p*=.141 and the null hypothesis is not rejected.

Task 7.e. Initiates missed approach at full scale or anytime required tolerances not met

Task Importance: 4

Rationale: This task applies to the approach itself (not the missed approach), and the high task value reflects the required procedural knowledge as well as the potentially close proximity of terrain.

Participant Number	1	2	3	4	5	6	7	8	9	10	11
Pre-Test Group	A (Pass)	A (Pass)	A (Pass)	D (Fail)							
Test Group	F (Fail)	F (Fail)	A (Pass)	D (Fail)	F (Fail)	F (Fail)	A (Pass)	F (Fail)	A (Pass)	F (Fail)	F (Fail)

Fisher Test Contingency Table:

	Pre-test Group	Test Group
Pass	3	3
Fail	1	8

***p*=.143**

This specific task was easy to grade; pilots either abandoned the approach when instruments indicated full-scale course deviation or they did not. Unfortunately, most did not. No fewer than 8 of the 11 test group pilots and one pre-test group pilot continued the approach with needles at full scale, frequently in a vain attempt to “catch up” to the approach. Sometimes, these pilots never got established on the approach course with acceptable needle indications, and at least once this was due (at least partially) to a poor vector from ATC (see Chapter V, section 6.f.).

The Fisher score for this task is *p*=.143 and the null hypothesis is not rejected. However, it should be noted that the inability to reject the null hypothesis at the required confidence level is heavily influenced by the one failing grade in the Pre-test group.

Area Of Operation 8: Alternate Destination

Task 8.a. Selects legal alternate for flight plan

Task Importance: 1

Rationale: The selected legal alternate is not necessarily the *actual* alternate and rarely affects the progress or ultimate destination of the flight, thus the very low task value.

Participant Number	1	2	3	4	5	6	7	8	9	10	11
Pre-Test Group	A (Pass)	A (Pass)	A (Pass)	A (Pass)							
Test Group	B (Pass)	F (Fail)	C	A (Pass)	A (Pass)	C	A (Pass)	C	C	F (Fail)	C

Fisher Test Contingency Table:

	Pre-test Group	Test Group
Pass	4	4
Fail	0	2

***p*=.333**

For the purposes of IFR flight planning an “alternate destination” is a default, secondary destination that meets multiple legal criteria. The reader is strongly encouraged to refer to Chapter V, section 8.a. to learn more about the alternate selection process, as certain selection criteria is described in detail and is relevant to the grading process. A reader might assume this task to be an easy one to grade as it would be logically assumed that that any potential alternate is either legal or it is not. In reality, however, the grading of the alternate selection was complicated by the effort to appropriately grade the alternate selection *process*, and by the fact that the effort that the participants invested in the process was not always entirely clear. Further, ambiguity regarding alternate airport legalities emerged as grades were assigned, since the “appropriateness” of certain weather forecasts for determining alternate airport suitability are questioned within the industry. Again, the reader is encouraged to see the corresponding section in Chapter V for more information.

In any event, 2 test group pilots received failing grades on this task for choosing alternate airports that were clearly illegal. Five others chose a marginally legal alternate destination and received a “C” grade. Three others chose a clearly legal alternate.

The *p*-value for this task is *p*=.333 and the null hypothesis is not rejected.

Task 8.b. Assimilates appropriate weather information to determine suitable alternates, including non-legal (for flight plan) alternates

Task Importance: 3

Rationale: Legally (or illegally) filed alternates rarely affect progress or destination of flight. However, pilot knowledge of the selection process is considerable. Task value, therefore, is a "median" value.

Participant Number	1	2	3	4	5	6	7	8	9	10	11
Pre-Test Group	A (Pass)	A (Pass)	A (Pass)	A (Pass)							
Test Group	B (Pass)	F (Fail)	D (Fail)	C	C	D (Fail)	A (Pass)	C	C	F (Fail)	D (Fail)

Fisher Test Contingency Table:

	Pre-test Group	Test Group
Pass	4	2
Fail	0	5

***p*=.045**

As noted in the table above, only two test group pilots spent adequate time assessing weather forecasts to make an informed alternate airport selection. Most test group pilots checked nothing more than the provided Terminal Area Forecast before making their decision, and 2 still chose alternate destinations that this document showed to be illegal. Others offered destinations that were generally in the direction of better weather, but again, little or no actual weather reporting documentation was consulted.

The *p*-value for this task is *p*=.045, and the null hypothesis CAN be rejected at the 95% confidence level.

Task 8.c. Performs appropriate planning to proceed to suitable alternate

Task Importance: 3

Rationale: Though part of the en route structure of flight and therefore significant, only moderate planning for this phase of flight was required in the Class C airspace of the simulated flight due to radar vectors and ATC assistance. Thus, task value remains moderate.

Participant Number	1	2	3	4	5	6	7	8	9	10	11
Pre-Test Group	A (Pass)	A (Pass)	A (Pass)	A (Pass)							
Test Group	A (Pass)	F (Fail)	A (Pass)	A (Pass)	F (Fail)	C	A (Pass)	C	C	A (Pass)	D (Fail)

Fisher Test Contingency Table:

	Pre-test Group	Test Group
Pass	4	5
Fail	0	3

***p*=.255**

Since the weather information communicated to pilots clearly showed better weather west and southwest (and relatively close), participants needed only ATC authorization and routing to get there. Little or no fuel planning or weather interpretation was required, and since the initial routing provided by ATC was little more than a vector in the chosen direction, pilots had little trouble complying. The only pilots that failed this task had already crashed or landed, and as per methodology, earned a default failing grade. Pilots who received a “C” grade for this task made no inquiries to ATC regarding current weather at the alternate.

The *p*-value for this task is *p*=.255 and the null hypothesis is not rejected.

Task 8.d. Acquires appropriate route/clearance to proceed to alternate, and implements initial route to alternate

Task Importance: 3

Rationale: Though part of the en route structure of flight and therefore significant, implementation of the clearance to the alternate in the Class C airspace of the simulated flight was greatly simplified due to radar vectors and ATC assistance. Thus, task value remains moderate.

Participant Number	1	2	3	4	5	6	7	8	9	10	11
Pre-Test Group	A (Pass)	A (Pass)	A (Pass)	A (Pass)							
Test Group	A (Pass)	F (Fail)	A (Pass)	A (Pass)	F (Fail)	A (Pass)	A (Pass)	A (Pass)	A (Pass)	A (Pass)	F (Fail)

Fisher Test Contingency Table:

	Pre-test Group	Test Group
Pass	4	8
Fail	0	3

***p*=.363**

Grades for this task will, by necessity, reflect the grades of the previous task, though weather interpretation/planning did not affect the grade. All pilots (except for those who had already crashed or landed) were easily able to comply with ATC instructions to fly an assigned heading towards their alternate destination, and all, therefore, received a passing grade. Had the flight been a real one, ATC would likely have eventually assigned a route on airways or radials, and the procedures and tasks of the en route portion of the flight would have been repeated. Since all of these tasks had been previously graded, the flight was terminated at this point.

The *p*-value for this task is *p*=.363 and the null hypothesis is not rejected.

CHAPTER V

EXPLANATION OF RESULTS OF THE STUDY

Introduction

This chapter further explains findings from the research project. It is intended to provide meaningful explanation of findings already reported in Chapter IV, and the rationale for certain conclusions that may not otherwise be obvious. To support these explanations, observations from notes made during the research flights will be included. While some of these observations are lengthy, they are useful in understanding exactly what some research participants did wrong and how certain pilot errors or omissions may have been unintentionally learned or *not* learned during training. These observations and related commentary also provide some insight into what research participants were likely thinking during errant parts of the flight, as some pilots were "thinking out loud" or showed evidence of being conditioned by the location or other specifics of their training. This will be more fully explained in the text. Knowing what pilots were thinking (or *may* have been thinking) is particularly useful, since tracing the links in the logic chain that lead to pilot error is necessary to beneficially change instrument training. Finally, certain opinions will be offered as they relate to research findings, and it is hoped that the reader will grant some license to the researcher to do so. The importance grades reported in Chapter IV will be repeated here, as will Fisher contingency tables summarizing pre-test and test group pilot performance. The *p*-value will also be reported.

We turn then, to the data and conclusions of each task.

Area of Operation 1: ATC Clearance

Task 1.a. Adequate knowledge of the elements related to ATC clearances and pilot/controller responsibilities

Task Importance: 4

Fisher Test Contingency Table:

	Pre-test Group	Test Group
Pass	4	8
Fail	0	3

***p*=.363**

This task is quite broad, as it deals with the "elements related to ATC clearances," and comments here will serve as sort of an overview for all clearance tasks. As such, it may be stated from the outset that acquiring an IFR clearance appeared to be an intuitive function for most instrument pilots. This is likely due to the integral relationship of the IFR clearance to the IFR flight; all instrument rated pilots know that the flight does not proceed without it. That is, all instrument pilots likely know that they must get this clearance to know what to do next, and all research participants began with this important step and generally completed it.

Another contributor to overall pilot competence in this series of tasks is likely the fact that the clearance is received and radios "set up" while stationary on the ground, as there is little time pressure or need for the pilot to divide attention among tasks.

Still, the fact that 5 of the test group pilots made less than perfect grades and 3 made failing grades, suggests that not all pilots found clearance tasks to be easy. Also, it should be understood by the reader that this task requires knowledge of "clearance elements and the pilot's responsibility," not necessarily ability. In fact, perhaps the most that could be said is that all pilots understood their responsibility to *get* a clearance. In practice, several of the test group pilots exhibited some difficulty regarding "elements related to ATC clearances." As noted in Chapter IV, "six of the test group pilots did not set one or both navigation radios to the correct frequency before takeoff, eight did not pre-set navigation instruments entirely in accordance with clearance, six required multiple "repeats" of the clearance and/or corrections from ATC, and one requested the clearance on the wrong communication frequency." All of these errors will be analyzed more fully within the appropriate task section of this report; this task is really an overview of them all. Thus, the overview is that pilot knowledge of clearance tasks is generally sufficient, but clearance knowledge application, for at least some of the test group pilots, needs more practice, as will be seen in subsequent tasks.

Task 1.b. Copies ATC Clearance

Task Importance: 4

Fisher Test Contingency Table:

	Pre-test Group	Test Group
Pass	4	8
Fail	0	1

***p*=.692**

All but one pilot passed this important task. However, some struggled though the process (one required three complete readbacks from ATC, two required two readbacks, and most had a correction or two). The reason was simple: pilots were assigned a route different than they had requested. A few words about the clearance process may be helpful.

Before any flight may proceed under IFR, a clearance must be issued by ATC. The initial request for this clearance actually occurs before the flight begins, and is usually made in the form of a flight plan that the pilot files verbally over the telephone with a Flight Service Station or online textually via DUATS . The flight plan, as noted, is really more of a *request* than a plan, and in it the pilot requests a time of departure, an altitude, a route, and other relevant flight parameters. ATC, during the time of flight plan filing and actual departure, attempts to harmonize this proposed flight with all other known traffic. Once ATC successfully integrates the proposed flight into the "system," a clearance is issued by ATC to the pilot immediately before departure. This clearance may contain exactly the route and altitudes that the pilot requested and can be communicated to the pilot with a simple "cleared as filed." But it may also be very different. In fact, other than the points of departure and arrival, the actual clearance issued by ATC may have little in common with the filed route, and may send the pilot scrambling for charts and pencil, as the route, altitudes, clearance limit, etc. may be completely different than what was filed. And, while this is not an uncommon occurrence in the greater ATC system, it *is* uncommon in the semi-rural environment (where there is generally less traffic for ATC to harmonize) where all of the test group pilots trained. In fact, anecdotal statements from the pilots before the flight suggested that they expected the common route clearance "as filed," and were likely caught off guard by something different.

Even so, most of the pilots were able to adapt, and all eventually got the route "on paper" and read back to ATC successfully. It should be understood by the reader that seeking clarification from ATC is *not* an error, and is in fact encouraged to eliminate possible ambiguity or misunderstanding (Jeppesen Guided Flight Discovery Team, ATC Clearances, 2006). Therefore, all possible latitude was given the research participants, and grades for this task were relatively high. At some point, however, continued pilot queries or ATC corrections suggest insufficient pilot knowledge or ability. The definitions of C and D grades, as reported in Chapter III, are as follows: "C- Task completed and/or knowledge demonstrated, but multiple attempts/clarification, and, D- Task partially completed and/or knowledge partially demonstrated, but elements of task not done or done incorrectly and/or gaps in knowledge observed or suspected." These definitions provided the basis for grade assignments for this task. The one test group pilot that failed this task was finally able to record the clearance assigned by ATC (or so it appeared), but not without multiple attempts, corrections, and lingering errors.

Task 1.c. Determines Ability to Comply

Task Importance: 3

Fisher Test Contingency Table:

	Pre-test Group	Test Group
Pass	4	7
Fail	0	2

***p*=.462**

This task was difficult to grade for two reasons. First, the ability of the *airplane and equipment* to comply (which is likely what the FAA had in mind when creating this task) was not a factor. If this were all that were graded on this task, all pilots would have received passing grades, though little actual *testing* would have been involved since they were supplied an adequate "airplane" and assigned no impossible tasks.

The ability of the *pilot* to comply was quite another matter, and while this could be more meaningfully graded, the validity of the grade may be questionable. This is due to the fact that all pilots knew that they were conducting a simulated, data-generating flight. They were therefore likely inclined to attempt it whether they thought they could execute the clearance or not. The flight was, after all, an *experiment*, and since it was simulated, little was at stake. In other words, in a real airplane, self-assessment may have been more accurate, and the flight may not have even been attempted, especially given the bad weather. Several of the pilots pointed this out after the flight. In hindsight, it may have been an informative exercise to ask pilots to make a go/no-go "ability" decision before the flight and glean some knowledge regarding pilot self-assessment. Future researchers should consider incorporating this task.

It should be noted that one pilot accurately self-assessed his inability to comply with the clearance while en route. This pilot grudgingly declared an emergency and asked ATC for radar vectors to an “uncongested airport.” This pilot’s grade for this task was raised to a “D” since he did indeed correctly “determine ability to comply” and proceed accordingly. Still, a D is considered a failing grade for this project as this pilot (and one other) was flatly unable to comply with the clearance. The reader should be careful, however, to not read too much into the grading of pilot self-assessment for reasons noted above. In any event, the *p* value for this task is *p*=.462 and the null hypothesis is not rejected.

Task 1.d. Correctly Interprets/Requests Clarification of Clearance.

Task Importance: 4

Fisher Test Contingency Table:

	Pre-test Group	Test Group
Pass	4	7
Fail	0	3

***p*=.330**

This was a difficult task to grade since what the pilot correctly interpreted and/or needed clarification of was not readily observable. What *could* be observed was how the pilot complied with the clearance, so the grade assignments necessarily reflect the grades for task 1.c. Affecting grade assignments for this task, at least somewhat, was the occasional disinclination of pilots to seek clarification from ATC. As can be seen by the grades, three of the pilots did not demonstrate adequate interpretation of the clearance and/or should have asked more questions about it.

The single most common error made by pilots was setting navigation radios incorrectly. This was a relatively common error throughout the research flights and is noted multiple times in this report. The phrase "incorrectly set radios," however, can have different meanings depending on context. Here, it means that radios were likely set incorrectly because of pilot confusion regarding the fix (or "route" to the fix) to which he/she was directed in the initial clearance. If so, pilots should have addressed this confusion with queries to ATC. Pilots who received a failing grade on this task did not, or at least did not do so enough.

Task 1.e. Reads Back Clearance

Task Importance: 3

Fisher Test Contingency Table:

	Pre-test Group	Test Group
Pass	4	8
Fail	0	1

***p*=.692**

As noted earlier, several of the test group pilots required at least a second "repeat" of the clearance and one required three repeats before it could be read back correctly. Additionally, there were multiple corrections from ATC for incorrect elements of the readback, and one attempt to contact ATC on the wrong frequency. It should be emphasized once again that pilot requests for a clearance to be repeated or clarified is not necessarily a bad thing, as it is an appropriate pilot action if there is any ambiguity regarding the clearance. For that reason, "repeats" did not automatically receive a lower grade unless the apparent need for a repeat was pilot confusion or inability to keep up with ATC. Indeed, some of the pilots who received high grades on this task queried ATC regarding some element of the clearance. Not coincidentally, some of these same pilots received higher grades in the implementation of the clearance and frequently demonstrated an ability to think “farther ahead” of the airplane and set up the radios and navigation instruments accordingly. There appeared to be a relationship between receiving, copying, understanding (sometimes requiring dialogue), and implementing the clearance which is reflected by the grades. The test group pilot who received a failing grade on this task struggled with all three elements of the clearance receipt/copy/readback process, and ATC had considerable doubt about the pilot’s comprehension of it. ATC accepted the pilot’s readback so that the research “flight” could continue, but the readback was quite muddled and the pilot’s struggle to execute what he had read was no surprise.

Most pilots were able to get and read back the clearance, so the Fisher score for this task is *p*=.692 and the null hypothesis is not rejected.

Task 1.f. Standard Phraseology

Task Importance: 1

Fisher Test Contingency Table:

	Pre-test Group	Test Group
Pass	4	10
Fail	0	1

***p*=.733**

As reflected by the grades, few pilots had trouble with this relatively unimportant task. In fact, as phraseology relates to this Area of Operation pilots *shouldn't* have trouble, as the requirement is only to repeat back to ATC what has just been read to the pilot. Of course, phraseology is a task that routinely confronts the instrument pilot, as elements of holding clearances, approach clearances, and landing clearances are routinely "read back" to ATC. And, in fact, the only test group pilot to receive a failing grade for this task struggled with phraseology whenever asked to repeat elements of a clearance.

Task 1.g. Sets Communication/Navigation systems & Transponder in Compliance With Clearance

Task Importance: 4

Fisher Test Contingency Table:

	Pre-test Group	Test Group
Pass	4	5
Fail	0	4

***p*=.176**

This task proved to be one of the more problematic, in part because of poor pilot technique, and also because the errors committed during the pre-take off radio set-up compounded other errors en route. No less than seven of the test group pilots set navigation instruments incorrectly (or not at all) before takeoff, though one of them discovered and corrected the omission during initial climb-out. Six also set wrong navigation radio frequencies (or, again, none at all), and another set *almost* correct navigation instrument settings. One of the pilots never set the transponder code. Again, it should be emphasized that these pre-takeoff set-up errors and/or omissions led to many other errors, since once underway aircraft control assumed a large part of the pilot's attention. A few examples of these compounded errors, taken from notes made during the research flights, are informative:

> During pre-takeoff set up, Test group pilot 1 made no effort to align the course indicating arrow of the HSI to the direction of flight. Instead, the arrow was aligned to the *reciproca*l of selected course. This is not necessarily incorrect, as the HSI will still provide correct needle sensing as long as the course being flown is not a Localizer. Unfortunately, TG1 continued the "reversed arrow" right up to and *including* the localizer, where it did initially cause reverse needle sensing.
>
> Test group pilot 2 started off with nav instruments set incorrectly. Specifically, the SWO 118° radial was not set on either indicator. TG2 noticed this only at the last minute as he realized something "looked wrong," and set the HSI to 118° just about the time it centered. He corrected adequately and intercepted course, but continued to be "behind the radios" throughout the flight.
>
> As Test Group Pilot 5 took off , the #1 nav. radio was set to 113.2 (Pioneer VORTAC near Ponca City) with the OBS set to 360°, and #2 set to 114.4 (Tulsa VORTAC) with the OBS set to 250°. Since the #2 nav indicator is a standard indicator (not HSI, see pilot #1 above) confusion is likely to result, and did. The 250° radial was set in #2 nav., (which roughly defines V140) but the on-course heading is 070°. If directly on

the radial, the CDI will be centered, but once off, reverse needle sensing will result, and again, it did. TG5 intercepted V140 and turned to the appropriate heading, but over time he drifted off. With the aforementioned reverse needle sensing of the indicator, TG5 quickly became confused. ATC intervened with “Radar shows you 2 miles North of V140, say intentions,” to which TG5 responded that he was “going direct to YARNS intersection.” TG5 was then reminded of clearance and given a vector to rejoin the airway. He did so successfully, but as a clearance amendment (the next task) was issued, 5 again drifted off of the airway, struggled with reading back the clearance, and became disoriented.

At (TG6’s) departure the radios were not set correctly, which greatly complicated initial navigation. #1 nav. radio was set on 114.4 (Tulsa VORTAC) with the OBS set to 180°. #2 nav. radio was set to 108.0 (?) with OBS set to 360. However, soon after takeoff TG6 realized his mistake and attempted to fix it; he set #1 OBS to 118° (consistent with clearance) but still had 114.4 in the #1 radio. Several minutes later, the radios were finally set correctly, and 6 established himself on course but only after confessing to ATC that he had flown through the assigned course. He declined ATC’s offer for vectors onto the course, and instead turned to a heading which provided an intercept angle of 120°. In other words, he was going the wrong way. Still, he intercepted the course and tracked it in the correct direction, though again, it appeared that some pre-takeoff planning might have avoided much confusion.

Once the clearance (for TG8) was copied correctly, little pre-takeoff planning went into its execution. Neither of the nav. radios were set, nor was the OBS of the VOR or HSI, nor were anticipated com. frequencies. After takeoff, things improved little as the HSI was set to 090° instead of 118° (with TG8 undoubtedly confusing heading and radial to intercept) without the nav. frequencies being set at all. Indeed, about 5 minutes into the flight, #1 nav. radio was set to the Tulsa localizer frequency, which produced a “nav. flag” which was ignored. Finally, TG8 took off with the TUL VORTAC set in the GPS (only because it was set during preflight demonstration), but it was soon replaced with Direct Tulsa *airport*, which was less useful information given the clearance. Without VHF navigation capability, TG8 simply headed to Tulsa airport direct via GPS. After several minutes of this, ATC intervened with “radar shows you 4 NE of IBAAH, say intentions.” TG8 responded that he was “tracking to IBAAH,” to which ATC again reminded that he was already *past* IBAAH. ATC rejected TG8’s offer to go back to IBAAH and instead offered vectors to V140, which were accepted. However, without the nav. radios set, there was little chance to intercept the airway and TG8 was eventually well south of it. [Note: after the flight, TG8 admitted that he had flown on an airway only once during his training.] Finally, after ATC

> advised TG8 of his whereabouts, another vector was given to V140 and the correct frequency and radial were dialed in.
>
> Test Group Pilot 11 departed with navigation radios set incorrectly. #1 nav. was set correctly to 108.4, but the HSI was set to 110° instead of 118°, introducing a small navigation error. The #2 nav. radio/ indicator were not set, nor was the GPS. However, 10 minutes after departure [and probably due to waning situational awareness] the GPS was set direct to IBAAH. This tended to encourage "GPS direct" navigation, which persisted throughout the flight. GPS direct navigation was not technically legal given the VFR only GPS [which was discussed with the pilot before the flight].

Again, these excerpts from the research flights, though lengthy, are offered to inform the reader of the variety and number of pre-takeoff navigation errors that were observed. In fairness, it should be noted that some of the navigation instrument errors may have been compounded by participant unfamiliarity with an HSI. One participant made a reference to this during the post flight debriefing. As required per methodology, all participants confirmed during the pre-flight briefing that they had at least some exposure to the navigation instruments and no questions regarding their use. However, not all of the training aircraft in which the test group pilots trained had an HSI, and some may have been more familiar with it than others. Some may have overestimated their understanding of the HSI, and learned their *actual* level of HSI expertise during the research flight! Still, the HSI operates similarly to a conventional VOR indicator and since all of the participants claimed at least a passing familiarity with it, the results are assumed valid. Indeed, a conventional VOR indicator was on the "aircraft" panel for any who preferred it to the HSI.

As noted, this was a problematic part of the flight, and for many pilots it set the tone for recurring and/or compounded errors. The Fisher score for this task is p=.176, which suggests that the null hypothesis could be rejected at roughly the 82% confidence level. And, while this perceived performance disparity between the groups *suggests* a verifiable difference between them, we will not reject the null at this confidence level for this task. Once again, the null hypothesis is not rejected.

Area of Operation 2: Compliance With Clearance/Procedures

Task 2.a. Adequate knowledge of elements of departure, en route, & arrival clearance and pilot/controller responsibility

Task Importance: 4

Fisher Test Contingency Table:

	Pre-test Group	Test Group
Pass	4	9
Fail	0	2

p=.524

As can be readily seen by the grades in the table, most pilots received a passing grade for this important task. The task itself, however, is quite broad and an effort was made to evaluate only the pilots' *knowledge* of it, as specific knowledge *application* is graded in subsequent tasks. It is more accurate to say that the pilots were graded on their knowledge of what was *supposed* to be done, and most of the pilots appeared to know what ATC meant when issuing clearances.

Two pilots appeared to not understand either the departure, en route, or amended clearances. In fact, as one of these two pilots took off, turned the wrong way and eventually drifted off course, he was questioned by ATC of his intentions. His response, that he was “proceeding direct YARNS,” revealed that he did not understand where ATC wanted him to go. This pilot had to be reminded of his clearance, but it still may not have been fully understood. This was later confirmed, as ATC’s request to get ATIS information was misunderstood to be more route information. As the route clearance was amended, the pilot was unable to comply with the change and wound up receiving radar vectors from ATC as a last resort.

Two pilots of the test group received less than passing grades for this task and the Fisher score is p=.524, thus the null hypothesis is not rejected.

Task 2.b. Uses correct publication

Task Importance: 2

Fisher Test Contingency Table:

	Pre-test Group	Test Group
Pass	4	10
Fail	0	1

***p*=.733**

Since all of the publications used during this “flight” were provided to participants, it is seems highly unlikely that the wrong publication *could* be used! However, one pilot managed to do just that.

On this relatively short flight only one en route and one approach chart was used, though the entire book of approach charts was supplied (in case of diversion, this being a “real” flight). All participants were advised on what approach would likely be assigned at Tulsa, and, in fact, a large photocopy of this approach was provided. All participants were allowed to review the approach before the flight. This review is consistent with real IFR flight procedures since, given the weather, all pilots would naturally deduce that a precision approach would be required and only one ILS is aligned to the North (consistent with forecast wind) at Tulsa. Still, one pilot (TG2) requested the ILS 18L approach (despite the strong north wind) but accidentally referred to the ILS 18R approach *chart*, and set up the navigation instruments accordingly. He later explained that he requested the ILS 18L approach because he had recently practiced it and felt more confident in its execution. However, the ILS 18R is *not* the ILS 18L, and setting up for one approach and flying another is most definitely not “using the correct publication.” A failing grade for this task was therefore assigned.

The Fisher score for this task is *p*=.733 so the null hypothesis is not rejected.

Task 2.c. Uses and identifies correct communication and navigation facilities

Task Importance: 4

Fisher Test Contingency Table:

	Pre-test Group	Test Group
Pass	4	5
Fail	0	4

***p*=.176**

Assigned grades for this task, as well as synopses of the flights, will reflect task 1.g. In fact, is it difficult to make a distinction between “sets communication/navigation systems…” (1.g.) and “uses and identifies correct communication and navigation facilities” (2.c.). Differences between the two grade tables could be attributed to: legal and profitable use of GPS, diligence in identifying navigation stations, and some subjectivity in grading.

Without restating what has already been said regarding task 1.g., it should be reaffirmed that this was a problematic phase of the flight. It should also be noted that the use of GPS played a significant role in situational awareness and overall “use and identification of correct navigation facilities.”

Since the GPS was “VFR only,” its only legal use was for situational awareness. However, it is probably *impossible to overstate the importance of situation awareness*, and the legal means of navigation for this flight - VHF navigation instruments - provide this awareness only with considerable pilot interpretation. The GPS was *very* useful in helping pilots know exactly where they were, and for “making sense” of VHF navigation instrument indications. Some pilots who did not effectively use the GPS simply could not correctly set or interpret navigation instruments, and ATC statements of “off course, say intentions” were commonplace. Conversely, a few pilots made *too much* use of GPS and appeared to be using it for primary navigation. Generally, this kept the GPS-savvy pilots on course, but not technically legal. Again, certain observations from the flights will be informative for the reader:

> Test Group pilot 2 never became established at IBAAH intersection. In fact, TG2 set the 140° radial off TUL since his clearance was to "Victor 140." Actually, V140 is defined by the 253° radial off TUL. TG2 continued southeast without noticing his mistake until ATC informed him that he was 2 miles southeast of IBAAH and asked for his intentions. Without being able to provide any or figure out his mistake, he simply confessed that he "was way off," and implied that he did not know how to fix the problem. ATC then offered vectors to get back on the airway. He accepted the vectors, but still did not dial in the correct radial, so there was little chance of getting on course. Faced with this, ATC "reminded" TG2 that Victor 140 is defined by the 253° radial of TUL, which the participant then set correctly and became established on the airway. The next task, copying and complying with the new clearance, went no better. Once the clearance was copied (with minimal difficulty), the nav. radios were again set incorrectly to define V532, which is necessary to identify SEARS and KEVIL intersections. Given that the new route could not be implemented, ATC assigned "Direct TUL," and the compliance with clearance task was considered failed, as per agreed methodology.
>
> A "direct to TUL VORTAC" clearance was issued to Test Group Pilot 5 (for the same reason that it was issued to TG2; see above), which was read back correctly. However, neither VOR nor nav. radio was reset.

