A SURVEY OF SPATIAL DISORIENTATION TRAINING

AT FAR PART 141 CERTIFICATED SCHOOLS

FOR AIRPLANE CATEGORY

By

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CHAPTER I

INTRODUCTION

Wilbur Wright won the coin toss with his brother Orville and climbed behind the controls of the Wright Flyer on December 14, 1903 with almost tragic results. The flying machine stalled and hit the ground immediately after take off. However, three days later after making repairs the Wright brothers were again poised to forge history. Wilbur and Orville's flight on December 17, 1903 was the logical progression of previous research conducted with balloons, gliders, and power gliders (Bilstein, 1984). Humankind has dreamed of flight from the beginning of recorded time. "From the winged deities of ancient Egypt, to the Greek legend of Icarus, to German Valkyries, to a score of other myths, themes of flight occur again and again" (Bilstein, 1984, p. 4). The Montgolfier brothers and the Charles brothers pioneered hot air and hydrogen filled balloons in the late 1700s. Otto Lilienthal, a German inventor, invented a glider using bird flight as a model. In 1896 Samuel Langley designed and built pilotless mechanically propelled heavier-than-air machines. Sadly, Langley was unsuccessful in his lifelong attempt to perfect a powered airplane piloted by a human (Bilstein, 1994). The Wright brothers subsequently introduced the human element to the mechanically propelled heavier-than-air machines and provided the foundation for the extraordinary advancement of human flight that has marked the twentieth century.

Notwithstanding the great achievements in aviation, the path to progress has been laden with peril. Human limitations to the new flight environment quickly came to the fore as an area of concern. One of the first problems aeronauts discovered dealt with the reduction in the partial pressure of oxygen at increased altitudes. In 1804 a hydrogen filled balloon took three Italian airmen to a height of 23,000 feet. All three lost consciousness (Conway, 1995). Subsequent balloon flights took two aeronauts to an altitude of 34,000 feet. Both men experienced multiple physiological problems including cyanosis, blurred vision, and extreme fatigue (Conway, 1995). Paul Bert, a physiologist and physician, was a pioneer in human factors research. To facilitate his research he designed and constructed the first hypobaric chamber to test the effects of the human body to reduced atmospheric pressures (Conway 1995). Since the nineteenth century multiple human limitations to the flight environment have been identified.. Examples of human limitations to the flight environment include: hypoxia, hyperventilation, fatigue, jet lag, alcohol and other drug effects at the reduced pressure of altitude, the ergonomic layout of cockpit design, and spatial disorientation (Hawkins, 1993, Del Vecchio, 1977).

In 1926 Major William Ocker first discovered the problem of pilots losing their orientation with the earth during flight (Cheung, Money, Wright, & Bateman, 1995). The problem studied by Major Ocker in 1926 is known today as spatial disorientation.

> The evolution of humans saw them develop over millions of years as aquatic, terrestrial, and even arboreal creatures, but never aerial ones. In this development, humans subjected themselves to and were subjected to many different varieties of transient motions, but not to the relatively sustained linear and angular accelerations commonly experienced in aviation. As a result, we acquired sensory systems well suited for maneuvering under our own power on the surface of the earth but poorly

> suited for flying. Even the birds, whose primary mode of locomotion is flying, are unable to maintain spatial disorientation and fly safely when deprived of vision by fog or clouds. Only bats seem to have developed the ability to fly without vision, and then only by replacing vision with auditory echolocation. Considering our phylogenetic heritage, it should come as no surprise that our sudden entry into the aerial environment resulted in a mismatch between the orientational demands of the new environment and our innate ability to orient. The manifestation of this mismatch is spatial disorientation (Armstrong Laboratory, Gillingham, Undated, p. 2).

When pilots are unable to correctly perceive the position, attitude, and motion of an aircraft in relation to the earth's surface they are experiencing spatial disorientation. Primarily, spatial disorientation is the result of false perceptions of the visual and vestibular systems. However, additional human senses can impact a person's ability to orient oneself. These additional senses include: muscle and tendon senses, joint sensation, cutaneous exteroceptors, and auditory orientation (Gillingham & Wolfe, 1986; Jaslow, 1998). In the intervening 62 years since Major Ocker identified spatial disorientation as a human limitation in flight numerous accidents have been attributed to this phenomenon. Gillingham and Previc (1993), Collins, Hasbrook, Lennon, and Gay (1977), Ensting and King (1994), Del Vecchio (1977), and Jaslow (1998) have concluded that spatial disorientation in pilots is a potential and verified source of aircraft accidents.

Accidents

Kirkham, Collins, Grape, Simpson, and Wallace (1978) reported that between 1968 to 1975 there were 888 general aviation accidents attributed to spatial disorientation by the National Transportation Safety Board (NTSB) with the majority

(883) citing spatial disorientation as a cause. Particularly disturbing were the fatalities that resulted from spatial disorientation accidents. In 1970 spatial disorientation accidents accounted for only 2.4 percent of general aviation accidents yet resulted in 14.9 percent of all fatal accidents. The results were similar for 1971 through 1975 (Kirkham, et al. 1978). Collins and Dollar (1996) reported that between 1976 and 1992 the NTSB detailed 1022 general aviation accidents resulting from spatial disorientation as either a cause or factor. The majority of these accidents (947) listed spatial disorientation as the cause of the accident.

Fortunately the number of general aviation spatial disorientation accidents reported by the NTSB have been decreasing annually (Collins & Dollar, 1996). The decrease has been accompanied by a corresponding reduction in general aviation hours flown. It remains unclear whether the reduction in spatial disorientation accidents is the result of spatial disorientation training, the increased number of pilots with instrument ratings, the reduction of hours flown, or reporting inconsistency by the NTSB.

Another potential source of spatial disorientation accidents may be disguised under the term controlled flight into terrain (CFIT). Hughes (1995) noted that of the 179 CFIT accidents involving civil transports since 1959, only 13 have occurred during day visual meteorological conditions. The remaining 167 have occurred in instrument conditions, night, or dusk, prime conditions for spatial disorientation. Hughes (1995) reported some CFIT accidents occurred during "black hole" approaches at night. Gillingham and Previc (1993) state that without peripheral visual cues, black hole approaches are difficult and potentially dangerous because the illusions result in spatial disorientation. Scott (1996) reported that 9000 fatalities have been attributed to CFIT since jet operations began in the late 1950s. Scott (1996) further reported that CFIT remains the dominant factor of aircraft hull losses and fatalities. Although many factors can result in CFIT, spatial disorientation should be a prime consideration. Scott (1996) cited a study conducted by Khala and Roelow of CFIT fatal accidents from 1988 to 1994. Loss of situational awareness, lack of ground proximity warning systems, and procedural and decision making errors by pilots dominated these accidents. Loss of situational awareness under conditions of limited visibility can be the resultant effect of spatial disorientation. The majority of the accidents (167) described by Hughes (1995) occurred during limited visibility conditions.

The military has traditionally taken a human factors approach to accident investigation. Bellenkes, Bason, and Yacavone (1992) reported that between 1980 through 1989 five percent of the total Class A mishaps in the United States Navy occurred from spatial disorientation. The United States Air Force reported that from 1980 through 1986 approximately 13 percent of accidents and 14 percent of fatalities resulted from spatial disorientation. Interestingly, not all of the spatial disorientation accidents were the result of extreme attitudes flown by fighter or attack aircraft. Forty percent of the Class A spatial disorientation mishaps from 1980 through 1986 occurred in other than fighter or attack aircraft (AFMAN 11-217, Volume 1, 1996). One possible solution to minimize the effects of spatial disorientation, thus preventing accidents, is to conduct specifically designed training for pilots on this subject.

Training

Spatial disorientation accidents may be minimized by improved aircraft equipment design and improved pilot training. Gillingham and Previc (1993) reported that additional ground-based training and inflight spatial disorientation awareness training should be developed. Kirkham, et al. (1978) recommended that lectures on spatial disorientation be given at all flight schools, that ground-based demonstrations of spatial disorientation be utilized, and that inflight demonstrations be incorporated into pilot training.

A review of military and civilian training relating to spatial disorientation will follow. For a complete review of military pilot training requirements refer to United States Air Force (USAF) T-37 Joint Specialized Undergraduate Pilot Training syllabus P-V4A-A (1997). Refer to the Federal Aviation Regulations (FARs), particularly FAR part 61 and FAR part 141 for civilian pilot training requirements.

Military Pilot Training

The United States Air Force has conducted extensive research at the Armstrong Laboratory to understand the mechanisms of spatial disorientation in an attempt to develop effective countermeasures against the phenomena. As a result of their research, the United States Air Force incorporates ground based lectures, demonstrations using ground based trainers, and inflight demonstrations into spatial disorientation training. The military approach closely approximates the recommendations of the Civil Aeromedical Institute (Kirkham, et al. 1978). Joint Specialized Undergraduate Pilot

Training (USAF, P-V4A-A syllabus, 1997) trains pilots for the United States Air Force, the United States Navy, and the United States Marine Corps. Nascent military pilots are given specialized training in aerospace physiology. Two hours are dedicated to vision including daytime visual illusions and nighttime visual illusions that can lead to spatial disorientation. An additional two hour block of instruction is dedicated specifically to spatial disorientation during which visual, vestibular, somatosensory, and auditory disagreements that result in disorientation are discussed. In conjunction with the lecture, a ground-based spatial disorientation trainer is used to induce spatial disorientation. The vista vertagon, barany chair, or the advanced spatial disorientation demonstrator are used as ground based spatial disorientation trainers (USAF, P-V4A-A-C-JP-SG, 1998). Inflight demonstrations are conducted in accordance with the flying training syllabus (USAF, P-V4A-A syllabus, 1997).

Additional training on spatial disorientation is provided on a continuing basis throughout an Air Force pilot's flying career. A day long instrument refresher course is required on a recurring basis, approximately once every 18 months. Spatial disorientation is a required topic for the instrument refresher course (AFMAN 11-220, 1996).

Special emphasis on spatial disorientation training for military pilots is twofold. One, military pilots often operate at extreme attitudes which put the pilots at risk for spatial disorientation. And two, the military assumes that student pilots have had no previous training in spatial disorientation. The military has traditionally used an ab initio ("from the beginning") approach to training pilots. A prospective pilot with little or no flying time is subjected to an intensive flying training program and upon completion is transformed into an operational pilot in systems as complex as the F-15, F-16, etc. This process is expensive and time consuming requiring more than two years.

Although used by foreign carriers, e.g. Lufthansa, ab initio training has not been adopted by United States air carriers (Hansen & Oster, 1977). United States air carriers have traditionally opted for pilots that have paid for their own flying training. A surplus of pilot applicants has allowed United States air carriers to seriously consider pilots for employment only after they have acquired the requisite flying experience. Historically, the majority of pilots hired by the airlines in the United States had received their training from the military (Hansen & Oster, 1997). In the post cold-war era, civilian pilot training is now the primary source of pilots for the airlines (Hansen & Oster, 1997).

Civilian Pilot Training

Civilian flying training in the United States is primarily governed by FAR part 61 or FAR part 141 as applicable. If initial training is not conducted using FAR part 61 guidance then training will be conducted using the guidance in FAR part 141.

The general aviation pilot uses a building block approach to flying training. Typical progression includes achieving a private pilot certificate, a commercial pilot certificate, an instrument rating, and a flight instructor certificate. Additional certificates may be added for the professionally oriented pilot. FAR part 61 lists the requirements for certification for the private pilot certificate, commercial pilot certificate, instrument rating, and flight instructor certificate.

FAR part 61 requires that students desiring a private pilot certificate for an airplane category with a single-engine class rating receive and acquire ground training from an authorized instructor or complete a home study course on the aeronautical knowledge areas required by FAR part 61.105. The aeronautical knowledge areas required are: federal aviation regulations, accident reporting requirements, the Aeronautical Information Manual and Federal Aviation Administration (FAA) advisory circulars, use of aeronautical charts, radio communication procedures, use of aeronautical weather reports and forecasts, safe and efficient operation of aircraft to include collision and wake turbulence avoidance, effects of density altitude on takeoff and climb performance, weight and balance computations, principles of aerodynamics, powerplants and aircraft systems, stall and spin awareness, aeronautical decision making and judgment, and preflight operations. Aeromedical factors, which includes spatial disorientation, are not specifically listed but are included under areas that are listed, specifically the Aeronautical Information Manual and FAA advisory circulars. Additionally, candidates for a private pilot certificate must pass a computer based pilot knowledge examination. The examination consists of 60 multiple-choice questions selected from 713 questions in the FAA's private pilot knowledge test bank (Gleim, 1998). The student must answer 70 percent of the questions correctly to achieve a passing score. Spatial disorientation is not ignored, but is relegated to a low priority on the pilot knowledge examination administered for the private pilot certificate. Only 15 of the 713 questions are allocated for all seven categories comprising aeromedical factors and only four questions specifically address spatial disorientation (Gleim, 1998). Table 1 identifies the number of FAA questions per knowledge area for the private pilot certificate. In addition to a knowledge base, the private pilot candidate must develop requisite flying skills.

TABLE 1

NUMBER OF FAA QUESTIONS PER KNOWLEDGE AREA FOR PRIVATE PILOT

Chapter	# of Questions	Knowledge Areas
1	35	Airplanes and Aerodynamics
2	77	Airplane Instruments, Engines, and Systems
3	83	Airports, Air Traffic Control (ATC), and Airspace
4	184	Federal Aviation Regulations
5	57	Airplane Performance and Weight and Balance
6	15	Aeromedical Factors
	(4)	(Spatial Disorientation)
7	56	Aviation Weather
8	73	Aviation Weather Services
9	58	Navigation: Charts, Publications, Flight Computers
10	29	Radio Navigation
11	46	Cross-Country Flying
	713	Total Questions

Note: As organized by Gleim, 1998

The person striving for their private pilot certificate must log a minimum of 40 hours flight time that includes at least 20 hours of instruction from an FAA authorized flight instructor. Part of the 20 hours of dual instruction must include 3 hours of flight training in a single-engine airplane on the control and maneuvering of an airplane solely by reference to instruments and 3 hours of night flight training (exceptions can be made to the night requirement). The instrument and night training contribute to the development of skills that enable the pilot to successfully negotiate a spatial disorientation incident. General aviation pilots without an instrument rating flying into instruments conditions can encounter spatial disorientation and this has been a continuing source of accidents (Kirkham, et al. 1978).

Upon completion of the required ground and flying training for the private pilot certificate, the student pilot must successfully complete a practical test administered by an FAA inspector or designated pilot examiner. The practical test consists of both an oral and flight examination. The FAA inspector or designated pilot examiner uses practical test standards published by the FAA to administer the practical test. The practical test standards for the private pilot certificate require that an evaluator determine adequate knowledge of aeromedical factors (FAA-S-8081-14S, 1997). To assess a student's knowledge of aeromedical factors, the student pilot must explain the symptoms, causes, effects, and corrective actions of at least three from a taxonomy of seven categories of aeromedical factors of which one is spatial disorientation. The seven categories of aeromedical factors listed in the practical test standards for private pilot include: hypoxia, hyperventilation, middle ear and sinus problems, spatial disorientation, motion sickness, carbon monoxide poisoning, and stress and fatigue.

The training for the commercial pilot certificate, instrument rating, and flight instructor certificate are similar to that for the private pilot certificate. Each certificate or rating requires a multiple-choice knowledge test, flight training from qualified instructors, and a practical test administered by a FAA inspector or designated pilot examiner. As with the private pilot knowledge examination, the questions on spatial disorientation are limited in scope. With a passing score of 70 % for the knowledge test, a person could pass the examination with little or no preparation in knowledge areas with a limited number of questions such as aeromedical factors.

The knowledge examination for the commercial pilot certificate consists of a 100 question multiple-choice test from a test bank of 565 questions (Gleim, 1997). Only nine of the 565 questions are targeted to aeromedical factors and just one of the nine aeromedical factor questions is on spatial disorientation. The knowledge examination for instrument pilot consists of 60 multiple-choice questions selected from a test bank of 900 airplane related questions (Gleim, 1997). Eighteen of the 900 question are targeted toward aeromedical factors. However, on the instrument pilot exam, 10 of the 18 aeromedical factors questions are spatial disorientation questions. The knowledge examination for flight instructor consists of a 100 multiple-choice questions from a test bank of 833 questions. Twenty three questions target aeromedical factors with only four spatial disorientation questions. Tables 2, 3, and 4 identify the number of FAA questions per knowledge area for the commercial certificate, instrument rating, and flight instructor certificate.