Instead, KTUL was entered in the GPS with a “Direct To” command. Note that KTUL is the airport, not the VORTAC. After listening to ATIS and returning to Tulsa Approach frequency, TG5 admitted that he was confused and asked for “vectors to airport due to inability to control aircraft and lack of situational awareness.” ATC asked if he was declaring an emergency, to which TG5 grudgingly agreed that he was. He was then told to turn to a new heading and expect vectors to final approach course for ILS 36R. TG5 asked if he could “just get vectors to an airport,” to which ATC reminded him of ceiling and visibility and that an instrument approach would be necessary.

A minor problem for TG7 was not setting OBS radials accurately enough. This was relevant only on the initial intercept of the SWO 118° radial. TG7 had the HSI set about 15° off (presumably by accident) and actually intercepted V140 before the radial to *get* to V140.

Unsure of the navigation instrument indications (though needle was beginning to center), TG8 finally asked for “vectors to SEARS” which ATC provided. Again, however, V532 (the next airway) was not set in the nav. radios (frequency dialed in *standby only* in nav. radio) and TG8 flew through his clearance. ATC intervened again with “radar shows you 2 SE of SEARS, say intentions.” With no real plan in response, ATC asked TG8 if he could take a “direct to TUL VORTAC” to which TG8 responded “negative, GPS is VFR only.” Therefore, with the execution of

> the amended clearance and accompanying hold no longer options, ATC told TG8 to "expect vectors to final approach course ILS 36R."
>
> Test Group Pilot 11 appeared to be navigating GPS direct, though he did so in a way that mostly kept him on the assigned route and quasi-legal. Usually, TG11 waited until the assigned fix (using GPS), then set GPS to next fix and followed the DTK (direct) headings. He set VOR indicators and frequencies to match, which made his procedure legal (sort of) as long as he was on the assigned course. Occasionally he was not, and using the above procedure (instead of setting indicators to charted radials) kept him from noticing his mistake.

And so it went. Pilots who correctly visualized their position, and used GPS to do so, fared better than pilots who didn't. Also, as was noted during task 1.g., setting radios and radials correctly and *as needed* was a fundamental instrument pilot skill that compounded other errors if done poorly. Finally, it should be noted that while nearly all pilots attempted to identify (using audible tone) at least some navigation stations, it appeared that few (if any) Test Group Pilots identified them all. This may have been due, in part, to the difficulty that the PI had in hearing/observing this pilot task (due to a simulator flaw, the tone was not audible over the headsets). However, it was due mostly to the heavy pilot workload that reduced the task to such a low priority that it was sometimes neglected by pilots altogether.

The Fisher score for this task is p=.176, and as tempting as it may be to do so, at roughly a 82% confidence level the null hypothesis cannot be rejected.

Task 2.d. Performs appropriate checklist

Task Importance: 2

Fisher Test Contingency Table:

	Pre-test Group	Test Group
Pass	4	11
Fail	0	0

***p*=1.0**

This relatively unimportant task presented little difficulty to participants. The simulator accurately reproduced the flight sensations of a Cessna 172, with which all of the participants had considerable familiarity. Therefore, most checklist items were intuitive and well rehearsed by the participants. There was, however, the occasional landing light left on en route (typically it should be turned on for takeoff and extinguished soon after) or power setting left at incorrect RPM. However, since neither of these (or related) items are particularly relevant to the instrument pilot skills of interest in this study, they were ignored by the PI.

Obviously, the null hypothesis for this task is not rejected.

Task 2.e. Establishes communication with proper ATC facility

Task Importance: 2

Fisher Test Contingency Table:

	Pre-test Group	Test Group
Pass	4	11
Fail	0	0

***p*=1.0**

This was another relatively unimportant task that presented little difficulty. The flight originated at Stillwater Regional Airport where frequencies were well known by all participants. Once en route, frequencies for successive ATC facilities were verbally assigned by ATC as needed; participants were only required to “look up” the Tulsa ATIS frequency and possibly McAlester FSS frequency. Even then, these two frequencies were provided by ATC if requested by the pilot. Grades for this relatively easy task were high, and the null hypothesis is not rejected.

Task 2.f. Complies with ATC instructions and airspace restrictions

Task Importance: 5

Fisher Test Contingency Table:

	Pre-test Group	Test Group
Pass	4	6
Fail	0	5

***p*=.154**

While a very important task, little can be said about “compliance with ATC instructions and airspace restrictions” that has not already been described in regard to specific tasks (or soon will be). Many things can cause non-compliance with ATC instructions and/or intrusion into uncleared airspace, and all of these items are best described under specific task headings. It should be understood that at no time was non-compliance with ATC willful, reckless, or due to carelessness. It should also be understood that there were no TFR’s or charted airspace restrictions along the route, neither of which are particularly relevant to flight under IFR anyway. Therefore, for this flight at least, the task element “complying with airspace restrictions” is indistinguishable from “complying with ATC instructions.” As noted in the grade tables, the same pilots that were “non-compliant with ATC instructions” or in violation of “airspace restrictions” were the same pilots that were grossly off course at some point during the flight or did not “remain within holding airspace.” All of these are separate tasks that are included within this one, and grades will necessarily show similarities.

The Fisher score for this broad task is *p*=.154 and the null hypothesis *is* rejected at roughly the 85% confidence level. The rejection of the null hypothesis at this reduced level of confidence is fully explained in Appendix K.

Task 2.g. Intercepts appropriate radials and bearings as published in procedures

Task Importance: 4

Fisher Test Contingency Table:

	Pre-test Group	Test Group
Pass	4	6
Fail	0	4

***p*=.210**

Due to the similarity and/or interrelationship of tasks, grades for this section will necessarily reflect the grades in sections 1.g. and 2.c. An overview of pilot errors related to “intercepting appropriate radials” is worth repeating here, as it was, once again, a recurring pilot error during the research flights.

Three test group pilots set the reciprocal of actual course in a VHF navigation instrument during at least one part of the flight. This error leads to reverse needle sensing and is a common cause of pilot disorientation and/or navigation errors. However, this error had a greater impact on *maintaining* radials than intercepting them. Mention of it is made here for the sake of completeness.

Six test group pilots simply set the wrong radial in a VHF navigation instrument. Two more set radials that were *close* to the correct radial (off by only 5°-10°). This suggested that the pilots knew how to find and set the correct radial, but just weren't careful enough. During an actual IFR flight, a slight "prod" from ATC would likely fix this problem, or ATC might ignore it altogether depending on distance from the navigation station and corresponding course divergence.

Two more test group pilots set wrong radials at some point in the flight, but caught and fixed their error "at the last second," or at least before it caused a course or approach deviation.

One test group pilot employed a flatly incorrect intercept angle - 120° from the assigned radial.

Finally, one test group pilot set radials mostly correctly, but somewhat "after the fact." This pilot appeared to be navigating from fix to fix using the "Direct To" function of the (VFR only) GPS, and once en route, centered the CDI of the navigation instruments accordingly. This procedure generally kept the pilot on course, but not technically legally. It also reduced this pilot's grade on this task, although he did receive a passing grade since he "stayed on the radial" and did, at least some of the time, set and intercept radials correctly using VHF navigation instruments.

Note, yet again, that multiple errors were committed by individual pilots, so the errors catalogued above are not to be understood to be referring to different pilots for each error.

The Fisher score for this task is *p*=.210, so the null hypothesis is not rejected.

Area Of Operation 3: Basic Instrument Maneuvers

Task 3.a. Adequate knowledge and skill related to attitude instrument flight

Task Importance: 5

Fisher Test Contingency Table:

	Pre-test Group	Test Group
Pass	4	8
Fail	0	3

***p*=.363**

As suggested by the task importance, instrument pilots are taught to "fly the airplane first." The importance of this simple axiom cannot be overstated, as nearly all the other tasks in this exercise become irrelevant if the pilot cannot maintain adequate aircraft control. Also, it must be understood that maintaining control is not always easy, since increasing pilot workload encroaches on the attention that a pilot can devote to monitoring aircraft attitude. In fact, as aircraft types become more complex, mechanical autopilots and multi-member crews are commonly employed for this reason. During the research flights in this study, pilots received no assistance from autopilot or crew members and none lost control of the aircraft. Thus, no "F grades" were assigned, though heading and altitude deviations were commonplace and three pilots did receive less than passing grades.

This task, as interpreted for this project, probes the *knowledge* and *skill* required for adequate aircraft control. Both involve adequate instrument scan, instrument interpretation, and setting appropriate pitch and bank attitudes. And, since all of these skills are difficult to measure solely through observation, some subjectivity in grading is inevitable. Pilots that received less than passing grades for this task had, in the judgment of the PI, *excessively recurring* heading, altitude, or attitude deviations. Specific altitude or heading deviations will be more fully discussed in the next task.

The Fisher score for this task is *p*=.363 and the null hypothesis is not rejected.

Task 3.b. Maintains altitude +/- 200 feet, heading +/- 20°, and airspeed +/- 20 knots.

Task Importance: 4

Fisher Test Contingency Table:

	Pre-test Group	Test Group
Pass	3	7
Fail	0	3

***p*=.420**

As noted in the previous task, none of the pilots lost control of the aircraft. Not all, however, stayed within the stated tolerances, and the three pilots who failed this task had excessive and/or recurring heading or altitude deviations. Excessive enough, in fact, that ATC would likely intervene during a real flight. These deviations increased proportionally with pilot workload, as attention that was needed for aircraft control was necessarily diverted to other tasks such as navigation, chart reading, communication, etc. A note in the summary of one of the pilot's flight illustrates the difficulty of attention division, and may help to explain it:

> Over-controlling was the rule throughout the flight, and the attention required for (barely) adequate attitude control made most other tasks very difficult. After the flight, [this pilot] noted repeatedly that he was unimpressed with the simulator's fidelity to real flight.

And, in fact, this pilot may have had a point. Pilots in both groups occasionally commented on the fidelity of the simulator to a real airplane, particularly the sensitivity of the elevator trim control. In truth, the simulator, at times, did not perfectly reproduce all of the nuances of actual flight, such as the sound of changing slipstream noise or engine RPM. These sensations (and others) do tend to alert a pilot to changing speed or attitude in a real airplane and they are notably missing in the simulator. However, these nuances are rarely reproduced in even the most sophisticated simulators, and the simulated flight is, after all, *simulated*. And, in fairness, the simulator doesn't crash like a real airplane either, so imperfect fidelity is not all bad!

It should be noted that one pilot who demonstrated excellent attitude control made frequent use of the heading bug, and this seemed to help keep him aware of assigned headings and alert him to heading deviations, particularly as he divided his attention among other tasks.

The Fisher score for this task is p=.420 and the null hypothesis is not rejected

Area Of Operation 4: Holding Procedures

Task 4.a. Adequate knowledge and skill related to holding procedures

Task Importance: 3

Fisher Test Contingency Table:

	Pre-test Group	Test Group
Pass	4	3
Fail	0	7

***p*=.035**

Holding procedures proved to be a problematic part of the flight. And, significantly, a knowledge deficiency was sometimes evident in pilots who were quite knowledgeable and skilled in other tasks. At least one skilled test group pilot admitted during the flight that he was "weak on holds" and another noted that he had the same problems with holds on the research flight that he had on his instrument checkride!

It should be noted that the task importance assigned to holds is relatively low. This is due to the fact that holds are an "auxiliary" part of any instrument flight and contribute little to the completion of it. They are assigned by ATC as a delaying function so that something else - other traffic, weather, etc. - may proceed. However, though the relative task importance of holds is low, their difficulty level can be high. All instrument pilots are taught standard holding procedures, and some of these procedures require considerable pilot "headwork" as radial reciprocals, divergence angles, intercept angles and other tasks must be determined and correctly executed. Compounding the difficulty of these tasks for this exercise is the fact that all of the test group pilots trained at Stillwater Regional Airport. At this airport, nearly all of the holds associated with instrument approaches (where a pilot focuses much of his instrument training) employ non-standard holds (turns to the left instead of right). As one might guess, Stillwater-trained pilots have more experience visualizing all of the above procedures *backwards*, and the potential for these same pilots to be confused by unpracticed, standard holds is great. In fact, some research participants may have never visualized anything *except* a non-standard hold due to the unintended conditioning of the holds at Stillwater.

Errant turns were not the only holding errors committed during the research flights. In fact, errors regarding holds ran the gamut of common causes: visualizing the hold incorrectly (confessed during debriefing), confusing inbound and outbound radials, incorrectly identifying the holding fix, incorrect timing procedures, and others. Once again, considering a few examples is informative:

> A hold was assigned at TUL about 15 miles before reaching it. The holding clearance was "hold north, 5,000." This caused some confusion, with TG2 audibly admitting (not necessarily to ATC) that he "didn't know how to do it." However, the hold is published on the en route chart and once the participant saw this, he visualized the hold and proceeded. He did not proceed correctly, however, and employed a modified teardrop entry to a hold with left turns (outside of protected airspace). Further, he never got established on the assigned 358° radial, and he could make no sense of the direction of needle deflection inbound or outbound (which he admitted). The needle remained at full scale throughout the task.
>
> "Hold South, 5,000" was assigned and read back. While nearing the fix (TUL VORTAC) TG4 asked ATC if "holding south of the fix and right turns" is what was meant. Though this was confirmed, there

continued to be some confusion about what was assigned. The participant flew past the fix headed east and continued east for one and a half minutes or so. Then, a right turn was initiated to a heading of 270 which was maintained for a minute or so until finally the participant called ATC and confessed that his hold was on the "wrong radial." A clearance was requested to return to the VORTAC and try again. A clearance to "proceed direct TUL VORTAC, hold south 5,000" was again issued. Again, the participant proceeded to the fix and then went outbound to the west and executed a parallel entry to a hold on the 270 radial.

…the holding clearance caused problems. The clearance, which included instructions to "hold south, 5,000'," was read back as "hold south, 5 miles." ATC corrected this read back error, but there was still some confusion about what ATC wanted. A few minutes later, still en route to the holding fix, TG6 asked ATC if he should go to the fix, then south for 5 miles to hold. Again, ATC clarified what was expected, but plain language was required to do so.

This was the only phase of the flight that presented a problem for TG7. While en route to both holding fixes (during en route and again during the missed approach), the participant asked for "vectors to the hold." Both times vectors were received, but the hold itself was not clearly understood. The first holding clearance was "hold south, 5,000'," but the participant held southwest on the 210° radial, though this appeared to be by accident with constant "tweaking" and apparent confusion

> throughout. The second hold never happened, as the participant asked for the vector, got it and flew to the fix, but then turned the wrong way. After that, ATC simply gave him an on-course vector. After the flight, the participant revealed that he was visualizing the hold incorrectly, with the outbound instead of the inbound leg on the assigned radial.
>
> …ATC intervened with "radar shows you 4.5 west of Tulsa, proceed to TUL VORTAC, hold south, 3,000'." This clearance was read back correctly, but not fully executed. Instead, TG8 flew to TUL VORTAC using GPS, noted station passage with mileage on GPS readout, and then turned *left*. From there, the participant did indeed hold south of TUL and did get the #1 nav. correctly tuned, but employed left turns throughout and was generally in unprotected airspace.
>
> Interestingly, TG9 performed all holding operations well but demonstrated notable apprehension while doing it. While en route to the hold, he queried ATC to confirm that the hold he was visualizing was the hold that ATC assigned, which it was. He also announced (not necessarily to ATC) that his experience at Stillwater was a source of confusion as most holds there are done to the left.

Clearly, there was an observable difference between the demonstrated knowledge of pre-test and test group pilots regarding holding procedures. This is particularly true since some of the pre-test group pilots were assigned more difficult holds than were test group pilots (since certain route details were still evolving during the pre-test). In fact, the Fisher score for this task is *p*=.035, which represent a 96% probability of a difference between the experienced pre-test group pilots and the less experienced test group pilots. Clearly, the null hypothesis can be rejected for this task.

Task 4.b. Remains within holding airspace

Task Importance: 3

Fisher Test Contingency Table:

	Pre-test Group	Test Group
Pass	4	3
Fail	0	6

***p*=.049**

Though this task is related to the previous one and shares the same task importance, it would appear to be a task that is much easier to grade than “knowledge… of holding procedures.” An observer might assume that pilots either stayed in holding airspace or they didn’t. However, the term “holding airspace” requires some definition.

Whenever ATC assigns a hold, they prohibit other traffic from penetrating that airspace; it is thus protected for the holding aircraft. Logically enough, this area is commonly referred to as “protected airspace.” The dimensions of protected airspace, however, are not necessarily as intuitive, and are generally known only by ATC. AFMAN (Air Force Manual describing civil airspace operations) 11-217 notes that “holding pattern sizes can vary greatly depending on the altitude of the holding pattern, primary aircraft the procedure was designed for, and other factors. Pilots have no way of knowing the design limits of protected airspace for a particular holding pattern.” Thus, the PTS term “holding airspace” could be defined rigidly as “*any* excursion from airspace defined by prescribed holding procedure" or it could be defined loosely, as "deviations from holding procedure great enough to *likely* cause departure from protected airspace." Further complicating the definition is the fact that "prescribed holding procedures" actually contain certain *recommended* procedures; they are not mandatory.

For this exercise, then, deviations from holding procedures received failing grades only if they were egregious. Minor deviations from holding procedures received passing, but less than perfect, grades.

Six test group pilots received less than passing grades for this task and most were the same pilots who demonstrated a lack of *knowledge* regarding holding procedures. However, one pilot who failed the previous task generally remained in holding airspace, and received a passing grade for this task. Still, six pilots in a group of eleven is a lot. The Fisher score for this task is p=.049 and the null hypothesis is rejected at the 95% confidence level. Holding procedures, both in theory and practice, were a problematic part of the flight for most test group pilots.

Task 4.c. Recognizes arrival at holding fix

Task Importance: 2

Fisher Test Contingency Table:

	Pre-test Group	Test Group
Pass	4	7
Fail	0	3

***p*=.330**

This relatively unimportant task caused problems for some test group pilots. Indeed, the specific holding procedure error “recognizes arrival at holding fix” was all but lost in the confusion of other holding procedure errors. Still, three test group pilots received less than passing grades for this task. Two of these used the “direct to” function of the GPS to track to the holding fix, but did so poorly enough that they did not fly directly over the fix. Instead, they evidently saw the GPS mileage to the fix stop decreasing and begin increasing and assumed they were close enough.

Incidentally, it is noteworthy that *any* of the pilots had difficulty with this task, as proceeding to a fix and noting station passage is a very basic instrument pilot skill.

The Fisher score for this very specific task is *p*=.330, and the null hypothesis is not rejected.

Task 4.d. Complies with ATC reporting requirements

Task Importance: 1

Fisher Test Contingency Table:

	Pre-test Group	Test Group
Pass	4	8
Fail	0	2

***p*=.495**

This relatively unimportant task also caused problems for a few test group pilots. Three pilots either did not report or reported incorrectly, though only two received failing grades. As previously noted, there were a plethora of holding errors, and reporting was likely a low priority for all. Indeed, the fact that two test group pilots received less than passing grades on this task is misleading, as some never established themselves in a position *to* report!

In any event, the Fisher score for this task is *p*=.495 and the null hypothesis is not rejected.

Task 4.e. Times holds correctly

Task Importance: 1

Fisher Test Contingency Table:

	Pre-test Group	Test Group
Pass	4	5
Fail	0	4

***p*=.176**

This is another relatively unimportant holding task. Also, it is another holding task that can be adequately graded only if the *rest* of the hold is done correctly. As noted previously, some pilots never actually entered the hold and some never even arrived at the holding fix. Even so, four pilots made identifiable timing errors. The Fisher score for this task, therefore, is *p*=.176 and the null hypothesis is not rejected, though it should be noted yet again that holding pattern procedures were generally performed poorly by many test group pilots.

Area Of Operation 5: Intercepting and Tracking Navigational Systems

Task 5.a. Adequate knowledge of the elements of intercepting and tracking navigational systems

Task Importance: 4

Fisher Test Contingency Table:

	Pre-test Group	Test Group
Pass	4	7
Fail	0	4

***p*=.242**

Task 5.b. Tunes and identifies navigational facility and sets & intercepts course to be intercepted

Task Importance: 4

Fisher Test Contingency Table:

	Pre-test Group	Test Group
Pass	4	6
Fail	0	4

***p*= .210**

Task 5.c. Intercepts course at correct angle, inbound or outbound

Task Importance: 2

Fisher Test Contingency Table:

	Pre-test Group	Test Group
Pass	4	7
Fail	0	4

***p*= .242**

Pilot performance regarding “Intercepting and Tracking Navigational Systems” is thoroughly discussed in tasks 1.g. (sets communication/navigation systems), 2.c. (uses and identifies correct communication and navigation facilities), and 2.g. (interprets appropriate radials and bearings as published in procedure). In fact, many of the flight note excerpts included in the description of pilot performance regarding those tasks were made during the en route portion of the flight. Clearly, there is overlap among these tasks in various phases of an IFR flight. Therefore, in the interest of brevity, the reader is referred to the task narratives for tasks 1.g., 2.c., and 2.g. in this Chapter and in Chapter IV for the three similar tasks of Area of Operation 5. Only grade assignment summaries have been reported for the tasks within this section.

The Fisher score for this task is *p*=.242 and the null hypothesis is not rejected.

Area Of Operation 6: Precision Approach

Task 6.a. Adequate knowledge of precision instrument approach procedures

Task Importance: 4

Fisher Test Contingency Table:

	Pre-test Group	Test Group
Pass	4	7
Fail	0	3

***p*=.330**

The precision approach proved to the *most* problematic part of the flight. It may also be the most important, since by design an ILS Category I approach (standard ILS) guides an aircraft to within 200 feet of the ground when visibility may be as low as 1800 feet (about ¼ mile). Further, it is one of the more difficult instrument training tasks to reproduce in the training environment. In actual flight conditions where an ILS approach (easily the most common type of precision approach, and the only one on which most instrument students receive training) is necessary, the flight environment may look very different than it does during training. For instance, 1800 feet Runway Visibility Range (again, about ¼ mile) is worse than most instrument trainees (and many experienced instrument pilots) have ever *seen*, and things may look very different in actual weather than they did in training. In bad visibility, visually *finding* the landing environment at the completion of an approach can be difficult, and most students who have trained in VMC with a hood have never done it. Instead, the common training paradigm is to wear the hood (view limiting device) until the completion of the approach, at which time the flight instructor will direct the student to take the hood off and land or leave it on and conduct a Missed Approach. Either way, the *instructor* winds up making the decision, not the flight conditions[2]. It became apparent during research flights that many newly rated instrument pilots were unequipped to make this decision. Several participants, many who were otherwise skilled instrument pilots, simply descended below minimum approach altitude without an awareness of their proximity to the ground. Two of the pilots crashed into terrain, and others would have had there not been a simulator glitch that provided a bit of terrain clearance even at indicated altitudes below ground level. Other pilots had difficulty becoming or remaining established on the approach course, set instruments

---

[2] By regulation, a precision approach must be terminated at an appropriately termed “Decision Height” unless certain criteria are met. These criteria include: (1) the aircraft must be in a position to descend normally to a landing on the touchdown zone of the intended runway, (2) the flight visibility is not less than that required for the procedure, and (3) certain touchdown zone identifiers are distinguishable. The emphasis here is that the pilot must *decide* if these criteria are met.

incorrectly, or committed some other error. One even set the instruments for the wrong approach.

This specific task, "knowledge of precision instrument approach procedures," was generally passed by participants (task 6.g. will deal directly with flight below minimums). Still, there appeared to be some knowledge gaps, as illustrated by quotations from participant flight notes below:

> …it appeared that a Localizer approach was being attempted (though not cleared), but descent continued right through localizer minimums…
>
> TG6 set the localizer frequency well in advance. However, he did not set the correct radial in the OBS, but rather set the reciprocal. This is one of the few ways to create reverse needle sensing with an HSI, and this complicated the approach greatly. At first, TG6 managed to make corrections away from the needle (which would be correct with HSI set as above). However, as workload increased TG6 began correcting toward the needle, which took him farther from the approach course...

Note that this is only a sampling of the "knowledge errors" committed during the approach phase of the flight, and these will be revisited under specific tasks. Still, they are helpful to the reader to understand "knowledge errors" and are thus included here.

Overall, three test group pilots did not demonstrate sufficient *knowledge* of precision instrument approach procedures, though like all "observed knowledge" tasks, some grading subjectivity is inevitable. In any event, the Fisher score for this task is p=.330 and the null hypothesis is not rejected, at least as it pertains to *knowledge*. The pending *skill* tasks are still to come.

Task 6.b. Establishes and uses correct ATC facility & correct phraseology for approach

Task Importance: 2

Fisher Test Contingency Table:

	Pre-test Group	Test Group
Pass	4	8
Fail	0	2

***p*=.495**

This relatively unimportant task offered little difficulty for most participants. Indeed it shouldn't, as "using the correct ATC facility" was no more difficult than setting the communication radio to the frequency just assigned by the previous ATC facility. Using correct phraseology proved to be a bit more difficult, however, as approach clearances tend to be lengthy. A typical example is: "Cessna 09OSU, Tulsa Approach. Six miles southeast of OILER. Turn right heading 330° to join the localizer, maintain 2,500' until established. Cleared ILS 36R. Report established on the localizer." This approach clearance, like all clearances, requires a "readback" from the pilot, and some pilots didn't quite get all of the information read back. Minor corrections from ATC were common. Still, most of the pilots were able to eventually read back the clearance, and most appeared to know what the controller was asking them to do. Two of the participants received failing grades for this task, however, due to either reading back the incorrect approach (or not hearing the correct one) or so muddling the approach clearance that compliance and/or understanding was affected.

The Fisher score for this task is *p*=.495 and the null hypothesis is not rejected.

Task 6.c. Complies with clearance instructions and procedures

Task Importance: 4

Fisher Test Contingency Table:

	Pre-test Group	Test Group
Pass	4	5
Fail	0	5

***p*=.126**

As already noted, there were multiple deviations from clearances and/or procedures. One of the more common, as seen in previous tasks, was to set navigation equipment incorrectly for the approach. Four test group pilots did not tune in the LOM (OILER), and five set either wrong radials or frequencies or both. Further, four pilots did not successfully stay on the localizer, and three did not remain established on the glideslope. As already noted, one flew the wrong approach. Multiple mistakes were committed by individual pilots so the above numbers are not cumulative. In fact, five pilots received failing grades but five others received excellent grades. It should be noted, however, that task 6. g., “Missed approach at DH if visibility requirements not met” was an approach “procedure” that has not been taken into consideration for the grading of this task. If it were, grades would be lower. In other words, a few pilots who otherwise flew the approach well went below minimums! Again, that task will be graded separately. For now, notes on approach procedural errors, though lengthy, are included here:

> The problems with the approach began when the localizer frequency was never set. Since vectors were being provided from ATC, TG5 was

eventually given a vector onto the localizer. However, TG5 flew through the approach course (with no frequency set). Just as he passed through it though, he noticed his mistake and set the localizer frequency in #1. However, it was too late and TG5 got a full scale deflection in the "wrong" direction and was again confused. At that point, ATC offered a new vector to join the localizer. This time, TG5 intercepted the localizer and tracked it successfully, but missed the glideslope intercept indication. He did notice, however, the outer marker beacon sounding/illuminating and began a shallow descent well beyond glideslope intercept with a full scale deflection of the glideslope indicator. Indeed, the glideslope indicator remained at full scale throughout the final approach segment.

Well past full scale deflection, ATC advised TG6 that he was 2 miles east of approach course and offered a vector to get back on it (which ATC would probably *not* actually do). This vector did indeed get TG6 back on course, but inside the Outer Marker. Thus, the glideslope needle centered while the localizer needle was at full scale. Still, TG6 followed the glideslope indication down, and eventually got the localizer needle centered as well. Unfortunately, the glideslope did not *stay* centered and a full scale deflection occurred.

As ATC vectored TG8 to the approach course, the navigation radios were again set incorrectly. The localizer frequency was reset in #1, but in standby only (not active). Also, the HSI was set on 090°. The ADF was never set to OILER. After the final vector onto the approach course and approach clearance, TG8 finally set the #1 radio correctly, but set the OBS to 055 (?). Once established on the localizer, this caused some confusion as heading wandered between final approach course and 055°, and needle deflection ultimately went to full scale. When it did, ATC again intervened with “radar shows you a mile east of approach course,” and another vector was provided…

TG11 followed radar vectors to the final approach course correctly. However, neither the HSI nor VOR indicators were set to the inbound course. Instead, both were left on the last-used 060° setting. Further, the localizer frequency was not set during vectoring. This was problematic, since ultimately the localizer course began to be crossed but TG11 did not know it. He did, however, catch his mistake before passing completely through the localizer. However, as he looked for the charted frequency, heading once again drifted right to about 360° so that he was paralleling the inbound course on the right side of the localizer (full scale). With the OBS still set to 060°, TG11 apparently didn’t notice this and paralleled the course all the way to OILER. Once there, the marker beacon alerted TG11 of his progress on the approach course, and he made a correction onto the localizer and reported established though no descent was initiated. ATC then informed him that he was “inside OILER,” and asked him to “state intentions.” TG11 reported intentions as “full stop landing.” ATC then cleared 11 for the *Localizer* approach and cleared him to land.

> An initially lethargic descent was then initiated until the middle marker, at which point the descent became aggressive…
>
> During the en route phase, TG2 was instructed to listen to ATIS which informed him that wind was "350@16 G24," and that the "ILS 36R approach was in use," as well as "landing and departing runways 36R and 36L." Still, 2 requested the ILS 18L approach, which ATC granted with some reluctance. When asked his intentions at completion of the approach, he responded "land full stop," which suggests that 2 did not really understand wind conditions and did not intend to circle. Vectors were provided to the final approach course, though not without some problems. 2 set up for the 18*R* approach, with the accompanying localizer frequency dialed in. In an attempt to salvage a gradable approach from the flight, the PI allowed 2 to continue to the 18R approach course and provided vectors accordingly.

Clearly, much confusion accompanied some of the approaches. Still, other test group pilots executed approaches nearly perfectly, and the Fisher test score is p=.126. Despite the major errors, multiple mistakes were confined to a relatively small number of test group pilots and the null hypothesis is not rejected.

Task 6.d. Advises ATC if unable to comply

Task Importance: 5

Fisher Test Contingency Table:

	Pre-test Group	Test Group
Pass	3	6
Fail	1	5

***p*=.462**

During this research flight, pilots were assigned no tasks with which they would *technically* be unable to comply. In other words, there were no assigned speeds too fast, no altitudes too high, and no electronic courses that the equipment aboard the research "aircraft" could not identify. Still, there were occasions when pilots should have confessed to ATC (and themselves) that continuing was ill-advised. A full-scale deflection on an approach instrument is an example of one such occasion, as was the frequent realization that a course had been missed or a minimum exceeded. However, the confessions rarely happened. Instead, there appeared to be an ongoing attempt to "catch up to" the clearance and comply no matter how far out of hand things got. Not surprisingly, the pilots with the most approach errors missed the most opportunities to advise ATC, and grades for this task are similar to the previous one. The Fisher score for this task is again *p*=.462 and the null hypothesis is not rejected.

Task 6.e. Selects, tunes, and identifies correct approach facilities

Task Importance: 5

Fisher Test Contingency Table:

	Pre-test Group	Test Group
Pass	4	5
Fail	0	5

***p*=.126**

As noted above and in Chapter IV section 6.c., there were multiple occurrences of setting approach instruments incorrectly, which included the setting of incorrect localizer frequencies, incorrect VOR or HSI indicator settings, or omissions of ground-based approach facilities. Sometimes these errors were serious (such as setting an incorrect localizer frequency) and the approach could not proceed correctly. At other times the error was minor (omission of an LOM frequency in an ADF), and the approach continued without incident. Obviously, some evaluator discretion was necessary in grading. In any event, all possible consideration was given to participants, and pilots who received failing grades on this task “earned” them by making some major “set-up” error that seriously affected the flight.

The *p*-value for this task is *p*=.126 and the null hypothesis IS rejected at the 87% confidence level. The rejection of the null hypothesis at this reduced level of confidence is fully explained in Appendix K.

Task 6.f. Stabilized approach with no more than ¾ scale deflection on both localizer and glideslope

Task Importance: 4

Fisher Test Contingency Table:

	Pre-test Group	Test Group
Pass	3	5
Fail	1	4

***p*=.490 or *p*=.255**

This task proved to be difficult for some pilots. This is somewhat surprising given that the practicing of instrument approaches, particularly ILS approaches, occupies a large part of an instrument pilot's training. Most of the difficulty associated with this task appeared to be connected with, or compounded by, errors in judgment. For instance, a few pilots were inside the final approach fix and still trying to become established on the approach course. Others had the HSI or VOR indicator set incorrectly and became confused by needle indications.

It is important for the reader to understand that to differentiate this task from tasks 6.g. (Missed approach at DH if visibility not met) and 7.e (Initiates missed approach at full scale) generally only the pilots' ability to *intercept* and *track* the localizer and glideslope have been considered for this task. Some pilots who kept the needles centered went below minimums. Similarly, all pilots who lingered at or below minimums without initiating a missed approach had, by definition, a full scale needle deflection on the glideslope indicator, and sometimes on the localizer. Therefore, pilots may receive passing grades on this task but failing grades on similar ones that better describe what they did wrong.

It should be noted that the sole pre-test group failing grade was likely influenced by an ATC error. Since the simulator does not provide the equivalent of a radar image to the "controller," the person providing vectors simply does not have the same position information that a real ATC controller would, and must, in fact determine aircraft position by looking at the aircraft instrument indications (which were sometimes set incorrectly by the participants). Therefore, providing the turn onto the final approach course at the right time and within the correct angle (30°) was sometimes difficult. The final vector provided to the errant pre-test group pilot actually caused the final approach course intercept to occur within the final approach segment, making a full scale instrument indication almost a certainty. However, the failing grade assigned for this task was deemed justified by the fact that the pilot did not advise ATC of inability to comply, and in fact tended to "chase" the needle in an effort to catch it, and the glideslope needle remained at full scale, even through localizer approach minimums. Still, in fairness, the foregoing controller error should be considered in an assessment of this pilot's performance.

The Fisher score for this task is *p*=.490 and the null hypothesis is not rejected. If the errant pre-test pilot's grade is thrown out the score is *p*=.255. Either way, the null hypothesis is not rejected.

Task 6.g. Missed approach at DH if visibility requirements not met

Task Importance: 4

Fisher Test Contingency Table:

	Pre-test Group	Test Group
Pass	3	3
Fail	0	8

***p*=.055**

The unwillingness of pilots to initiate a missed approach at decision height is noteworthy. In fact, it was among the most striking observations made during the research flights, as some participants who were otherwise skilled instrument pilots continued descending below minimums. No less than eight pilots made this error, and most appeared to do so very deliberately. Again, observations from the research flight are enlightening:

> The approach was relatively uneventful, at least until minimums. Before the final approach fix, TG4 was "cleared to land," and in later de-briefing revealed that he "intended to do so." The approach was flown quite well down to minimums, at which point the pilot intentionally continued 100' *below* minimums. Even here, with no visibility criteria being met, there was not an aggressive missed approach initiated. Instead, there was a lethargic level off, and an intense search for approach lights [which were now well behind the aircraft!]…
>
> The marker beacon indicator sounded/illuminated with altitude at 1,050', but the slow descent continued. In fact, the descent continued to the ground and resulted in a crash. By then, TG5 reported that he "was going to land," and the descent below DH was obviously slow and deliberate.
>
> …TG6 followed the glideslope indication down, and eventually got the localizer needle centered as well. Unfortunately, the glideslope did not *stay* centered and a full scale deflection occurred. This did not end the descent, however, and 6 descended to DH and beyond. Indeed, ATC intervened with "radar shows you at north airport boundary… say intentions" when the altimeter read 640'. Since the TDZE for 36R is 650', a minor altimeter error must have saved 6's simulated life.

…TG8 flew the approach fairly well and avoided full scale deflections down to minimums. Unfortunately, the approach did not terminate at minimums. Instead, 8 leveled off at 50’ below DH for 30 seconds or so. Then, there was a gradual letdown to 610’ (!) and another level off.

…the marker beacon alerted TG11 of his progress on the approach course, and he made a correction onto the localizer and reported established, although no descent was initiated. ATC then informed him that he was “inside OILER,” and asked him to “state intentions.” TG11 reported intentions as “full stop landing.” ATC then cleared TG11 for the *Localizer* approach and cleared him to land. An initially lethargic descent was then initiated until the middle marker, at which point the descent became aggressive. In fact, the descent continued below localizer minimums (1300’ MSL) with intermediate level-offs at 940’, 700’, and just below 600’.

Once on the approach, the localizer and glideslope needles remained centered. In fact, it appeared that TG10 would execute a textbook approach until 50’ above minimums. At that point, because of a simulator programming error, TG10 got a glimpse of the sequenced flashing lights (approach lights). It was *only* a glimpse, however, and 10 went back into IMC. After the sighting though, 10 seemed to be “locked in” to landing and continued his descent well below minimums with the localizer and glideslope needles centered. At 700’ indicated, 10 “broke

> out," acquired full view of the runway markings (at 50' AGL!) and announced "runway in sight." ATC reminded him that he was cleared to land, which he did.

TG 10's performance seemed to confirm what he and other pilots were thinking at minimums. Like other pilots, TG 10 seemed to have pre-decided to land even before the approach began. The glimpse of the runway before minimums during TG10's flight appeared to have only reinforced this decision to complete the approach with a landing, which is decidedly *not* what students are taught during training. In fact, students are taught to make a decision at DH (Decision Height) based on their ability to see the runway and proceed visually. Or, at least, the *intent* is to teach this to students. In practice, it is *very* difficult to simulate this decision-making scenario during training. Remember that during training flights, vision is not obscured by weather but by a device worn by the student. Usually, the flight instructor decides whether or not the view limiting device (the "hood") will come off at the end of the approach, and sometimes this decision is made and announced during the approach or even before it begins. Indeed, a common question posed by ATC during practice approaches in VMC weather is, "how will this approach terminate?" and the answer is usually announced publicly long before arriving at minimums. In short, students are frequently (though unintentionally) not taught to *decide* at decision height but to *comply*, and perhaps consequently, decision making at DH on the research flights was poor.

It should be noted that the tendency to fly below minimums may have been influenced by the fact that the flight was simulated. Obviously, there are no dire consequences for errors (accidental or deliberate) in a simulated flight; there is no crash nor is there an enforcement action against the pilot for breaking regulations. Further, in this particular simulated flight students were uniformly briefed that they would be conducting a flight from “Stillwater to Tulsa International.” This may have led to the erroneous assumption that the flight would definitely *end* at Tulsa International airport, even though the weather forecast showed that a missed approach was quite possible. Finally, all participants knew that this was an experimental, data-gathering exercise conducted for research purposes. All knew that their performance would be neither graded nor personally associated with them; they simply may not have exercised the due diligence of a real flight. In short, the pre-conditioning of the training environment and the artificiality of the simulated flight may have been working against participants during this task. At least the PI hopes so; he would like to think that these same pilots, in actual flight in IMC at 200’ AGL, would not just keep descending!

A savvy reader might note that some pilots descended below ground elevation. This was due to a glitch within the simulator, but it is not a glitch that would affect research findings; pilots either stopped at minimums or they didn’t.

The *p*-value for this important task (4) is *p*=.055 and the null hypothesis IS rejected at the 94.5% confidence level (see Appendix K). Once again, pilot performance on this task was one of the more striking findings of the entire project.

Area Of Operation 7: Missed Approach

Task 7.a. Adequate knowledge of missed approach procedures and prepares for missed approach

Task Importance: 3

Fisher Test Contingency Table:

	Pre-test Group	Test Group
Pass	4	4
Fail	0	7

***p*=.051**

Few test group pilots prepared for the missed approach, and it appeared that not very many pilots appeared to have considered the possibility of actually conducting one! Instead, the missed approach seems to have been an afterthought for most test group participants. Luckily, the published missed approach procedure was not difficult. Further, it was well illustrated on the approach chart so conducting it as an afterthought was entirely feasible and many pilots managed to do so.

The real problem, as seen in task 6.g. was *initiating* it! The PI determined that the judgment required to initiate the missed approach at the proper time is an integral part of "adequate knowledge of missed approach procedures" and doing so was necessary for a passing grade on this task, thus several pilots failed it. One pilot set up for the wrong approach but crashed while conducting it, and another crashed simply by exceeding minimums. Both crashes reset the simulator computers and the missed approach could not be conducted. As per methodology, incomplete tasks were thus considered failed. Other pilots did not seem to understand the integral relationship of the missed approach to the ILS approach and received less than passing grades. Finally, one pilot seemed to create his own missed approach procedure and flew a course that was nothing like the published one.

The Fisher score for this task is *p*=.051 and the null hypothesis can once again be rejected at the 95% confidence level.

Task 7.b. Initiates missed approach with correct control inputs

Task Importance: 3

Fisher Test Contingency Table:

	Pre-test Group	Test Group
Pass	4	6
Fail	0	4

***p*=.210**

Presumably, this task from the PTS is intended to capture an examiner assessment of pilot control skill at the missed approach. In other words, the FAA appears to want instrument pilots to demonstrate that they have the skill to *not* over or under control the aircraft at this important phase of flight. Also, it seems reasonable to conclude that turning in the correct direction is a logical part of "correct control inputs." Thus, with the foregoing criteria in mind, most pilots passed this task. Those that did not receive a passing grade either did not conduct a missed approach because they crashed, or simply did not follow published procedure (one pilot immediately began turning and continued through 420°!). Another pilot intentionally delayed the climb and continued at a dangerously low altitude beyond the missed approach point even after being informed by ATC of his position (beyond *north* field boundary!) and assigned a missed approach. None of the pilots grossly over-controlled the airplane.

The Fisher score for this task is therefore is *p*=.210 and the null hypothesis is not rejected.

Task 7.c. Reports to ATC

Task Importance: 1

Fisher Test Contingency Table:

	Pre-test Group	Test Group
Pass	4	5
Fail	0	5

***p*=.126**

As most instrument pilots know, the initiation of a missed approach is a mandatory reporting point. This required report keeps ATC abreast of the flight's progress. During this flight in simulated Class C airspace, however, "informing" ATC of the missed approach is mostly a formality since comprehensive radar coverage allows ATC to know more about the pilot's progress than the pilot! This fact influences the importance assigned to this task. Still, the rule is that pilots are to report at the missed approach, and this was the criteria for the grade assignment. Again, two of the pilots did not conduct a missed approach due to a crash. A few others, as shown by the accompanying grades, did not report satisfactorily. Indeed, a few pilots had to be "prodded" by ATC to initiate the missed approach, thus some dialogue did accompany the missed approach, but hardly the kind that would earn a passing grade on this task.

The Fisher score for this task is *p*=.126 and the null hypothesis is not rejected though overall pilot performance on this task was rather poor.

Task 7.d. Complies with missed approach clearance and procedures

Task Importance: 4

Fisher Test Contingency Table:

	Pre-test Group	Test Group
Pass	4	4
Fail	0	4

***p*=.141**

All of the participants in this exercise were issued the published NOAA approach chart, so all pilots had the procedure on paper in both textual and graphic form. This is significant, as pilots were not required to copy and read back a clearance, and the printed procedure could be referenced at the pilot's discretion while (or before) executing it. Further, the procedure was not overly complicated and required little more than a straight climb to 2,000' and then a climbing turn to 2,500' direct to the Tulsa VORTAC followed by a hold to the East. As previously noted, holds were not easy for some of the pilots, though this did not greatly influence the grades on this task since holds are specifically graded in Area of Operation 4. Again, two pilots received failing grades for this task because they crashed before getting to it. Another pilot completely botched the procedure beginning with the initial climb. One other pilot simply delayed too long in implementing the assigned clearance and his grade was reduced accordingly.

The Fisher score for this task is *p*=.141 and the null hypothesis is not rejected.

Task 7.e. Initiates missed approach at full scale or anytime required tolerances not met

Task Importance: 4

Fisher Test Contingency Table:

	Pre-test Group	Test Group
Pass	3	3
Fail	1	8

***p*=.143**

As noted in the table above, 8 test group pilots and one pre-test group pilot continued the approach with “approach tolerances” not being met. Much has already been said regarding pilot decision making during the approach, and most of that applies here. Pilots were generally unwilling to terminate the approach regardless of visibility at DH, deviation from approach course, or dangerous proximity to the ground. Readers are referred to task 6.g. for more information regarding faulty pilot decision making during the approach.

Common instrument pilot training procedures may be further indicted for pilot performance on this task. Theoretically, pilots are trained to abandon an ILS approach any time the localizer or glideslope needles indicate a full scale deflection (greater than 2.5° lateral or .7° vertical divergence) from the final approach course. Doing so may not always be encouraged in training, however. Instead, after conducting the initial and intermediate approach segments (which can be rather lengthy), instrument trainees may be encouraged by their instructors to “stick with” the final approach segment even when needle deflections go to full scale. After all, much time and effort has already been invested in the approach by this point, and practice on the actual localizer and glideslope was likely the reason the practice approach was initiated in the first place. Further, abandoning the approach due to a full scale deflection equates to an admonition of having "failed" on the approach, and in practice for the instrument checkride, few instructors are inclined to teach students to do *that*! It may be, then, that students simply are not taught this during training; it may be taught it in theory, but not in practice. It was certainly under-practiced on the research flight!

The Fisher score for this task is *p*=.143 and the null hypothesis is not rejected. Once again, however, pilot performance on this task was poor.

Area Of Operation 8: Alternate Destination

Task 8.a. Selects legal alternate for flight plan

Task Importance: 1

Fisher Test Contingency Table:

	Pre-test Group	Test Group
Pass	4	4
Fail	0	2

***p*=.333**

As might be logically assumed, an alternate destination is a sort of fail-safe "plan B" in case the primary destination can't be reached. However, due to the intended "fail-safe" nature of the *legal* alternate, a pilot's actual *intended* alternate is often an entirely different destination. Some explanation of the alternate selection process, along with certain legalities, is in order.

An alternate destination must be filed with an IFR flight plan any time weather forecasts indicate that certain ceiling and visibility minimums at the primary destination may not be met. In general, these minimums are, from one hour before to one hour after the planned time of arrival a ceiling at least 2,000’ and visibility of at least 3 miles (Federal Aviation Regulations 91.169 **(b)**). For the simulated research flight, then, an alternate was definitely required. As might also be logically expected, the alternate itself must meet certain visibility and ceiling requirements. Generally, the weather at the alternate at the time of arrival (remember, it is an *alternate* destination; a pilot must estimate his arrival time considering time to and from the primary destination first) must be no worse than 600’ ceiling and 2 miles visibility if the proposed alternate airport has a precision approach, or 800’ ceiling and 2 miles visibility if it has only a non-precision approach (Federal Aviation Regulations 91.169**(c)**). It is worth noting here that not all cloud bases are ceilings, but only those classified as “broken” or “overcast”; pilots must know this legal tidbit, too. Finally, many airports have alternate minimums different than that noted above. Indeed, they can be as the FAA dictates and these “non-standard” alternates are published, and pilots must know how to find and read them. In short, before a pilot declares an alternate he/she must know certain legalities and check the weather and the potential alternate for compliance. The pilot must first determine where, at the estimated time of arrival, the weather is better. Then, some thought must be given to the suitability of any given airport within that “better weather region” as an alternate since some airports are specifically prohibited from being filed as such. Also, some airports are “conditional” alternates with conditions being anything from specific weather minimums to time of use. Before filing one, a pilot had better know those conditions.

As noted earlier, the *filed* alternate may not be the pilot’s *intended* alternate, which explains the low importance value for this task. Though it further complicates the discussion, it should be understood that many of the technicalities prohibiting the listing of a given airport as an alternate do not affect the airport’s utility as, well, an *airport*. Pilots routinely do *not* proceed to the alternate that they went to considerable trouble to legally choose. Instead, they proceed to airports that are close by, or have approaches with lower minimums, or that ATC recommends, or any combination of these reasons. Instrument trainees or newly rated instrument pilots may know much of the above in theory only. The savvy required to query ATC about a potential plan B, or contact a Flight Service Station to develop one on the fly, may not be learned during training, but through experience.

Not surprisingly then, the pre-test group pilots fared better than the test group pilots on this task. Indeed, most of the test group pilots went to remarkably little effort to select an alternate, though it was sometimes unclear just what was being checked and how thoroughly. Some simply volunteered an alternate airport without checking *anything*, or at least no more than a quick glance at forecast weather. Presumably, their choice was an airport with which they had some familiarity.

Both in terms of consideration given and airport selected, test group pilots chose a diverse group of alternates. One of the test group pilots chose Okmulgee Regional airport as his alternate. However, had the pilot checked the approach charts for this airport, he would have discovered that they are marked with a symbol meaning “alternate minimums are Not Authorized due to unmonitored facility or absence of weather reporting service." In other words, Okmulgee is not a legal alternate. Further, there is no terminal weather forecast for Okmulgee and the weather reported there before takeoff was 200' broken, which is well below legal alternate minimums. Four test group pilots chose Stillwater Regional airport as their alternate. This was a better choice than Okmulgee, since the weather at the time of departure was VFR and forecast to improve. However, the ILS approach at Stillwater was not authorized for determining the suitability of this airport as an alternate after the tower closed, nor were *any* of the approaches if local weather was unavailable. For this flight, the Tower would be open at time of arrival and *reported* weather could be assumed available. However, *forecas*t weather is available at Stillwater only in the form of an *Area Forecast*, leading to some ambiguity as to the legality of this airport as an alternate[3]. Pilots who selected Stillwater as an alternate were given an admittedly ambiguous "C" grade. One of the test group pilots chose Richard LLoyd Jones Jr. (Tulsa Riverside) airport as the alternate. This was a poor (and illegal) choice due to low ceilings. Three pilots chose Will Rogers (in Oklahoma City) as their alternate. This was a good choice, since weather was above legal alternate minimums (though non-standard minimums applied) and forecast weather would obviously be available at a large, metropolitan airport.

In general, the alternate airport selection process, which is critical to the grading of this task, appeared to receive diverse amounts of attention among the participants. Some likely selected a legal alternate by "luck." However, this project contained no

---

[3] 14 CFR 91.169 **(c)** lists the alternate airport minimum weather requirements that must be stated in an "appropriate weather report or forecast." However, detailed terminal forecasts are not reported for some airports, and forecast weather must therefore be gleaned from less specific "area" forecasts. Various opinions exist as to the "appropriateness" of these forecasts for alternate airport legality, and the FAA opinion remains unclear.

mechanism for penalizing (or determining) accidentally correct answers and participants were graded accordingly. Only one pilot spent considerable time studying forecast weather for alternate selection purposes, and he explained his decision making process in picking a legal one.

Finally, none of the pilots of either group were unable to proceed *somewhere* (unless they had already crashed), and all were generally headed to better weather and an airport where an approach could be completed. It should be noted, however, that ATC assisted pilots in proceeding to the alternate, which would likely be the norm in actual Class C airspace. Usually, ATC was queried by pilots as to suitable alternate destinations and/or weather at area airports or "where people were getting in." All of the pre-test group pilots did this. Two test group pilots simply asked for vectors to Stillwater without asking any questions about area airports. One pilot had to be dissuaded from attempting the same approach again with a report of worsening weather. As noted earlier, three pilots did not proceed anywhere since they had already crashed or landed. These three pilots did receive a grade for *this* task, as the alternate selection process occurred before the flight.

The Fisher score for this task is p=.333 and the null hypothesis is not rejected

Task 8.b. Assimilates appropriate weather information to determine suitable alternates, including non-legal (for flight plan) alternates

Task Importance: 3

Fisher Test Contingency Table:

	Pre-test Group	Test Group
Pass	4	2
Fail	0	5

***p*=.045**

As previously noted, some test group pilots did not do well on this task. The training environment may have contributed to this, as all of the test group pilots had only recently been *student* instrument pilots who may have been unintentionally conditioned to conduct “canned” flights as outlined by their instructor. Thus, when these same pilots were told that they were conducting a flight from Stillwater to Tulsa, they may have logically assumed that it would end *at Tulsa* with few considerations beyond that. The admonition that it was a “real” IFR flight may have made little impact, especially since all pilots knew that it was really only a *simulated* “real” IFR flight!

The importance value for this task is somewhat elevated because of the required pilot knowledge, which is considerable. However, the weather reported to pilots during the pre-flight planning did not require intense scrutiny (or weather knowledge) as it clearly showed better weather west and southwest, and most pilots earned passing grades on this task with no more than a glance at the weather. In retrospect, more challenging weather and/or more complicated weather reports might have led to more telling grades for this task. As the task was conducted and evaluated, however, the Fisher score is *p*=.045 and the null hypothesis can be rejected at the 95% confidence level.

Task 8.c. Performs appropriate planning to proceed to suitable alternate

Task Importance: 3

Fisher Test Contingency Table:

	Pre-test Group	Test Group
Pass	4	5
Fail	0	3

***p*=.255**

This proved to be an easy task for most pilots. The weather forecasts showed much better weather west and southwest and not very far away. Therefore, any pilot who managed to get headed in that direction demonstrated “appropriate planning to proceed to suitable alternate.” Further, since the pilots were in class C airspace with comprehensive radar coverage, ATC determined the routes and communicated them via radar vectors with little pilot planning required. Had the flight to the alternate continued, more specific routing could have been communicated and graded. However, these tasks were already graded under Areas of Operation 1, 2, and 5. The only pilots who did not receive passing grades this on this task crashed or landed off airport and thus demonstrated “inappropriate planning to proceed to alternate.”

The Fisher score for this task is *p*=.255 and the null hypothesis is not rejected.

Task 8.d. Acquires appropriate route/clearance to proceed to alternate, and implements initial route to alternate

Task Importance: 3

Fisher Test Contingency Table:

	Pre-test Group	Test Group
Pass	4	8
Fail	0	3

***p*=.363**

Little can be said of this task that was not said about the previous one. All pilots who did not crash or permanently land were given radar vectors in the appropriate direction and told by ATC to expect a route clearance. Since route copying and execution had already been graded, the PI decided to terminate the flight at this point. Therefore, all pilots who proceeded to alternates received passing grades, and those pilots who did not received a failing grade as per agreed methodology.

The Fisher score for this task is *p*=.363 and the null hypothesis is not rejected.

CHAPTER VI

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

Introduction

The purpose of this study was to acquire information that can be used to evaluate the effectiveness of airman instrument rating training and testing. Specifically, answers to the following research questions were sought:

1. Did the recently certified instrument pilot have the skills and knowledge required to successfully complete a simulated, non-training, point-to-point, IFR flight?
2. Did the training that the recently certified instrument pilot receive adequately prepare him/her to apply the skill and knowledge required by 14 CFR FAR 61.65 **(b)** and **(c)** to successfully surmount common challenges during a real-world IFR flight?

Answering these questions will require a careful analysis of pilot performance for each Area of Operation, with comparison of pre-test and test group pilot performance considered. This chapter will attempt to do just that. It will show overall pilot performance for each area of operation in a pass/fail format; pilots must have passed all tasks within an area of operation to receive a passing grade. Fisher contingency tables showing pass/fail summaries will be also be included, as will calculated *p* values. It should be noted that pilots who received "C" grades on individual tasks (neither pass nor fail in Chapter IV) received a passing grade for this summary; pilots had to genuinely fail a task to fail the Area of Operation. Finally, text summarizing overall pilot performance and the degree of confidence at which the null hypothesis may be rejected or retained will be included.

We turn, then, to the data summaries of each Area of Operation:

Area of Operation 1: ATC Clearance

Participant Number	1	2	3	4	5	6	7	8	9	10	11
Pre-Test Group	Pass	Pass	Pass	Pass							
Test Group	Pass	Fail	Pass	Pass	Fail	Fail	Pass	Fail	Pass	Pass	Pass

Fisher contingency table:

	Pre-test Group	Test Group
Pass	4	7
Fail	0	4

***p*=.242**

This area of operation required receiving, copying, reading back, understanding and implementing an IFR clearance. As can be seen in the table above, all of the pre-test group pilots successfully completed these tasks, but four of the test group pilots did not.

Failing grades were assigned for multiple reasons, but the most common were related to the tasks “setting communication/navigation systems in compliance with clearance,” and the more general “adequate knowledge of the elements related to ATC clearances and pilot responsibilities.” Applying the data for the entire area of operation to the Fisher Exact Test (as was done for individual tasks in Chapter IV), shows that the level of confidence at which a statistically significant difference between the pre-test and test groups may be detected is 76% (*p*=.242). While statistical constraints keep us from rejecting the null hypothesis, it is unlikely that any flight school would be satisfied with being 36% confident that randomly tested instrument pilots can acquire and execute an IFR clearance! Indeed, observations made during the test suggest that a significant number of test group pilots had difficulty with clearances. Note this observation from Chapter IV: “… six of the test group pilots did not set one or both navigation radios to the correct frequency before takeoff, eight did not pre-set navigation instruments entirely in accordance with clearance, six required multiple “repeats” of the clearance and/or corrections from ATC, and one requested the clearance on the wrong communication frequency. …[this performance] suggests that most of the test group pilots could use more practice in acquiring and implementing IFR clearances.” The reader is reminded that the above errors do not necessarily reflect tabulated pass/fail performance, since some pilots made multiple errors and some errors were not deemed grounds for failure.