TABLE 2

NUMBER OF FAA QUESTIONS PER KNOWLEDGE AREA
FOR COMMERCIAL PILOT

Chapter	# of Questions	Knowledge Areas
2	65	Airplanes and Aerodynamics
3	47	Airplane Performance
4	43	Airplane Instruments, Engines, and Systems
5	8	Airports, Airspace, and ATC
6	17	Weight and Balance
7	138	Aviation Weather
8	119	Federal Aviation Regulations
9	91	Navigation
10	9	Aeromedical Factors
	(1)	(Spatial Disorientation)
11	28	Flight Operations
	565	Total Questions

Note: As organized by Gleim, 1997

TABLE 3

NUMBER OF FAA QUESTIONS PER KNOWLEDGE AREA FOR INSTRUMENT RATING-AIRPLANE

Chapter	# of Questions	Knowledge Areas
2	68	Airplane Instruments
3	101	Airports and Air Traffic Control
4	164	Aviation Weather
5	82	Federal Aviation Regulations
6	83	Navigation
7	18	Aeromedical Factors
	(10)	(Spatial Disorientation)
8	76	Flight Operations
9	155	Instrument Approaches
10	59	Instrument Flight Rules (IFR) En Route
11	94	Comprehensive IFR Trip Review
	900	Total Questions

Note: As organized by Gleim, 1997

TABLE 4

NUMBER OF FAA QUESTIONS PER KNOWLEDGE AREA
FOR FLIGHT/GROUND INSTRUCTOR PILOT

Chapter	# of Questions	Knowledge Areas
2	98	Airplanes and Aerodynamics
3	52	Airplane Performance
4	65	Airplane Instruments, Engines, and Systems
5	68	Airports, Airspace, and ATC
6	41	Weight and Balance
7	140	Aviation Weather
8	165	Federal Aviation Regulations
9	98	Navigation
10	81	Flight Maneuvers
11	23	Aeromedical Factors
	(4)	(Spatial Disorientation and Illusions in Flight)
	831	Total Questions

Note: As organized by Gleim, 1997

Flight requirements for the commercial pilot certificate include: 250 hours of pilot time, 100 hours as pilot in command, 20 hours of flight instruction including 10 hours of instrument training. Upon completion of the requisite ground and flight training, the pilot must complete a practical test for the commercial pilot certificate.

The practical test standards for the commercial pilot certificate require that the evaluator determine adequate knowledge of aeromedical factors (FAA-S-8081-12, 1994). The pilot must explain the symptoms, causes, effects, and corrective actions of at least four from a taxonomy of seven categories of aeromedical factors to the FAA inspector or designated pilot examiner. Additionally, the pilot must exhibit knowledge of the physiological aspects of night flying.

Flight requirements for an instrument rating include: 50 hours as pilot in command on cross country flights, 40 hours of simulated or actual instrument time, and 15 hours of instrument instruction. Upon completion of the requisite ground and flight instruction the pilot must complete a practical test for the instrument rating administered by a FAA inspector or designated pilot examiner. The FAA has been concerned with numerous fatal accidents involving instrument rated pilots that become spatially disoriented in instrument conditions following a malfunction in their gyroscopic equipment. As a result the FAA requires performance of basic instrument tasks under both full-panel and partial-panel (simulating inoperative gyroscopic indicators) for the instrument rating practical test (FAA-S-8081-4B, 1994).

Flight requirements for the flight instructor certificate are not measured in hours. Instead, pilots must obtain logbook endorsements from an authorized instructor for each area of operation listed in FAR part 61, subpart 4. Upon completion of the requisite training, the pilot must complete a practical test for the flight instructor certificate. The practical test standards for flight instructor requires knowledge of 11 objectives on aeromedical factors plus night optical illusions. The possibility does exist that aeromedical factors may not be covered during the practical test. Thus, the possibility exists that an individual could progress through FAR part 61 training from private pilot, commercial pilot, instrument rating, to flight instructor and never be evaluated on spatial disorientation with the exception of partial-panel instrument crosscheck procedures. Ultimately, a comprehensive training program would ensure adequate coverage in all aspects of training including spatial disorientation training. One potential advantage of FAR part 141 schools is prior approval of training syllabi by the FAA.

FAR part 141 prescribes the requirements for issuing pilot school certificates. A pilot school may receive certification for the following courses: private pilot course, commercial pilot course, instrument rating course, airline transport pilot course, flight instructor course, instrument flight instructor course, aircraft category or class rating courses, or aircraft type rating courses. To offer these courses a school must demonstrate they have the resources to operate under this statute.

First, the school must have an enrollment of at least 50 students at the time of application for certification. The FAA requires that a chief flight instructor be designated for each of the schools approved training courses. Chief flight instructor qualifications can range from 1000 hours pilot in command to 2000 hours pilot in command depending on the course. Extensive flight instructor experience is required. Hour and experience requirements are also required for the assistant chief flight instructor and check instructor. The check instructor conducts student stage checks, end-of-course tests, and instructor proficiency checks.

In addition to regulating minimum personnel qualifications, the FAA retains authority for curriculum approval. The FAA requires a training syllabus be submitted for each training course to be offered under FAR part 141. Although not as ubiquitous as FAR part 61 flight training, FAR part 141 schools provide an assessment of training courses approved by the FAA and previously have been used by researchers to assess general aviation pilot training.

Statement of the Problem

Historically the military has provided the majority of pilots for the commercial airline industry in the United States. The military placed an emphasis on spatial disorientation training because the military pilot may be asked to fly at the extreme edge of human performance. As a consequence military pilots received formal training on spatial disorientation. Traditionally, military training for spatial disorientation has included lecture, ground-based demonstrations, inflight demonstrations, and training on a regular continuing basis. However, following the large draw down by the Department of Defense during the late 1980s and 1990s the military can no longer provide the number of pilots required by commercial airlines (Hansen & Oster, 1997). As a consequence civilian pilot training must now train the majority of pilots for United States air carriers. The requirements for formal training in the field of spatial disorientation for general aviation pilots is less structured. The small number of spatial disorientation questions on the FAA knowledge tests limits emphasis on the subject. Potentially, the general aviation pilot may receive the majority of their training from certified flight instructors who rank their knowledge of aeromedical factors last among all the areas they are required to teach (Alluisi, 1997). Therefore, the potential exists for the next generation of commercial airline pilots to be minimally trained in spatial disorientation. The problem is that commercial aviation industry training managers, based on historical precedent, may assume a level of spatial disorientation training in pilot candidates that is not present.

Purpose of the Study

The purpose of this study was to determine if spatial disorientation training conducted by FAR part 141 schools met the training guidelines outline by Kirkham, et al. (1978) of the Civil Aeromedical Institute.

Significance of the Study

National Transportation Safety Board accident reports and military accident reports confirm that spatial disorientation is a continuing cause of fatal accidents. Using the Bird and Loftus (1976) accident ratio, we find that for each spatial disorientation accident resulting in serious injury, there are 10 resulting in minor injury, 30 property damage accidents and 600 incidents with no visible damage or injury. Although Bird's accident ratio was not developed for the aviation environment, it is widely accepted throughout the safety industry and one can still postulate that for each spatial disorientation accident there may be numerous near accidents. Gillingham and Previc (1993), and Collins, et al. (1977) report that training for pilots is important to prevent these accidents. The Civil Aeromedical Institute published guidance on spatial disorientation training (Kirkham, et al., 1978). Civil Aeromedical Institute guidance included flight school lectures on spatial disorientation, ground-based demonstrations of disorientation combined with appropriate briefings, and inflight demonstrations. The guidance prescribed by the Civil Aeromedical Institute is consistent with the training programs developed and in use by the United States Air Force for spatial disorientation training. The FAA does not minimize the importance of spatial disorientation training and provides special training sessions for pilots on the subject, although these training sessions are not mandatory. Notwithstanding, the training required in FAR part 61 falls short of the Civil Aeromedical Institute recommendations. Therefore an accurate assessment on the state of spatial disorientation training for civilian trained pilots is important at this juncture in time for general aviation instructors and commercial airline industry pilot training managers to assess future training requirements.

Assumptions of the Study

The following assumptions were made for the purposes of this study:

1. Because the survey promised anonymity and confidentiality, the participants responded to the questionnaire honestly.
2. That a survey of FAR part 141 approved certificated schools is a valid measure of assessing civilian pilot training.
3. Because all chief flight instructors have FAA dictated requisite flight instruction training and experience, it was assumed that no additional explanations would be needed for respondents to comprehend and accurately complete the questionnaire. All flight instructors and instrument flight instructors require endorsements stating they exhibit instructional knowledge of spatial disorientation, its causes, effects, and corrective action (FAA-S-8081-6AS, 1991; FAA-S-8081-9A, 1990).

Limitations of the Study

This study is limited to FAR part 141 certificated schools.

Definition of Terms

Attitude. The relationship of an aircraft to the earth's horizon. To be parallel with the earth's horizon is a level attitude, climbing requires a nose up attitude, turning requires a banked attitude, etc. A pilot must remain acutely aware of the aircraft's attitude at all time to maintain situational awareness and remain oriented.

Aeromedical Factors. The category of knowledge dealing with human performance and limitations. The taxonomy developed by the FAA for aeromedical factors include the following seven categories: hypoxia, hyperventilation, middle ear and sinus problems, spatial disorientation, motion sickness, carbon monoxide poisoning, and stress and fatigue.

Airline Transport Certificate (ATP). A certificate required to operate as pilot in command for a regularly scheduled airlines.

Black Hole Illusion. This is an illusion caused by an absence of ambient cues. If only the runway lights are visible and the remaining visual field is black, focal vision alone is trying to accomplish what focal and ambient vision normally accomplish. Without peripheral (ambient) visual cues, a pilot may feel the aircraft is stable and the runway moves or remains in an improper position. Black hole illusions often result in aircraft landing short of the runway.

Certificated Flight Instructor (CFI). An instructor authorized by the FAA to provide instruction leading to pilot certificates.

Certificated Instrument Flight Instructor (CFII). An instructor authorized by the FAA to provide instruction leading to an instrument rating.

Class A Mishap. A mishap that results in the loss of life, the loss of an aircraft, or damage in excess of a predetermined dollar amount.

Coriolis Illusion. The coriolis illusion results from cross-coupling of the fluid in the vestibular apparatus. A subject perceives rotation in a plane, even though no actual rotation has occurred on that plane

Fovea. The central focusing area of the retina comprised of cones. The fovea is a small area and is primarily used for object recognition.

Instrument Meteorological Conditions (IMC). Meteorological conditions less than required for VMC. Normally expressed in terms of visibility, distance from clouds, and ceiling. No discernible horizon.

False Horizon. Sloping cloud formations, an obscured horizon, a dark scene spread with ground lights and stars, and certain geometric patterns of ground lights can create an incorrect perception of a horizon. The actual horizon may be on a different plane. (Aeronautical Information Manual, 1998)

Multiengine Class Rating. An authorization by the FAA to operate airplanes with more than one engine.

Multiengine Instructor (MEI). An authorization by the FAA to instruct pilots to operate aircraft having more than one engine.

Otolith Organs. The mechanisms used to determine the position of the head, both for and aft and side to side. The otolith organs are located in the inner ear. The otolith organs are comprised of two sensory mechanisms located in perpendicular planes, one in the Utricle and one in the Saccule. Hair cells (cilia) project into a gelatinous structures containing calcium carbonate crystals (Otoliths) for mass and are surrounded by fluid (endolymph). Changes in gravitoinertial forces will cause the hair cells to deflect denoting a change in the position of the head.

Parafovea. The area immediately surrounding the fovea centralis. This area has a mixture of rods and cones and is used for object recognition lighting situations insufficient for the fovea centralis.

Somatogravic Illusion. Illusions that result from false sensations of gravity. Gravity is a stable reference for the vertical during normal earthbound activities. However, during periods of low visibility flight, the perceptual mechanisms (otolith organs) are unable to distinguish between acceleration and gravity creating false perceptions of attitude.

Somatogyral Illusion. Illusions that result from incorrect perceptions of rotation. The perceptual mechanisms (Vestibular Apparatus) give correct information only during the first few seconds (10-20 seconds) of prolonged rotation. This illusion can lead to false perceptions regarding the direction of turns resulting in a graveyard spiral or graveyard spin.

Spatial Disorientation. "The failure to perceive, correctly and unequivocally, the position, attitude, or motion of the aircraft" (Cheung et al. 1995). "A false perception of distance, attitude, or motion of the pilot and the aircraft, relative to the plane of the earth's surface" (Collins & Dollar, 1996).

Vestibular Apparatus. The mechanism used to measure angular acceleration. The vestibular apparatus is located in the inner ear and consist of three semicircular ducts (canals) filled with fluid (endolymph) and oriented in three mutually perpendicular planes. The acceleration is detected by hair cells (cilia) of the crista ampullaris which extend into a gelatinous structure called the cupula. Whenever inertial forces of the endolymph ring deviate the cupula, the cilia are bent and angular acceleration is perceived.

Visual Meteorological Conditions (VMC). Meet conditions required for operating according to visual flight rules. Discernible horizon.

Research Question

Does spatial disorientation training conducted by FAA approved part 141 certificated schools comply with the recommended training guidelines issued by Kirkham, et al. (1978) of the Civil Aeromedical Institute? Specifically, are flight schools providing lectures relative to spatial disorientation; are ground-based demonstrations of disorientation provided; and are inflight demonstrations on two or more occasions during pilot training provided?

Organization of the Study

Chapter I is the introduction. Chapter I includes the following: introduction, statement of the problem, significance of the study, assumptions of the study, definition of terms, statement of the hypothesis, and organization of the study. Chapter II is a review of the literature. Chapter III is methodology. Chapter III includes an introduction, subjects, instrument, collection of data, and data compilation and analysis. Chapter IV is the results of the study. Chapter V is the summary, findings, conclusions, and recommendations.

CHAPTER II

REVIEW OF THE LITERATURE

Introduction

Human physiology can and does adversely effect humankind's ability to fly safely. Del Vecchio (1977) developed a taxonomy of physiological factors that adversely affect humans ability to operate in the aviation environment. The taxonomy includes: the physiology of respiration and circulation at reduced atmospheric pressure, pressure breathing, hyperventilation, hypoxia, altitude dysbarism, noise and vibration, fatigue, body heat balance, hypoglycemia, acceleration, sensory illusion, and vision. Research reports the last three, acceleration, sensory illusions, and vision, are key elements in spatial disorientation (Gillingham & Wolfe, 1986, Ernsting & King, 1994).

Spatial disorientation can result in one of three categories of disorientation classified as type I (unrecognized), type II (recognized), and type III (incapacitating) (Gillingham & Previc, 1993; Ernsting & King, 1994)). The pilot does not recognize that his or her perception of orientation is incorrect with type I spatial disorientation. Type I spatial disorientation may pose the greatest potential hazard to flight safety because it remains unrecognized. With type II spatial disorientation the pilot experiences a conflict between his or her perception of aircraft orientation when compared to aircraft orientation described by the aircraft instruments. Type II is recognized posing the least threat to the trained aviator. Type III spatial disorientation is incapacitating, the pilot probably knows he or she is disoriented but can do little about it. One example of type III disorientation is vestibular-ocular disorganization, where the pilot can no longer read the cockpit instrumentation because of vestibular nystagmus. Fortunately, type III spatial disorientation is rare. Various mechanisms may cause the different types of spatial disorientation.

The mechanisms of equilibrium and orientation are complex and involve multiple sources of sensory information including visual, vestibular, and stretch receptors in muscles and tendons (Marieb, 1995). The visual and vestibular apparatus are the primary components in orientation in three-dimensional space with the visual system as the dominate system between the two (Marieb, 1995; Gillingham & Previc, 1993).

This chapter will focus on the mechanisms that cause spatial disorientation, specifically vestibular and visual illusions, and the countermeasures that a pilot can employ to cope with spatial disorientation.

Vestibular Illusions

The vestibular apparatus is located in the inner ear and is composed of the bony semicircular canals and otolith organs (Gillingham & Previc, 1993). The primary purpose of the vestibular system is to provide angular and linear acceleration information to stabilize the eyes during motion of the head to enhance vision. Without this system, during rapid head movements our vision would be blurred (Gillingham & Previc, 1993). The vestibular system is highly effective when used in conjunction with the visual system to maintain one's orientation. In the absence of adequate visual cues the vestibular system becomes the primary apparatus in a human's ability to orient in three-dimensional space. However, in the absence of visual information the vestibular system can provide inaccurate information. False perceptions in angular, linear, and radial acceleration can result in vestibular illusions. In the absence of adequate visual cues, using the vestibular and somatosensory systems to orient oneself in relation to the earth's surface has killed many aviators. Pilots must be able to orient themselves in relation to earth even when experiencing angular, linear, and radial acceleration.