Many instrument training flights do not include adequate practice on these tasks, but instead incorporate rehearsal of stand-alone *simulated* IFR tasks. For instance, the “clearance” in a training flight may be nothing more than an overview of tasks to be practiced during that flight, stated by the instructor to the student in plain English with no time pressure. As most instrument pilots will attest, a real clearance from ATC is definitely *not* the same. Training opportunities for student exposure to the flight plan filing/clearance receiving process may be limited by the fact that the student cannot legally file IFR (the instructor must do it or oversee the process), as well as by the aircraft, instructor, and student time constraints inherent at a busy flight school. It definitely appears that instructors (and school administrators) need to be aware of the student "seasoning" that occurs simply through repeated exposure to the "real thing," and make time for these learning opportunities. Also, the training syllabus should mandate that certain IFR tasks actually be conducted by the student a minimum number of times, and *not simulated*. A summary of recommendations inspired by pilot performance in this area of operation, therefore, includes:

  - More exposure to the *process* of actually acquiring IFR clearances. This process must include creating an IFR route using federal airways, and must also include *receiving* and *understanding* the route communicated, and potentially modified, by ATC.
  - More practice in *implementing* the clearance. The practice should include translating the stated route into its charted equivalent and setting up navigation equipment accordingly.

- During the FAA practical test for the instrument rating, acquiring and implementing an IFR clearance should be required, and an appropriate evaluation of the applicant's ability to do so should be made by the examiner through observation, not simulation. Further, the regulations (14 CFR 61.3 **(e)**) and the Examiner's Handbook (8710.3D) should be modified to allow not-yet-rated instrument pilots to file IFR for the practical test. Indeed, this precedent already exists as student pilots taking Sport, Recreational, or Private pilot practical tests are allowed to legally serve as pilot in command (and log PIC time) without meeting the requirements of 14 CFR 61.51 (e)(4).

As noted in chapter II, the flight training syllabus in use at the school where this project was conducted requires instrument trainees to actually file and receive an IFR clearance three times. This is simply not enough![4] Interestingly, the same syllabus (during later or concurrent Commercial pilot training) recommends 47 hours of combined dual and solo cross country training under VFR. Clearly, some of this VFR practice should be IFR practice, since there is no equivalent clearance acquisition and implementation under VFR. Notably, the FAA seems to have reached the same conclusion (independently) as a just-released notice of proposed rulemaking recommends an allowance for 10 hours of post-instrument complex aircraft training be replaced with 10 hours of "advanced instrument" training.

Area of Operation 2: Compliance with Clearance Procedures

Participant Number	1	2	3	4	5	6	7	8	9	10	11
Pre-Test Group	Pass	Pass	Pass	Pass							
Test Group	Pass	Fail	Pass	Pass	Fail	Fail	Pass	Fail	Pass	Fail	Pass

Fisher contingency table:

---

[4] Post flight comments revealed that most test group pilots who did well during the research project received, either voluntarily or at their instructor's insistence, significantly more IFR experience (though less than the maximum allowed 25 hours) than the minimum required by the syllabus during or soon after receiving their instrument rating.

	Pre-test Group	Test Group
Pass	4	6
Fail	0	5

***p*=.154**

This area of operation involved multiple tasks related to compliance with a clearance. These tasks, though somewhat diverse, include using correct publications, navigation facilities, checklists, communication procedures, airspace, and radials. Overall, the Fisher test suggests that differences between the pre-test and test groups for this area of operation are evident at the 85% confidence level (*p*=.154), which is not enough to reject the null hypothesis for this series of tasks given the mean task value, but *is* enough to suggest that changes to the pilot training paradigm should be considered.

By far, the most common pilot errors involved the tasks "intercepting appropriate radials as published in procedure" and "using the correct navigation facilities." As was noted in Area of Operation 1, test group pilots appeared to simply need more practice on both. Summaries of test group pilot performance within these two specific tasks include the following:

A few pilots set navigation frequencies incorrectly (wrong frequency set or set in standby only) and were simply too busy to identify the station and discover their mistake. Sometimes this was a major error and sometimes a relatively minor one if it was quickly noticed and corrected.

Three test group pilots set the reciprocal of actual course in a VHF navigation instrument during at least one part of the flight. Six test group pilots simply set the *wrong* (not the reciprocal) radial in a VHF navigation instrument. Two test group pilots set radials that were *close* to the correct radial (off by only 5°-10°), which suggests that they knew how to do it but just weren't careful enough. Two test group pilots set wrong radials at some point in the flight, but caught and fixed their error "at the last second," one test group pilot used a flatly wrong intercept angle (120°), and one appeared to set radials only as a formality and navigated via (VFR only) GPS. It should be remembered that some test group pilots made multiple errors, so not all of the above numbers are cumulative and explains why only five total pilots failed this area of operation.

To address these errors, more practice on tuning radios and setting navigation instruments in accordance with clearance and charted routing is needed. The first two recommendations made for Area of Operation 1 (more exposure to the *process* of acquiring IFR clearances and more practice in *implementing* the clearance) are just as applicable here, and for the same reasons. It should be noted that while these (and other) tasks appear under-practiced, they needn't be. Using IFR en route charts and employing the charted airways and navigation facilities can be easily practiced in even the most rudimentary training aircraft. In fact to practice these skills, unlike the skills in Area of Operation 1, filing IFR is not required. The recommendation here is to incorporate the use of IFR charts and navigation procedures in certain advanced VFR training flights, as well as the previous recommendation (Area of Operation 1) to incorporate more training under IFR.

Area of Operation 3: Basis Instrument Maneuvers

Participant Number	1	2	3	4	5	6	7	8	9	10	11
Pre-Test Group	Pass	Pass	Pass	Pass							
Test Group	Pass	Fail	Pass	Pass	Fail	Fail	Pass	Pass	Pass	Pass	Pass

Fisher contingency table:

	Pre-test Group	Test Group
Pass	4	8
Fail	0	3

***p*=.363**

Applying the overall data for this Area of Operation to the Fisher test reveals that the null hypothesis can only be rejected at the 64% confidence level (*p*=.363), thus it is not. Further, while the test group flights included multiple altitude and heading deviations, basic instrument flying skills appeared to be sound. Deviations that did occur were likely aggravated by the less-than-perfect fidelity of the simulator to a real aircraft as noted in Chapter V, section 3.b. Pilot competence in attitude instrument flight is not surprising given that all receive no less than 35 hours (most receive considerably more) of practice flying the aircraft by instrument reference during their instrument training, plus additional practice during previous Private pilot certification and concurrent Commercial pilot certification; instrument trainees receive ample practice in attitude instrument flight. The heading and altitude deviations noted in this project, when they occurred, were almost always related to pilot workload; the attention required to decipher charts, find and set radials and frequencies, and other tasks simply over-taxed the pilot attention that needed to be focused on attitude instruments. Recommendations from this area of operation are similar to previous ones: more practice on specific instrument pilot competencies such as chart reading, clearance implementation, and navigation instrument and radio manipulation. Once pilots can deftly perform these tasks while dividing their attention between them and aircraft attitude control, heading and altitude deviations will likely disappear.

Area of Operation 4: Holding Procedures

Participant Number	1	2	3	4	5	6	7	8	9	10	11
Pre-Test Group	Pass	Pass	Pass	Pass							
Test Group	Fail	Fail	Pass	Fail	Fail	Fail	Fail	Fail	Pass	Pass	Fail

Fisher contingency table:

	Pre-test Group	Test Group
Pass	4	3
Fail	0	8

***p*=.026**

Tasks involving holding procedures proved to be a problematic part of the flight. As noted by the table above, no less than 8 test group pilots failed one or more tasks in this area of operation, and the failures included pilots who were quite skilled in most other tasks. The reasons for task failures included general knowledge relating to holds (7), inability to remain in holding airspace (6), inability to recognize arrival at holding fix (3), reporting errors (2), and timing errors (4). Results from the Fisher test suggest that the null hypothesis of a difference between the pre-test and test groups can be rejected at the 97% confidence level (*p*=.026). Clearly, something was amiss with the training and/or task execution of test group pilots regarding holding procedures, especially considering that none of the pre-test group pilots failed any holding tasks.

As alluded to in Chapter V, part of the problem with holding procedures was likely the non-standard holding patterns incorporated almost universally in the instrument approaches at Stillwater Regional airport, where all of the test group pilots trained. Non-standard holding patterns incorporate left turns (instead of standard right turns), and since entering and executing holds involves considerable pilot visualization and multiple time-specific tasks, thinking through a mirror image execution of the same tasks can be quite daunting!

Still, it is likely that not all of the pilots' problems with holds can be blamed on the left turns. It may be that some test group pilots are competent in *practiced* holds only. This possibility is more plausible than one might think, since most of an instrument pilot's training is focused on instrument approaches. The holds that that same trainee most commonly (only?) performs are the ones that are part of those same approach procedures. Thus, when these holds are practiced enough times, the holding pattern entry procedures, headings, altitudes, and timing may involve only rote, not applied, knowledge. Further, instrument rating candidates' instructors may be incentivized to assign for practice only those holds that are known, or highly suspected, to be assigned during their student's practical test. Again, due to the need for test efficiency, these holds are likely to be the ones that are part of instrument approaches so that multiple tasks may be completed concurrently. Taken out of the comfort zone of familiarity, the same pilot may be unable to apply the knowledge required to perform unpracticed holds. Certainly, many of the test group pilots were unable to apply this knowledge.

The recommendations ensuing from findings from this task are twofold: (1) Incorporate more unpracticed holds during instrument training, and (2) vary the types and difficulty level of practiced holds. Incorporating both recommendations would be easy to do. Indeed, the training syllabus in use at the flight school where research participants trained already includes no less than 10 lessons that require practice on holding procedures, and the practice area around Stillwater contains a variety of navigation facilities/fixes at which holds may be assigned. Further, holding fixes that are part of familiar instrument approaches could be employed more creatively, thereby being equally time efficient, but considerably more challenging. For instance, instructors should assign right turns, or holds to the east or west (instead of the usual north or "as published"). Additionally, intersection holds should be assigned and practiced. Finally, these assignments should occur "on the fly," so that students must visualize the hold and think through the entry and timing procedures while dividing attention among other tasks. The fact that the thinking must be done before arriving at the holding fix also adds an element of time pressure, which increases the hold difficulty and better simulates how holds are actually assigned by ATC. Again, all of these recommendations may be easily incorporated, and should be mandated in the flight training syllabus.

Area of Operation 5: Intercepting and Tracking Navigational Systems

Participant Number	1	2	3	4	5	6	7	8	9	10	11
Pre-Test Group	Pass	Pass	Pass	Pass							
Test Group	Pass	Fail	Pass	Pass	Fail	Fail	Pass	Fail	Pass	Pass	Pass

Fisher contingency table:

	Pre-test Group	Test Group
Pass	4	7
Fail	0	4

***p*=.242**

As can be seen in the accompanying data tables, generally the pilots who failed this task also failed Area of Operation 2, and generally for the same reasons. Little can be said here that was not said in the summary of that section. To restate those conclusions, the reader is reminded that "… the most common pilot errors involved the tasks 'intercepting appropriate radials as published in procedure' and 'using the correct navigation facilities'… test group pilots appeared to simply need more practice on both." And that is, in fact, the recommendation generated by findings from this Area of Operation: more practice on en route IFR procedures, particularly the use of federal airways and other charted routes.

The null hypothesis of a difference between the pre-test and test groups can only be rejected at the 76% confidence level (*p*=.242) for this area of operation. However, like other instrument pilot skills, "intercepting and tracking navigation systems" appears to be one that would profit from the inclusion and/or emphasis of specific en route VHF navigation tasks within the training syllabus. That is the recommendation.

Area of Operation 6: Precision Approach

Participant Number	1	2	3	4	5	6	7	8	9	10	11
Pre-Test Group	Pass	Pass	Pass	Fail							
Test Group	Fail	Fail	Pass	Fail	Fail	Fail	Pass	Fail	Pass	Fail	Fail

Fisher contingency table:

	Pre-test Group	Test Group
Pass	3	3
Fail	1	8

***p*=.143**

The null hypothesis of a difference between the pre-test and test groups CAN be rejected at the 86% confidence level. While this is well short of the normal 95% confidence level usually required in the social sciences, the high mean task value (4.1) for this series of tasks justifies the conclusion that a measurable performance difference exists between the experienced pre-test pilots and the less experienced test group pilots (see Appendix K). Indeed, 8 of the 11 test group pilots and even one experienced pre-test group pilot failed on this important Area of Operation. In fact, it was the failure of the pre-test group pilot (given the weight of all pilot data in the *very* small pre-test pilot group) that reduced the confidence level at which the null hypothesis could be rejected to less than 95%. Further, it should be remembered that the pre-test group pilot who failed met the “second tier” pre-test group criteria only (active pilot with no less than 900 hours total time and 200 under IFR), which tends to suggest that experience is, in fact, a major predictor of instrument pilot skill and may be the real teacher of basic instrument competencies.

Further, the PI feels some urgency to point out just how critically important certain tasks within this Area of Operation really are! Consider that the mean task importance grade for the area of operation “Precision Approach” is 4.1, with only one task having an importance grade lower than 4. The mean of the other Area of Operation task importance grades are 3.4 (ATC Clearance), 3.3 (Compliance with Clearance/Procedures, 2.0 (Holding), 3.8 (Intercepting and Tracking Navigational Systems), 3.0 (Missed Approach), and 2.5 (Alternate Destination). Only Basic Instrument Maneuvers had a higher mean importance grade at 4.5, and no pilots failed any task within that Area of Operation. Conversely, 8 pilots failed tasks within the Precision Approach Area of Operation, with 2 flying into the ground and others kept from doing so only by a simulator glitch that provided terrain clearance even at indicated altitudes below ground level!

The reader should remember that ILS approaches routinely guide instrument rated pilots, regardless of experience or skill level, to within 200’ of the surface. For most pilots, being 200’ above unseen terrain is a sobering experience, and one that demands well-honed pilot skills and an understanding of the potential dangers involved. Therefore, observing multiple pilots descending *below* minimums during this project was alarming, and suggests that the traditional instrument training paradigm could be improved. If pilot performance on this task is an accurate indicator, flight training providers need to create training techniques that replace post-graduation experience as the primary teacher of instrument pilot competencies. These techniques must (1) embrace and utilize technological advances in flight simulation, (2) provide opportunities for students to exercise aeronautical decision making.

Besides descending below minimums, pilots in the test group found other ways to fail this Area of Operation: 3 displayed inadequate knowledge of approach procedures, 2 used incorrect ATC facility or phraseology, 5 were not compliant with approach instructions or procedures, 5 were unwilling to advise ATC of approach errors and/or need to terminate approach, 5 did not tune the correct approach facility, and 4 were unable to keep the localizer and glideslope indicators within acceptable limits (above numbers are cumulative; some pilots made multiple errors). Still, the most troubling errors involved descent below minimums with, again, no less than 8 individual test group pilots doing so. As noted in Chapter V, this is possibly a result of the training environment being markedly different than the actual IMC flight environment in two major ways. Both will be described below.

First, pilots in the simulator know that they are insulated from both crashing and from the legal ramifications of violating regulations. Possibly, participants were particularly emboldened to do both during this research project since they were told that they would definitely *not* be graded, and because they obviously knew that the aircraft and airspace weren’t real. It may be (and the PI hopes!) that the same pilots could do better than the simulator flight suggests.

Second, there is simply not a realistic way, in a real airplane in VMC weather (where the vast majority of instrument training takes place) to simulate the low visibility recognition of approach lights and/or touchdown environment inherent in a real instrument approach in seriously restricted visibility. As a result, instrument trainees that conduct all of their training in actual aircraft have never actually made the decision to continue or abort as per 14 CFR 91.175 (c) and (e)[5]. Indeed, they may be unintentionally pre-programmed by their training to have this decision made for them by their instructor. For safety reasons, flight schools are hardly encouraged to expose students (or instructors) to the actual in-flight weather conditions that would teach these skills.

The obvious solution to this problem, and the recommendation offered here, is to teach these skills in a flight simulator or flight training device. Modern flight simulators and FTD's can *very* accurately simulate severely reduced visibility, which can be quite eye-opening for students who have never seen it!

Surprisingly, the current flight training syllabi in use at many FAA approved schools require that no lessons be conducted in a simulator, though they do *allow* the use of a simulator or FTD and identify the lessons that are bested suited to it. Under 14 CFR 141 Appendix C, the regulations quite liberally allow 50% of the training required for an instrument rating to be conducted in a simulator, 40% of the required training to be done in an FTD, or 50% of the required training to be done in a combination of the two. And, while this allowed use of flight simulation represents a potential cost savings for the student and enhanced realism for some training tasks, "simulated" flight appears to remain unpopular with students. Unfortunately, flight students at the flight school where this research was done eschew the simulator for the real airplane. Flight instructors do too, since logged "airplane time" is commonly assumed to be more valuable than "simulator time" in furthering their employability. Thus, part of this recommendation

---

[5] This regulation requires a pilot to determine that (1) the aircraft is in a position to land, (2) flight visibility is at or above published minimums, and (3) the specifically defined landing environment is visible before descending below the minimum altitude of an instrument approach procedure. If these conditions are not met, a missed approach must be immediately executed.

involves limitations on the student's and/or instructor's choice between airplane and simulator. Students should be required to perform specific training operations in the simulator, and these should include exposure to ½ mile visibility (or less) and unplanned missed approaches, initiated by the trainee, due to on-the-fly evaluation of weather at minimums. A simple checklist or matrix within the student's training record could document that the training is done (and done to minimum standards), while allowing maximum use of actual training aircraft if that is what the student prefers.

As noted, other common reasons for task failures within this Area of Operation included the apparent disinclination of test group participants to advise ATC if unable to comply with clearance or procedure, the oft-mentioned inability to set navigation (approach) instruments correctly, and the unwillingness to break off the approach when localizer or glideslope indications became excessive. In general, these errors appear to be symptoms of "training syndrome," in which the final disposition of the flight is assumed even before takeoff. For instance, if a student is training on an ILS approach and makes a serious error, breaking off the approach (and informing ATC accordingly) is rarely considered. Instead, the student is more apt to continue the approach for training purposes. The instructor is also incentivized to dissuade a student from voluntarily terminating an approach for fear that doing so on a checkride is grounds for failure. In general, then, the planned flight in the training environment usually ends just as the plan dictates. For the research flight, participants were universally told that the flight "was to Tulsa International Airport," and the idea that it might end somewhere else may have not even been considered! Such is the training environment. The savvy needed to modify plans "on the fly" may need to be more deliberately taught; it may otherwise not be taught at all! Perhaps a needed recommendation is to better emphasize sound aeronautical decision making, and guide pilots through specific scenarios where it must be employed. These scenarios should be specified in the training syllabus (and include missed approach decision making in the simulator, as noted above) and constructed with appropriate rewards for sound decision making, not just "stick-and-rudder" skills, during training and/or testing.

Area of Operation 7: Missed Approach

Participant Number	1	2	3	4	5	6	7	8	9	10	11
Pre-Test Group	Pass	Pass	Pass	Fail							
Test Group	Fail	Fail	Pass	Fail	Fail	Fail	Pass	Fail	Pass	Fail	Fail

Fisher contingency table:

	Pre-test Group	Test Group
Pass	3	3
Fail	1	8

***p*=.143**

For this area of operation the null hypothesis is not rejected. However, several pilots had considerable difficulty with it as no less than 8 of the test group pilots failed at least one task. The most commonly failed task was "initiates missed approach at full scale or anytime required tolerances not met," which is in many ways equivalent to the Area of Operation 6 task, "missed approach at DH if visibility requirements not met."

Again, “training syndrome” is likely culpable here, and the reader is encouraged to review the Area of Operation 6 summary and section 7.e. in Chapter V for more on this phenomenon.

Even so, many of the test group pilots showed a marked lack of planning for the missed approach quite apart from their unwillingness to initiate it. Most of this is likely due to pilot workload; pilots busy with the approach had little opportunity to plan for what came after. A logical recommendation, once again, is to create unscripted scenarios in the simulator in which trainees are exposed to “continue or miss” decision making at minimums and are thus taught (and forced!) to plan accordingly. It might also be noted here that the simulator scenarios should employ unfamiliar approaches so that trainees are not allowed to simply conduct memorized missed approach procedures. In short, the recommendations described in Area of Operation summary 6 are just as applicable here.

Area of Operation 8: Alternate Destination

Participant Number	1	2	3	4	5	6	7	8	9	10	11
Pre-Test Group	Pass	Pass	Pass	Pass							
Test Group	Pass	Fail	Fail	Pass	Fail	Fail	Pass	Pass	Pass	Fail	Fail

Fisher contingency table:

	Pre-test Group	Test Group
Pass	4	5
Fail	0	6

***p*=.092**

Once again, “training syndrome” may have been affecting pilot decision making regarding this task. It appeared that most of the test group pilots automatically assumed that the flight would terminate at the destination, just as they almost always do in training. Therefore, the selection of the alternate may have been assumed a formality with the corresponding effort invested. In truth, the legal alternate submitted on the IFR flight plan usually *is* a formality, and the odds of actually landing there are often slim. The reader is encouraged to see Chapter V section 8.a. for more on legal alternate selection.

In any event, only two of the test group participants chose clearly illegal alternate destinations. Four others chose legal (but questionable) alternates, three chose perfectly legal alternates, and nearly all spent remarkably little time making their choice, especially when one considers the potential legalities affecting this decision. However, the methodology for this exercise includes no mechanism for penalizing accidentally correct answers, so participants who selected correctly, whether by accident or design, profited accordingly. The null hypothesis for this task is not rejected, as this could only be done at the 91% confidence level (p=.092).

Future researchers should consider different methodology for evaluating this area of operation. Selecting a legal alternate is mostly a matter of applied knowledge, and knowledge is difficult to observe! Further, some participants may not have applied the knowledge that they possessed, since neither legalities nor safety during a simulated flight require them to do so. Future researchers are encouraged to create a more realistic “flight” environment for this task, with appropriate motivators to apply subject knowledge and perhaps a more challenging (for alternate selection) weather scenario.

Summary

The following table represents the collective data of each task and Area of Operation within this research project, showing passing grades only for pilots who passed *all* tasks:

Participant Number	1	2	3	4	5	6	7	8	9	10	11
Pre-Test Group	Pass	Pass	Pass	Fail							
Test Group	Fail	Fail	Fail	Fail	Fail	Fail	Fail	Fail	Fail	Fail	Fail

Fisher contingency table:

	Pre-test Group	Test Group
Pass	3	0
Fail	1	11

***p*=.009**

As can be seen, 3 pre-test group pilots and 0 test group pilots passed all tasks. Based on these results, the null hypothesis of a difference between the two groups can be rejected at the 99% confidence level (*p*=.009). The reader is cautioned, however, against concluding that none of the test group participants in this research project are competent instrument pilots, as several are. Indeed, all of the pre-test group pilots and several test group pilots often demonstrated impressive instrument skills. Several failed only a few tasks during the flight (while others failed *many*!), and some of these may have been influenced by the “artificiality” of the simulated flight, as discussed in Chapter V, section 6.g. Indeed, the average aggregate (all tasks combined) grade point average of the top six test group pilots was 3.48. The one pre-test group pilot who received failing grades was also a skilled pilot; this pilot's aggregate GPA was 3.55. Conversely, the aggregate GPA of the other five test group pilots was 1.37; it was these pilots who committed most of the errors! Clearly, a measurable skill difference was evident in the research participants, and as the project progressed, three distinct levels of pilot skill emerged: the experienced pre-test group pilots with an aggregate GPA of 3.88, the less experienced but skilled new instrument pilots with an aggregate GPA of 3.48, and the unskilled new instrument pilots with an aggregate GPA of 1.37.

In summary, experience *and* fundamental pilot skill are both important in developing instrument pilot competencies. To better integrate both into instrument pilot training, the following recommendations have been made:

- Modify instrument rating and/or Commercial certification training syllabi to include:
    - More lessons that specifically require instrument trainees to acquire and implement actual IFR clearances, issued by ATC, that include routing on federal airways.
    - More practice on reading, understanding, and implementing (particularly manipulating radios and navigation instruments) the information on IFR en route charts.
    - More practice on holding procedures, with specific requirements to vary the type, direction, and difficulty of holds and to issue holding clearances en route.

  - Specific scenarios designed to teach aeronautical decision making, particularly scenarios, due to approach errors and/or full-scale instrument deflections, in which a missed approach should be executed.
  - Practice of and greatly increased exposure to en route IFR procedures for post-instrument rated pilots.
- Make better and more specific use of a flight simulator or flight training device during instrument training. A mandatory training matrix (or specific syllabus items and minimum standards) should be developed to provide documentation that each instrument trainee has received, in the simulator, exposure to:
  - ½ mile or less visibility at Decision Height
  - Approach procedures that terminate, alternately and randomly, with a missed approach or a descent to a landing depending on and determined by the trainee's ability to identify the landing environment described by Federal Aviation Regulation 91.175 (3) (i-x).
- Modify Federal Aviation Regulation 61.3 (e), 61.5,1 and/or The Designated Pilot and Flight Engineer Examiners' Handbook (8710.3D) so that instrument rating applicants may file IFR and legally act as pilot-in-command for the instrument rating practical test.

Conclusion

Clearly, more research is needed on new instrument pilot ability. Findings from this project strongly suggest that a measurable skill difference exists between experienced and inexperienced instrument pilots, and further, that some newly rated instrument pilots lack certain fundamental instrument pilot competencies. Unfortunately, the generalizability of findings from this project is hampered by the small sample size, which was a result of the small population of available instrument rating graduates.

To illustrate this, consider the task “Missed Approach at DH if Visibility Requirements not met.” On this task, 3 of the pre-test group pilots earned a passing grade and none received a failing grade. Conversely, only 3 of the 11 test group pilots earned a passing grade while 8 eight earned failing grades. This performance disparity between the groups suggests a statistically significant difference between them, and an analysis using the Fisher Test supports this assumption. Indeed, the *p* value for this task is p=.055 which suggests that the null hypothesis - that there is no difference the groups – can be rejected at the 94.5% confidence level. But had there been twice as many participants in the test and the pass/fail *ratio* had remained exactly the same, the *p* value would be p=.002, which would allow the null hypothesis to be rejected at a compelling 99.8% confidence level! Clearly, future researchers should broaden the scope of this project to include more participants, as both the findings and their potential ramifications suggest that more research should be done on this subject. Indeed, the recommendations noted above may represent important modifications to the current instrument rating training paradigm. As noted in Chapter II, “instrument rated pilots are allowed to fly without outside visual references; this one fact mandates an entirely new set of skills.” It may be that those skills are better taught with an entirely new curriculum, one that emphasizes practical application, simulator technology, and practice independent of the training/testing environment.

REFERENCES

AOPA Air Safety Foundation. (2007). *2007 Nall report: Accident trends and factors for 2006.* Retrieved June 8, 2009, from http://www.aopa.org/asf/publications/07nall.pdf

Bilstein, R. (1994). The aviation business. In *Flight in America* (pp. 73-74). Baltimore: John Hopkins University Press.

Blickensderfer, B., Summers, M., & Schumacher, P.M. (2005, April). *FY 2004 Task 5, Report 1: Investigation of Current Practices Relating to the PTS.* Daytona Beach, FL: Embry-Riddle Aeronautical University, Department of Human Factors & Systems.

Blickensderfer, B., Summers, M., & Schumacher, P.M. (2005, May). *FY 2004 Task 5, Report 2: Methodology for Validation of Tasks and Completion Standards in FAA Practical Test Standards.* Daytona Beach, FL: Embry-Riddle Aeronautical University, Department of Human Factors & Systems.

Blickensderfer, B., Summers, M., & Schumacher, P.M. (2005, July). *FY 2004 Task 5, Report 3: Results of Initial Validation of Tasks and Completion Standards in FAA Practical Test Standards.* Daytona Beach, FL: Embry-Riddle Aeronautical University, Department of Human Factors & Systems.

Canadian Aviation Regulations, Part VI- General Operating and Flight Rules, 602-611 (2009).

Collins, R. L. (2008, November) Getting An Instrument Rating. *Flying,* 140, 69-70.

Craig, P.A., Bertrand, J.E., Dornan, W., Gossett, S., Thorsby, K.K. (2005). *Ab initio training in the glass cockpit era: new technology meets new pilots.* Murfreesboro, Tennessee: Middle Tennessee State University.

Creswell, J. W. (2002). *Educational research: Planning, conducting, and evaluating quantitative and qualitative research.* Upper Saddle River, NJ: Merrill Prentice Hall.

Durden, W. K. (1998). World war I from the viewpoint of american airmen. Aerospace Power Journal, Summer 1998. Retrieved December 6, 2005, from http://www.air power.maxwell.af.mil/airchronicles/apj/apj88/durden.html

FAA-Industry Training Standards (FITS) Program Plan. (2003, February 13). *FAA-industry training standards*. Retrieved July 29, 2008 from ttp://www.faa.gov/ education_research/training/fits/media/program%20plan.doc

FAA Historical Chronology, 1926-1996. Retrieved October 10, 2008, from http:// www.faa.gov/about/media/b-chron.pdf

Federal Aviation Administration. (2004). *Airplane flying handbook.* Washington, D.C.: Author.

Federal Aviation Administration. (1999). *Aviation instructor's handbook.* Washington, D.C.: Author.

Federal Aviation Administration. (2004). *Designated pilot and flight engineer examiner's handbook*. Washington, D.C.: Author.

Federal Aviation Administration. (n.d.). *Issue an faa industry training standards (fits) acceptance when requested by a flight school, training center, or other training provider.* Retrieved March 11, 2010, from http://fsims.faa.gov/wdocs/8900.1 /v05%20airman%20cert/chapter%2009/05_009_005rev1

Federal Aviation Regulations/Aeronautical Information Manual, l4 C.F.R. (2009).

Flexman, R. E., Matheny, W. G., & Brown, E. L. (1950). Evaluation of the School Link and Special Methods of Instruction in a ten-hour private pilot flight-training program. *University of Illinois Bulletin, Aeronautics Bulletin Number Eight*, 47(50), 1-44.

Flight Safety Foundation (2006, June 13). *Aviation Safety Network*. Retrieved http://aviation-safety.net/database/record.php?id=19670719-0

Flight Standards Service. (2002). *Commercial Pilot For Airplane Single- and Multi-Engine Land and Sea Practical Test Standards* (FAA-S-8081-12B). Washington, D.C.: Federal Aviation Administration.

Flight Standards Service (2002). *Private Pilot For Airplane Single-Engine Land and Sea Practical Test Standards* (FAA-S-8081-14AS). Washington, D.C.: Federal Aviation Administration.

Flight Standards Service (2006). *Flight Instructor For Airplane Single-Engine Land and Sea Practical Test Standards* (FAA-S-8081-6CS). Washington, D.C.: Federal Aviation Administration.

Flight Standards Service. (2004). *Instrument Rating For Airplane, Helicopter and Airship Practical Test Standards* (FAA-S-8081-4D). Washington, D. C.: Federal Aviation Administration.

General Aviation TAA Safety Study. (2003). Federal Aviation Administration.

General Philosophies Behind FAA and JAA Pilot Licensing Systems. Retrieved July 1, 2008, from http://www.jaat.eu/conference/20th/code/Philosophies%20FAA%20and%20JAA%20Licensing%20System.doc

Goh, J., & Wiegmann, D. (2001). Visual flight rules flight into instrument meteorological conditions: an empirical investigation of the possible causes. *The International Journal of Aviation Psychology*, 11(4), 359-379.

Instrument Commercial Syllabus (2002). Englewood, Colorado: Jeppesen Sanderson Training Products.

Jeppesen, CFI Renewal Online Course. (n.d.) *System Safety* Retrieved September 12, 2008 from https://www.CFIrenewalonline.com

Jeppesen guided flight discovery team (2006). Advanced human factors concepts. In *Guided flight discovery instrument commercial* (p. 1-41). Englewood, Co.: Jeppesen Sanderson, Inc.

Jeppesen guided flight discovery team (2006). ATC clearances. In *Guided flight discovery instrument commercial* (p. 3-65). Englewood, Co.: Jeppesen Sanderson, Inc.

Jeppesen guided flight discovery team (2006). Enroute procedures. In *Guided flight discovery instrument commercial* (p.5-27). Englewood, Co.: Jeppesen Sanderson, Inc.

LASORS (2008). Instrument rating, instrument meteorological conditions rating and night qualification. Retrieved Jan. 7, 2009, from http://www.caa.co.uk/docs /175*/Section %20E %20 –20INSTRUMENT%20RATING,%20INSTRUMENT %20 METEOROLOGICAL 20CONDITIONS%20RATING%20AND%20 NIGHT %20QUALIFICATIONS.pdf*

Lauber, J.K., & Foushee, H.C. (1981). *Guidelines for line-oriented flight training*, volume 2 (NASA-CP-2814-VOL-2). Moffett Field, CA: National Aeronautics and Space Administration.

Lintern, G., & McMillan G. (1993). Transfer for flight simulation. *Aviation Instruction and training*, 130-162.

McClellan, J. Mac (2008, September). Staying Sharp While Flying Less. *Flying, 135*, 13-17.

Millbrooke, A. M. (2000). Aviation radio and military aviation. In R. Snyder (Ed.), *Aviation history* (p. 6-46). Englewood, Co: Jeppesen Sanderson, Inc.

National Museum of the USAF. *Aircraft communications.* Retrieved December 12, 2008, from http://www.nationalmuseum.af.mil/factsheets/factsheet.asp? id=723

National Transportation Safety Board. (2005). *Risk factors associated with weather-related general aviation accidents.* (NTSB Publication No. PB2005-917004). Springfield, Va: National Technical Information Service.

National Transportation Safety Board. (n.d.). *Accident report NTSB identification: DFW07FA 149.* Retrieved May 5, 2009, from http://www.ntsb.gov/ntsb/ brief.asp?ev-id=20070716X00943&key=1

National Transportation Safety Board. (n.d.). *Accident report NTSB identification: MIA07FA154.* Retrieved June 18, 2009 from http://www.ntsb.gov/ntsb/brief2. asp?evid=20070925X01444&ntsbno=MIA07FA154&akey=1

Oser, R. (1999). A structured approach for scenario-based training. In Proceeding of the Human Factors and Ergonomics Society 43rd annual meeting (pp.1138-1142). Houston, TX:HFES.

Pilot In Command Proficiency Check And Other Changes To The Pilot And Pilot School Certification Rules, Docket no. FAA-2008-0938, Federal Aviation administration, (2009).

Price, J., & Groff, L. (n.d.) *Risk factors for fatal general aviation accidents in degraded visual conditions.* Retrieved June 15, 2009, from http:// hfskyway.faa.gov/

Spartan School of Aeronautics. (1990). *Commercial Pilot Certification Course (Airplane).* Tulsa, Oklahoma: Author.

APPENDIXES

APPENDIX A

CONDUCT OF THE FLIGHT

Conduct Of The Flight

The research participant was briefed on the flight, including destination, filed route, and filed altitude. To assure that all test group participants received the same information, the briefing was in a written format (appendix B) and provided to the participant to read before the flight.

The participant was provided a nearly-complete flight plan (appendix C). The flight plan, however, did not list an alternate. The participant was required to interpret TAF’s (Terminal Aerodrome Forecasts, Appendix D) and select a suitable alternate based on weather and other legalities. A participant could select any alternate destination. The participant was graded on his/her pre-flight alternate selection in block 8a (grading matrix), based on legalities and suitability. All other flight plan information was made available to the participant, as well as any required charts, approach plates, TAF’s, or supplementary data. The Participant was allowed to review the proposed route and related information as much as he/she felt necessary (within a one hour time limit), and was in fact, allowed to ask questions or seek clarification before the exercise began, though care was taken to not divulge details about the “challenges” within the flight. After takeoff, questions could only be posed to ATC or Flight Service Station in the same manner (phraseology, content, etc.) that they would be posed during an actual flight. Responses from ATC -whose verbal interaction with participants was provided by the principal investigator- followed this same format. All instructions and clearances initiated by ATC were based upon actual communications with Kansas City ARTCC, Tulsa Approach Control, and Stillwater and Tulsa Control Towers, though they were somewhat modified for clarity or continuity during this research project.

The participant was made aware of his/her responsibilities during the flight. In short, they were the same responsibilities that any single-pilot PIC assumes during an IFR flight. These responsibilities include setting correct navigation and communication frequencies and transponder codes, identifying navigation stations, navigating, maintaining aircraft control, and interacting with ATC. It was emphasized to participants that clearances, headings, altitudes, etc. could be questioned or clarified without fear of reprisal. Further, and significantly, it was made clear that clearances could be refused for whatever the participant believed to be legitimate reasons. It was pointed out to the participant that there would be no attempt to "trick" or mislead him/her into an error or violation. Further, it was explained that there would be no equipment failures or planned emergencies, though nothing was to prevent the participant from declaring an emergency if he/she deemed it necessary. Again, the intent was to make the flight as much like a real IFR flight as possible, with the same (but no extra) resources or challenges.

The route that the participant "filed" was *not* the route that he/she received. Instead, ATC assigned a very specific route (see Learning Objective 1 below) that approximated a simple "pilot nav" departure procedure and Victor Airway routing. The weather at the point of departure, en route, and destination was IFR (visibility less than 3 miles and ceilings lower than 1,000') or marginal VFR (visibility 3-5 miles and ceiling from 1,000'-3,000'), though this was mostly irrelevant operationally, since the pilot was in IMC soon after takeoff and remained there throughout the flight. There was no "dangerous" weather (such as embedded thunderstorms, icing, or complete obscurations) forecast or encountered along the route, though an AIRMET containing icing in an area farther North and East was reported to the pilot to justify the route change in Learning

Objective 2. There was, of course, the possibility of weather below minimums at the destination (which was indeed the case); pilots were expected to glean this from the provided weather reports. The participant was informed of the weather and filed route, but not the route change or pending missed approach.

The participant was informed that he/she was allowed to use *most* of the avionics installed in the simulator. These include a Garmin 430 GPS/NAVCOM with a “VFR Only” database, a dedicated King KX 155 navigation/communication radio, a King KX 87 ADF, and a King KX 76C transponder. The simulator was also equipped with an HSI. The participant was not allowed to use the autopilot, and it was placarded “inoperative” as per 14 CFR 91.213. Further, participants were not allowed to use the Nav 2 page on the GPS. The Nav 2 page presents a moving map display with course guidance lines and other helps. It was determined that these helps might constitute a sort of “synthetic vision” for this exercise, and while this could be very helpful during a real flight, it might have been a bit *too* helpful for this research flight. These helps could have been used to circumvent (or make it impossible to grade) some of the required instrument pilot competencies that this exercise sought to test, thus they were not allowed. This was explained to the participant.

It was verified through oral questioning that all participants had exposure to the avionics, and that there were no unanswered questions regarding their operation. If a participant was unfamiliar with a device, or for any reason was uncomfortable in its use, he/she was not required to use it as long as it was not required by regulation, and this was explained to participants.

Once the “flight” began, the research participant was to start the simulated C-172 using a checklist (if desired). He/she was immediately positioned for takeoff on runway 17 at the Stillwater airport with no taxiing required. Using this particular position as a starting point for the flight was necessary since the simulator database includes few ground graphics, making many ground operations impractical. Also, extraneous ground operations were not being tested during this exercise; the elements of Learning Objective 1 relating to clearances are the *only* ground operations that were tested.

Once start-up was complete, the participant requested a clearance to his destination (Tulsa International Airport, as described in the briefing). The participant was not prompted to do this, and no response was provided if selected frequencies were incorrect (which was the rule throughout the flight).

The flight was finished once the pilot was established in the hold at the Tulsa VORTAC after the missed approach off Runway 36R at Tulsa International, and a suitable alternate destination had been determined and the pilot was en route to it. This alternate could (and probably was) different than the filed alternate, which was selected based on legal requirements, not practicality (the reader is encouraged to see Chapter V, section 8 for more on the legalities and technicalities of alternate airport selection). The intent here was to require the participant to apply some ADM (Aeronautical Decision Making) to provide an informed answer to the question “what next?” The participant’s decision was graded as per the grading scale above, with his/her use of available resources (Flight Service Station, Approach Control, etc.) affecting the grade. Since it was anticipated that a savvy pilot might elect *not* to proceed elsewhere, but to hold and/or conduct the same approach again in hopes of breaking out of the weather and reaching the primary destination, all were told at this stage of the flight that weather in the Tulsa area was deteriorating and, if necessary, were encouraged to state other intentions. The intent, of course, was to complete the “proceed to alternate” task.

If the pilot was unable to complete a segment of the flight, that segment was terminated after the allotted time or equivalent completion of task. If possible, the participant was then advanced to the next segment and the “flight” continued, if possible. This happened once, when a pilot successfully landed and was asked to take off again and complete the missed approach segment of the flight. In two other cases, pilots actually crashed and the crash reset the simulator computers to the extent that continuing the flight was impractical. In every case, the time allotted for the segment was allowed unless, of course, the segment was completed early, which was the norm, or the participant crashed. The participant was informed of possible stopping, repositioning, and restarting in the event of uncompleted objectives, though this was never actually done. When objectives simply could not be completed due to participant ability (or in the case of the crashes, the reset simulator computers), objectives not tested were considered failed and graded accordingly. The graded objectives for this flight, imbedded within the planned conduct of the flight, follows:

Learning Objective 1: AIR TRAFFIC CONTROL CLEARANCES AND PROCEDURES

Time allowed for completion: 8 minutes

Individual items to be tested:

Participant:

a. Exhibits adequate knowledge of the elements related to ATC clearances and pilot/controller responsibilities (…).

b. Copies correctly, in a timely manner, the ATC clearance as issued.

c. Determines that it is possible to comply with the ATC clearance.

d. Interprets correctly the ATC clearance received and, when necessary, requests clarification, verification, or change.

e. Reads back correctly, in a timely manner, the ATC clearance in the sequence received.

f. Uses standard phraseology when reading back clearance.

g. Sets the appropriate communication and navigation systems and transponder codes in compliance with the ATC clearance.

Procedure:

Once Clearance is requested, ATC will respond: "*November 09OSU is cleared to the Tulsa International airport via heading 090 to join SWO 118° Radial to IBAAH Intersection, Victor 140 Tulsa. Climb and maintain 4,000', expect 5,000' 10 minutes after departure. Departure frequency Kansas City Center 127.8, Squawk 4777.*"

Participant will copy clearance and respond (1a, 1b, 1c, 1d, 1e, 1f).

Participant will correctly set navigation radios and transponder (1g).

ATC will respond as appropriate, either with "*Read back correct, contact Tower when ready,*" or with correction. If correction is required, participant will correctly copy and comply before proceeding to segment 2.

Learning Objective 2: COMPLIANCE WITH DEPARTURE, EN ROUTE,

AND ARRIVAL PROCEDURES AND CLEARANCES

Time allowed for completion: 40 minutes

Items to be tested:

Participant:

a. Exhibits adequate knowledge of the elements related to ATC routes, and related pilot/controller responsibilities.

b. Uses the current and appropriate navigation publications for the proposed flight.

c. Selects and uses the appropriate communication facilities; selects and identifies the navigation aids associated with the proposed flight.

d. Performs the appropriate aircraft checklist items relative to the phase of flight.

e. Establishes two-way communications with the proper controlling agency, using proper phraseology.

f. Complies, in a timely manner, with all ATC instructions and airspace restrictions.

g. Intercepts, in a timely manner, all courses, radials, and bearings appropriate to the procedure, route, or clearance.

Procedure:

Participant will contact Tower on 125.35 and request Takeoff clearance.

ATC will respond: "*Cessna 09OSU, cleared for takeoff runway 17, leaving 1,500' left turn-out approved*".

Participant will respond.

The research participant will initiate take-off and departure. He/she will climb, turn, and level-off as directed (2a, 2d, 2e).

ATC will direct: "*Cessna 09OSU, contact Kansas City. Good day*."

Participant will respond.

Participant will navigate as directed (2b, 2c, 2f, 2g).

Participant will contact Kansas City Center (2e). ATC will respond: "*Cessna 09OSU, Kansas City Center. Radar contact 2 SE of Stillwater, Climb and maintain 5,000', proceed on course*".

Participant will respond.

After proceeding past Yarns intersection, ATC will amend the clearance as follows: *"Attention all aircraft: The National Weather Service has issued AIRMET Zulu from20 West of Tulsa, to 50 North of Bartlesville, to 40 Southeast of Razorback to 20 West of Tulsa in effect until _____ Zulu (two hours will be allotted for Airmet). Freezing rain from freezing level' to 12,000' covering 30% of area. Expect traffic delays."*

Break.

"Cessna 09OSU, advise when ready to copy clearance."

Participant will respond.

ATC will direct: "Cessna 09OSU is cleared to Tulsa International airport via V140 to SEARS Intersection, V532 KEVIL intersection, V14 Tulsa."

Participant will respond and comply with amended clearance (2a, 2b, 2c, 2e, 2f, 2g).

ATC will direct: *"Cessna 09OSU, contact Tulsa Approach on 124.0. Good day."*

Participant will respond.

Learning Objective 3: BASIC INSTRUMENT FLIGHT MANEUVERS

Time allowed for completion: N/A; will be assessed throughout flight.

Items to be tested:

Participant:

a. Exhibits adequate knowledge of the elements related to attitude instrument flying during straight-and-level, climbs, turns, and descents while conducting various instrument flight procedures.

b. Maintains altitude within +/- 200 feet during level flight, headings within +/- 20°, and airspeed within +/- 20 knots.

c. Uses proper instrument crosscheck and interpretation, and applies the appropriate pitch, bank, power, and trim corrections when applicable.

Procedure:

Participant will correctly and safely control the aircraft throughout the flight using instrument references. Any loss of control or inability to achieve or maintain a required flight attitude will be grounds for failure of this segment (3a, 3b, 3c).

Learning Objective 4: HOLDING PROCEDURES

Time allowed for completion: 15-20 minutes

Items to be tested:

Participant:

a. Exhibits adequate knowledge of the elements related to holding procedures.

b. Uses an entry procedure that ensures the aircraft remains within the holding pattern airspace for a standard, nonstandard, published, or non-published holding pattern.

c. Recognizes arrival at the holding fix and initiates prompt entry into the holding pattern.

d. Complies with ATC reporting requirements.

e. Uses the proper timing criteria, where applicable, as required by altitude or ATC instructions.

Procedure:

Upon arriving at KEVIL intersection, the participant will be advised by ATC: *"Cessna 09OSU, weather is causing multiple traffic delays in the Tulsa area. Expect holding instructions. Advise when ready to copy clearance."*

Participant will respond.

ATC will direct: *"Cessna 09OSU, proceed direct to the TULSA VOR. Hold South of Tulsa, 5,000. Expect further clearance ____ minutes after the hour, time now ____ (one hour will be allotted between current time and EFC time)."*

Participant will comply with clearance, demonstrating correct navigation technique, holding pattern entry, and compliance with reporting requirements (4a, 4b, 4c, 4d). Once established in the hold, participant will demonstrate correct timing technique (4e).

Learning Objective 5: INTERCEPTING AND TRACKING NAVIGATIONAL SYSTEMS

Time allowed for completion: N/A; will be assessed throughout flight.

Items to be tested:

Participant:

a. Exhibits adequate knowledge of the elements related to intercepting and tracking navigational systems (…).

b. Tunes and correctly identifies the navigation facility.

c. Sets and correctly orients the course to be intercepted into the course selector or correctly identifies the course on the ADF.

d. Intercepts the specified course at an appropriate angle, inbound or outbound from a navigational facility.

e. Determines the aircraft position relative to the navigational facility.

Procedure:

Participant will correctly tune and identify appropriate navigation facilities, as well as intercept and track assigned courses and radials. Inability to tune, identify, intercept or track the appropriate navigation facility, course, or radial will be grounds for failure of this segment (5a, 5b, 5c, 5d, 5e).

Learning Objective 6: PRECISION APPROACH

Time allowed for completion: 15 MINUTES

Items to be tested:

Participant:

a. Exhibits adequate knowledge of the precision instrument approach procedures.

b. Accomplishes the appropriate precision instrument approaches as selected by the examiner.

c. Establishes two-way communications with ATC using the proper communications phraseology and techniques, as required for the phase of flight or approach segment.

d. Complies, in a timely manner, with all clearances, instructions, and procedures.

e. Advises ATC anytime that the applicant is unable to comply with a clearance.

f. Selects, tunes, identifies, and monitors the operational status of ground and airplane navigation equipment used for the approach.

g. Maintains a stabilized final approach, from the Final Approach Fix to DA/DH allowing no more than three-quarter scale deflection of either the glide slope or localizer indications.

h. Initiates immediately the missed approach when at the DA/DH, and the required visual references for the runway are not unmistakably visible and identifiable.

Procedure:

While en route, ATC will direct: *"Cessna 09OSU, verify you have information Bravo at Tulsa International."*

Participant will respond. If participant does not have information Bravo (current weather information), he/she will be instructed to get it. If he/she has already reported receipt of ATIS information, the above dialogue will be omitted. In either case, the participant will be informed of the following weather at Tulsa International airport:

"Tulsa International airport information Bravo, 1352z. Wind 350@16, Gusting 24. Visibility ¾ variable to 2 miles, light rain and mist. Sky condition overcast 200. Temperature 02. Dew point minus 04, altimeter 29.90. Rain began 30 minutes after the hour. ILS 36R approach in use, landing and departing runways 36L and 36R. Taxiway Alpha closed north of main ramp, unlighted tower 4 miles northeast. Departing aircraft contact Clearance Delivery 134.05 before contacting Ground Control. Report on initial contact you have information Bravo."

Participant will inform ATC that he/she has acquired information Bravo, as appropriate.

ATC will direct: *"Cessna 09OSU, expect Radar Vectors final approach course ILS Runway 36R. Turn right (or left, as appropriate) heading 180, descend and maintain 3,000'."*

When the aircraft is approximately 5SE of OILLR, ATC will provide final Radar Vector to approach course (though intermediate vectors may be provided to create a correct vector onto the localizer): *"Cessna 09OSU, 5 miles southeast of OILLR. Turn right heading 330 degrees to join the localizer, maintain 3,000' until established on the localizer. Report established on the localizer."*

Participant will respond as appropriate. Participant will comply with clearance, as appropriate. Participant will become established on localizer and report established (6c, 6d, 6f).

ATC will respond: *"Cessna 09OSU, descend and maintain 2,500', cleared for the ILS 36R approach. Contact Tower 121.2"*

Participant will comply.

ATC will respond with, "*Cessna 09OSU, Tulsa Tower, cleared to land 36R*."

Participant will conduct the ILS 36R approach (6a, 6b, 6e, 6g). At DH, the participant will not be able to meet the required criteria to descend below Decision Height. Participant will initiate a missed approach (6h).

Learning Objective 7: MISSED APPROACH

Time allowed for completion: 20 MINUTES

Items to be tested:

Participant:

a. Exhibits adequate knowledge of the elements related to missed approach procedures associated with standard instrument approaches.

b. Initiates the missed approach promptly by applying power, establishing a climb attitude, and reducing drag in accordance with the aircraft manufacturer's recommendations.

c. Reports to ATC beginning the missed approach procedure.

d. Complies with the published or alternate missed approach procedure.

e. Advises ATC anytime that the aircraft is unable to comply with a clearance, restriction, or climb gradient.

Procedure:

Participant will initiate the missed approach at the DH (7a, 7b), and report the missed approach to ATC (7c).

ATC will respond: *"Execute published missed approach. Contact Departure 124.0"*

Participant will comply. After contacting Departure, the participant will be instructed: "*Cessna 09OSU, Tulsa Departure. Upon reaching Tulsa VORTAC hold as published. Report established in the hold. Expect further clearance* **____** *minutes after the hour."* (20 minutes will be allotted for missed approach and hold).

Participant will respond and proceed to Tulsa VORTAC and enter the hold (7d, 7e).

Learning Objective 8: "Preflight" Preparation (Determination of/Proceeding to alternate)

Time allowed for completion: 30 MINUTES

Items to be tested:

Participant:

a. Correctly analyzes the weather information pertaining to the route of flight and destination airport, and selects alternate destination as appropriate.

b. Correctly analyzes weather information (in flight), and determines suitable alternate destination.

c. Determines the calculated performance is within the aircraft's capability and operating limitations.

d. Correctly interprets (and applies) charts (and procedures) to proceed to suitable alternate destination.

Procedure:

After the participant has reported established in the hold, ATC will inform and query: *"Cessna 09OSU, National Weather Service has issued amended AIRMET Zulu 2 at 1440 Zulu, for low IFR conditions due to fog and low clouds, and decreasing ceilings and visibility in the Tulsa area, and to the area North and East of Tulsa. Say intentions."*

Participant will respond. If participant asks to leave frequency to contact FSS, this request will be granted and weather report with generally better weather west and south will be provided. If participant seeks weather information from ATC, only local conditions will be provided. If participant persists with ATC, he/she will be told that *"Permission granted to leave frequency for 5 minutes. Contact McAlester Radio (FSS) 122.2. Report returning this frequency."*

Participant will contact McAlester Flight Service Station. He/she will be told icing conditions persist to the North and East of Tulsa. Participant will be asked by ATC to "*Say intentions."*

Participant will respond. If more weather information is required, it will be provided, and will generally show better weather West and South. If the participant asks for weather at specific destinations, it will be provided as follows:

"Tulsa International, 100' overcast, ¾ mile visibility, freezing rain and mist."

"Pogue (Sand Springs), 100' overcast, 1 mile visibility, mist."

"Claremore Regional, estimated ceiling 100' overcast sky obscured, ¼ mile visibility, freezing rain."

"Okmulgee Regional, 300 overcast, 3 miles visibility, light rain and mist."

"Stillwater Regional, 1,500' overcast, 5 miles visibility."

The participant, or course, may choose some other alternate destination. If so, the weather at that airport will follow the general trend of better weather west and south. If the participant elects to try a nearby airport, they will be told to "expect radar vectors to final approach course" and told which approach to expect. If the participant selects an alternate more than 25 nautical miles away from Tulsa, he/she will be given a "Direct" or appropriate radial or airway route clearance. If the participant elects to continue holding to wait for better weather and another attempt at the same approach, he/she will be informed that weather conditions are deteriorating.

Once the Participant has gleaned weather information and determined, communicated (8 b, c), and correctly (though only initially) implemented his/her route to the alternate destination (8d), the exercise is complete. Grades will be assigned for the alternate selection based on weather, general suitability, and legalities.

The exercise is complete.

APPENDIX B

INSTRUCTIONS PROVIDED TO RESEARCH PARTICIPANTS

Instructions Provided to Research Participants

"You have been asked to participate in a research project dealing with newly certified instrument rated pilots and their ability to operate in the IFR environment. Your task will be to conduct an IFR flight in a "flight simulator" from Stillwater Regional Airport to Tulsa International Airport. The flight will take approximately 1 to 1.5 hours and will involve the normal IFR flight tasks: acquiring an IFR clearance, interaction with Air Traffic Control, manipulation of the appropriate aircraft controls, instruments and avionics, the interpretation of charts, etc. All of the paperwork needed for the flight will be provided. This will include a completed flight plan and flight log, en route and approach charts, and printed weather forecasts. Important details about the flight, including route, altitude, time, etc. will be found in the flight log and flight plan. Questions may be asked about these details before the flight begins, but not after. One detail that will be notably absent from the flight plan is an alternate destination. You will be asked to select an appropriate alternate based on weather or any other relevant data.

Note that the flight is designed to be a fairly challenging IFR flight with IMC weather prevailing. However, there will be **no** planned dangerous weather such as embedded thunderstorms or unforecast icing. Further, there will be no attempt to "trick" the pilot, nor will there be any equipment failures or planned emergencies. Nothing, however, is to prevent the pilot from declaring an emergency if it is deemed necessary. Again a routine, but challenging, IFR flight is the intent. Superfluous ground operations, such as taxi and runup, will not be conducted. In fact, the IFR clearance will be received from Ground Control while in takeoff position on runway 17.

Throughout the flight, you will interact with ATC just like during a real flight. This may mean amendments to your clearance and other instructions. You will be expected to select and set correct frequencies and use standard pilot phraseology. If you set wrong frequencies you may get no response- just like in the real world. All ATC and Flight Service station services will be provided, and the principal investigator will act as both ATC controller and FSS specialist. To enhance the realism of the flight, headsets will be worn.