Angular acceleration has a change in speed and a change in direction occurring simultaneously; radial acceleration is a change in direction while moving at a constant speed; and linear acceleration is a change of speed while moving in a straight line (Del Vecchio, 1977). Illusions caused by angular acceleration are categorized as somatogyral illusions and illusions caused by linear acceleration are categorized as somatogravic illusions (Gillingham & Wolfe, 1986).

Somatogyral illusions result from the inability of the semicircular canals to accurately represent a prolonged rotation or a rotation induced so gradual that a it is not recognized at all. Examples of somatogyral illusions include the graveyard spin, graveyard spiral, and the coriolis illusion (Gillingham & Previc, 1993). The graveyard spin is caused by the stabilization of the fluid in the vestibular organ during a period of angular motion.. Initially, the fluid in the semicircular canals deflect the cupula (a gelatinous structure in the vestibular organ that is deflected by fluid to indicate angular acceleration) resulting in the accurate sensation of the angular motion of the spin. Following several turns of a spin the cupula has returned to its resting position giving the false perception that the spin has ceased. When the pilot recovers from and stops the spin, the fluid again deflects the cupula and the pilot experiences the false sensation of spinning in the opposite direction. If the pilot reacts to the false perception, the pilot will reenter a spin in the opposite direction. A pilot is more susceptible to this illusion under periods of reduced visibility such as night or instrument conditions. A similar and more common illusion is the graveyard spiral. Again, a pilot is more susceptible during periods of low visibility such as night or instrument conditions. The graveyard spiral is caused by a pilot entering a banked turn and losing the sensation of turning because the cupula in the semicircular ducts have returned to their resting position. When the pilot levels the wings the fluid again deflects the cupula and the pilot has the false sensation he or she is banked in the opposite direction. If the pilot reacts to this false sensation the pilot will return to original banked condition which is falsely perceived as level. The pilots instruments will then denote a loss of altitude. If the pilot does not recognize the banked position by referencing appropriate instrumentation, the pilot will apply back pressure to decrease altitude loss. However, the back pressure will tighten the turn and increase the descent rate. In 1988 the pilot of an USAF C-141 cargo aircraft experienced a somatogyral illusion and entered into a graveyard spiral and subsequently lost control of the aircraft temporarily. The aircraft lost approximately 16,000 feet before the pilot was able to regain control of the aircraft. The pilot was able to regain control of the aircraft only upon reaching visual meteorological conditions. At one point during the descent the aircraft was inverted in the weather (Wiseman, personal communication, February 20, 1998). Another somatogyral illusion is the coriolis illusion which is caused by vestibular sensation of movement in two planes at once, a phenomena known as cross-coupling. The result can be extremely disorienting. Often the feeling of tumbling can occur. This can be caused by movement of the aircraft in one plane and the pilot moving his or her head in another plane. Whether the angular velocities associated with instrument flying are sufficient to result in coriolis illusions of any great magnitude is debatable (Gillingham & Wolfe, 1986). One key to minimizing coriolis illusions is limiting head movement.

The otolith organs are primarily responsible for illusions associated with linear acceleration. Illusions associated with linear acceleration are known as somatogravic illusions. (Green, Muir, James, Gradwell, & Green, 1996). The otolith organs are housed in the utricle (for the horizontal plane) and the saccule (for the vertical plane). and are responsible for orientation of head tilt. The otolithic membrane (a gelatinous structure containing calcium carbonate crystals) is heavier than the underlying fluid and its inertia is transmitted via cilia structures to the brain indicating head movement. A very common somatogravic illusion is one associated with acceleration for takeoff or a go around following a missed approach in limited visibility. "The inertial force resulting from the forward acceleration combines with the force of gravity to create a resultant gravitoinertial force directed down and aft. The pilot will falsely perceive an excessive nose high attitude" (Gillingham & Wolfe, 1986, p. 71). This illusion is especially dangerous during a go-around from a low approach or missed approach during marginal weather conditions because the pilot is in close proximity to the ground and if the pilot believes the false perception of excessively nose high attitude the natural reaction is to lower the nose. Lowering the nose, because linear acceleration is falsely perceived as a nose high climbing attitude, will initiate a descent. Initiating a descent is extremely dangerous when one is already close to the ground and may result in controlled flight into terrain.

An additional somatogravic illusion is the inversion illusion. The inversion illusion (jet upset) results from the gravitoinertial force vector rotating so far backward that it is no longer pointing to the earth's surface and the pilot mistakenly believes he or she is upside down when in truth they have in just transitioned to level flight. The Centrifugal (-Gs) and tangential inertial force (+Gs) during an abrupt level-off from a steep climb combine with the force of gravity to produce the inversion illusion (Gillingham & Previc, 1993). External conditions such as turbulence contributes to the onset of this illusion.

The leans is probably the most common of all vestibular illusions. Gillingham and Wolfe (1986) and Ernsting and King (1994) classify this illusion as a somatogravic illusion. They classify the linear acceleration as curvilinear. Del Vecchio (1977) classifies this case as radial acceleration. Regardless, the pilot falsely perceives a bank when actually in straight and level flight or falsely perceives straight and level flight while in a banked condition. This condition is created during a prolonged turn because the cupula in the semicircular canals cease to indicate angular acceleration and the net G force being directed toward the floor is approximately equal to gravity.

Visual Illusions

Focal vision and ambient vision are two important concepts one must understand to comprehend the susceptibility of a pilot to be victimized by visual illusions. Focal vision is what we use to recognize objects and originates when light is focused on the fovea and parafovea regions of the retina. Vision in the remaining areas of the retina is ambient vision (Gillingham & Wolfe, 1986). Ambient vision is used to orient one's self to the environment. When we are exposed to conditions of reduced visibility, such as dusk, dawn, night, and instrument meteorological conditions, our ambient vision can no longer orient us to our environment and we become highly susceptible to spatial disorientation. Visual illusions occur when ambient visual cues are absent and excessive orientation demands are placed on focal vision or when strong but erroneous cues are misinterpreted through focal vision (Gillingham & Previc, 1993).

Inherently a pilot flying at night feels the environment is less safe and comfortable than a similar mission flown during daylight hours. Haines and Flatau (1992) list numerous visual illusions that pilots should be familiar if they are going to fly at night. These illusions are not exclusively the domain of night flying and can be experienced in daylight under conditions of limited visibility when ambient visual cues become unreliable. The Haines and Flatau taxonomy of visual illusions include: static illusion, runway length to width illusion, foreshortening illusion, sloped illusion, vertical position illusion, fog and rain produced illusion, false horizon illusion, Ganzfeld depth loss illusion, reversible perception illusion, up-sloped lighted city illusion, altered reference plane illusion, autokinetic illusion, black hole approach illusion, and the dark terrain takeoff illusion.

The static illusion is characterized by a false perception of movement. Lack of ambient visual cues can create the sensation that the cockpit is fixed and does not seem to move, only the outside scene appears to move (Haines & Flatau, 1992). Closely related is the reversible perspective illusion. Here the cause is erroneous ambient visual cues

(Gillingham & Previc, 1993). A common example that has been experienced by most of us in our automobile is the false sensation that we are moving when we are actually stationary. The car next to us creeps forward and we apply brakes based on the false assumption we are rolling backward.

Shape consistency is also an important aspect for maintaining orientation. The foreshortening illusion is characterized by false shapes of objects when viewed from a distance. The shape of objects appear shortened or more elliptical when viewed from a distance (Haines & Flatau, 1992). The runway length to width illusion is an illusion of shape consistency. Solid objects such as a runway will appear to change shapes depending upon the distance and altitude one is from the runway. Additionally, if the runway length and width are nonstandard, they can give a pilot a false perception as to height and distance (Gillingham & Previc, 1993). A pilot adjusting his or her glidepath based upon a runway width illusion can cause a steep approach resulting in a hard landing or a shallow approach resulting in an early touchdown (CFIT). The sloped illusion is a common one many pilot's have experienced and results from false shape cueing (Gillingham & Previc, 1993). If a runway is sloped, the resulting visual cues can effect a pilots perception of height and influence the glidepath the pilot chooses to fly (Hawkins, 1993).

The vertical position illusion is an illusion of contrast where lighted objects or terrain features are perceived in error. Haines & Flatau (1992) report that lighted objects at a distance tend to appear higher on the horizon than objects that are closer. Fog and rain can reduce the apparent brightness of lights creating an illusion that a runway is farther away than it actually is (Haines & Flatau, 1992).

The false horizon is another common illusion most pilots have experienced. Illusions of contrast can create false horizons and surface planes (Gillingham & Previc, 1993). The blending of stars and ground lights can cause a false horizon to be perceived. Correspondingly, when the blending of overcast skies with unlighted terrain or water causes a false horizon, the horizon will appear lower than its actual position. A false horizon can result from a sloping cloud deck or a false horizon of lights that is not aligned with the actual horizon (Haines & Flatau, 1992). Up-sloped lighted city illusions is the result of a level runway in the foreground and a lighted city in the background on an up-slope. The illusion can create confusion as to which plane is correct (Haines & Flatau, 1992). The altered reference plane illusion occurs when one is flying towards clouds or mountains. The pilot may experience a strong desire to climb to gain altitude (Haines & Flatau, 1992).

Flight over featureless smooth terrain predisposes one to spatial disorientation due to the loss of ambient cues and sometimes focal cues (Gillingham & Previc, 1993). The Ganzfeld depth loss illusion results from flight over featureless smooth terrain. Examples of featureless smooth terrain include snow covered fields, plains, water, etc. Ganzfeld is a German word for an even, smooth, featureless visual scene and thoroughly describes this illusion (Haines & Flatau, 1992). Judging altitude and distance can be extremely difficult. Black hole approach illusions are also caused by loss of ambient cues. Black hole approach illusions are disorienting because lights normally used as ambient visual cues for reference are not available except for the landing runway. Often the runway is built next to the ocean or desolate terrain. Gillingham and Previc (1993) write that black hole approaches are difficult and potentially dangerous. The correct angle to the runway is difficult to judge under these circumstances. The dark terrain takeoff illusion is similar to the black hole approach illusion. Taking off from a lighted runway without a visible horizon ahead or to the side with no associated ambient cues can lead to a descent immediately after takeoff without the realization that one is descending (Haines & Flatau, 1992, Gillingham & Wolfe, 1986).

Another unique illusion is the autokinetic illusion. If one stares at a single motionless light in an otherwise dark environment one can experience the autokinetic illusion (Gillingham and Previc, 1993). The exact cause is unknown but a stationary light will appear to move up to 20 degrees per second.. If a pilot makes flight control inputs based solely on the apparent movement a stationary light a potential flight hazard exists.

Visual illusions are often insidious and dangerous because they lead to type I spatial disorientation. Ultimately a pilot must know when he or she encounters conditions favorable for spatial disorientation, anticipate and assume disorientation, and take appropriate action to prevent unsafe consequences. Regardless of whether spatial disorientation is the result of visual or vestibular illusions, the pilot must cope with the situation.

Spatial Disorientation Countermeasures

We know that flight in instrument meteorological conditions, night, over featureless terrain, or at high altitude reduces the ability of our visual system to orient us to our flight environment. We know that angular or linear acceleration or deceleration, prolonged angular motion, and sub-threshold changes in angular motion, when combined with limited visibility situations, are highly conducive to spatial disorientation. We know that while under conditions of limited visibility the functions of ambient and focal vision are disrupted and increase the possibility of spatial disorientation. Ernsting and King (1994) report that virtually all pilots experience spatial disorientation sometime during their flying career. Ernsting and King (1994) conducted a survey of 300 Royal Navy helicopter pilots and found that 98 percent had experienced spatial disorientation. Therefore it is imperative that pilots develop adequate knowledge to recognize spatial disorientation and effective countermeasures to negotiate an incident.

Cheung, et al. (1995) reported the cognitive phenomena of selective (channelized) attention, inappropriate expectancy, and supra arousal effect associated with spatial disorientation are poorly understood and should be studied. Also, between 1982 and 1992 14 Canadian Air Force (CAF) accidents involving the loss of an aircraft, loss of life, or both, were found with spatial disorientation as one possible cause. Of these 14 accidents, one was the result of recognized spatial disorientation (type II). One was the result of incapacitating spatial disorientation (type III). The remainder of the accidents were the result of unrecognized spatial disorientation (type I). The results of the Cheung, et al. (1995) study suggest that type II spatial disorientation can normally be dealt with effectively when proper recognition and countermeasures are taught. Type III spatial disorientation is relatively rare, even with the aerobatic maneuvers often required of military aviators. Ultimately, Cheung, et al.(1995) concluded 12 accidents involving type I spatial disorientation are too many and recommended the CAF should allocate appropriate resources, attention, and training to reduce the number of type I spatial disorientation accidents.

The Royal Air Force treats approximately five crewmembers each year for flying phobia. The flying therapy program administered by the Consultants in Psychiatry is designed for professionally trained aircrews who develop a flying phobia (McCarthy & Craig, 1996). The German Air Force has a similar program. Spatial disorientation can serve as the catalyst for flying phobia. McCarthy and Craig (1995) reported on a 24 year old jet pilot that developed an uneasy feeling and eventually hyperventilation during the second of two night sorties. He experienced the same panic attacks five days later in the simulator. He was administered relaxation training and returned to flying status. Yet, he continued to develop these panic attacks on the golf course, while walking, and while driving. "When thinking about flying he heard two voices; one wants to fly, the other to go sit under a tree" (McCarthy & Craig, 1995, p. 1180). The results of McCarthy and Craig's (1995) study reinforce the analysis by Cheung, et al.(1995) that some cognitive aspects associated with spatial disorientation are poorly understood.

Shappell and Weigmann (1996) reviewed United States Naval Aviation mishaps from 1977 to 1992 and compared single-piloted and dual-piloted aircraft. These researchers found that single-piloted aircraft had a higher rate of landing accidents during the hours of darkness when compared to dual-piloted aircraft. One possible explanation is the assistance provided by the other flight crew member in dual-crew aircraft to provide information as necessary and when needed by the pilot to mitigate landing illusions somewhat.

Decision-making is a complex construct. Wiener, Kanki, and Helmreich (1993), and Wiener and Nagel (1988) have included decision-making in the cockpit as a topic in their books. Yet, none of these adequately address selective attention, inappropriate expectancy, and supra-arousal effect associated with spatial disorientation as described by Cheung, et al. (1995).

Hopefully, if a pilot is experiencing spatial disorientation, the pilot has been thoroughly trained to recognize the conditions that contribute to spatial disorientation and would be alert to the disparity in orientations. Kirkham, et al. (1978) suggested that pilots receive lectures on spatial disorientation, receive ground demonstration training where spatial disorientation is induced, and receive inflight demonstrations of spatial disorientation. Once pilots have recognized they are disoriented, they must focus on the instruments and maneuver the aircraft in order to make them read correctly (Gillingham & Wolfe, 1986). Ernsting and King outlined 10 steps that may prove beneficial for a pilot that is experiencing spatial disorientation:

1. Remain convinced that you cannot fly by the 'seat of the pants'.
2. Do not allow control of the aircraft to be based at any time on 'seat of the pants' sensations even when you are temporarily deprived of visual cues.
3. Do not unnecessarily mix flying by instruments with flying by external visual cues.
4. Aim to make an early transition to instruments in poor visibility; once on instruments, stay on instruments until external cues are unambiguous.
5. Maintain a high proficiency and be in practice at flight in IMC.
6. Avoid unnecessary maneuvers of aircraft or head movements that are known to induce disorientation.
7. Be particularly vigilant in high-risk situations, such as night and in poor visibility, in order to maintain intellectual command of the orientation and position of the aircraft.
8. Do not fly: (a) With an upper respiratory tract infection. (b) When under the influence of drugs or alcohol. (c) When mentally or physically debilitated.
9. Make your first flight after a period off from flying a day visual meteorological conditions (VMC) sortie.
10. Remember: experience does not make you immune.

(Ernsting & King, 1994, p.316)

Another set of countermeasures for spatial disorientation have been outlined by the United States Air Force. The United States Air Force teaches seven procedures to undergraduate pilot training students to overcome spatial disorientation:

1. Transition to instruments.
2. Believe the Instruments.
3. Back-up the pilot flying on instruments.
4. Minimize head movements.
5. Fly straight and level (30 to 60 seconds of straight and level flight while concentrating on your instruments should settle your semicircular canals).
6. Be prepared to transfer/assume control
7. Egress (USAF, P-V4A-A-C-JP-SG, 1998, p. 53).

The final set of countermeasures developed for spatial disorientation were prepared by the FAA. The FAA recommends seven procedures to prevent or cope with spatial disorientation:

1. Before you fly with less than 3 miles visibility, obtain training and maintain proficiency in aircraft control by reference to instruments.
2. When flying at night or in reduced visibility, use your flight instruments, in conjunction with visual references.
3. Maintain night currency if you intend to fly at night. Include cross-country and local operations at different airports.
4. Study and become familiar with unique geographical conditions in areas in which you intend to operate.
5. Check weather forecasts before departure, en route, and at destination. Be alert for weather deterioration.
6. Do not attempt visual flight rule flight when there is a possibility of getting trapped in deteriorating weather.
7. Rely on instrument indications unless the natural horizon or surface reference is clearly visible (FAA AC 60-4A, 1983, p. 2).

CHAPTER III

METHODOLOGY

Introduction

The purpose of this study was to determine if spatial disorientation training conducted by FAR part 141 schools met the training guidelines outlined by Kirkham, et al. (1978) of the Civil Aeromedical Institute. The study was based on the results of a questionnaire mailed to 506 FAR part 141 certified flight schools throughout the United States. The following sections are included in this chapter: (1) population selection, (2) instrument, (3) collection of data, and (4) analysis of data.

Population Selection

Federal Aviation Administration Circular 140-2Z (1997) lists flight schools certified under FAR part 141. One hundred percent of the schools listed that provided instruction in the airplane category were subjects for this study. Schools that provided instruction exclusively for glider, helicopter, or lighter-than-air aircraft categories were excluded.

Instrument

A survey instrument was developed by the researcher with the assistance from the faculty of the Department of Aviation and Space Education at Oklahoma State University using guidance from the Civil Aeromedical Institute (Kirkham, et al. 1978). The validity of the questionnaire for content and consistency was verified by five individuals, each an expert in his or her field. The validity review was conducted from the following: a physiologist at Oklahoma State University, a United States Air Force aerospace physiologist, an assistant professor in research design, a flight instructor with FAR part 141 chief flight instructor experience, and an assistant professor in Aviation Education at Oklahoma State University. The pilot test was an in-person interview by this researcher with selected certified flight instructors to validate responses.

Data gathered from the questionnaire was divided into four categories.

1. School biographical data (four-year college, two-year college, private pilot courses, commercial pilot courses etc.).
2. Self reported assessment of the schools training program on spatial disorientation.
3. Self reported assessment of the training material used for spatial disorientation training.
4. Opinion questions concerning the training needs for spatial disorientation training. Data gathered in this category included perceived importance of spatial disorientation training, perceived importance of current levels of

spatial disorientation training, and suggested improvements in training programs.

Collection of Data

Five hundred six questionnaires and letters of introduction were mailed to FAR part 141 schools. The letters of introduction emphasized the purpose and importance of the survey. The schools were selected from FAA Advisory Circular 140-2Z, List of Certificated Pilot Schools (1997). All schools that provided instruction for the airplane category were included. Schools that provided instruction exclusively for glider, helicopter, or lighter-than-air aircraft categories were excluded. This resulted in 506 schools in the population

The questionnaire and cover letter were mailed in March, 1998. One week later follow-up cards were mailed. Three weeks from the date of the initial mail out, an additional survey was mailed to those schools that had yet to respond. The return envelopes were numbered to identify which schools should receive a follow-up questionnaire. However, the questionnaire did not ask for the name of individuals or the name of schools. Once the questionnaires were removed from the envelope by the researcher, it would be improbable if not impossible to track an individual response to a school or individual, thus ensuring anonymity.

Data Analysis

Responses to the questionnaire were recorded in a personal computer based spreadsheet processor. The data were summarized and the responses reported. Data analysis to test the research question was accomplished using frequency counts, percentages, chi-square test, and descriptive statistics.

CHAPTER IV

RESULTS OF THE STUDY

Introduction

The purpose of this study was to determine if spatial disorientation training conducted by FAR part 141 schools met the training outlined by Kirkham, et al. (1978) of the Civil Aeromedical Institute. The results of the study are presented in four sections. The first section examines biographical data. Responses to questionnaire (Appendix A) items 1, 2, & 6 are reported under this section. The second section addresses the methods of spatial disorientation training. Responses to questionnaire (Appendix A) items 3, 4, 5, 7, and 9 are reported in this section. The third section reports on training materials used for spatial disorientation instruction. Responses to questionnaire (Appendix A) items 8 and 12 are reported in this section. The final section examines the respondents assessment on the need for spatial disorientation training and opinions for training improvement. Responses to questionnaire (Appendix A) items 10, 11, and 13 are reported in this section.

The first section, biographical data, reports frequencies and/or percentages concerned with:

1. Whether flight schools are associated with institutions of higher learning.
2. The types of training programs offered by respondents.

3. The qualification of spatial disorientation instructors.

The second section, spatial disorientation training programs,. reports frequencies and/or percentages concerned with:

1. Formal lecture or films presented on spatial disorientation.
2. Spatial disorientation training conducted in academic or specialized training courses.
3. The number of hours of formal ground instruction per course.

   Additionally, a chi-square test (α=.05) was used to determine if frequency distributions (frequency observed) matched our theoretical flat distribution (frequency expected) for the number of hours of formal ground instruction per course.
4. Ground-based spatial disorientation demonstrators used in training programs.
5. Inflight demonstration of spatial disorientation used in training programs.

The third section, training materials, lists and reports the frequencies concerned with:

1. Films used for spatial disorientation training.
2. Training resources used for spatial disorientation training.

The fourth section, training needs assessment, lists or reports central tendency measures concerned with:

1. The determination of the level of perceived importance of spatial disorientation training.

2. The determination of the level of perceived satisfaction with current levels of spatial disorientation training.

3. Suggested improvements for spatial disorientation training.

Responses to the Study

Federal Aviation Administration Advisory Circular 140-2Z (1997) listed FAR part 141 certificated schools and was obtained from the Federal Aviation Administration. FAR part 141 schools that provided instruction for the airplane category were included in the survey. Questionnaires were mailed to 506 FAR part 141 schools in March, 1998. A total of 263 questionnaires were returned that were usable for this study. Twenty two of the original 506 subject schools were considered invalid because the addresses listed in FAA Advisory Circular 140-2Z were undeliverable, the school no longer offered flight training under FAR part 141, or the school was no longer in operation. The return rate for this study was 54.3 percent.

Biographical Data

The determinant if a flight school is authorized to conduct training in accordance with FAR part 141 of the Federal Aviation Regulations rests solely with the FAA. In the past the FAA has supported instruction of aviation courses at institutions of higher learning through their sponsorship of airway science program; although, the FAA has withdrawn active participation with these institutions through the airway science program. The FAA provides guidance and oversight for a vast network of private enterprises providing flight training through both FAR part 61 and FAR part 141 operations. The resources to conduct spatial disorientation training may be different between the diverse types of FAR part 141 flight and ground schools.

Therefore, the first questionnaire item asked if flight schools were affiliated with a two-year associate degree granting institutions, four-year bachelor degree granting institutions, or were not associated with either a two or four-year college degree. Sixty seven schools reported they were affiliated with a 2-year associate degree, 60 schools reported they were associated with a four-year degree granting institution, and 148 schools reported they were not associated with either a two-year or four-year degree granting institution (Figure 1). Twelve of the schools reported they were affiliated with both a two-year associate and four-year bachelor degree granting institution and one school responded positively to all three categories.

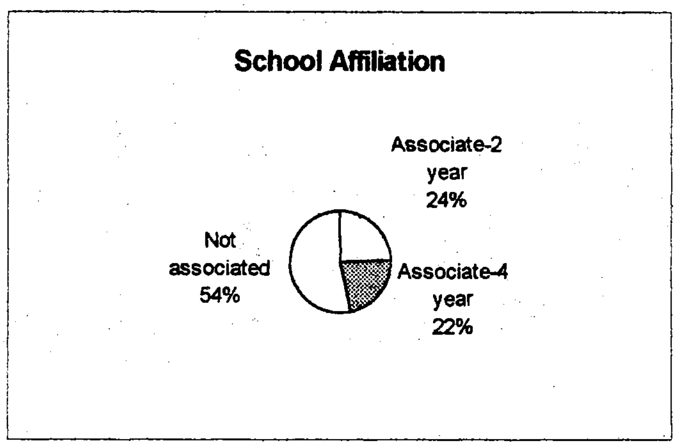

Figure 1. Flight School Affiliation

As the professionally oriented pilot progresses through flight training, he or she must acquire different levels of pilot certificates. These typically include: private pilot, commercial pilot, instrument rating, flight instructor, instrument flight instructor, airline transport pilot, multiengine class rating, and multiengine-instructor.

Questionnaire item 2 asked each school what courses were offered at their schools. Two hundred sixty one schools offered courses for private pilot, 258 offered courses for commercial pilot, 259 offered courses for an instrument rating, 244 offered courses for flight instructor, 238 offered courses for instrument flight instructor, 170 offered courses for airline transport pilot, 222 offered courses for the multiengine class rating, and 198 offered courses for multiengine instructor (Figure 2).

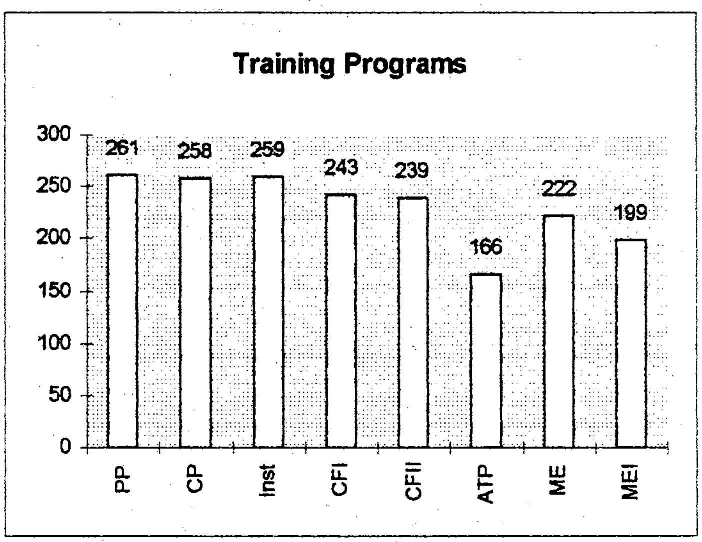

Figure 2. Training Programs Offered at Flight Schools Surveyed

Spatial disorientation is categorized by the FAA under the aeromedical factors knowledge area. Flight Instructors are required to exhibit knowledge of spatial disorientation, its causes, effects, and corrective actions (FAA, FAA-S-8081-6AS, 1991). Alluisi (1997) reported that flight instructors ranked their knowledge of and confidence to teach aeromedical factors last from a list of knowledge areas flight instructors are required to teach.

Questionnaire item 6 asked for the qualification of spatial disorientation instructors. One hundred seventy schools reported they used flight instructors, 224 reported they used instrument flight instructors, 11 reported they used individuals with a doctorate of education, eight reported they used individuals with a doctorate of philosophy, nine reported they used medical doctors, one reported they used a doctor of osteopathy, 23 reported they used human factors instructors, and finally, 30 reported they used individuals with other qualification to teach spatial disorientation (Figure 3). Those respondents that described qualifications in the 'other' category are detailed in table 5.

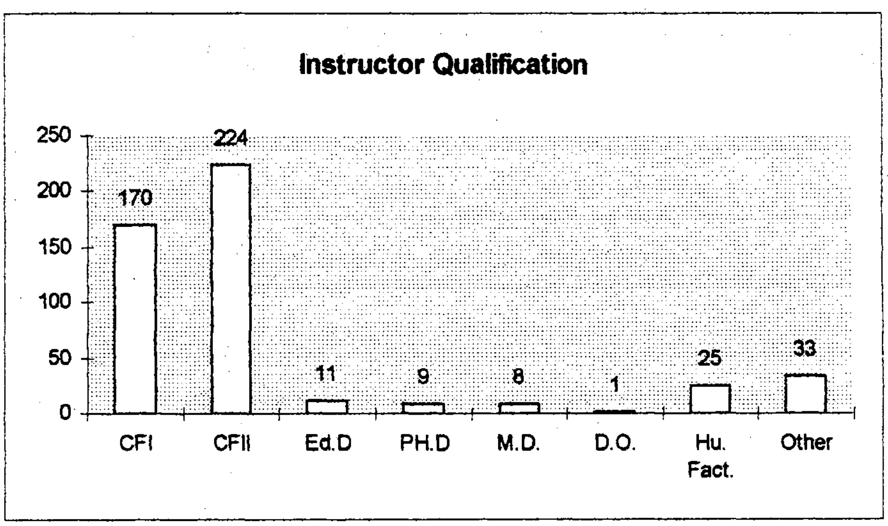

Figure 3. Spatial Disorientation Instructor Qualification

TABLE 5

QUALIFICATIONS OF SPATIAL DISORIENTATION INSTRUCTORS
AS REPORTED BY THE FAR PART 141 SCHOOLS
IN THE OTHER CATEGORY

Qualification of Instructor	Number of Schools
Masters degree	5
Master of Science in Aviation Safety	2
Master of Aeronautical Science	1
Military (military pilots)	5
Airline pilots	3
Bachelor degree	3
Bachelor degree in Aviation Training	1
FAA	3
Airline transport pilot certificate	2
USAF human factors training (military physiologist)	2
USAF test pilot school	2
Advanced ground instructor	1
Civil Aeromedical Institute physiological training course	1
Iowa teaching license	1
RAF	1

Spatial Disorientation Training Programs

The Civil Aeromedical Institute published a study by Kirkham, et al. (1978) which recommended:

(i) improved flight school lectures relative to spatial disorientation.
(ii) ground-based demonstrations of disorientation with appropriate briefings.
(iii) inflight demonstrations on two or more occasions during student pilot training. Appropriate briefings and lecture material must accompany these experiences (Kirkham, et al., 1978, p. 10).

The following questions were used to assess the degree of compliance of spatial disorientation training by FAR part 141 schools to the aforementioned guidelines. Questionnaire item 3 asked if formal instruction (lectures/films) was provided in the private/commercial pilot courses, the instrument course, or the flight instructor course. For the private pilot/commercial pilot courses, 194 schools (74.0 %) reported providing lectures on spatial disorientation whereas 68 schools reported they did not provide lectures on the subject (Figure 4).

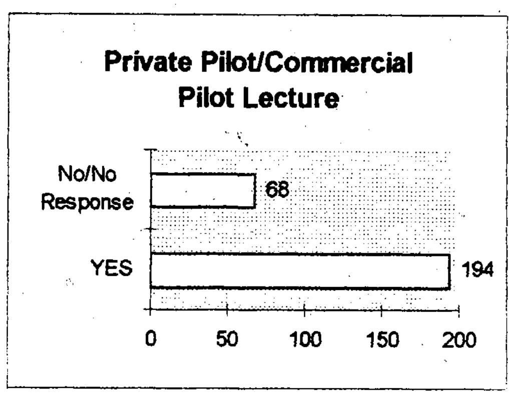

Figure 4. The Number of Schools Reporting Lectures on Spatial Disorientation for Private Pilot/Commercial Pilot Courses

The number of schools that reported providing lectures and/or films on spatial disorientation was 223 (85.1%) contrasted with 39 schools that did not provide lectures and/or films on the subject (Figure 5).

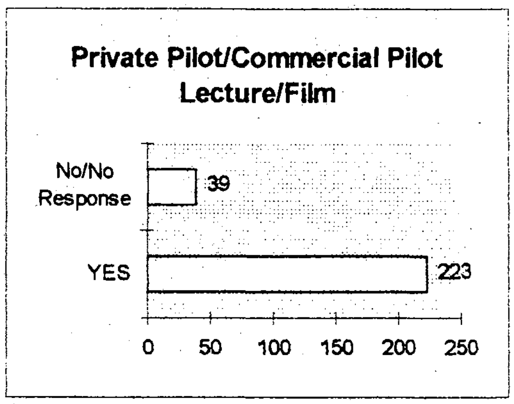

Figure 5. The Number of Schools Reporting Lectures and/or Films on Spatial Disorientation for Private/Commercial Pilot Courses

For the instrument rating course, 189 schools (73.0%) reported they provided lectures on spatial disorientation with 70 reporting they did not provide lectures on the subject (Figure 6). The number of schools that reported providing lectures or films on spatial disorientation for the instrument rating was 220 (84.9%) compared to 39 schools that did not provide lectures or films on the subject (Figure 7).