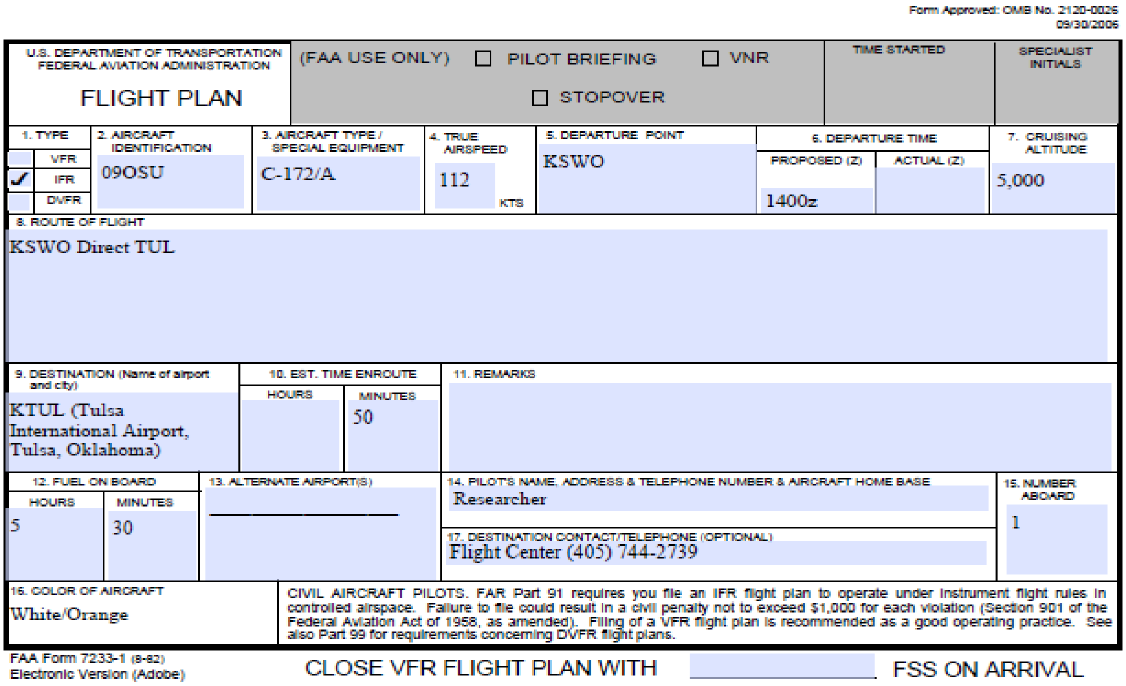
Navigation radio frequencies and radials will need to be set correctly as well. The GPS is VFR only and is so placarded. You may **not** use the moving map display on the GPS (nav. page 2) as this could influence certain research conclusions. All other avionics may be used or *not* used at the pilot's discretion. Additionally, you are asked to NOT discuss specifics of the flight with anyone until after the research project has been completed, as knowledge of flight tasks leaked to subsequent participants could also affect research conclusions.

Your actual interaction will be **only** with the principal investigator listed above (and possible assistant to operate simulator or play the part of ATC), and **the flight is not a test that can be failed or academically graded in any way**. Any errors you may make during the flight will be recorded for research purposes only, and will not be associated with you personally. In fact, your identity will in no way be associated with collected research data or published in research findings.

Participation is voluntary and you can discontinue the research activity at any time without reprisal or penalty. There are no risks related to withdrawing from the activity. You cannot be involuntarily dismissed from the activity for any foreseeable reason."

APPENDIX C

FLIGHT PLAN FORM



Form Approved: OMB No. 2120-0026
09/30/2006

U.S. DEPARTMENT OF TRANSPORTATION
FEDERAL AVIATION ADMINISTRATION

FLIGHT PLAN

(FAA USE ONLY) ☐ PILOT BRIEFING ☐ VNR ☐ STOPOVER

TIME STARTED

SPECIALIST INITIALS

1. TYPE	☐ VFR ✓ IFR ☐ DVFR	2. AIRCRAFT IDENTIFICATION	09OSU	3. AIRCRAFT TYPE / SPECIAL EQUIPMENT	C-172/A	4. TRUE AIRSPEED	112 KTS
5. DEPARTURE POINT	KSWO	6. DEPARTURE TIME PROPOSED (Z)	1400z	6. DEPARTURE TIME ACTUAL (Z)		7. CRUISING ALTITUDE	5,000

8. ROUTE OF FLIGHT: KSWO Direct TUL

9. DESTINATION (Name of airport and city): KTUL (Tulsa International Airport, Tulsa, Oklahoma)

10. EST. TIME ENROUTE: HOURS: MINUTES: 50

11. REMARKS:

12. FUEL ON BOARD: HOURS: 5 MINUTES: 30

13. ALTERNATE AIRPORT(S): ____________

14. PILOT'S NAME, ADDRESS & TELEPHONE NUMBER & AIRCRAFT HOME BASE: Researcher

15. NUMBER ABOARD: 1

16. COLOR OF AIRCRAFT: White/Orange

17. DESTINATION CONTACT/TELEPHONE (OPTIONAL): Flight Center (405) 744-2739

CIVIL AIRCRAFT PILOTS. FAR Part 91 requires you file an IFR flight plan to operate under instrument flight rules in controlled airspace. Failure to file could result in a civil penalty not to exceed $1,000 for each violation (Section 901 of the Federal Aviation Act of 1958, as amended). Filing of a VFR flight plan is recommended as a good operating practice. See also Part 99 for requirements concerning DVFR flight plans.

FAA Form 7233-1 (8-82)
Electronic Version (Adobe)

CLOSE VFR FLIGHT PLAN WITH ____________ FSS ON ARRIVAL

APPENDIX D

RESEARCH FLIGHT WEATHER

METARs & TAFs For Tulsa Area Weather

(Stillwater Weather)

```
KSWO 241355Z AUTO 30012G18KT 10SM BKN016 OVC033 06/M03 A2992 RMK AO2
SLP135 T0038M0028
```

(Tulsa International Weather)

```
KTUL 241352Z 01012G18KT 1SM BR BKN002 OVC004 02/M01 A2990 RMK AO2
SLP135 T0018M0008

KTUL 2414Z 2414/2514 02008G16 3SM -SHRA BR BKN003 OVC004
     TEMPO 2415/2417 02018G24KT 2SM BR OVC002 OVC30 OVC080
     FM2417 35012G18KT 3SM VCSH OVC006 OVC008 OVC200
     TEMPO 2420/2501 31016G24KT 1/2SM SHRA BR OVC001 OVC120
     FM2501 30015G26KT 1SM -RA BR BKN005 OVC010
     FM2510 32012KT P6SM SCT010 BKN060 BKN120
```

(Tulsa Riverside Weather)

```
KRVS 241352Z 01012G18KT 1SM BR BKN002 OVC004 02/M01 A2989 RMK AO2
SLP135 T0018M0008

KRVS 2414Z 2414/2514 02010G18 2SM -SHRA BR BKN002 OVC004
     TEMPO 2415/2417 01020G30KT 2SM OVC002 OVC30 OVC080
     FM2417 35012G18KT 2SM VCSH OVC005 OVC008 OVC200
     TEMPO 2420/2501 31016G24KT 1/2SM SHRA BR OVC001 OVC120
     FM2501 30015G26KT 1SM -RA BR BKN005 OVC010
     FM2510 32012KT P6SM SCT010 BKN060 BKN120
```

(Bartlesville Weather)

```
KBVO 241352Z 01010G18KT 1/2SM BR OVC 001 OVC004 01/M01 A2989 RMK AO2
SLP135 T0018M0008

KBVO 2414Z 2414/2514 02010G18 1SM -SHRA BR OVC002 OVC004
     TEMPO 2415/2417 01020G30KT 1/2SM OVC001 OVC30 OVC080
     FM2417 35012G18KT 1SM VCSH FZDL OVC005 OVC008 OVC200
     TEMPO 2420/2501 31016G24KT 1/2SM SHRA BR OVC001 OVC120
     FM2501 30015G26KT 1SM -RA BR BKN005 OVC010
     FM2510 32012KT P6SM SCT010 BKN060 BKN120
```

(Wichita Weather)

```
KICT 241352Z 01010G18KT R31/2400 –RABR OVC 001V002 01/M01 A2989 RMK AO2
SLP135 T0018M0008

KICT 2414Z 2414/2514 02010G18 1SM -SHRA BR OVC002 OVC0040
     TEMPO 2415/2417 01020G30KT 1/2SM OVC001 OVC30 OVC080
     FM2417 35012G18KT 1SM VCSH FZDL OVC005 OVC008 OVC200
     TEMPO 2420/2501 31016G24KT 1/2SM SHRA BR OVC001 OVC120
     FM2501 30015G26KT 1SM -RA BR BKN005 OVC010
     FM2510 32012KT P6SM SCT010 BKN060 BKN120
```

(Okmulgee Weather)

```
KOKM 2414/2514 01012G18KT 3SM -RA BKN002 OVC0010 04/M01 A2990 RMK AO2
SLP135 T0038M0008
```

APPENDIX E

TASK/GRADE MATRIX

Date ________________________________ Participant Identification Code ______________________

1. ATC Clearance	**2. Compliance With Clearance/Procedures**	**3. Basic Instrument Maneuvers**	**4. Holding Procedures**	**5. Intercepting and Tracking Navigational Systems**	**6. Precision Approach**	**7. Missed Approach**	**8. Alternate Destination**
a. Adequate knowledge of the elements related to ATC clearances and pilot/controller responsibilities: **Importance: 4** **Grade:**	**a.** Adequate knowledge of elements of Dep., en route, & Arrival Clearance and Pilot/controller Responsibility: **Importance: 4** **Grade:**	**a.** Adequate knowledge & skill related to attitude instrument flight: **Importance: 5** **Grade:**	**a.** Adequate knowledge of elements related to holding procedures: **Importance: 3** **Grade:**	**a.** Adequate knowledge of the elements of intercepting and tracking navigational systems: **Importance: 4** **Grade:**	**a.** Adequate knowledge of precision instrument approach procedures: **Importance: 4** **Grade:**	**a.** Adequate knowledge of missed approach procedures and prepares for missed approach: **Importance: 3** **Grade:**	**a.** Selects **Legal** alternate for flight plan: **Importance: 1** **Grade:**
b. Copies ATC Clearance: **Importance: 4** **Grade:**	**b.** Uses Correct Publication: **Importance: 2** **Grade:**	**b.** Maintains altitude +/- 200 feet, headings +/- 20°, and airspeed +/- 20 knots: **Importance: 4** **Grade:**	**b.** Remains within holding airspace: **Importance: 3** **Grade:**	**b.** Tunes and identifies navigational facility and sets & intercepts course to be intercepted: **Importance: 4** **Grade:**	**b.** Establishes and uses correct ATC facility & correct phraseology for approach: **Importance: 2** **Grade:**	**b.** Initiates missed approach with correct control inputs: **Importance: 3** **Grade:**	**b.** Assimilates appropriate weather information to determine **suitable** alternates, including non-legal (for flight plan) alternates: **Importance: 3** **Grade:**
c. Determines ability to comply: **Importance: 3** **Grade:**	**c.** Uses and identifies correct comm. and nav. facilities: **Importance: 4** **Grade:**		**c.** Recognizes arrival at holding fix: **Importance: 2** **Grade:**	**c.** Intercepts course at correct angle, inbound or outbound: **Importance: 2** **Grade:**	**c.** Complies with clearance instructions and procedures: **Importance: 4** **Grade:**	**c.** Reports to ATC: **Importance: 1** **Grade:**	**c.** Performs appropriate planning to proceed to **suitable** alternate: **Importance: 3** **Grade:**

d. Correctly interprets/requests clarification of Clearance: **Importance: 4** **Grade:**	**d.** Performs appropriate checklist: **Importance: 2** **Grade:**		**d.** Complies with ATC reporting requirements: **Importance: 1** **Grade:**		**d.** Advises ATC if unable to comply: **Importance: 5** **Grade:**	**d.** Complies with missed approach clearance and procedures: **Importance: 4** **Grade:**	**d.** Acquires appropriate route/clearance to proceed to alternate, and implements initial route to alternate: **Importance: 3** **Grade:**
e. Reads Back Clearance: **Importance: 3** **Grade:**	**e.** Establishes communication with proper ATC facility: **Importance: 2** **Grade:**		**e.** Times holds correctly: **Importance: 1** **Grade:**	**e.** Determines the aircraft position relative to the navigational facility: **Importance: 5** **Grade:**	**e.** Selects, tunes, and identifies correct approach facilities: **Importance: 5** **Grade:**	**e**. Initiates missed approach at full scale or anytime required tolerances not met. **Importance: 4** **Grade:**	
f. Standard Phraseology: **Importance: 1** **Grade:**	**f.** Complies with ATC instructions and airspace restrictions: **Importance: 5** **Grade:**				**f.** Stabilized approach with no more than ¾ scale deflection on both localizer and glideslope: **Importance: 4** **Grade:**		
g. Sets communication/ navigation systems & transponder in compliance with clearance: **Importance: 5** **Grade:**	**g.** Intercepts appropriate radials & bearings as published in procedure: **Importance: 4** **Grade:**				**g.** Missed approach at DH if visibility requirements not met: **Importance: 5** **Grade:**		

APPENDIX F

FISHER EXACT TEST

Fisher's Exact Test

Due to the small sample sizes used in this project and the pass/fail nature of pilot testing, the Fisher exact test is uniquely suited to analyze the results. As suggested by the name, Fisher's test is an "exact test," which means that the significance of the deviation from a null hypothesis can be calculated exactly rather than by determining a relationship between the test result and a supposed theoretical distribution (such as a chi-squared distribution or a Student's t-distribution). Although the Fisher test can be used in a fairly general set of experiments, it is especially useful when comparing the dichotomous distribution of outcomes between two relatively small groups of test subjects. For large sample sizes, the Fisher test reduces to the well-known chi-squared test.

The test's namesake, R.A. Fisher, is said to have devised the test to determine if his friend, Muriel Bristol, could detect whether the tea or milk had been poured into her cup first, as she claimed she could. In that simple case, the dichotomous outcomes are (tea, then milk) or (milk, then tea), and the two "subject groups" are the actual division and that claimed by Mrs. Bristol in a taste test. The test result, then, showed whether or not there was an association between the two distributions of ordered pourings, and therefore quantified Mrs. Bristol's ability to discern between milk first or tea first through a taste test.

In this study, Fisher's test was used to determine whether or not the results from the experienced pre-test pilot group and the less experienced test pilot group are similar. For each task, the dichotomous outcome is the ability or inability of a pilot to satisfactorily complete that task. In Chapter III, the basis for the various grade assignments was defined, and the definition of the D grade is as follows: "task partially completed and/or knowledge partially demonstrated, but elements of task not done or done incorrectly and/or gaps in knowledge observed or suspected." The F grade definition is simpler: "task never completed or knowledge never demonstrated." And, since the Fisher test requires a dichotomous relationship between outcomes, an F or D grade assigned for any participant task was converted to a "Fail" in the Fisher contingency tables. Pilot performance that met A or B grade criteria, defined in chapter III as "A- task easily completed or knowledge easily demonstrated" or "B- task fully completed and/or knowledge demonstrated, but at least one extra attempt/clarification/query required" respectively, was converted to a "Pass" grade. More troubling was the C grade. In chapter III, C performance was defined as "task completed and/or knowledge demonstrated, but multiple attempts/clarification required." Admittedly, this level of performance could be considered passing or failing on an airman certification test depending on task importance, performance on other tasks, grading subjectivity, or some other variable. Therefore, it was decided to simply omit ambiguous C grade performance from the Fisher contingency tables; C's weighted neither the pass nor fail groups.

To better understand how the Fisher test works, a somewhat lengthy explanation is in order. To begin, consider this crude example: suppose it is hypothesized that experienced pilots can fly an instrument approach within PTS tolerances but inexperienced pilots cannot. A test is then logically constructed in which experienced and inexperienced pilots, individually, are asked to fly an approach in a flight simulator. As predicted, all five members of the experienced pilot group fly the approach within limits, while only three (of seven) of the inexperienced pilots successfully fly the approach. Our test (and common sense) suggests that we have "proven" that experienced pilots can fly an instrument approach better than inexperienced pilots. But our test has not really proven *anything* because, at best, our test can only *suggest to varying degrees* that something else (such as pure chance) did not determine the test results. And when working with small sample sizes, the occasional "outlier" in the data can make even the most intuitive hypothesis hard to "prove," or, more accurately, *hard to suggest to a high degree of certainty*.

Consider again the results of our hypothetical test. A table showing the test data would look like this:

Table 1- Pilot Experience Test

	Experienced pilots	Inexperienced Pilots	Marginal Total
Approach flown within limits	5	3	8
Approach not flown within limits	0	4	4
Marginal Total	5	7	12

All five (100%) of the experienced pilots "passed" the test, while only 3 (43%) of the inexperienced pilots did. While these numbers might lead one to assume a statistically significant difference in the groups, we must first define what we mean by "statistically significant." Once again, to conclude that something besides chance caused the results, we must be quite sure. In the social sciences, "quite sure" is commonly interpreted as at least 95% sure, though even this number is considered quite low in some disciplines (Creswell, 2002).

Consider all the possible experiments in which a total of 8 pilots correctly flew the approach and 4 did not, which are the numbers we observed. Note that to construct tables (like the one above) showing this, we must keep the horizontal marginal totals (5 and 7) and the vertical marginal totals (8 and 4) the same. If we were to do so, the possible tables (besides the actual table) that we could create would look like this:

Table 2

	Experienced pilots	Inexperienced pilots	Marginal Total
Approach flown within limits	4	4	8
Approach not flown within limits	1	3	4
Marginal Total	5	7	12

Table 3

	Experienced pilots	Inexperienced pilots	Marginal Total
Approach flown within limits	3	5	8
Approach not flown within limits	2	2	4
Marginal Total	5	7	12

Table 4

	Experienced pilots	Inexperienced pilots	Marginal Total
Approach flown within limits	2	6	8
Approach not flown within limits	3	1	4
Marginal Total	5	7	12

Table 5

	Experienced pilots	Inexperienced pilots	Marginal Total
Approach flown within limits	1	7	8
Approach not flown within limits	4	0	4
Marginal Total	5	7	12

Our "null hypothesis" is that there is *no difference between the groups*; any variation in the pass/fail ratio of the different groups is due to random variations. And, with the possible numbers in place, we can now consider just how probable or improbable (mathematically) these results might occur, if in fact the null hypothesis - that there is no difference between the groups - is true. Consider table 1. Of the 8 participants that successfully flew the approach, 5 were experienced and 3 were not. How many ways are there of dividing eight participants into groups of size 5 and 3, respectively? The answer is referred to as "8 choose 5" and $\binom{8}{5}$ is used to denote it. If we are to randomly select five objects from a group of eight, there are eight ways to select the first object, seven ways to select the second object (remember, one has been previously selected), six ways to select the third object (two previously selected), five ways to select the fourth object (three previously selected), and four ways to select the third object (four previously selected). This means that there are 8×7×6×5×4 = 6,720 ways of selecting all five *in order*. But in this experiment, order is irrelevant; there is no significance in picking the objects in any certain order so long as the correct objects are picked, just as these is no significance, in the hypothetical experiment, in the order in which pilots passed or failed the test.[6] The significance is in which group - experienced or inexperienced - that the pilots belonged to. Therefore, the odds of picking, by chance, the correct five in *any* order is determined by dividing the number just calculated (6,720) by the number of permutations of the selected objects, in this case 5×4×3×2×1. So, there are

$$\binom{8}{5} \text{ or}$$

$$\frac{8\times 7\times 6\times 5\times 4}{5\times 4\times 3\times 2\times 1} = \frac{6{,}720}{120} = 56$$

different ways of choosing the objects, again, if we accept the null hypothesis and order doesn't matter. In general, we construct the "possible chance selections" as a fraction with the numerator determined thusly: the product of "entire group" numbers, starting with the entire group, and then successively decreasing by 1 as the group shrinks after we make selections. The denominator is determined by the product of how many we are choosing from the group, with each successive selection attempt showing the decreasing number left to choose. We should note also the special cases in which zero or all are selected

---

[6] At least there is no significance in *theory*. In practice, pilot order *does* matter if pilots later in the sequence of our test "network" about what is required in the experiment and prepare accordingly. This networking could provide an unfair advantage to the later pilots and therefore skew test data.

There is some evidence that networking did occur in the actual experiment in this project. Test group pilot number 4, who did well on the flight, made the comment during a difficult task that "his roommate told him to expect it" (his roommate was an earlier participant). Because of this comment and its implications to test data, the principal investigator considered omitting the pilot 4 data from the test results. He did not, however, for two reasons: (1) any improvement in pilot 4's performance caused by the illicit networking would argue against rejecting the null hypothesis, and not in support of any "pet" hypothesis of the investigator, and (2) advance information of the flight could improve pilot performance operationally, but not technically. In other words, advance knowledge of the flight might help a pilot prepare for operations such as route changes or holds, but it would have little effect on pilot technique such as recognizing fixes or complying with minimums.

$$\binom{8}{0} = \binom{8}{8} = 1;$$

there is only one way of not selecting *anybody* (or, equivalently, of selecting *everybody*).

Alternatively, we can calculate the number of ways of choosing the 3 inexperienced pilots (instead of the 5 experienced) from 8. This is:

$$\binom{8}{3} = \frac{8 \times 7 \times 6}{3 \times 2 \times 1} = 56,$$

which is, of course, the same as $\binom{8}{5}$. Remember, we are suggesting in this example that chance is the only determiner, so the odds of selecting one group or the other should be the same, which they are.

Returning to table 1, we see that the number of ways of selecting 5 successful approach flyers from eight (the passes), and no unsuccessful approach flyer from four (the fails) is:

$$\binom{8}{5} \times \binom{4}{0} = 56 \times 1 = 56.$$

Now, in the hypothetical experiment there were 12 participants, predivided into groups of 5 (the experienced pilots) and 7 (the inexperienced pilots). The total number of ways of dividing the pilots into these groups, without regard to the pass/fail outcome, is

$$\binom{12}{5} \text{ or } \binom{12}{7} \text{ or}$$

$$\frac{12 \times 11 \times 10 \times 9 \times 8}{5 \times 4 \times 3 \times 2 \times 1} = 792 \quad \text{or} \quad \frac{12 \times 11 \times 10 \times 9 \times 8 \times 7 \times 6}{7 \times 6 \times 5 \times 4 \times 3 \times 2 \times 1} = 792$$

Since the *null hypothesis dictates that any of these 792 groupings is equally likely*, the probability of getting the pass/fail results in Table 1 is:

$$\binom{8}{5} \times \binom{4}{0} \div \binom{12}{5} = \frac{56 \times 1}{792} = \mathbf{.071}$$

Applying the same formula to the other possible tables (for reasons we will see in a moment), shows that the probabilities of getting the results in Tables 2 – 5 are:

Table 2:

$$\binom{8}{4} \times \binom{4}{1} \div \binom{12}{5} = \frac{70 \times 4}{792} = \frac{280}{792} = \mathbf{.354}$$

Table 3:

$$\binom{8}{3} \times \binom{4}{2} \div \binom{12}{5} = \frac{56 \times 6}{792} = \mathbf{.424}$$

Table 4:

$$\binom{8}{2} \times \binom{4}{3} \div \binom{12}{5} = \frac{28 \times 4}{792} = \mathbf{.141}$$

Table 5:

$$\binom{8}{1} \times \binom{4}{4} \div \binom{12}{5} = \frac{8 \times 1}{792} = \mathbf{.010}$$

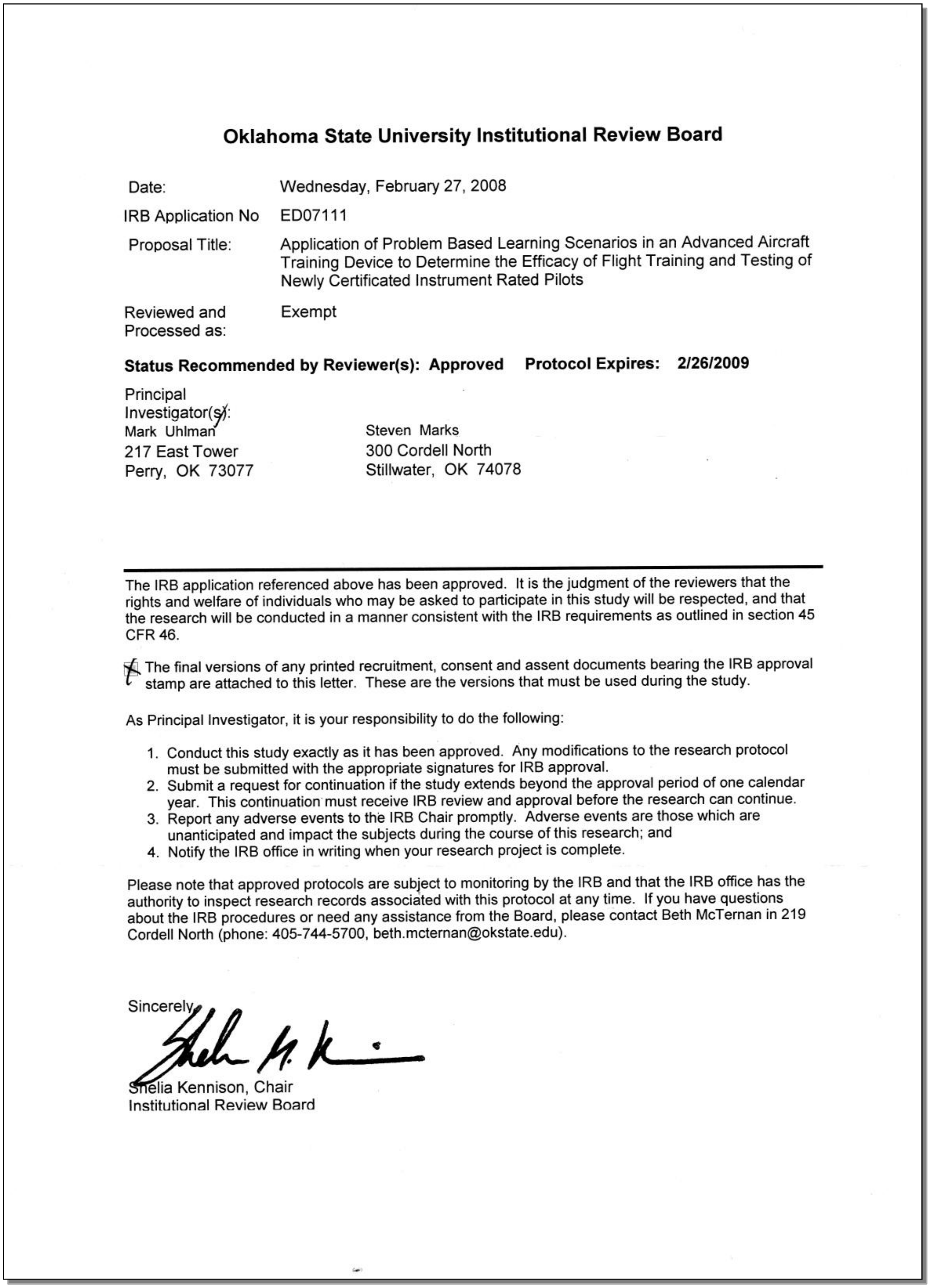
Notice that the sum of all the probabilities in bold equals 1, as required. We might also notice that the sum of the numerators equals the denominator (792), which is also required and provides a useful check on the accuracy of the math.

But we are not done yet. Even though the results of the hypothetical test are duly reported in Table 1, what we really want to know is how probable they are. Or, more particularly, how *improbable* it is that chance alone determined these results. Therefore, we are interested in the probability of getting a result *at least* this extreme. By extreme, we mean more biased toward a difference between the experienced and inexperienced pilots. A perusal of the tables shows that none of the tables is more extreme. So, the probability of getting a result at least as extreme as was actually observed is p=.071. Thus, there is only about a 7% chance that this result was due to chance; we are 93% confident that there really is a difference between the approach flying abilities of the experienced pilots and the inexperienced pilots. And while 93% sounds like a lot, we should remember that we noted earlier that in the social sciences we should be at least 95% certain before we stake any claims on our findings. And in this case (and occasionally in the actual study) , we cannot say at the desired level of confidence that chance alone did not determine the test results, as tempting as it may be to do so, and as frustrating as it may be that we can't! Sometimes, the unfortunate researcher may be left with the difficult decision of either professing positive findings at a lower confidence level or null findings of which he is highly suspect. Such are the perils of small sample size! Potentially compounding the researcher's dilemma may be the gravity of the subject matter; flying an instrument approach is not just an academic exercise! The interested reader is encouraged to see Appendix K for more on this conundrum, and to see how the PI attempted to resolve it in this study.

The *p*-values for all tasks in this project were calculated in a similar manner. To avoid tedious calculation of all the combinatoric values, the website at http://www.physics.csbsju.edu/stats/fisher.form.html was used, which not only calculates the probabilities of every possible Table of outcomes, but also adds the values for Tables at least as extreme, thereby giving the overall *p*-value for the Fisher test. (The *p*=0.071 result in the example above is readily verified using this site.)