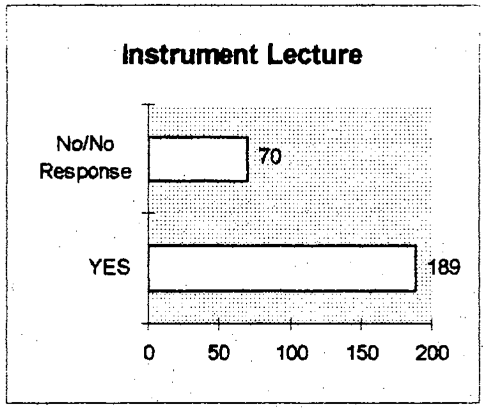

Figure 6. The Number of Schools Reporting Lectures on Spatial Disorientation for the Instrument Rating Course

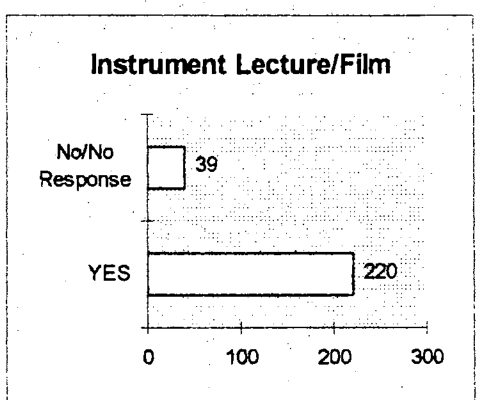

Figure 7. The Number of Schools Reporting Lectures and/or Films on Spatial Disorientation for the Instrument Rating Course

For the flight instructor course, 161 schools (64.4%) reported they provided lectures on spatial disorientation compared to 89 schools that did not provide lectures on the subject (Figure 8).

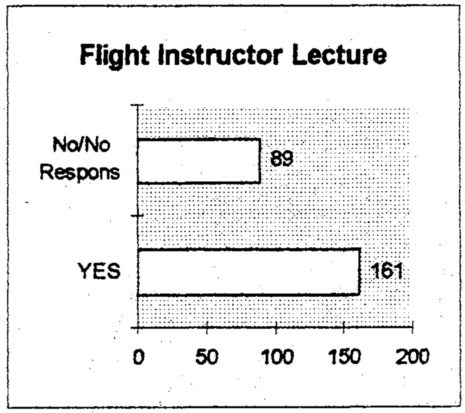

Figure 8. The Number of Schools Reporting Lectures on Spatial Disorientation for the Flight Instructor Course

One hundred eighty schools (72.0%) reported providing lectures and/or films on spatial disorientation compared to 70 schools that did not provide lectures on the subject (Figure 9).

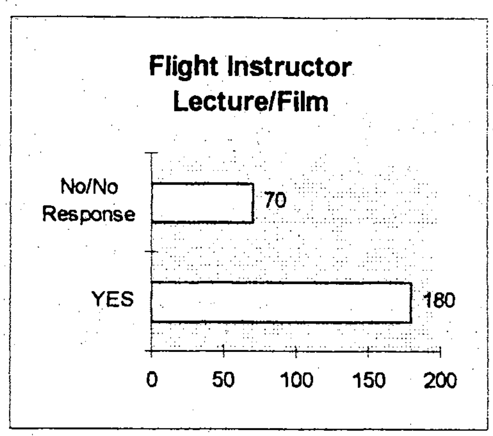

Figure 9. The Number of Schools Reporting Lectures and/or Films on Spatial Disorientation for the Flight Instructor Course

Questionnaire item 4 was designed to determine if courses were taught that included spatial disorientation training in addition to the ground or flight courses listed in questionnaire item 3. A total of 57 schools (28.2%) reported they taught additional courses that included spatial disorientation training compared with 202 that did not report providing additional courses that included spatial disorientation training.(Figure 10). A list of the additional courses are listed in Table 6.

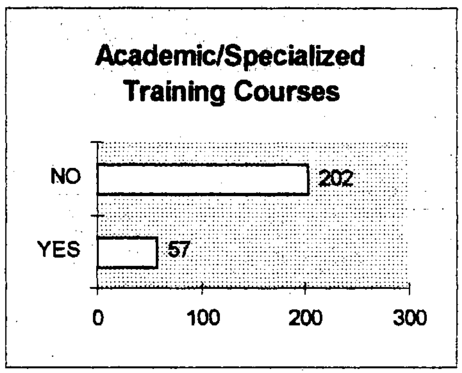

Figure 10. The Number of Schools that Reported Academic or Specialized Training Courses that Included Spatial Disorientation

Interestingly, school affiliation had an impact on the responses to questionnaire item 4. Eighteen schools (28.6%) that were affiliated with two year colleges reported they offered additional courses that included spatial disorientation training whereas 45 did not report additional courses that included spatial disorientation (Figure 11).

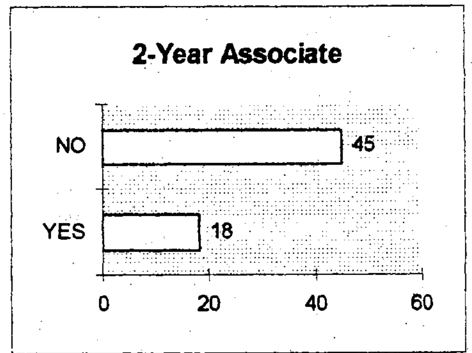

Figure 11. The Number of Schools Affiliated with Two-Year College Programs that Reported Additional Courses that Included Spatial Disorientation Training

Thirty one schools (52.5%) that were affiliated with four-year colleges reported they offered additional courses that included spatial disorientation training compared with 28 that did not offer additional courses that included spatial disorientation (Figure 12).

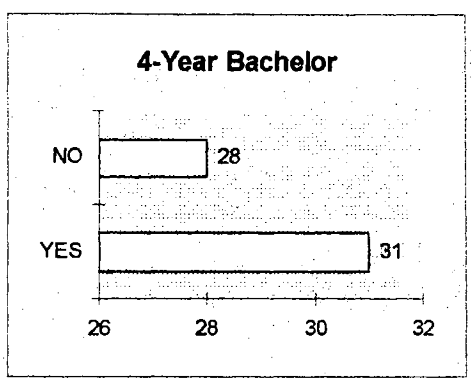

Figure 12. The Number of Schools Affiliated with Four-Year College Programs that Reported Additional Courses that Included Spatial Disorientation Training

Eight schools (5.4%) that were not associated with two or four-year degree programs reported they offered additional courses that included spatial disorientation training compared with 139 that did not offer additional courses that included spatial disorientation (Figure 13).

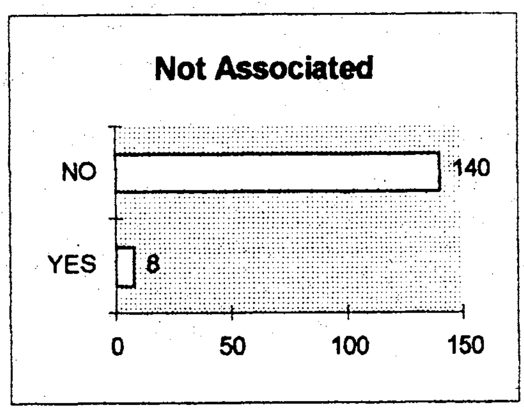

Figure 13. The Number of Schools Not Affiliated with Degree Programs that Reported Additional Courses that Included Spatial Disorientation

TABLE 6

ACADEMIC OR SPECIALIZED TRAINING COURSES THAT INCLUDE SPATIAL DISORIENTATION TRAINING

Academic or Specialized Course	Number of Schools
Human Factors	21
Flight (Aviation) Physiology	12
Flight (Aviation) Safety	12
Crew Resource Management	10
Not Listed	2
Psychology of Flight	2
Aerobatics	1
CFII Course	1
CFI Refresher Course	1
Civil Aeromedical Institute	1

Questionnaire item 5 requested the number of hours of ground instruction each school spent on spatial disorientation in the private pilot/commercial pilot courses, instrument course, flight instructor course, and academic or specialized training courses. Respondents were asked to select from the following range of hours: less than .5 hour, .5 to 1 hour, 1 to 2 hours, 2 to 3 hours, or greater than 3 hours. For the private pilot/commercial pilot courses, instrument course, and flight instructor course, the range of hours spent teaching spatial disorientation reported most often was .5 to 1 hour by a large margin. The range of hours dedicated to spatial disorientation for academic or specialized training courses was more evenly distributed. Specifically, for the private pilot/commercial pilot courses, schools reported the following hours of instruction on spatial disorientation: 57 responded less than .5 hour, 122 responded .5 to 1 hour, 51 responded 1 to 2 hours, 9 responded 2 to 3 hours, and 4 responded greater than 3 hours (Figure 14). Schools reported the following hours of instruction dedicated to spatial disorientation for the instrument course: 33 responded less than .5 hour, 110 responded .5 to 1 hour, 63 responded 1 to 2 hours, 20 responded 2 to 3 hours, and 14 responded greater than 3 hours (Figure 15). Schools reported the following hours of instruction dedicated to spatial disorientation for the flight instructor course: 43 responded less than .5 hour, 89 responded .5 to 1 hour, 45 responded 1 to 2 hours, 13 responded 2 to 3 hours, and 10 responded greater than 3 hours (Figure 16). Schools reported the following hours of instruction dedicated to spatial disorientation for academic or specialized instruction: 13 responded less than .5 hour, 20 responded .5 to 1 hour, 20 responded 1 to 2 hours, 19 responded 2 to 3 hours, and 10 responded greater than 3 hours (Figure 17).

TABLE 7

THE NUMBER OF HOURS OF GROUND INSTRUCTION

	.5<	.5 to 1	1 to 2	2 to 3	>3
PP/CP	57	122	51	9	4
Instrument Rating	33	110	63	20	14
CFI	43	89	45	13	10
Academic/Specialized	13	20	20	19	10

A chi-square test was used to determine if the actual frequency distributions (frequency observed) matched our theoretical flat distribution (frequency expected). The results indicated a significant (α=.05) uneven distribution in the number of hours of ground instruction for the private pilot/commercial pilot courses, the instrument course, and the flight instructor course (Tables 8, 9, & 10; Figures 14, 15, & 16). These courses were skewed to the low end of the continuum for hours of ground instruction. The results indicated a flat distribution (α=.05) in the number of ground instruction for the academic/specialized courses (Table 11; Figure 17).

TABLE 8

THE NUMBER OF HOURS OF GROUND INSTRUCTION FOR THE PRIVATE PILOT/COMMERCIAL PILOT COURSES

Hours	Observed	Expected
.5-1	122	48.6
1-2	51	48.6
2-3	9	48.6
>3	4	48.6

Note: α=.05, *df* = 4, $\chi 2$ = 185.6214 > $\chi 2$ critical 9.4877

TABLE 9

THE NUMBER OF HOURS OF GROUND INSTRUCTION FOR THE INSTRUMENT COURSE

Hours	Observed	Expected
.5<	33	48
.5-1	110	48
1-2	63	48
2-3	20	48
>3	14	48

Note: α=.05, *df* = 4, $\chi2$ = 129.8750 > $\chi2$ critical 9.4877

TABLE 10

THE NUMBER OF HOURS OF GROUND INSTRUCTION FOR THE FLIGHT INSTRUCTOR COURSE

Hours	Observed	Expected
.5<	43	40
.5-1	89	40
1-2	45	40
2-3	13	40
>3	10	40

Note: α=.05, *df* = 4, $\chi2$ = 101.6000 > $\chi2$ critical 9.4877

TABLE 11

THE NUMBER OF HOURS OF GROUND INSTRUCTION FOR ACADEMIC OR SPECIALIZED TRAINING COURSES

Hours	Observed	Expected
.5<	13	16.4
.5-1	20	16.4
1-2	20	16.4
2-3	19	16.4
>3	10	16.4

Note: α=.05, *df* = 4, $\chi 2$ = 5.1951 > $\chi 2$ critical 9.4877

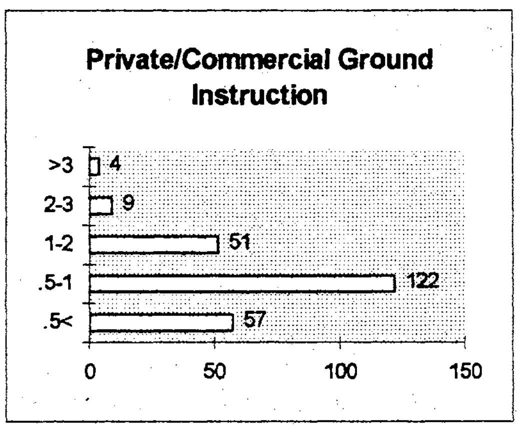

Figure 14. The Number of Hours of Ground Instruction Dedicated to Spatial Disorientation for the Private Pilot/Commercial Pilot Courses.

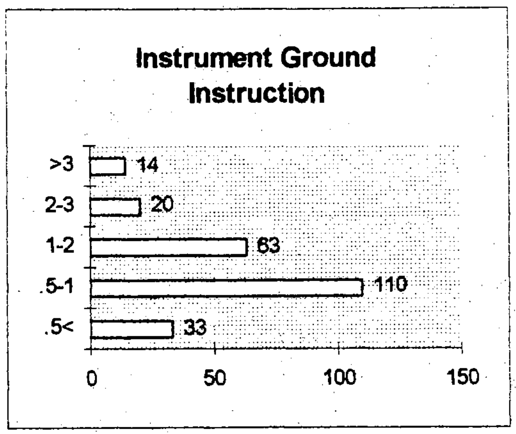

Figure 15. The Number of Hours of Ground Instruction Dedicated to Spatial Disorientation for the Instrument Course

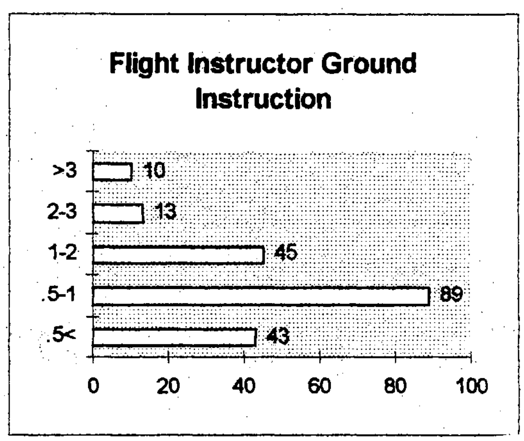

Figure 16. The Number of Hours of Ground Instruction Dedicated to Spatial Disorientation for the Flight Instructor Course

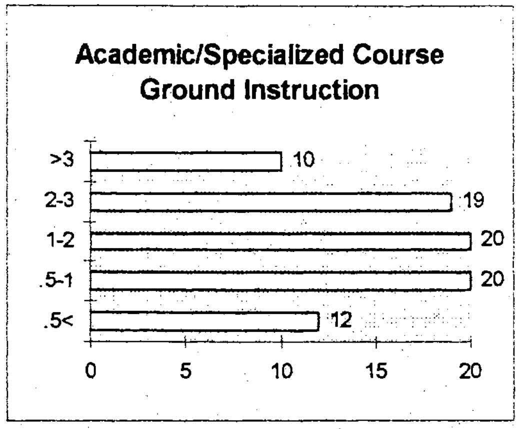

Figure 17. The Number of Hours of Ground Instruction Dedicated to Spatial Disorientation for Academic or Specialized Training Courses

Questionnaire item 7 asked respondents if ground demonstration trainers were used in their schools. Forty two (16.0%) reported that ground demonstration trainers were used and 220 did not report that ground demonstration trainers were used (Figure 18). Table 12 list the type and frequency of ground demonstration trainers.

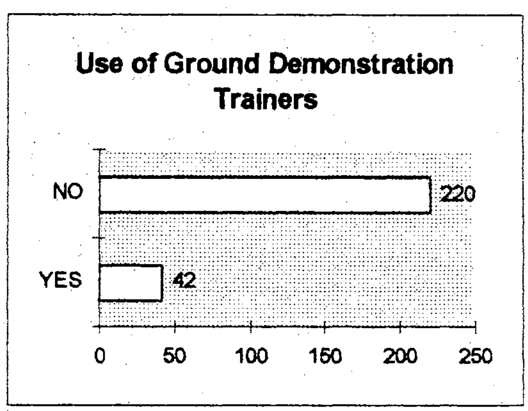

Figure 18. The Number of Schools that Use Ground Demonstration Trainers.

TABLE 12

GROUND DEMONSTRATION TRAINERS

Ground Demonstration Trainer	Number of Schools
Barany Chair	22
Barany Chair (improvised)	11
Vista Vertigon	5
ATC 300	1
Frasca F-141 Trainer	1
Gyro I Trainer	1
Military Resources	1
Simulator	1

Questionnaire item 9 asked respondents if inflight demonstrations of spatial disorientation on two or more flights were used in the private pilot/commercial pilot courses, the instrument course, and the flight instructor course. Two hundred three schools (84.9%) reported they used inflight demonstrations of spatial disorientation in the private pilot/commercial pilot courses and 36 did not report using inflight demonstrations (Figure 19). Two hundred fourteen schools (89.5%) reported they used inflight demonstrations of spatial disorientation in the instrument course and 25 did not report using inflight demonstrations (Figure 20). One hundred forty one schools (72.3%) reported they used inflight demonstrations of spatial disorientation in the flight instructor course and 54 did not use inflight demonstrations (Figure 21).

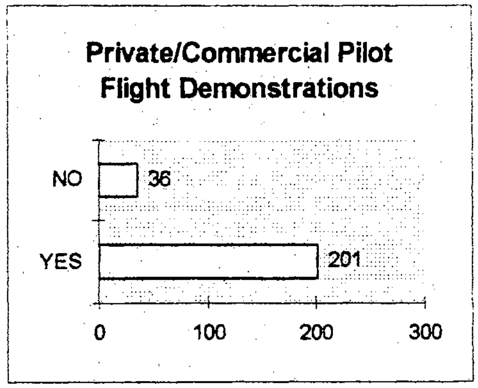

Figure 19. Number of Schools that Reported Inflight Demonstrations of Spatial Disorientation for the Private Pilot/Commercial Pilot Courses

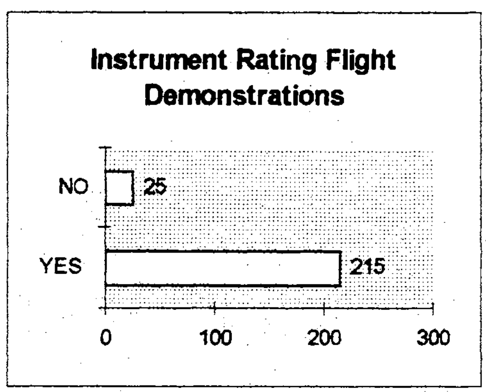

Figure 20. Number of Schools that Reported Inflight Demonstrations of Spatial Disorientation for the Instrument Course

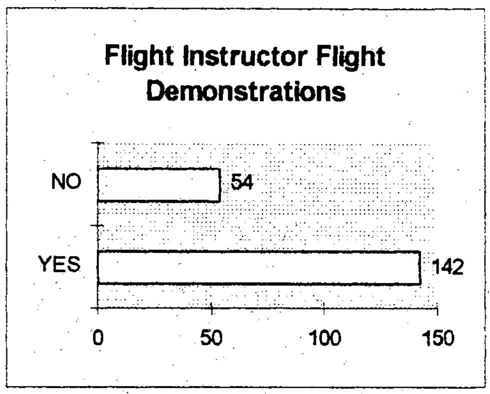

Figure 21. Number of Schools that Reported Inflight Demonstrations of Spatial Disorientation for the Flight Instructor Course

Training Materials

Questionnaire item 8 requested respondents to list the films used in spatial disorientation training. Table 13 lists the films reported in use at the FAR part 141 schools that responded to questionnaire item 8.

TABLE 13

FILMS USED IN SPATIAL DISORIENTATION TRAINING
AT FAR PART 141 SCHOOLS

Film	Number of Schools
Jeppesen	79
Basic Aviation Physiology	11
Jeppesen Private Pilot Series	7
Jeppesen Human Factors Video	2
From Dusk to Dawn (Jeppesen)	1
Guided Flight Discovery (Jeppesen)	1
Spatial Orientation (Jeppesen)	1
Cessna	16
FAA	13
Disorientation (FAA)	3
Rx for Flying (FAA)	1
Stall and Spin (FAA)	1
King	7
USAF (includes Military, USAF physiology)	6
AOPA Air Safety Foundation	3
Sporty's	3
CFTI (Flight Safety Institute)	2
Crew Resource Management Video	1
Nova	1
Safety Films	1
Single Cockpit IFR (AOPA)	1
Visual Illusions	1

Questionnaire item 12 requested respondents to list the source material used for spatial disorientation training. Table 14 lists the training material reported in use at the FAR part 141 schools that responded to questionnaire item 12.

TABLE 14

SOURCE MATERIAL USED IN SPATIAL DISORIENTATION TRAINING AT FAR PART 141 SCHOOLS

Spatial Disorientation Training Source Material	Number of Schools
Jeppesen-Sanderson Products (Pilot Courses, Advanced Pilot Manual, Aviation Fundamentals, etc.)	187
Airman Information Manual	127
ASA Pilot Manual	28
FAA Material (Aviation News, Safety Handouts, Medical Facts or Pilots, etc.)	9
AC 61 27C, Instrument Flying Handbook	17
AC 61-21A, Flight Training Handbook	11
AC 61-23, Handbook of Aeronautical Knowledge	3
Cessna Products	13
USAF Training Manuals (or other military)	11
Internally Developed Material	6
Basic Flight Physiology, (Reinhart)	5
Kershner Pilot Courses	5
An Invitation to Fly	3
Human Factors for General Aviation (Trollip & Jensen)	2
Rod Machado's Pilot Books	2
Trevor Thom Instrument Flight Manual	2
Accident Reports	1
Aircraft Safety (Krause)	1
AOPA Safety Foundation Material	1
Aviation Medicine, (Ernsting & King)	1
Aviation Space and Environmental Medicine	1
Complete Private Pilot	1
Flight Training (Thom)	1
Human Factors in Aviation (Wiener & Nagel)	1
Human Factors in Flight (Hawkins)	1
Human Factors - The Forces Within (Taylor)	1
Gleim	1
Instrument Flight Manual (Dogan)	1
Jeff's Instrument Rating Manual	1
Medical Facts for Pilots	1

Training Need Assessment

To assess the level of perceived importance of spatial disorientation training questionnaire item 10 asked respondents to assess the necessity of training in the subject on a scale of 1 to 10 (Figure 22). The range of scores was 3 to 10. The mean was 8.46, the median was 9.01, and the mode was 10. The results were negatively skewed indicating more FAR part 141 schools ranked the necessity of training higher than lower.

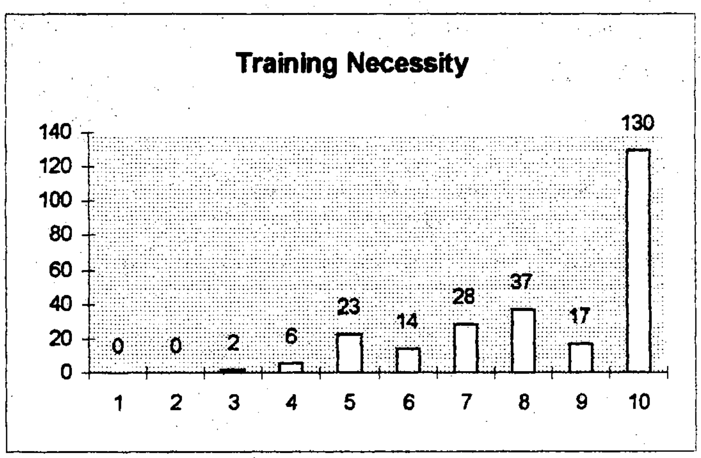

Figure 22. The Perceived Need for Spatial Disorientation Training

Questionnaire item 11 asked respondents to rate the amount of time allotted to spatial disorientation training on a scale of 1 to 10 to assess the level of perceived satisfaction with the time allocated to spatial disorientation training (Figure 23). The range of scores was 4 to 10. The mean score was 7.37, the median score was 7.82, and the mode was 8. Once again the results were negatively skewed indicating more time should be allocated to the subject.

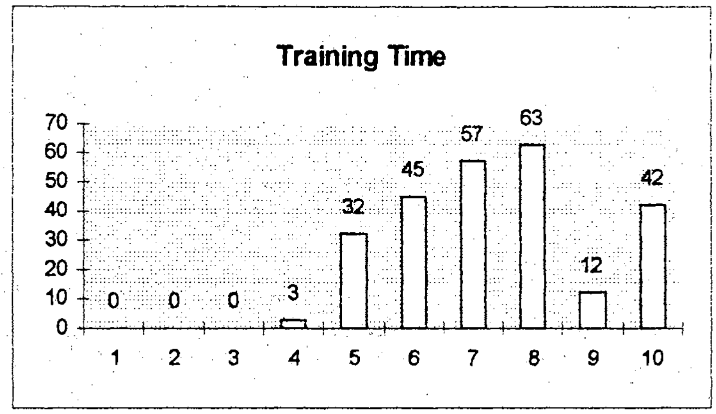

Figure 23. The Perceived Satisfaction with the Amount of Time Spent on Spatial Disorientation Training

The final questionnaire item asked respondents to describe what they consider to be the optimum spatial disorientation training program. The respondent's answers were transcribed and attached at Appendix C. Although the responses were varied, more training in spatial disorientation was considered desirable by most of the respondents. This was consistent with the response to questionnaire item 12 which indicated more time should be allotted to spatial disorientation training. Videos were often mentioned as important and one respondent desired a video solely on the subject.

Fifty-eight respondents stated that ground demonstration trainers were desirable and should be used in an optimum training program. Prohibitive costs were cited as the primary reason for the low use of ground demonstration trainers in FAR part 141 schools. Inflight demonstrations were consistently cited as important in an optimum training program. Interestingly, six respondents described their methodology for inducing spatial disorientation while one respondent remarked that spatial disorientation was too dangerous to teach in an aircraft.

CHAPTER V

SUMMARY, FINDINGS, CONCLUSIONS, AND RECOMMENDATIONS

Summary

The purpose of this study was to determine if spatial disorientation training conducted by FAR part 141 schools met the training guidelines outlined by Kirkham, et al. (1978) of the Civil Aeromedical Institute. Training for the commercial airline industry, which historically was conducted by the military, must now be conducted by civilian aviation. The problem is that commercial aviation industry training managers, based on historical precedent, may assume a level of spatial disorientation training in pilot candidates that is not present. This study provides information for general aviation instructors and commercial airline industry training managers to assess the future training requirements for pilots in the specific area of spatial disorientation.

The participants in this study were 263 FAR part 141 schools that offered private pilot, commercial pilot, instrument rating, or flight instructor courses for the airplane category. The participants were selected from FAA Advisory Circular 140-2Z, List of Certificated Pilot Schools (1997). All schools that offered the aforementioned courses were included.

A survey instrument was developed, validated, and disseminated to gather data from the various schools listed in FAA Advisory Circular 140-2Z (1997). The questionnaires and cover letters were mailed to 506 schools in March, 1998 along with prepaid envelopes to return the questionnaire. Approximately one week after the initial mail out a post card was mailed to encourage participation in the survey. Approximately three weeks after the initial mail out an additional survey was mailed to those participants that had yet to complete and return the questionnaire. Two hundred sixty three questionnaires were returned and were suitable for data interpretation.

The data from the questionnaires was extrapolated and entered into a personal computer based spreadsheet processor for data compilation and generation of graphs and charts. Frequency counts were tabulated and percentages reported where appropriate. A chi-square test (α=.05) was used to determine if frequency distributions (frequency observed) matched our theoretical flat distribution (frequency expected) for the number of hours of formal ground instruction per course.

The research question was analyzed. Does spatial disorientation training conducted by FAR part 141 certificated schools comply with the recommended training guidelines issued by Kirkham, et al. (1978) of the Civil Aeromedical Institute? Specifically, are flight schools providing lectures relative to spatial disorientation; are ground-based demonstrations of disorientation provided; and are inflight demonstrations on two or more occasions during pilot training provided?

Findings

1. The percentage of schools that reported providing lectures for the private pilot/commercial pilot courses was 74.0 percent. When films were included to augment lectures the percentage increased to 85.1 percent.

2. A chi-square test indicated a significant (α=.05) uneven distribution in the hours of ground instruction dedicated to spatial disorientation for the private/commercial pilot courses. The hours of ground instruction were skewed to the low end of the continuum. The percentage of schools that allotted one hour or less to spatial disorientation for the private pilot/commercial pilot courses was 73.7 percent. The specific breakdown was: 23.5 percent .5 hour or less, 50.2 percent .5 to 1 hour, 21.0 percent 1 to 2 hours, 3.7 percent 2 to 3 hours, and 1.6 percent greater than 3 hours.

3. The percentage of schools that reported providing lectures on spatial disorientation for the instrument rating course was 73.0 percent. When films were included to augment lectures the percentage increased to 84.9 percent.

4. A chi-squared test indicated a significant (α=.05) uneven distribution in the hours of ground instruction dedicated to spatial disorientation for the instrument rating course. The hours of ground instruction were skewed to the low end of the continuum. The percentage of schools that allotted one hour or less to spatial disorientation for the instrument course was 59.6 percent. The specific breakdown was: 13.8 percent .5 hour or less, 45.8 percent .5 to 1 hour, 26.3 percent 1 to 2 hours, 8.3 percent 2 to 3 hours, and 5.8 percent greater than 3 hours.

5. The percentage of schools that reported providing lectures on spatial disorientation for the flight instructor course was 64.4 percent. When films were included to augment lectures the percentage increased to 72.0 percent.

6. A chi-square test indicated a significant (α=.05) uneven distribution in the hours of ground instruction dedicated to spatial disorientation for the flight instructor course. The hours of ground instruction were skewed to the low end of the continuum.

The percentage of schools that allotted one hour or less to spatial disorientation for the flight instructor course was 66.0 percent. The specific breakdown was: 21.5 percent .5 hour or less, 44.5 percent .5 to 1 hour, 22.5 percent 1 to 2 hours, 6.5 percent 2 to 3 hours, and 5.0 percent greater than 3 hours.

7. A total of 57 schools (28.2 %) reported they provided additional academic or specialized courses that included spatial disorientation training. Eighteen of the schools affiliated with two-year college programs (28.6%), 31 of the schools affiliated with four-year college programs (52.5%), and eight of the schools that were not affiliated with college programs (5.4%) offered additional academic or specialized courses that included spatial disorientation.

8. A chi-squared test indicated a flat distribution (α=.05) in the hours of ground instruction dedicated to spatial disorientation for the academic or specialized courses. The specific breakdown was: 15.9 percent .5 hour or less, 24.4 percent .5 to 1 hour. 24.4 percent 1 to 2 hours, 23.2 percent 2 to 3 hours, and 12.2 percent 3 hours or more.

9. The number of schools that reported utilizing ground demonstration trainers was 42 (16.0%).

10. Two hundred three schools (84.9%) reported they provided inflight demonstrations of spatial disorientation for the private pilot/commercial pilot courses.

11. Two hundred fourteen schools (89.5%) reported they provided inflight demonstrations on spatial disorientation for the instrument rating course.

12. One hundred forty one schools (72.3%) reported they used inflight demonstrations of spatial demonstrations for the flight instructor course.

13. The perceived need for spatial disorientation training was absolutely necessary. On a Lickert scale of 1 to 10, with 10 representing absolutely necessary, the mean score was 8.46 with a standard deviation of 1.90.

14. Respondents indicated they would desire additional time allocated to spatial disorientation training. On a Lickert scale of 1 to 10, with 10 representing much more, the mean score was 7.37 with a standard deviation of 1.61.

Conclusions

The study assessed the spatial disorientation training at FAR part 141 schools as compared to the guidelines published by Kirkham, et al. (1978) of the Civil Aeromedical Institute. Specifically, do FAR part 141 schools provide lectures on spatial disorientation; do they provide ground-based demonstrations of spatial disorientation, and do they provide inflight demonstrations of spatial disorientation?

The findings of the study identified that only a minority (38) of FAR part 141 schools comply with all three of the guidelines established by Kirkham et al. (1978). The largest discrepancy between certificated flight schools and the guidelines was the recommendation that flight schools provide ground-based demonstrations of disorientation. Only 16 percent of the schools provide ground-based demonstrations of spatial disorientation. In addition, 11 of the 42 schools that reported using ground demonstration trainers used improvised training devices.

The findings of the study identified that a majority (the highest percentage for any course was 74.0 percent) of the schools provided lectures on spatial disorientation. Lectures on spatial disorientation for the private pilot/commercial pilot courses were conducted by 74.0 percent of the schools. When films were used to augment lectures the percentage increased to 85.1 percent. Lectures on spatial disorientation for the instrument course were provided by 73.0 percent of the schools. When films were used to augment lectures the percentage increase to 84.9 percent. Lectures on spatial disorientation for the flight instructor course were conducted by 64.4 percent of the schools. When films were used to augment lectures the percentage increased to 72.0 percent.