APPENDIX G

INSTITUTIONAL REVIEW BOARD APPROVAL FORM



Oklahoma State University Institutional Review Board

Date:	Wednesday, February 27, 2008
IRB Application No	ED07111
Proposal Title:	Application of Problem Based Learning Scenarios in an Advanced Aircraft Training Device to Determine the Efficacy of Flight Training and Testing of Newly Certificated Instrument Rated Pilots
Reviewed and Processed as:	Exempt

Status Recommended by Reviewer(s): Approved Protocol Expires: 2/26/2009

Principal Investigator(s):

Mark Uhlman 217 East Tower Perry, OK 73077	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.

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

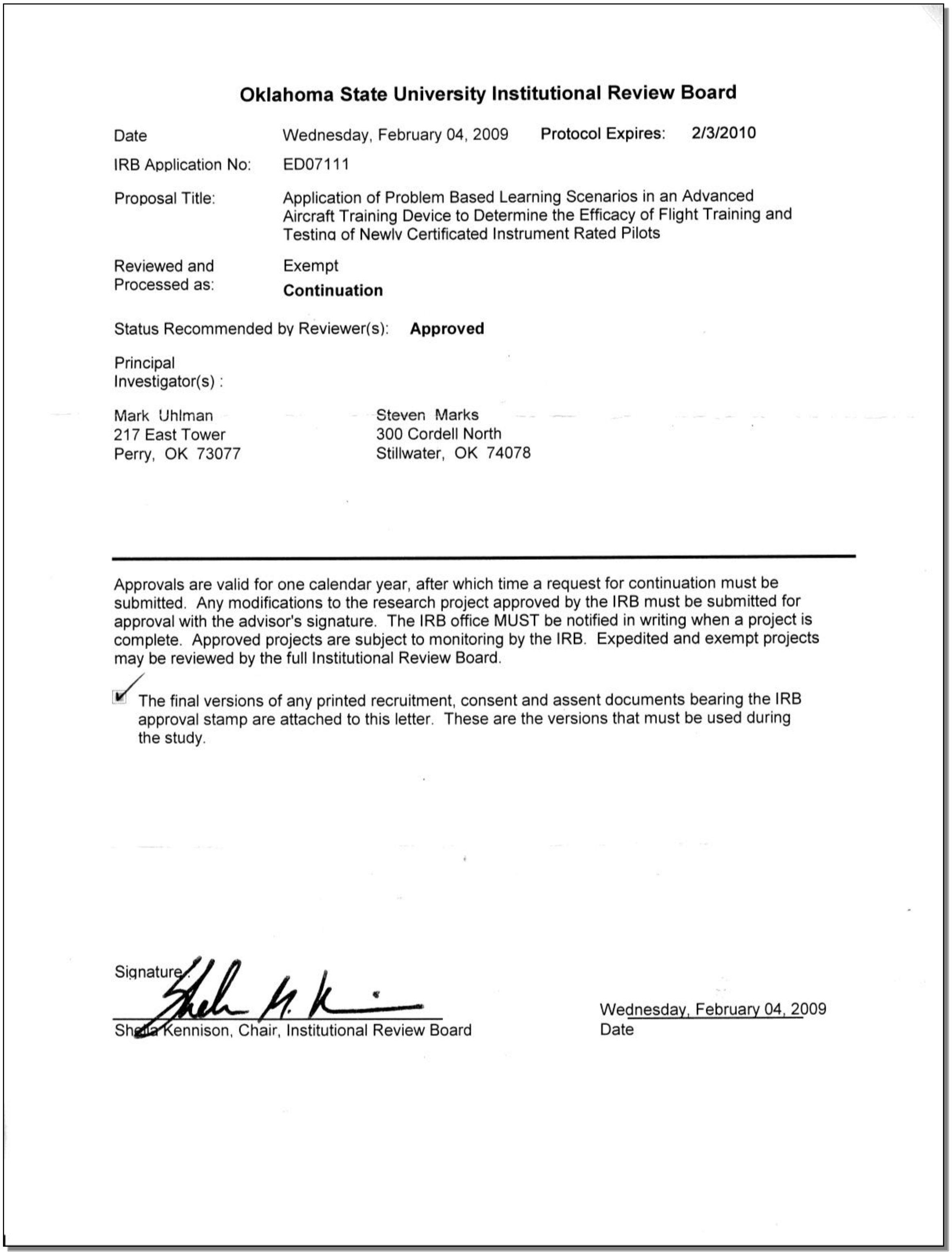
As Principal Investigator, it is your responsibility to do the following:

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

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

Sincerely,

Shelia Kennison, Chair
Institutional Review Board



Oklahoma State University Institutional Review Board

Date Wednesday, February 04, 2009 **Protocol Expires:** 2/3/2010

IRB Application No: ED07111

Proposal Title: Application of Problem Based Learning Scenarios in an Advanced Aircraft Training Device to Determine the Efficacy of Flight Training and Testing of Newly Certificated Instrument Rated Pilots

Reviewed and Processed as: Exempt **Continuation**

Status Recommended by Reviewer(s): **Approved**

Principal Investigator(s) :

Mark Uhlman
217 East Tower
Perry, OK 73077

Steven Marks
300 Cordell North
Stillwater, OK 74078

Approvals are valid for one calendar year, after which time a request for continuation must be submitted. Any modifications to the research project approved by the IRB must be submitted for approval with the advisor's signature. The IRB office MUST be notified in writing when a project is complete. Approved projects are subject to monitoring by the IRB. Expedited and exempt projects may be reviewed by the full Institutional Review Board.

☑ 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.

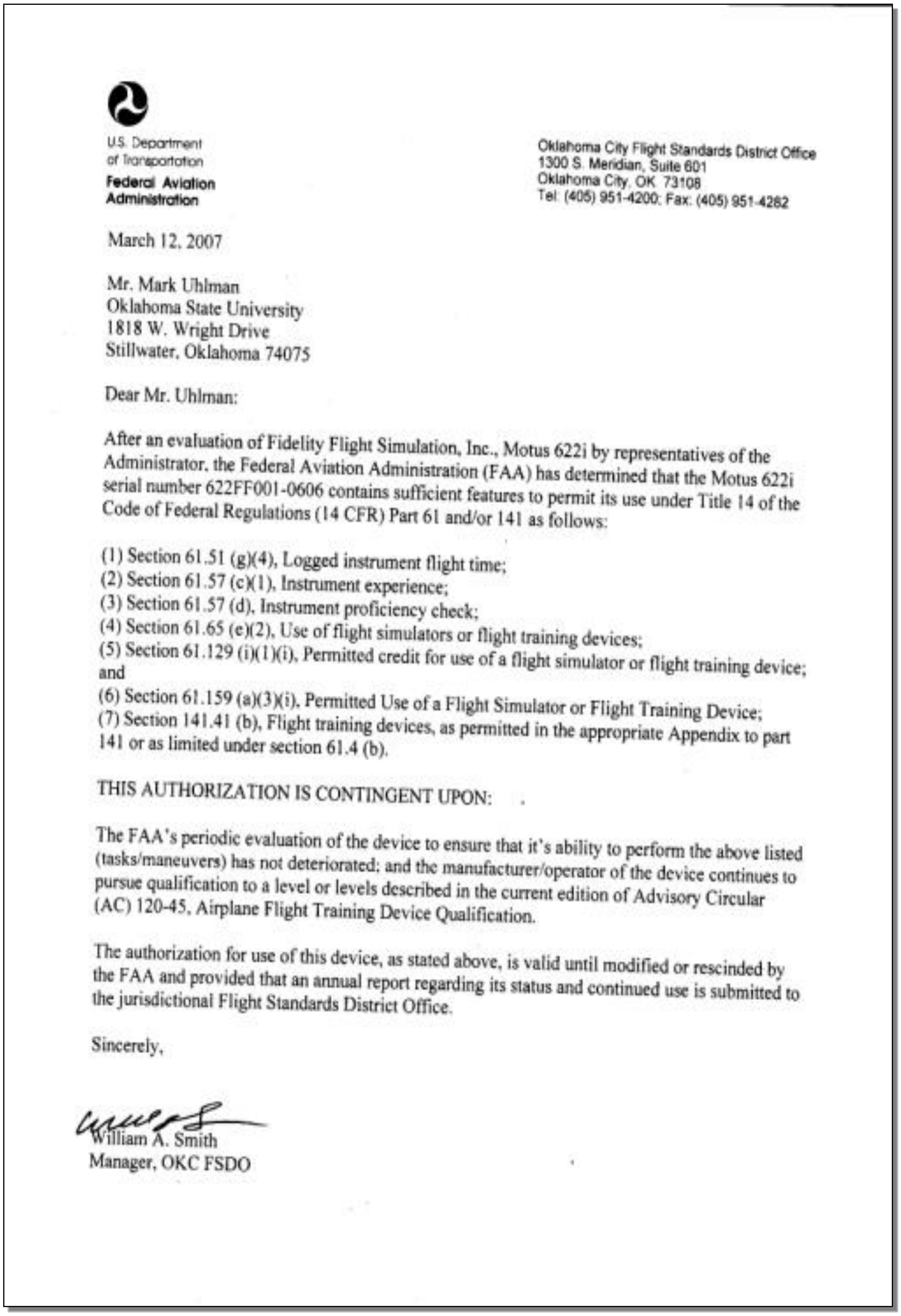
Signature :

Sheila Kennison, Chair, Institutional Review Board

Wednesday, February 04, 2009
Date

APPENDIX H

FAA APPROVAL OF FLIGHT TRAINING DEVICE (FLIGHT SIMULATOR)



U.S. Department
of Transportation
**Federal Aviation
Administration**

Oklahoma City Flight Standards District Office
1300 S. Meridian, Suite 601
Oklahoma City, OK 73108
Tel: (405) 951-4200; Fax: (405) 951-4282

March 12, 2007

Mr. Mark Uhlman
Oklahoma State University
1818 W. Wright Drive
Stillwater, Oklahoma 74075

Dear Mr. Uhlman:

After an evaluation of Fidelity Flight Simulation, Inc., Motus 622i by representatives of the Administrator, the Federal Aviation Administration (FAA) has determined that the Motus 622i serial number 622FF001-0606 contains sufficient features to permit its use under Title 14 of the Code of Federal Regulations (14 CFR) Part 61 and/or 141 as follows:

(1) Section 61.51 (g)(4), Logged instrument flight time;
(2) Section 61.57 (c)(1), Instrument experience;
(3) Section 61.57 (d), Instrument proficiency check;
(4) Section 61.65 (e)(2), Use of flight simulators or flight training devices;
(5) Section 61.129 (i)(1)(i), Permitted credit for use of a flight simulator or flight training device; and
(6) Section 61.159 (a)(3)(i), Permitted Use of a Flight Simulator or Flight Training Device;
(7) Section 141.41 (b), Flight training devices, as permitted in the appropriate Appendix to part 141 or as limited under section 61.4 (b).

THIS AUTHORIZATION IS CONTINGENT UPON:

The FAA's periodic evaluation of the device to ensure that it's ability to perform the above listed (tasks/maneuvers) has not deteriorated; and the manufacturer/operator of the device continues to pursue qualification to a level or levels described in the current edition of Advisory Circular (AC) 120-45, Airplane Flight Training Device Qualification.

The authorization for use of this device, as stated above, is valid until modified or rescinded by the FAA and provided that an annual report regarding its status and continued use is submitted to the jurisdictional Flight Standards District Office.

Sincerely,

William A. Smith
Manager, OKC FSDO

APPENDIX I

PARTICIPANT RECRUITMENT FLYER

Instrument Rating Training and Testing Study

Be part of an important airman certification study

- **Are you18 years old or older?**
- **Have you earned an Instrument Rating within the last 6 months?**
- **Have you logged less than 25 hours as PIC under IFR?**

If you answered yes to these questions, you may be eligible to participate in an Instrument Rating Study being conducted at Oklahoma State University.

The purpose of the study is to gauge the effectiveness of current Instrument Rating training and testing procedures. Participants will be able to log 1-1.5 hours of simulated flight time and will not be subject to any kind of written or flight test.

For more information: Contact Mark Uhlman
(580) 370-2126

APPENDIX J

INFORMED CONSENT DOCUMENT

Informed Consent Document

Project Title:

Scenario-Based Evaluation of the Skills of Newly-Certificated Instrument Pilots

Investigator:

Mark Uhlman, M.S. Applied Educational Studies; Aviation and Space Education. (Current research being conducted pursuant to Ed.D. Applied Educational Studies; Aviation and Space.)

Location:

The Oklahoma State University "Sim Room," located at the North end of the OSU aircraft maintenance facility at the Stillwater Regional Airport.

Purpose:

A study is being conducted to determine the effectiveness of instrument flight training and certification testing. This study involves research into the readiness of newly certificated instrument pilots to actually operate an aircraft under instrument flight rules. You have been asked to participate in this research because you meet certain criteria regarding recency and grade of certification (instrument rating earned within past 6 months and less than 25 hours PIC under IFR). During this research, it is hoped that certain findings may emerge from your conduct of a simulated instrument flight (in a flight simulator) that can be used to determine the readiness of newly certificated instrument pilots to actually conduct non-training, IFR operations under moderately challenging conditions.

Procedures:

You will be asked to conduct a routine point-to-point flight in a full motion "flight simulator" (Advanced Aircraft Training Device). The flight will take approximately 1 to 1.5 hours and will involve acquiring an IFR clearance, interaction with Air Traffic Control, manipulation of the appropriate aircraft controls, instruments and avionics, the interpretation of charts, and possible diversion to another destination with the associated revision of tasks. The entire session will require 2.5 to 3 hours including the flight and pre-flight planning and briefing. All of the operations will be **simulated only**, with the intent being an accurate duplication of a typical IFR flight. Your actual interaction will be **only** with the principal investigator listed above, and the flight is not a test that can be failed or academically graded in any way. Any errors you may make during the flight will be recorded for research purposes only, and will not be associated with you personally.

Risks of Participation:

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

Benefits:

Findings gleaned from this research, if any, may be used to improve instrument rating training and testing.

Confidentiality:

No record will be kept of your name. Identifying data such as gender, flight hours, scores on flight tests, etc. will be neither gathered nor maintained. Any reference in published research to your performance will refer to a randomly assigned code name (e.g., *"Pilot A"*). Observations noted during your performance will be compiled and kept in an electronic or paper format in a non-network accessible location (hard drive or paper records in possession of the principal investigator). The records will be kept only until the project is complete (projected completion August 2009) and will then be destroyed. During this time, only the principal investigator will have access to the records. **Additionally, you are requested to not discuss the "flight" in any way after its completion, as this could affect the performance of subsequent participants.**

Compensation:

One to one and one-half hours of loggable "flight time" will serve as compensation for your participation.

Contacts:

Principal Investigator Mark Uhlman, (580) 336-2118. For information on subjects' rights, contact Dr. Sheila Kennison, Institutional Review Board Chair, 219 Cordell North, irb@okstate.edu, (405) 744-1676.

Participant Rights:

Participation is voluntary and you can discontinue the research activity at any time without reprisal or penalty. There are no risks related to withdrawing from the activity. You cannot be involuntarily dismissed from the activity for any foreseeable reason.

Signatures:

I have read and fully understand the consent form. I sign it freely and voluntarily. A copy of this form has been given to me.

______________________________	____________________
Signature of Participant	Date

I certify that I have personally explained this document before requesting that the participant sign it.

______________________________ ____________________
Signature of Researcher Date

APPENDIX K

EXPLANATION OF *p*-VALUE GRADIENT

Explanation of *p*-value Gradient

A problem which plagued this study was the recurring inability to reject the null hypothesis. Not that the PI *wanted* to reject the null - an unbiased test was valued far higher - but there were times when it seemed like he *should*. For many of the tasks, there appeared to be an observable knowledge or skill difference between the experienced pre-test group pilots and the test group pilots that could not be “proven” by the data. At least, it could not be proven at the 95% confidence level (p=.05) that is commonly required in the social sciences (Creswell, 2002). Instead, performance differences suggested at the 70, 80, or even 90% confidence levels were frustratingly common, and conclusions of “thus, the null hypothesis is not rejected” accompanied many task summaries without, potentially, telling the whole story.

The problem was the small sample size. During the data collection phase of this project, potential participants who met the requirements of either the pre-test or test groups were in short supply, and all who were eligible were asked to participate. Most did. Still, the relatively small number of participants required a near-unanimous task failure of the test group set against a near-perfect score for the pre-test group to achieve the necessary 95% certainty of a difference between the two. To illustrate this mathematical constraint, consider the following example (which uses numbers which occurred often in the study):

Suppose all four of the pre-test group participants pass a task but six of the eleven test group participants do not. As duly (and repeatedly) reported in Chapter IV, this data set, when entered into the Fisher contingency tables at www.physics.csbsju.edu/stats/fisher.form.html, yields a *p*-value of .092. This *p*-value translates into a confidence level of 91%, well short of the required 95%. But had there been *twice as many* participants (in both groups) and their performance had yielded exactly the same pass/fail *ratio*, the *p*-value would be .007, which would allow us to reject the null hypothesis at a whopping 99.3% confidence level! And, while the *ratio* of passes to fails was eyebrow-raising throughout the study, the *statistical* results of the small sample size (and the required confidence level of 95%) repeatedly called for the rejection of the conclusion that there was a difference between the two groups.

Not surprisingly, the PI was frequently left with the "gut feeling" that the *objective* results said one thing, but the *subjective* results said something else. And, while any responsible researcher knows that he/she should publish the former and ignore the latter, researcher responsibility in this study seemed to require more. After all, the 95% confidence level is a social science construct, but this study only peripherally involves a social science. It is as much a study within the *technical* sciences, as the reader of Chapter V will likely agree. Indeed, it was often the technicalities of instrument flying - not human behavior - that caused problems for participants.

And *big* problems they were, as several pilots flew dangerously close to (or *in*to!) terrain or were unable to execute fundamental instrument pilot procedures. To be sure, some errors were bigger than others (and some consequences more grave) as indicated by the task values that accompany each task. Indeed, an effort was made to justify the assigned value of each task, and the task value rationalization is dutifully published in Chapter IV. Admittedly, these task values (as well as the rationales) are subjective, but it is hoped that the reader will agree that some instrument pilot tasks are simply more important than others, and that he/she will grant some latitude to the PI to assign values to them.

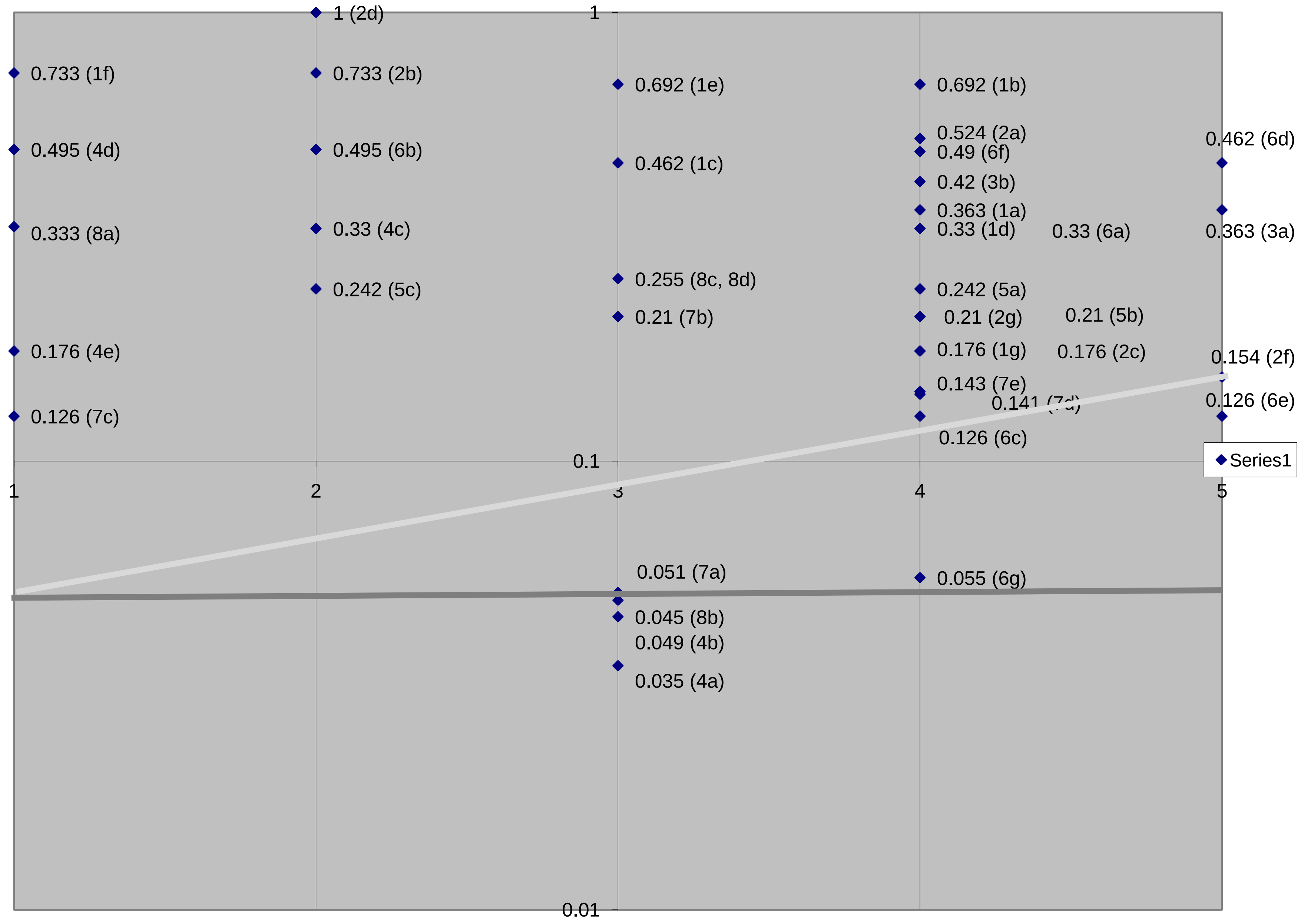
Ultimately, the PI decided that not only were task values relative, but that the 95% confidence threshold should be equally and proportionately so. His reasoning went like this: if it is to be concluded that certain tasks warrant a higher task value due to the potential consequences of doing them poorly, then surely the rigidity of the 95% confidence threshold should be equally, though inversely, proportional. In other words: the higher the task value, the greater the willingness to reject the null hypothesis at a lower confidence level.

The foregoing principal is illustrated in the accompanying graph (page 269). On this graph, the task values of 1 through 5 are arranged on the x-axis (horizontally). The data points on the y-axis (vertical) reflect overall participant scores as stated by the *p*-value (probability) for each task (remember that the lower the *p*-value numerical score, the greater the probability of a difference between the pre-test and test groups). The traditional social science probability threshold of 95% is illustrated by the horizontal grey line.

As one moves farther right on the graph, task values increase. Since, for reasons noted above, we are willing to reject the null hypothesis at a lower confidence level at these higher task values, the lighter diagonal line represents the modified confidence threshold at which the PI proposes that the null hypothesis be rejected. As can be seen, this line slopes from the 95% confidence level (p=.05) for tasks with a value of 1 to 85% (p=.15) for tasks with the highest task value of 5. Three task summaries that would otherwise have shown an insufficient difference to reject the null hypothesis have thus been modified to suggest otherwise, and this is duly noted in the text of the study. The astute reader of Chapters IV and V will likely agree, as the three tasks are: 2.f. “Complies with ATC instructions and airspace restrictions,” 6.e. “Selects, tunes, and identifies correct approach facilities,” and 6.g. “Missed approach at DH if visibility requirements not met,” all tasks that were, arguably, indicted by subjective research observations regardless of the *p*-value!

Exploring the graph further shows four general quadrants that illustrate both task significance and general participant ability. Data points biased towards the upper left corner are generally in the low importance/good performance region. Data points biased towards the upper right quadrant are in the high importance/good performance region, and data points biased towards the lower right are in the low importance/bad performance region. Notably, there was only one point in the lower right region and none in the lower left (low importance/bad performance). An overall visual summary of the graph shows that most points reflect reasonably good performance across the spectrum of task significance, which the PI finds heartening.

In summary, it should be noted yet again that the PI is fully aware that a graduated confidence threshold is definitely *not* the norm in quantitative research. It was employed in this project only after considerable deliberation, and only for the reasons noted above, which the PI deemed compelling. The PI is also aware that arguments could be made against both the assigned task values and their rationale, both of which are published in Chapter IV and/or the accompanying graph. It is hoped that the reader will grant some license to the PI to determine both, imperfect though they may be, for the greater good of improving instrument pilot training.



1 (2d)
1
0.733 (1f)
0.733 (2b)
0.692 (1e)
0.692 (1b)
0.524 (2a)
0.49 (6f)
0.462 (6d)
0.495 (4d)
0.495 (6b)
0.462 (1c)
0.42 (3b)
0.363 (1a)
0.33 (1d)
0.33 (6a)
0.363 (3a)
0.333 (8a)
0.33 (4c)
0.255 (8c, 8d)
0.242 (5c)
0.242 (5a)
0.21 (7b)
0.21 (2g)
0.21 (5b)
0.176 (4e)
0.176 (1g)
0.176 (2c)
0.154 (2f)
0.143 (7e)
0.141 (7d)
0.126 (6e)
0.126 (7c)
0.126 (6c)
0.1
Series1
1
2
3
4
5
0.051 (7a)
0.055 (6g)
0.045 (8b)
0.049 (4b)
0.035 (4a)
0.01

APPENDIX L

DEFINITION OF TERMS AND ACRONYMS

Definition of Terms and Acronyms Table

Abbreviation	**Name**	**Definition**
AATD	Advanced Aircraft Training Device	A *Flight Training Device* that has an interactive outside visual reference system and may have a force cueing system.
Actual	Actual Instrument Meteorological Conditions	Non-simulated meteorological conditions, such as clouds or fog, that require the pilot to control and navigate the aircraft with instrument references only.
ADF	Automatic Direction Finder	An instrument in an aircraft cockpit that receives and interprets signals broadcast from a *non-directional beacon* for the purpose of navigation or position verification.
ADM	Aeronautical Decision Making	A systematic approach to the mental process used by aircraft pilots to consistently determine the best course of action in response to a given set of circumstances.
	Advisory Circular	Printed and/or electronically disseminated non-regulatory aeronautical information and “best practices” procedures published by the FAA.
AGL	Above Ground Level	Height in feet above terrain.
AIM	Aeronautical Information Manual	A comprehensive manual published by the FAA providing definitions, explanations, and procedural guidance for many aeronautical terms and concepts. It is written in layman’s language, and is frequently published in conjunction with *Federal Aviation Regulations*, forming the *FAR/AIM.*
AIRMET	Airman’s Meteorological Information	A notice issued to pilots (either airborne or during preflight weather briefings)

		regarding weather meeting certain criteria that make it potentially hazardous to light aircraft, or aircraft having limited capability because of lack of equipment, instrumentation, or pilot qualifications.
Airway	Victor Airway	A charted route between, and defined by, *very high frequency* navigation facilities forming the basis of the IFR route structure. Victor Airways are assigned alphanumeric names, and will appear in this study as “V140,” “V532,” etc.
	Approach Control	A specific ATC function and/or facility that controls the movement of aircraft in flight in the vicinity of an airport through the use of radar observation and verbal commands, usually to facilitate the sequencing of aircraft inbound to an airport.
	Approach Lights	Any one of a combination of flashing or colored light configurations designed to distinguish the approach end of a runway to aid a pilot in the recognition of the landing environment.
ASOS	Automated Surface Observing System	An automated weather observation and reporting system that continually broadcasts local weather conditions on a dedicated frequency.
ATC	Air Traffic Control	A function of the national airspace system that sequences, separates, and controls the movement of aircraft, usually through controller observation and verbal instruction to pilots. “ATC” may also be a generic reference to any one of the specific ATC facilities that together constitute the air traffic control system, such as *Ground control*, *Tower*, *Center*, *Approach Control*, *Departure Control*, or *Clearance Delivery*.

ATIS	Automatic Terminal Information Service	The continuous broadcast of recorded non-control information in selected terminal areas. Its purpose is to improve controller effectiveness and to relieve frequency congestion by automating the repetitive transmission of essential but routine information.
	Aviation Safety Inspector	An employee of the FAA tasked with the oversight of specific aviation operators or operations. Among other tasks, certain Aviation Safety Inspectors may administer practical tests to airman applicants and provide oversight of designated pilot examiners.
CDI	Course Deviation Indicator	A component of the *VOR* indicator within the aircraft that shows relative lateral displacement from a selected course.
Center	Air Route Traffic control Center	A specific ATC facility that controls the movement of aircraft en route between terminal areas, usually through the use of radar observations and verbal commands.
CFI	Certified Flight Instructor	An airman certified to provide initial and recurrent flight training for certain grades of airman certification.
CFII	Certified Flight Instructor – Instrument	A Certified Flight Instructor who has earned an instrument rating on his/her instructor certificate, thereby earning the privilege to provide training towards instrument rating certification or currency.
Checkride	Practical Test	A knowledge and skill based test, including both an oral and demonstration component, that is administered by the FAA or an FAA delegate to an applicant for an airman certificate or rating.