Disturbingly, the length of time spent on formal ground instruction for spatial disorientation indicate the lectures may be restricted in scope. A chi-square test identified an uneven distribution (α=.05) in the hours of ground instruction dedicated to spatial disorientation for the private pilot/commercial pilot courses, instrument course, and flight instructor course. The hours of ground instruction were skewed to the low end of the continuum. A chi-square test identified a flat distribution (α=.05) in the hours of ground instruction dedicated to spatial disorientation for academic or specialized courses. Since the hours of ground instruction were not skewed to the low end of the continuum, one could generally expect to receive equal or greater hours of ground instruction on spatial disorientation in academic or specialized courses as compared to private pilot/commercial pilot courses, the instrument course, or the flight instructor course. Four-year college programs offered academic or specialized courses at a greater rate (52.6%) than did two-year college programs (28.6%) or schools that were not associated with college programs (5.4%).

The strength of spatial disorientation training in FAR part 141 schools was the use of inflight demonstrations on two or more occasions. Inflight demonstrations were provided 84.9 percent of the time in private pilot/commercial pilot courses. Inflight demonstrations were provided 89.5 percent of the time for the instrument rating course. Inflight demonstration were provided 72.3 percent of the time for the flight instructor course. Numerous suggestions were made in the answers to questionnaire item 13 on techniques for effective inflight spatial disorientation demonstrations.

Recommendations

Based on the findings and conclusions of this study, the following recommendations are made:

1. Federal Aviation Regulations part 141 schools should provide detailed lectures on spatial disorientation and inflight demonstrations of spatial disorientation for all private pilot, commercial pilot, instrument rating, flight instructor, and instrument flight instructor courses.

2. The FAA should incorporate at least two of the three guidelines recommended by Kirkham, et al. (1978) as requirements into Federal Aviation Regulations. Lectures and inflight demonstrations of spatial disorientation should be required for the private pilot, commercial pilot, instrument rating and the flight instructor courses. Ground demonstrations of spatial disorientation should be strongly encouraged.

3. The FAA should continue to provide spatial disorientation training and ground demonstrations through their Accident Prevention Program and the Pilot Proficiency Award Program (Wings) program and through the training courses offered through the Civil Aeromedical Institute in Oklahoma City, OK.

5. Commercial air carriers should assume minimal training in spatial disorientation. Commercial air carriers should conduct spatial disorientation training in conjunction with unusual attitude training, especially if their pilots are expected to fly non-precision approaches.

Recommendations for Future Research.

1. A more detailed survey of exactly what is taught at FAR part 141 schools and a post-graduation survey to find out what graduates retain.

2. A survey on spatial disorientation training at FAR part 61 training operations.

3. A needs assessment survey from commercial air carriers.

4. Develop protocol for sequencing spatial disorientation training into general aviation.

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APPENDIXES

APPENDIX A

COVER LETTER AND QUESTIONNAIRE

OKLAHOMA STATE UNIVERSITY

OSU

Department of Aviation and Space Education
300 Cordell North
Stillwater, Oklahoma 74078-8034
405-744-5856 or 405-744-7015
FAX 405-744-7785

March 4, 1998

Dear Chief Flight Instructor

We respectfully request your participation in a study of spatial disorientation training in pilot training programs. Your response is extremely important. We need your assistance to determine the current level of training in spatial disorientation and your opinions to improve flight training programs in this area. General aviation training, always important, is now the primary source of pilots for the airline industry following military downsizing.

A review of NTSB accident data since 1983 indicate spatial disorientation has contributed to 541 general aviation accidents resulting in excess of 1000 fatalities. Additionally, controlled flight into terrain continues to be a problem in general aviation and spatial disorientation may play a significant role in these accidents.

The data provided by you and other schools will be used in my doctoral dissertation at Oklahoma State University. Your participation is voluntary and your response will remain confidential. The data gathered will only be presented in aggregate statistical form. The report should provide an excellent view of the current state of training in spatial disorientation. A copy will be available to all participants.

A self-addressed prepaid envelope is included to return your survey. Please do not hesitate to call or write if you have any questions or comments. Thank you for your assistance.

Sincerely,

Roger Morrison
300 North Cordell
Stillwater, OK 74078-0442

(580)-233-1272

Kenneth E. Wiggins
Professor

Questionnaire Key

CFI - Certified Flight Instructor
CFII - Certified Instrument Flight Instructor
ATP - Airline Transport Pilot Rating
MEI - Multiengine Category Instructor
Ed. D. - Doctor of Education
Ph. D. - Doctor of Philosophy
M.D. - Medical Doctor
D.O. - Doctor of Osteopathy

A Survey on Spatial Disorientation Training at FAR Part 141 Certified Schools for Airplane Category

Please complete the questionnaire (front and back) and return in the prepaid envelope.

1. Is your flight school affiliated with a 2-year associate or 4-year bachelor degree granting institution?

Yes (2-year associate) _____ Yes (4-year bachelor) _____
No, not associated with a two or four year college degree _____

2. Please place a check beside each training program your school offers.

Private Pilot _____ CFI _____ Multiengine _____
Commercial Pilot ____ CFII _____ MEI _____
Instrument _____ ATP _____

3. Do you provide formal instruction (lectures, films, etc.) on spatial disorientation? Please place a check beside the types of formal instruction you provide for spatial disorientation.

	Lecture	Films
Private/Commercial Pilot	_____	_____
Instrument	_____	_____
CFI	_____	_____

4. If you provide training in spatial disorientation outside a formal flight training course in an academic or specialized training course (e.g. Human Factors), please list the course(s).

5. Please indicate the approximate number of hours of formal ground instruction on spatial disorientation by placing a check in the appropriate space.

	Ground Instruction Hours				
	.5<	.5-1	1-2	2-3	>3
Private/Commercial Pilot	___	___	___	___	___
Instrument	___	___	___	___	___
CFI	___	___	___	___	___
Academic courses (e.g. human factors)	___	___	___	___	___

6. What is the qualification of the spatial disorientation instructor(s)? Please check each applicable box as spatial disorientation may be taught by more than one instructor.

CFI _____ Ph. D _____ Human Factors Instructor ______
CFII _____ M.D. _____ Other (please specify training) _____
Ed. D. _____ D.O. _____ ______________________________

7. If you provide ground-based spatial disorientation training, please list the ground demonstration trainer(s) you use (e.g. Barany chair, Vista Vertagon, etc.):

8. If you show films on spatial disorientation, please list the films used:

9. Do you provide inflight demonstrations of spatial disorientation on two or more flights in the following programs:

Private/Commercial Pilot	**Yes _____**	**No _____**
Instrument	**Yes _____**	**No _____**
CFI	**Yes _____**	**No _____**

10. Personally, I feel formal instruction on spatial disorientation is _____:

unnecessary				necessary				absolutely necessary	
1	2	3	4	5	6	7	8	9	10

11. Personally, I would like to see _____ training on spatial disorientation.

much less			the same amount						much more
1	2	3	4	5	6	7	8	9	10

12. Please describe the source(s) of content for your spatial disorientation training (e.g. AIM, ASA Pilot Manual, Jeppesen Advanced Pilot Manual, etc.).

13. Describe in the space below what you consider to be an optimum spatial disorientation training program for pilots and any comments you have concerning this subject.

OKLAHOMA STATE UNIVERSITY

OSU

School of Educational Studies

College of Education
204 Willard
Stillwater, Oklahoma 74078-4045
405-744-6275; Fax 405-744-7758

April 3, 1998

Dear Chief Flight Instructor

About three weeks ago I wrote to you seeking your opinion on spatial disorientation training in pilot training programs. As of today we have not yet received your completed questionnaire.

We have undertaken this study to determine the current status of spatial disorientation training for the professionally oriented pilot. Accident statistics indicate this phenomenon continues to pose a threat to aviators. The Air Force has formed the Spatial Disorientation Countermeasures Task Force at Armstrong Laboratory to study this threat. Your reactions, attitude, and concerns about flying and ground training are very important to us in evaluating strengths and potential areas of improvement.

Adult Education
Aviation and Space Education
Higher Education
Human Resource Development
Organization and Leadership
Research and Evaluation
Social Foundations
Student Personnel
Technology

I am writing again because of the significance each questionnaire has to the usefulness of this study. Because it has been sent to only a small number of flight schools it is extremely important that yours also be included in the study if the results are to accurately represent the opinions of flight school operators.

In the event that your questionnaire has been misplaced, a replacement is enclosed.

Your cooperation is greatly appreciated.

Sincerely,

Roger Morrison

Roger Morrison
300 North Cordell
Stillwater, OK 74078-0442

(580)-233-1272

March 20, 1998

Recently you should have received a questionnaire seeking your opinions on spatial disorientation training in flying training programs. Your reactions, attitude, and concerns about flying and ground training are very important to us. This survey is part of an effort to determine the current state of spatial disorientation training.

If you have taken the time to return your completed survey, please accept my sincere thanks. If not, please do so today. Because it has been sent to only a small number of flight schools it is extremely important that yours also be included in the study if the results are to accurately represent the opinions of flight school operators.

We can't emphasize enough the value of your feedback and input. If by some chance you did not receive the questionnaire, or it got misplaced, please call me right now, collect (580-233-1272) and I will get another one in the mail to you today.

Sincerely,

Roger Morrison
Aviation and Space Education
Oklahoma State University

APPENDIX B

INSTITUTIONAL REVIEW BOARD APPROVAL FORM

OKLAHOMA STATE UNIVERSITY
INSTITUTIONAL REVIEW BOARD
HUMAN SUBJECTS REVIEW

Date: February 24, 1998 **IRB #:** ED-98-083

Proposal Title: **A SURVEY ON SPATIAL DISORIENTATION TRAINING AT FAR PART 141 CERTIFIED SCHOOLS FOR AIRPLANE CATEGORY**

Principal Investigator(s): Steven K. Marks, Roger G. Morrison

Reviewed and Processed as: Exempt

Approval Status Recommended by Reviewer(s): Approved

ALL APPROVALS MAY BE SUBJECT TO REVIEW BY FULL INSTITUTIONAL REVIEW BOARD AT NEXT MEETING, AS WELL AS ARE SUBJECT TO MONITORING AT ANY TIME DURING THE APPROVAL PERIOD.
APPROVAL STATUS PERIOD VALID FOR DATA COLLECTION FOR A ONE CALENDAR YEAR PERIOD AFTER WHICH A CONTINUATION OR RENEWAL REQUEST IS REQUIRED TO BE SUBMITTED FOR BOARD APPROVAL.
ANY MODIFICATIONS TO APPROVED PROJECT MUST ALSO BE SUBMITTED FOR APPROVAL.

Comments, Modifications/Conditions for Approval or Disapproval are as follows:

Signature: Date: February 26, 1998

Chair of Institutional Review Board

cc: Roger G. Morrison

APPENDIX C

RESPONDENTS COMMENTS TO QUESTIONNAIRE ITEM 13

Response 1.
Classroom lessons (relating to disorientation)
- Physiological, psychological factors.
- Aircraft and instruments
- Weather
- Prevention and recovery
- Aerobatics

Simulator Missions
- Apply Knowledge to simulation - exercise

Flight missions
- Recovery from unusual attitudes
- Aerobatics

Response 2.
A combination of ground school including spin awareness and the actual practice and demonstration in flight of unusual attitude recognition and recoveries. We use the T-34 mentor aircraft for this purpose and fly a spin orientation flight prior to solo followed by basic aerobatics instruction at the end of the commercial syllabus.

Response 3.
Actual Hood Training (private)
Flight at night over uninhabited areas (all levels)
Actual (IMC) Instrument, Commercial, CFII

Response 4.
Actual flight

Response 5.
Lecture, student reading, demonstration in aircraft.

Response 6.
1-2 hours seem to be adequate.

Response 7.
Emergency Maneuvers Training Program
- Spins - conventional/inverted
- Cross control stalls

Response 8.
Use of a simulator to induce disorientation.
Development of scanning techniques to minimize disorientation.
Development of Flight maneuvers for CFIs to use with students.

Response 9.
Inflight procedures are most effective.

Response 10.
Academics , then the chair (Barany chair), then flight.

Response 11.
Accessibility to spatial disorientation simulators.

Response 12.
The pilot should experience spatial disorientation due to flight instructor input.
Simulator to show instrument failure.
Failure of instruments inflight.

Response 13.
Cessna Jeps are adequate.

Response 14.
Ground simulators would be beneficial.

Response 15.
Thorough explanation taking care to achieve thorough understanding.

Response 16.
Spatial disorientation simulator

Response 17.
USAF Physiological Training Course.

Response 18.
At least a Barany chair demo.

Response 19.
One hour ground/one hour flight - unusual attitudes.

Response 20.
A good time to introduce the subject is just before training for unusual attitudes. A ride in the barany chair is a must, it's guaranteed to make a person a believer in the fact that anyone can develop vertigo and become spatially disoriented.

Response 21.
Military chamber and related equipment.

Response 22.
Too dangerous to train in aircraft. Can only talk about it. We do not have the equipment to train it any more deeply.

Response 23.
Discussion of physiology of the inner ear organs and common forms and causes of spatial disorientation, followed by a few inflight demonstration designed to reinforce the student's confidence in using the instruments for orientation when references are lost.

Response 24.
Structured training (Jeppesen course, etc.) and Barany chair or Vertigon experience.

Response 25.
Ground instruction on factors involved.
Ground based demonstration.
Inflight demonstration and recovery.
Note: A very effective inflight maneuver (at night) is to put the aircraft in a standard rate turn for greater than 720 degrees <u>very</u> smoothly, while having pilot look up something on a chart or similar task. Then allow the aircraft to enter a spiral and ask the pilot to recover. It can be quite enlightening.

Response 26.
Not enough is incorporated in instrument and CFI syllabus. Needed - possibly an old link trainer to create vertigo and learn to deal with it. I am prone (to spatial disorientation) and with hours learn to ignore.

Response 27.
Would like to see video based solely on subject.

Response 28.
Ground Training: physiological factors, human senses vs. limitations (i.e. inner ear, illusions), terrain familiarity, aircraft familiarity, rules of conduct (i.e. IFR/VFR/day-night), visual cues vs. appropriate instrument interpretation, basic aerodynamics vs. recovery from unusual flight attitudes, lost procedures, services available to pilots, weather vs. go-no/go decision making, the need for recurrent training/continuous education, encourage participation in voluntary training programs, share personal experiences (of susceptibility). Flight Training: Hood work (Full/partial panel), unusual attitudes and recovery, lost procedures/diversion to alternates, emergency procedures that could lead to spatial disorientation (i.e. pilot focuses on a problem and becomes disoriented). Very often the 141 <u>minimum training</u> is perceived as the only mandatory training to get through a course. Therefore students may limit the <u>scope</u> of such training to this absolute minimum, driven by cost considerations, and consider it as sufficient because it is FAA approved. It is sad to observe the quality of instruction given (often by large 141 schools that resemble "production lines") to deteriorate. It may be interesting

to conduct a survey at OSU and see how often pilots become disoriented (if you have not done it yet!).

Response 29.
The training offered at most schools is adequate, however practice (in my opinion is what makes the difference). One could have had the best possible training in the world 10 years ago but probably wouldn't do them much good unless they keep up with what they were shown and taught.

Response 30.
Tapes, books, and flight demonstrations.

Response 31.
It is important to give training on spatial disorientation.

Response 32.
Simulator for disorientation so the pilot can feel the effects.

Response 33.
Detailed ground training - cause/effect/preventative (countermeasures) enabling (the) student to correlate with the actual situation when created, usually by the student and identified by the instructor. Supplemental air training initiated by (the) instructor fills in the gaps of experience.

Response 34.
Ground Training: what it is, experience it, discuss how to overcome it, proper recoveries from unusual attitudes.
Airplane: experience it and overcome it (using induction techniques such as slow roll in; quick roll out.), let student "fly airplane' with eyes closed.

Response 35.
Minimum 3 hours/ 1 hour lecture/film - 1 hour Frasca/Barany chair - 1 hour flight.

Response 36.
Films, lectures, and one on one instruction.

Response 37.
Inflight demonstration with poor visibility or night time.

Response 38.
The FAA's gyro one vertigo simulator is extremely effective in teaching vertigo.

Response 39.
The optimal training program would consist of ground school and training in a centrifuge -type simulator. How do you provide this type training at an affordable cost.

Response 40.
Ground school training followed by inflight demonstration.