	Clearance	An authorization to proceed under the stated limitations and/or instructions.
	Clearance Delivery	A specific ATC function and/or facility in a terminal area that serves to integrate other ATC functions by collecting certain flight information from pilots and “delivering” it to controllers, or delivering related information back to pilots in the form of clearances.
	Commercial Pilot Certificate	A grade of airman certification that allows the holder to act as PIC or crewmember for most for-hire aircraft operations. A Commercial certificate may be modified with ratings, such as instrument, multiengine, etc.
	Compass Locator	A *non-directional beacon* co-located with a *marker beacon* for the purpose of establishing position on an instrument approach. All Compass Locators are given 5-letter names, e.g. “*OILLR*,” “*BLAKI*,” etc.
	Control Tower	A specific ATC function and/or facility that controls the movement of aircraft in flight in the vicinity of an airport, usually within visible distance of the physical facility and usually through the use of observation and verbal commands.
	Cross Country	A flight in an aircraft involving different points of departure and arrival, a certified pilot, and some form of navigation. For training purposes in airplanes, cross country generally means a flight more than 50 nautical miles.
DA/DH	Decision Altitude/Decision Height	The indicated altitude at which, at the completion of an instrument approach, a pilot must decide whether or not to continue descent to the runway or

		execute a missed approach. The two terms are generally used synonymously and interchangeably, though they have specific reference to the publisher of the approach chart being used.
	Departure Control	A specific ATC function and/or facility that controls the movement of aircraft in flight in the vicinity of an airport through the use of radar observation and verbal commands, usually to facilitate the sequencing of aircraft outbound from an airport.
	Direct	In this study, "direct" refers to routing instructions in a clearance or flight plan. "Direct" usually means that following a charted route or airway is unnecessary.
DME	Distance Measuring Equipment	Equipment (airborne and ground) employing the timing of electronic transmissions used to measure the slant range distance of an aircraft from the DME station. DME stations are sometimes co-located with *VOR* stations creating VOR/DME's, and DME signals may also be received from *TACAN* stations, making VOR/DME's (for civilian pilots) synonymous with *VORTAC's*.
	Dual	As used in this study, an actual or simulated flight or training session involving an on-board instructor.
DUATS	Direct User Access Terminal Service	A weather information and flight plan processing service contracted by the FAA for use by pilots and other authorized users. The DUAT Service is a telephone- and Internet-based system which allows access to a database to obtain weather and aeronautical information and to file, amend, and cancel domestic flight plans.
EFC	Expect Further Clearance	A time stated in some clearances that

		informs a pilot of when to expect further instructions, or when to terminate or begin a procedure, particularly in the event of losing communication capability with *ATC*.
	En Route Low Altitude Chart	A published chart showing airways, navigation facilities, airports and related data to be used for en route aerial navigation under *Instrument Flight Rules*.
Examiner	Designated Pilot Examiner	A delegate of the FAA with authority to administer airman certification practical tests and to issue new certificates and/or ratings to successful test applicants.
FAA	Federal Aviation Administration	An agency of the United States government with oversight authority over domestic aviation regulation, certification, operation, and infrastructure.
FAR	Federal Aviation Regulation	Acronym for Federal Aviation Regulation, which is a reference to the more formal Title 14 of the Code of Federal Regulations or some element of its contents.
	File IFR	Refers to a pilot's intention to fly under instrument flight rules (as opposed to the more common visual flight rules), and the submission of the *IFR flight plan* to do so.
	Fix	A means of determining a "fixed" and identifiable point in space, and involves some type of navigation device as well as a charted or otherwise communicated identifiable point. Usually, multiple "fixes" are identified by the pilot while en route and during an instrument approach procedure.
FMS	Flight Management System	A computer system that uses a large data base to allow routes to be pre-

		programmed and fed into the system by means of a data loader. The system is constantly updated with respect to position accuracy by reference to various navigation aids.
FTD	Flight Training Device	A full-size replica of the instruments, equipment, panels, and controls of an aircraft including the hardware and software for the systems installed, that is necessary to simulate the aircraft in ground and flight operations that has been approved by the administrator for airman training.
FSS	Flight Service Station	A specific function and/or facility within the ATC system that primarily (1) collects flight plan information from pilots for the creation of ATC clearances, and (2) disseminates weather information both to pilots in flight and on the ground for flight planning purposes.
	Glideslope	A ground-based navigation device that projects an electronic signal (usually at a 3° angle) from the approach end of the runway for the purpose of providing vertical guidance to an aircraft on an instrument approach to that runway.
GPS	Global Positioning System	A satellite-based navigation system that employs timed electronically transmitted data to inform a pilot of position, speed, course or related and/or projected information. "GPS" may refer to the system or to the receiver in the cockpit.
	Ground Control	A specific *ATC* function and/or facility that controls the movement of aircraft and vehicles on the surface of an airport.
	Heading Bug	A movable marker on a heading indicator or *HSI* that is used to note a

		heading for future reference by the pilot.
	Hold	A maneuver performed in flight, usually consisting of an oval shaped track over the ground, which keeps an aircraft in a relatively small, isolated area. A hold is usually assigned to an aircraft as a delaying mechanism so that other events may transpire, e.g., improvement of the weather, *ATC* attention devoted to other traffic, etc.
	Hood	A view limiting device that is used to restrict outside visual references and to therefore simulate *IMC* for training, testing, and currency purposes.
HSI	Horizontal Situation Indicator	A commonly encountered navigation instrument that simultaneously displays heading, selected course, and deviation from course and glideslope.
	IBAAH	An intersection of *VOR* radials on a victor airway in the vicinity of Stillwater, Oklahoma.
IFR	Instrument Flight Rules	A comprehensive set of rules and procedures that pertain to flight without the adequate outside visual references necessary for navigation or aircraft control. "*IFR*" may also be a generalized description of a situation with cloud heights below 1,000' and visibility less than 3 miles.
	IFR Clearance	An authorization to proceed under instrument flight rules, issued in a standardized format including route, altitude, relevant frequencies, certain clearance limitations, and other information.
	IFR Flight Plan	A prescribed body of information including aircraft type, altitude, route, destination, on-board equipment, etc.

		that must be submitted by the pilot to *ATC* for approval or modification before flight under *IFR* may be authorized.
ILS	Instrument Landing System	A precision instrument approach system which consists of ground based navigation devices to provide lateral and vertical guidance, range information, and visual cues to a pilot descending to an airport. The components of an ILS normally include a *localizer, glideslope, marker beacons*, and *approach lights*. See individual listings under these headings.
IMC	Instrument Meteorological Conditions	Weather-related flight conditions that eliminate or seriously inhibit outside visual references.
	Instrument Approach	A charted procedure designed to guide an aircraft through the descent and approach to landing phase of flight, commonly employed during periods of reduced visibility and/or low clouds when a pilot cannot navigate with outside visual references.
	Instrument Rating	A legal authorization, in the form of a printed "rating" on an airman certificate, for a pilot to operate an aircraft under *IFR* with or without outside visual references.
	Intersection	As used in this study, the intersection of *VOR* radials that has been charted for the purpose of establishing an identifiable, fixed position, usually on an airway.
	KEVIL	An intersection of *VOR* radials on a victor airway in the vicinity of Tulsa, Oklahoma.
	KTUL	The alpha-numeric code assigned to the Tulsa International Airport. Similar

		codes are assigned to all airports and are commonly used in avionics databases and FAA publications.
	Knowledge Test	A computer based, knowledge-only test administered by the FAA through its computer test center delegates. Most grades of airman certification and rating require a passing grade on a knowledge test as a prerequisite for certification.
LDA	Localizer-Type Directional Aid	An instrument approach that employs a *localizer* that is not aligned with a runway, requiring a pilot to maneuver to land after the completion of the instrument approach procedure.
	Localizer	A ground-based navigation device that projects an electronic signal, usually for the purpose of providing lateral guidance to an aircraft on an instrument approach to a runway aligned with the Localizer.
LOM	Locator Outer Marker	A *marker beacon* co-located with an *NDB* and situated along an approach course at the outer maker position.
	Marker Beacon	A ground-based navigation device employed in an instrument approach procedure. It transmits an elliptical beam vertically that triggers a device within the aircraft to alert the pilot, through a colored light and audible signal, of the aircraft's location along the approach course.
	Missed Approach	A charted procedure consisting of route, altitude, and other information to employ in the event that, at the completion of the final segment of an instrument approach, due to either weather, pilot error, or other circumstances, the aircraft is not in a position for continued descent and subsequent landing.

MSL	Mean Sea Level	Elevation in feet relative to the average sea level datum.
NAVCOM	Navigation/Communication Radio	An aviation specific, combination navigation and communication radio that operates within the very high frequency band width.
NDB	Non-directional Beacon	A ground-based navigational device transmitting an electronic signal through 360° for the purpose of navigation or establishing position. A non-directional beacon is sometimes co-located with a marker beacon to form a *Compass Locator*, and is used to establish position on an instrument approach.
NOTAM	Notice to Airmen	An information dissemination process used by the FAA to inform pilots and crew members of non-charted regulatory and/or advisory information pertaining to a flight, i.e. runway closures, change in charted altitudes, etc. Notices to Airmen are published electronically and on paper, and are routinely disseminated by *FSS* specialists during weather briefings.
OBS	Omni Bearing Selector	A component of the *VOR* indicator within the aircraft that may be manipulated to align the instrument with a desired course.
	OILLR	A specific *compass locator* in the vicinity of the Tulsa International airport.
PIC	Pilot-In-Command	An on-board aircraft crewmember exercising control over its operation, or a crew member otherwise meeting the legal definition of "pilot-in-command." In this study, it refers to the on-board crewmember with sole and/or ultimate operating authority of a flight.

	Private Pilot Certificate	A grade of airman certification that allows the holder to act as *PIC* or crewmember during non-commercial aircraft operations. A private certificate may be modified with ratings, such as instrument, multiengine, etc.
PTS	Practical Test Standards	Within the context of this study, the Practical Test Standards are a publication of the FAA, available in both paper and electronic format, that outline the content, minimum completion standards, and conduct of practical tests. Specific Practical Test Standards are published for each of the various grades and relevant ratings of airman certification.
	Radar	As used in this study, a device that provides graphic location, positive identification, and other information to *ATC* for the purpose of sequencing and separation of aircraft.
	Reverse Needle Sensing	As used in this study, a condition caused by incorrectly setting a *VHF* navigation instrument in which the depicted position from a selected course appears to be exactly opposite the actual position. Reverse needle sensing is a common cause of pilot confusion.
RNAV	Area Navigation	A method of navigation which permits en route or approach operations on any charted or approved flight path by means of electronic signals "interpreted" by area navigation equipment within the aircraft. Area Navigation is commonly understood to mean that circuitous en route navigation is unnecessary.
	SEARS	An intersection of *VOR* radials on a *victor airway* in the vicinity of Tulsa, Oklahoma.

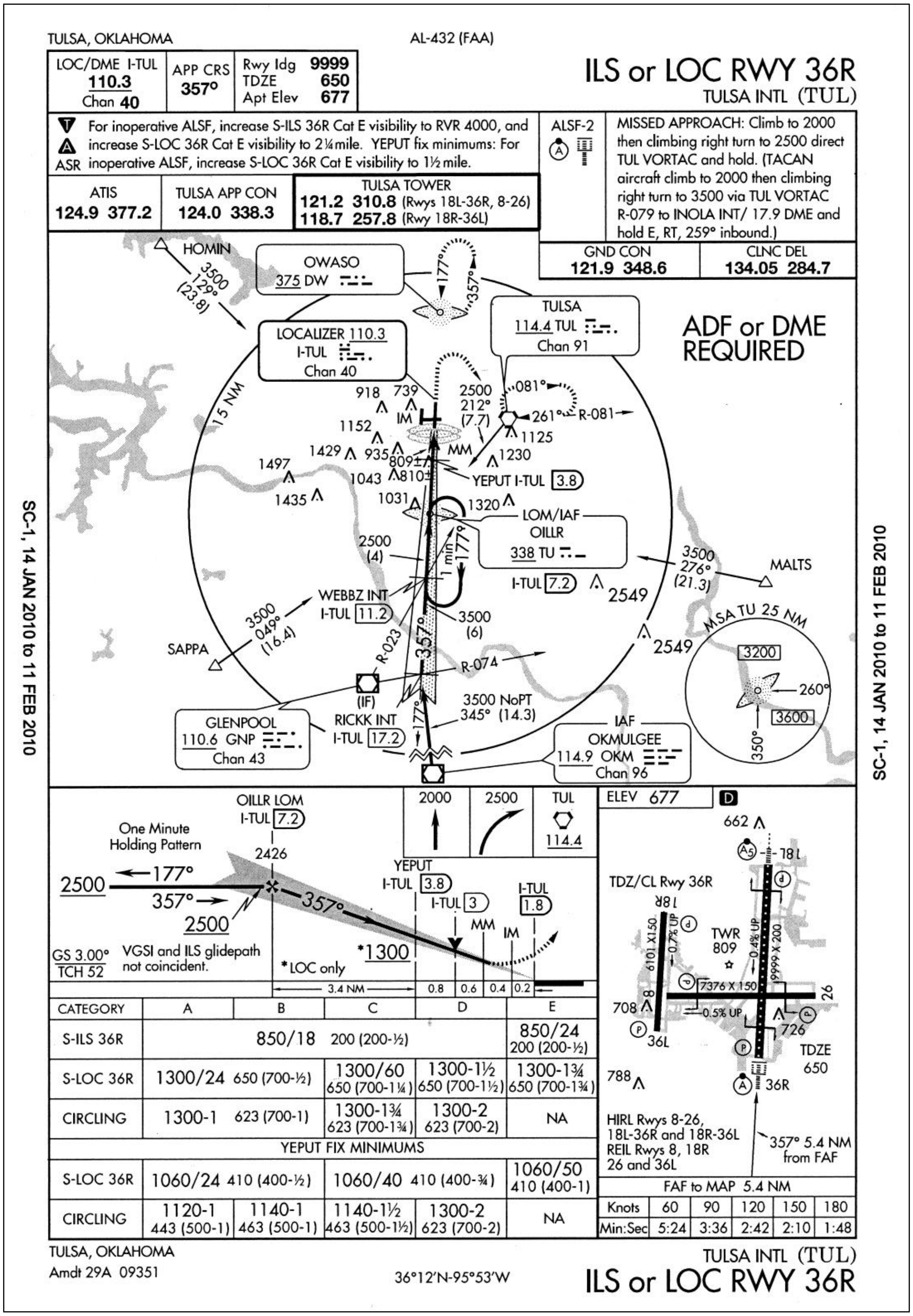
	Sequenced Flashing Lights	Any of a series of approach light configurations using ground-based fixed lights flashing in a sequence that "leads" a pilot's attention, particularly in reduced visibility, to the runway threshold.
	Simulated IFR	The simulation of flight conditions that artificially restrict, usually with the use of a view limiting device, outside visual references for training and/or testing purposes.
STAR	Standard Terminal Arrival Route	A published chart and/or procedure showing routing, navigation facilities, airports and related data to be used for terminal area aerial navigation under *Instrument Flight Rules*.
SWO	Stillwater VOR	A *VOR* in the Stillwater, Oklahoma area.
	Title 14 of the Code of Federal Regulations	The FAA's repository of regulations pertaining to the oversight of domestic aviation. The regulations are organized into "parts" according to that part of the aviation infrastructure to which they pertain. The parts that will be referenced in this study include: Part 61- Certification: Pilots, Flight Instructors, and Ground Instructors. Part 91- General Operating and Flight Rules. Part 141- Pilot schools.
	Transponder	A device in an aircraft that replies to radar interrogation with an enhanced signal. The signal normally includes an assigned code and other information for the purpose of informing ATC of the aircraft's location and altitude.
TDZE	Touchdown Zone Elevation	The elevation above mean sea level of the highest point of the first 3,000' of the landing runway.

TFR	Temporary Flight Restriction	Charted or uncharted airspace that is not usable for civil air navigation, frequently for national security reasons. TFR’s have generally become more prominent and restrictive post-911.
Vector	Radar Vector	Guidance provided to a pilot by ATC through the use of radar depiction and verbal commands. Radar vectors are commonly provided to a pilot in lieu of pilot-based navigation.
VFR	Visual Flight Rules	A comprehensive set of rules and procedures that may be used when weather conditions permit the use of outside visual references.
VHF	Very High Frequency	The radio frequency range from 30 MHz to 300 MHz, of which a select band width (108-137 MHz) is reserved for aviation communications and navigation.
VMC	Visual Meteorological Conditions	Weather-related flight conditions that permit flight under *VFR*. For certain applications, a generalized assessment of weather conditions better than 5 miles visibility and 3,000’ ceiling.
VOR	Very High Frequency Omni-directional Radio Range	A ground-based electronic navigation aid transmitting navigation signals through 360° oriented to magnetic north. Used as the basis for navigation in the National Airspace System, and therefore figuring prominently in the charting and flying of *IFR* airways, approaches, and other procedures.
VORTAC	Very High Frequency Omni-directional Radio Range/Tactical Air Navigation	A ground-based navigation device combining a *VOR* and a TACAN (Tactical Air Navigation). TACAN is an ultra high frequency device with little civilian application other than *DME*. Therefore, for the purpose of this study, VOR and VORTAC may be assumed by the reader to be

		synonymous.
Written	Knowledge Test	A computer-based knowledge test administered by a delegate of the FAA which must be satisfactorily passed for eligibility for certain airman certificates and/or ratings.
	YARNS	An intersection of *VOR* radials on a *victor airway* in the vicinity of Stillwater, Oklahoma.

APPENDIX M

TULSA ILS36R APPROACH CHART



TULSA, OKLAHOMA

AL-432 (FAA)

SC-1, 14 JAN 2010 to 11 FEB 2010

LOC/DME I-TUL	APP CRS	Rwy Idg **9999**
110.3 Chan **40**	**357°**	TDZE **650** Apt Elev **677**

ILS or LOC RWY 36R

TULSA INTL (TUL)

For inoperative ALSF, increase S-ILS 36R Cat E visibility to RVR 4000, and increase S-LOC 36R Cat E visibility to 2¼ mile. YEPUT fix minimums: For inoperative ALSF, increase S-LOC 36R Cat E visibility to 1½ mile.

ASR

ALSF-2

MISSED APPROACH: Climb to 2000 then climbing right turn to 2500 direct TUL VORTAC and hold. (TACAN aircraft climb to 2000 then climbing right turn to 3500 via TUL VORTAC R-079 to INOLA INT/ 17.9 DME and hold E, RT, 259° inbound.)

ATIS	TULSA APP CON	TULSA TOWER	GND CON	CLNC DEL
124.9 377.2	**124.0 338.3**	**121.2 310.8** (Rwys 18L-36R, 8-26) **118.7 257.8** (Rwy 18R-36L)	**121.9 348.6**	**134.05 284.7**

ADF or DME REQUIRED

GS 3.00°
TCH 52

VGSI and ILS glidepath not coincident.

*LOC only

CATEGORY	A	B	C	D	E
S-ILS 36R	850/18 200 (200-½)				850/24 200 (200-½)
S-LOC 36R	1300/24 650 (700-½)		1300/60 650 (700-1¼)	1300-1½ 650 (700-1½)	1300-1¾ 650 (700-1¾)
CIRCLING	1300-1 623 (700-1)		1300-1¾ 623 (700-1¾)	1300-2 623 (700-2)	NA
YEPUT FIX MINIMUMS					
S-LOC 36R	1060/24 410 (400-½)		1060/40 410 (400-¾)		1060/50 410 (400-1)
CIRCLING	1120-1 443 (500-1)	1140-1 463 (500-1)	1140-1½ 463 (500-1½)	1300-2 623 (700-2)	NA

HIRL Rwys 8-26,
18L-36R and 18R-36L
REIL Rwys 8, 18R
26 and 36L

FAF to MAP 5.4 NM

Knots	60	90	120	150	180
Min:Sec	5:24	3:36	2:42	2:10	1:48

TULSA, OKLAHOMA
Amdt 29A 09351

36°12′N-95°53′W

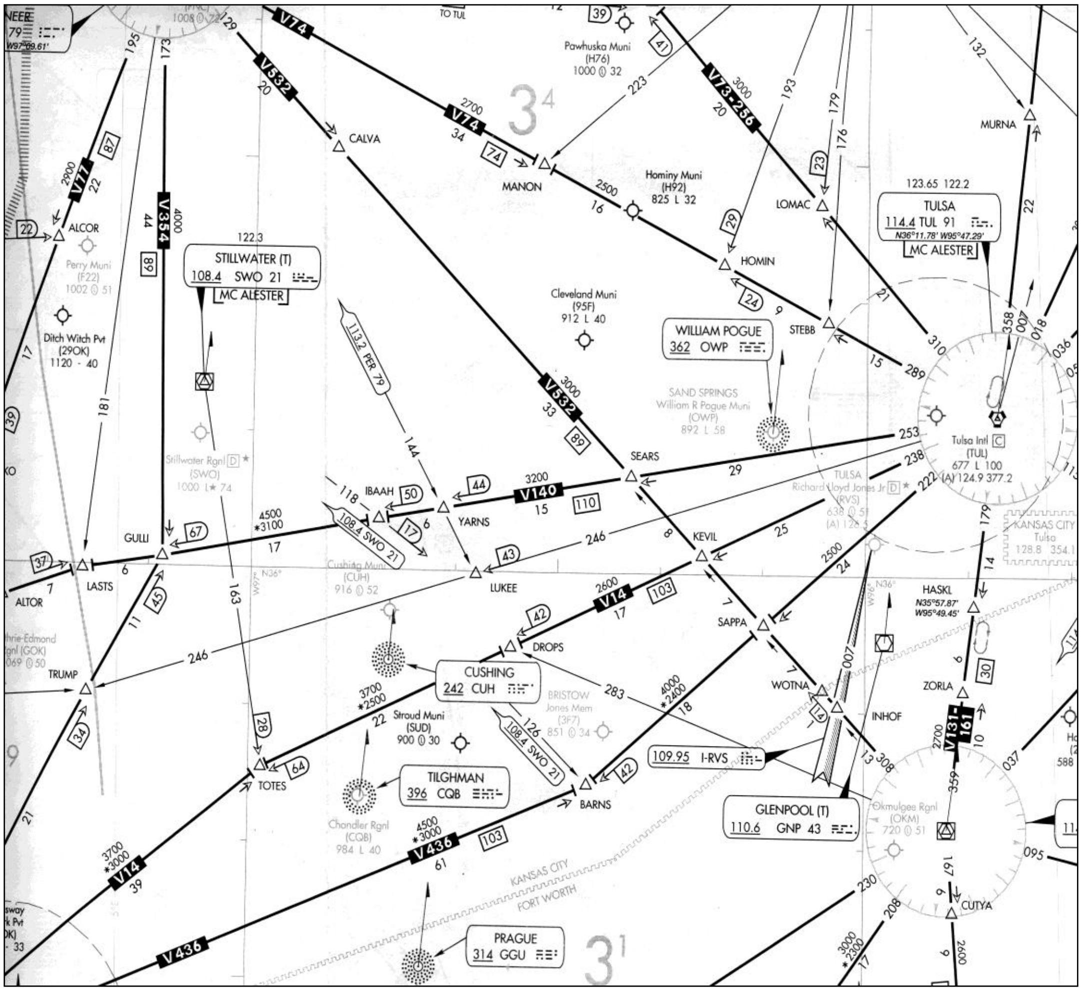
TULSA INTL (TUL)

ILS or LOC RWY 36R

SC-1, 14 JAN 2010 to 11 FEB 2010

APPENDIX N

EN ROUTE CHART EXCERPT


V74
V532
CALVA
MANON
Pawhuska Muni
(H76)
1000 L 32
Hominy Muni
(H92)
825 L 32
V73-256
LOMAC
MURNA
TULSA
123.65 122.2
114.4 TUL 91
N36°11.78' W95°47.29'
MC ALESTER
HOMIN
STEBB
Cleveland Muni
(95F)
912 L 40
WILLIAM POGUE
362 OWP
SAND SPRINGS
William R Pogue Muni
(OWP)
892 L 58
Tulsa Intl C
(TUL)
677 L 100
(A) 124.9 377.2
TULSA
Richard Lloyd Jones Jr
(RVS)
KANSAS CITY
Tulsa
128.8 354.1
V77
ALCOR
Perry Muni
(F22)
1002 L 51
Ditch Witch Pvt
(29OK)
1120 - 40
V354
STILLWATER (T)
122.3
108.4 SWO 21
MC ALESTER
Stillwater Rgnl D
(SWO)
1000 L 74
113.2 PER 79
IBAAH
YARNS
SEARS
V140
KEVIL
GULLI
LASTS
ALTOR
108.4 SWO 21
LUKEE
Cushing Muni
(CUH)
916 L 52
V14
DROPS
SAPPA
HASKL
N35°57.87'
W95°49.45'
TRUMP
CUSHING
242 CUH
BRISTOW
Jones Mem
(3F7)
851 L 34
Stroud Muni
(SUD)
900 L 30
108.4 SWO 21
WOTNA
INHOF
ZORLA
V131-161
109.95 I-RVS
TOTES
TILGHMAN
396 CQB
Chandler Rgnl
(CQB)
984 L 40
BARNS
GLENPOOL (T)
110.6 GNP 43
Okmulgee Rgnl
(OKM)
720 L 51
V436
KANSAS CITY
FORT WORTH
PRAGUE
314 GGU
CUTYA
3⁴
3¹

VITA

Mark Stephen Uhlman

Candidate for the Degree of

Doctor of Education

Dissertation: SCENARIO-BASED EVALUATION OF THE SKILLS OF NEWLY CERTIFICATED INSTRUMENT PILOTS

Major Field: Applied Educational Studies

Biographical:

Personal Data: Born in Wichita, Kansas, on February 12, 1964, the son of Virgil and Joy Uhlman.

Education: Graduated from Circle High School, Towanda, Kansas in May, 1982; received Bachelor of Science degree in Bible from Oklahoma Christian University of Science and Arts in April, 1986. Earned airman certificates and ratings from Spartan School of Aeronautics, Tulsa, Oklahoma in 1991. Received Masters of Science Degree in Applied Educational Studies from Oklahoma State University in December, 2003. Completed the requirements for a Doctor of Education degree in Applied Educational Studies with an emphasis in Aviation and Space Education at Oklahoma State University, Stillwater, Oklahoma in May, 2010.

Experience: Employed as associate minister in Chouteau, Oklahoma 1986 to 1990. Employed as flight instructor and corporate pilot by Mid-America Aircraft Sales and Service, Tulsa, Oklahoma 1991 to 1992. Employed as minister in Perry, Oklahoma 1992 to 1999. Employed as aerial patrol pilot in Guthrie, Oklahoma 1997 to 1998. Employed as training coordinator by Charles Machine Works in Perry, Oklahoma 1999 to 2001. Employed by Oklahoma State University as flight instructor from 2001 to 2003, Assistant Chief Flight Instructor from 2003 to 2007, and Chief Flight Instructor from 2008 to present.

Professional Memberships: National Association of Flight Instructors, Aircraft Owners and Pilots Association, Oklahoma Area Flight Instructors Association, Federal Aviation Administration FAAst Team.

Name: Mark Stephen Uhlman Date of Degree: May, 2010

Institution: Oklahoma State University Location: Stillwater, Oklahoma

Title of Study: SCENANIO-BASED EVALUATION OF NEWLY- CERTIFICATED INSTRUMENT PILOTS

Pages in Study: 291 Candidate for the Degree of Doctor of Education

Major Field: Applied Educational Studies Aviation and Space Science

Scope and Method of Study: The purpose of this study was to determine the efficacy of airman instrument rating training and testing. Using a scenario-based "flight" in a flight simulator, newly rated instrument pilots were tasked with completing an IFR flight involving realistic instrument pilot tasks. Task importance and pilot performance were both considered in the analysis of the data.

Findings and Conclusions: The results of the study indicate that instrument pilot training involves too much artificiality and not enough real-world experience. Specific tasks that proved under-practiced by new instrument pilots include the execution of IFR clearances, and elements of holds and instrument approaches. It was concluded that the current instrument training paradigm should be modified to include more practice on certain instrument pilot competencies, particularly the execution of clearances involving federal airways, unfamiliar holding procedures, and go/no go decision making at approach minimums.

ADVISER'S APPROVAL: Dr. Steven Marks