Response 41.
No matter what the resource material used, if all pilots gain the least little knowledge from spatial disorientation training, be it ground or flight, the pilot will benefit and become a better pilot from the experience.

Response 42.
1. The use of videos.
2. Discussion with flight instructor before flight.
3. Inflight demonstration.
4. Post flight review and discussion.

Response 43.
Talk about the causes, show how to avoid, and demonstrate inflight.

Response 44.
1. Reading on the subject in the aim and other texts.
2. Watching training videos about spatial disorientation.
3. Discussion with an instructor.
4. Use of a ground based trainer such as the Barany chair.
5. Listening to available ATC audio tapes of actual inflight emergencies involving spatial disorientation.

Response 45.
The program given by the Air Force Base (altitude chamber course) included a chair to help students experience spatial disorientation which I think is best. The best learning is experiencing the real thing!!!

Response 46.
Spatial Disorientation is a worthwhile part of flight training and more time should be dedicated to this area. At this time our flight center has no training program dedicated to this topic of training. I personally feel it would be an important area to concentrate on and would contribute to every pilots ability to operate safely.

Response 47.
1. 1 hour lecture referencing physiological factors.
2. Film (Flighttime video series "Basic Aviation Physiology" Jeppesen-Sanderson.

3. I hour flight demonstration.

A. Demonstrate attempt to fly or return aircraft to straight and level flight without visual reference to instruments or horizon (eyes closed).

B. Unusual attitudes - full and partial panel.

Response 48.
Incorporating textbook reading with classroom discussion followed by periodic inflight simulations of spatial disorientation. While we do not have one at this school, I have found the Barany chair to be useful in simulating spatial disorientation. In my previous training, using the chair was very effective for making an impact on an entire classroom, showing that no one is exempt. There are also many videos on this subject which I feel are valuable and should be promoted to flight schools, both 61 and 141.

Response 49.
Spatial disorientation is hard to simulate. Night flights and actual IFR are the time when this type of training is most effective.

Response 50.
Integrated mix of lecture, video, simulator, and finally real flight.

Response 51.
Ground instruction - reasons, concepts.
Chair - experience.
Airplane - experience.

Response 52.
Academics, flight, chair ride, and observe chair ride.

Response 53.
Knowledge and understanding of the factors leading to spatial disorientation and methods of overcoming the onset.

Response 54.
Integrated as part of training starting from private on up. The heaviest concentration should be in instrument and CFII training. It is a consideration that can be raised in human factors instruction in terms of crew coordination.

Response 55.
Should include lecture, the chair, and inflight demonstration.

Response 56.
Aircraft demonstration with no outside references. A good quote of past aircraft accidents (NTSB Reporter, etc.) is a good reference for this topic.

Response 57.
This is a big issue. We do much of our instrument training in actual IMC and partial panel.

Response 58.
Lecture. then video, then spatial disorientation simulator, then aircraft demonstration.

Response 59.
Basics of vestibular system and why disorientation can occur. Why you won't 'naturally" do "the right thing." Using training devices is ideal, budget permitting. More emphasis might be given to map/navigation disorientation, which is separate from the vertigo types of problems. I fear we may become too dependent on GPS and not know when we're in trouble because it is so reliable.

Response 60.
I am not sure, having never looked into the subject. I would think that much more could be done here on ground based training, maybe more on classroom training to accompany it.

Response 61.
Vertigon training is the best.

Response 62.
Spatial disorientation training should be included in the training program of all ratings. It needs to be discussed and demonstrated both in the aircraft and in the classroom.

Response 63.
In addition to a ground training device, I like to have a demonstration in an airplane. Rather than the instructor putting aircraft in unusual attitude, I will have the student continue flying aircraft but they must close their eyes. In doing this they rely on vestibular senses to control aircraft and eventually the aircraft ends up in unusual attitude. The student would have a hood on during this procedure so when they look up they must recover by instruments. What usually results is a descending turn. What they are supposed to do is keep wings level. Once the aircraft banks the student feels "G" force so they relax back pressure and as aircraft descends, the student feels the normal one "G" and assumes they are wings level and holding altitude. I use this for both private and instrument training.

Response 64.
Optimum would be a Vertigon chair to let them experience it. You can tell students theory all day and they still can't recognize it in the aircraft. It has been said that you can build up a tolerance to vertigo, but for the weekend/occasional pilot this is not a realistic expectation.

Response 65.
Lecture, simulator, aircraft.

Response 66.
The optimum program depends on:

1. Background and experience level of students.
2. Flight ratings student being prepared for.
3. Type of training program e.g. FBO, university.
4. How training fits in with other material being presented.

You need to consider:

1. Physical - physiological factors in sensation and perception.
2. Factors specific to aviation.
3. Typical scenarios producing spatial disorientation and other illusions.

Response 67.
Formal ground school. Two to three hours within a program.
Ground trainer if available.
Demonstration in the aircraft particularly prior to the instrument phase and night flying.

Response 68.
Lecture and demonstration with real life experience.

Response 69.
1. 1-2 hours of aircraft training.
2. videos/films.
3. .5-1 hour of artificially induced disorientation by a machine/chair etc. and demonstration of distracting nature of spatial disorientation.

Response 70.
I think we have a good training balanced training program. (This school uses the Gyro-1 trainer. They reported it can induce the following illusions: leans, coriolis, false horizon (daytime and nighttime), dark takeoff, runway width, up-slope runway, autokinesis, graveyard spiral, occulogyral, somatogyral, runway width, nystagmus, and black hole approach).

Response 71.
1. Barany chair.
2. Simulator.
3. In aircraft experience and training.

Response 72.
Emergency situation training course (visual and instrument). Definitely in aircraft - not simulator.

Response 73.
Spatial disorientation must be combined with situational awareness training.

Response 74.
A review of the maneuvers contained under the topic of "aircraft maneuvers for demonstrating spatial disorientation" along with a discussion of causes and how to cope would optimize training.

Response 75.
Spatial disorientation should be shown and taught to the private pilot student and reinforced continuously throughout the student's training, especially low visibility situations for non-instrument rated pilots and constant circumstances in IMC for the instrument student (and reinforced in higher certificates/rating). Any practical "hands-on" experience is worth 1000 spoken and 10,000 words real, i.e. using ground demonstration trainers.

Response 76.
1. Lecture.
2. Film.
3. Ground demonstration.
4. Inflight demonstration.
5. Late in-training review.

Response 77.
Disorientation training should ideally include classroom theory, ground demonstration in the Barany chair and inflight demonstrations of situations with high probability of inducing spatial disorientation.

Response 78.
They should have training in a simulator on spatial disorientation.

Response 79.
A thorough discussion in every ground school course and flight training course.

Response 80.
Ground training followed by inflight demonstration.

Response 81.
Our part 141 program does not have any ground-based training devices for the benefit of our students or instructors, however, we do use our airplanes for this purpose. We purposely fly into IMC with non-instrument rated pilots in an attempt to encourage them to remain clear of this type of weather. We also devote a large block of flight training

time in recovery techniques for our private, instrument, commercial, and instructor students. I do wish we had ground based facilities but our finances prohibit this type of equipment. A flight simulator that had the capabilities to fail systems in IMC would be the best of all worlds, if they were affordable.

Response 82.
Pilots should be acquainted with the various ways one can get into a spatial disorientation situation, the physiology of the inner ear, videos on spatial disorientation, flight and ground practical demonstrations.

Response 83.
Dedicated presentations in each ground school to include film presentations if available. Design of a more appropriate ground trainer that will show an instrument panel (full or partial) with which the operator can recover control of the trainer after becoming disoriented. Stress recovery from unusual attitudes on both full and partial panel.

Response 84.
We had FAA do a program using spin chair. That along with ground and flight simulation would be best.

Response 85.
.5 lecture, .3 film, .5 ground spatial disorientation simulator, 2.0 flight demonstration/recovery (situation awareness and unusual attitudes).

Response 86.
It should be a lesson (stand alone) within the training syllabus of the courses that address pilot certification requirements.

Response 88.
The typical ground instruction included in a part 141 training course seems adequate. It must be followed up with inflight recovery from unusual attitudes thoroughly and to proficiency. As important, biennial flight reviews need to include spatial disorientation/unusual attitude recovery, because these things are never practiced by pilots.

Response 89.
Fairchild AFB, Spokane WA.

Response 90.
Military type training.

Response 91.
I feel the traditional method of the instructor inducing the phenomenon artificially is not very good, as the student expects it to happen. What I prefer is to allow the applicant to induce the disorientation by himself, then recover.

Response 92.
1. It would be great if we could use ground training aids. Unfortunately they are cost prohibitive for small schools.
2. Most spatial disorientation accidents are actually a result of lack of personal flying discipline. Flying in conditions the pilot knows he/she should not be in.

Response 93.
Training program should include:
1. Physical factors and causes of vertigo.
2. Flight instruments and navigation equipment.
    a. How each is constructed and operates
    b. Indication of failure and procedures to follow.
    c. Triangles of agreement by flight and navigation instruments.
    d. Partial panel practice.
3. Pilots trained to know at all times their location both horizontally and vertically in relation to surface and obstructions.
4. Review of known examples of spatial disorientation and CFIT and causes of and failure to recognize malfunction of equipment, and/or proper procedures or currency training.

Response 94.
Film and/or use of Barany chair.

Response 95.
Thirty minutes ground instruction in private and instrument programs. And unusual attitude recoveries in both private and instrument programs. And spin recovery instruction (Flight and ground).

Response 96.
Complete academic training of what is, what causes, and the ways to recognize it, avoid it, and/or recover from it. Actual inflight demonstration and practice in recovery techniques.

Response 97.
Individual instruction and classroom training on the cause and effect of spatial disorientation. and the proper procedures to avoid or minimize the effects. Video, lecture, and a device such as the Barany chair are adequate for ground training.

Response 98.
Ground

Physiological aspects.
Various kinds of illusions/disorientation and circumstances in which they happen.

Flight

Training in attitude instrument flying.
Flight at night in uncongested areas and in IMC.

Response 99.
Should be considered as a separate task under the instrument airplane/helicopter practical test standards.

Vestibular Apparatus
Typical settings encountered
Physiological contributors

Response 100.
Actual inflight experience.

Response 101.
Begin with the academic portions - ground training.
Transition to flight training - hands on experience.
Repeat hands on experience along and throughout flight training ... drill.
As someone has said - "repetition is the mother of all learning!"

Response 102.
Barany chair, AIM, and Jeppesen are what we have found works the best

Response 103.
Mainly ground based training consisting of lecture, video then the Vertagon. This is the best, however not all can afford the expense.

Response 104.
Pilots must experience these effects in a safe environment either with the use of simulators or in an aircraft with an instructor. Flight in actual IMC conditions is one of the best methods of experiencing disorientation.

Response 105.
Videos, ground discussion, inflight training, FAA advisory circular, training manuals.

Response 106.
Human factors and spatial disorientation.

Response 107.
Optimal

.5 during private-demonstration	1.0 private-ground
3.0 IFR-demonstration/practice	4.0 IFR-ground
2.0 CFI demonstration/review/practice teaching	.5 ground review

Spatial disorientation training is critical. Number one current solution - educate. Increase awareness, teach effects of overloading (mental) and gradualism (as applied to rates of divergence). Number two solution - better instruments to reduce mental workload (See Burt Rutan on new instrument theories).

Response 108.
1. Good reference material to study.
2. Quality video or CD to reinforce reference material.
3. Workbook questions, open book.
4. Exam with the incorrect answer discussed.
5. Flight in the airplane and unusual attitudes.

Response 109.
In reference to (question) number 11, I feel that the quality of training material should be upgraded and updated, not necessarily the quantity. It is difficult for a student, or anyone, to relate to spatial disorientation as it applies to mail carriers in a Curtis Jenny. I feel that those of us in the training industry should take a more hands on approach to spatial disorientation training and rely less on outdated text.

Response 110.
Our program is still under development.

Response 111.
Yes, we feel spatial disorientation is an important part of all of our training from private through Part 135. We have moved away from the traditional means of recovery and entry into "unusual attitudes." We no longer use the "standard means of entry by putting the students head down with eyes closed while the instructor puts the aircraft into the "unusual attitude." Our methodology is allowing the student (to) enter the attitude with eyes closed and maintaining control of the aircraft. The instructor has the student execute several shallow and medium bank turns. Within 30 seconds, the student is usually in some sort of unusual attitude that he created himself (self induced), therefore making it more realistic. The students actually has a case of vertigo/spatial disorientation.

Response 112.
Air Force training.

Response 113.
Familiarization

.1 hours - common terms of spatial disorientation; equilibrium maintenance.
.3 hours - visual illusions; vestibular illusions; proprioceptive illusions
.4 hours - prevention of spatial disorientation; treatment of spatial disorientation.

Response 114.
Class lecture w/ videos and inflight demonstration (night time, poor visibility, simulated - hood or foggles).

Response 115.
I use demonstration in the plane to show how disoriented a person can become trying to discern kinesthetically the planes attitude (eyes closed) - slip feels like turn, coordinated turn = climb, etc. Demonstration for both private and instrument.

Response 116.
Most training centers (conduct ground instruction) on an oral/written/video discussion of the inner ear. Application is usually limited to unusual attitudes. I've used the Vista Vertigon on one occasion and found it excellent. I would use it if I could afford/had access to one.

Response 117.
Two to four hours total to include: causal factors, recognition, corrective procedures.

Response 118.
Inflight recovery from unusual attitudes.

Response 119.
For private pilot applicants I like them to read from as many of the above listed books (question 12: Aim, FAA Private Pilots Manual/Flight Training Handbook, Instrument Flying Handbook, Jeppesen Sanderson Private Pilot and Commercial Instrument Handbook) as possible. Then I have them watch the videos our school has available. Then, to apply what they have read about, they are taken on a VFR night flight out over the nearby Atlantic Ocean. A short flight to the northwestern parts of New Jersey is similarly dark and featureless. We then commence air work both full and partial panel. Instrument and other advanced students have the same type of training. In addition, we try to expose the instrument students to as much actual IFR and IFR night as possible/practical. This includes normal IFR procedures, air work, and partial panel.

Response 120.
IFR pilots need a lot more training in spatial disorientation.

Response 121.
Two to three hours combined training.

Response 122.
Ground instruction, briefing, demonstration, debriefing.

Response 123.
The optimum is whatever the individual needs. This varies from person to person. I have found it rare that a person is disoriented a lot of the time. It is also rare that a person is never disoriented. The rest of us are somewhere in between.

Response 124.
Ground schools can cover the literature. But only one thing can cover the actual experience with disorientation and that is to experience it inflight, either in a real airplane or a full motion simulator.

Response 125.
All students must get at least 5 hours of training.

Response 126.
The type of training that military pilots undergo.

Response 127.
Specific, individualized instruction. Class discussions and text assignments. Under hood using various combinations of pitch, bank, and acceleration and deceleration. Tasking in the aircraft - taking off, enroute, and landing/stopping. We do these tasks at our school.

Response 128.
Pilots in all phases of training should be provided training in spatial disorientation. More than 20 percent of inadvertent IFR (IMC) fatalities involve instrument rated pilots.

Response 129.
An optimum program would require an education of the facts regarding the causes of disorientation, recognition of the situation in which the various types of orientation occur, and good real world illustrations of the many illusions which cause the disorientation.

Response 130.
It is a very important part of the basic pilot training. We are interested in a 3 axis motion system (simulator) which includes embedded visual and vestibular illusions, recognition of spatial disorientation, and recovery procedures.

Response 131.
The one the FAA puts on at the FAA center in OKC is excellent.

Response 132.
Centrifuge at Brooks AFB, San Antonio.

Response 133.
I believe the current training we give is adequate. Having a Barany chair at the club would be great.

Response 134.
Take them up in a plane under the hood and get them disoriented.

Response 135.
One that includes: 1. A description of personal experiences; 2. At least one video tape; 3. A lecture on the different types of spatial disorientation (unrecognized, recognized, and incapacitating) as well as other illusions; 4. Experience with a demonstration trainer; and 5. The experience of attempting to fly with one's eyes closed.

Response 136.
Optimum training is that training which allows and provides skills to control the aircraft, and if unusual attitudes develop, recover from them promptly without over stressing the aircraft. I think this training can only realistically be performed with the use of an aircraft or advanced simulator. While ground training is important it doesn't provide the environment necessary to appreciate the situation nor develop the necessary recovery skills.

VITA

Roger Morrison

Candidate for the Degree of

Doctor of Education

Thesis: A SURVEY ON SPATIAL DISORIENTATION TRAINING AT FAR PART 141 CERTIFICATED SCHOOLS FOR AIRPLANE CATEGORY

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