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USING DECISION-MAKING TECHNIQUES IN SUPPORT OF SIMULATION TRAINING TRANSFER SELECTIONS

by

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B.S. May 1988, Mary Washington College

A Thesis Submitted to the Faculty of
Old Dominion University in Partial Fulfillment of the
Requirements for the Degree of

MASTER OF SCIENCE

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ABSTRACT

USING DECISION-MAKING TECHNIQUES IN
SUPPORT OF SIMULATION TRAINING TRANSFER SELECTIONS

Jane Taylor Bachman
Old Dominion University, 2012
Director: Dr. Patrick T. Hester

A general methodological approach for determining the selection of military training simulations with respect to military training requirements has not been developed. This thesis undertakes a literature review, which indicated that there was a need for a multi-criteria decision making model to assist acquisition and/or training planners in making training selection decisions. The Analytical Hierarchy Process (AHP) Model was selected from a multi-criteria decision-making model candidate list for evaluation of its efficacy in selecting military training simulations based upon the military training requirements. Four separate trainee populations, Alpha, Beta, Charlie, and Delta, were evaluated. Results from the Alpha study case showed evidence of the AHP model providing consistency between the participants' preferred choice and their demographic background. This indicates that the AHP model may be a useful multi-criteria decision-making method for acquisition and/or training planners. These results indicate that decision-makers should: 1) allow for more than a low-level of effort on the front-end when creating the necessary AHP input, 2) reflect on the selection of attributes as a critical step in establishing the AHP model hierarchy, and 3) consider the level of detail needed for input into the AHP model. Further, results from the Beta, Charlie, and Delta populations indicate that an approach has been developed which is consistent across groups and displays strong alternative preferences that are consistent.

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This thesis is dedicated to our service men and women who have demonstrated a willingness to stand for the defense of our country, to maintain the freedom by which our forefathers provided, to afford our country with their service and expertise, and last but not least, to our service men and women trainers, for providing their knowledge, wisdom and encouragement to pass the honor to the next generation.

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NOMENCLATURE

Augmented-reality system	is a combination of teleoperator system and a virtual environment system. "The operator's interaction with the real world (either directly or via a teleoperator system) is enhanced by overlaying the associated real-world information with information stored in the computer (generated from models, derived previously from other sensing systems, etc.)" (Durlach & Mavor, 1995 p. 2).
Classroom education	"provides valuable declarative knowledge to warfighters" (Alexander, Brunye, Sidman, & Weil, 2005, p. 1).
Computer-based	"Computer-based training systems, sometimes referred to as "lightweight simulations," are web or PC-based systems designed to provide individual instruction on specific mission skills" (Ibid, p. 1).
Fidelity (1)	"Fidelity refers to how closely a simulation imitates reality" (Alessi, 1988, p. 40).
Fidelity (2)	Simulation fidelity is the "degree to which a device can replicate actual environment, or how "real" the simulation appears and feels" (Vincenzi, Wise, Mouloua, & Hancock, 2009, p. 64). For the purposes of the thesis, fidelity is defined as the level of detail. "Simulation fidelity is an umbrella term defined as the extent to which the simulation replicates the actual environment" (Ibid, 2009, p. 62).

Immersion (1)	"The objective level of fidelity of the sensory stimuli produced by a technological system" (Sowndararajan, 2008, p. 4).
Immersion (2)	"is a psychological state characterized by perceiving oneself to be enveloped by, included in, and interacting with an environment that provides a continuous stream of stimuli and experiences" (Witmer & Singer, 1998, p. 227). For the purposes of this thesis, immersion is defined as the trainee's perception that s/he was included and interacting within an environment unlike their current physical one.
Involvement	"is a psychological state experienced as a consequence of focusing one's energy and attention on a coherent set of stimuli or meaningfully related activities and events" (Ibid, p. 227).
Live training (field exercises)	"practice applying the complex skills [warfighters] study, and practicing them to proficiency" (Alexander, et al., 2005, p. 1).
Negative transfer	"Negative transfer occurs when existing knowledge and skills (from previous experiences) impedes proper performance in a different task or environment" (Vincenzi, et al., 2009, p. 50).
Operator buy-in	Operator buy-in is the user acceptance, i.e. "buy-in refers to the degree to which a person recognizes that an experience or event is useful for training" (Alexander, et al., 2005, p. 8).
Positive transfer	Positive transfer occurs when an individual "correctly applies knowledge, skills, and abilities learned in one environment (e.g., in simulation) to a different setting" (Vincenzi, et al., 2009, p. 50).

Presence	"Defined as the subjective experience of being in one place or environment, even when one is physically situated in another. Both involvement and immersion are necessary for experiencing presence" (Witmer & Singer, 1998, p. 225). For the purposes of this thesis, presence is defined as, in the trainee's opinion; s/he believes that they were provided the experience of being involved within an environment other than the one that they were physically trained.
Simulation (1)	"A working representation of reality; used in training to represent devices and process and may be low or high in terms of physical or functional fidelity" (Cannon-Bowers & Bowers, 2008, p. 318).
Simulation (2)	"is the imitation of the operation of a real-world process or system over time" (Banks, 1998, p. 3).
Simulators	"are systems that emulate visual stimuli and physical controls from the operational environment" (Alexander, et al., 2005, p. 1).
Synthetic Environment (SE)	is "all systems that are of the types: teleoperator system, virtual environment (VE), or augmented-reality system" (Durlach & Mavor, 1995, p. 2).
Synthetic Learning Environment (SLE)	"A learning environment characterized in terms of a particular technology, subject matter, learner characteristics, and pedagogical principles; a synthetic experience, as opposed to a real-world interaction with an actual device or process, is created for the learner through a simulation, game, or other technology" (Cannon-Bowers & Bowers, 2008, p. 318).

Teleoperator system	"the machine is an electromechanical tool containing sensors and actuators (i.e. a telerobot) that effectively extend the operator's sensorimotor [sensorymotor] system and thereby allow him or her to sense and manipulate the real environment in new ways" (Durlach & Mavor, 1995, p. 1).
Training system	"A training system consists of the planned interaction of people, materials, and techniques, with the goal of improved human performance as measured by established criteria on the job" (Hays, 1992, p. 261)
Transfer	"is defined as the application of knowledge, skills and attitudes acquired during training to the environment in which they are normally used" (Alexander, et al., 2005, p. 2).
Virtual Environment (VE)	"the machine is an appropriately programmed computer that generates or synthesizes virtual worlds with which the operator can interact" (Durlach & Mavor, 1995, pp. 1-2).
Virtual Reality (VR)	"VR system can be defined as a 3 dimensional synthetic computer generated world using real-time graphics that can be controlled by interacting with the system from a first person perspective" (Sowndararajan, 2008, p. 1).

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CHAPTER 1

INTRODUCTION

In the United States (U.S.) of America, the military services are encouraged to promote and execute warfighting excellence. It is an aspect that is currently in the spotlight due to the current war status. The spotlight focuses on joint command operations, which includes all or combinations of the following battlespace issues: littoral, air, ground, unmanned aerial vehicles (UAVs), and associated communication networks involved in the joint battlespace. This joint battlespace is a complex environment needing complex models to conduct simulations. In addition, military personnel have discovered that their previous roles have changed and are continuing to change due to changes in the war zone. General Martin Dempsey, Commanding General, U.S. Army Training and Doctrine Command from the Association of the U.S. Army Winter Symposium in Fort Lauderdale, FL (2011) said, "2020 is the part of the future for which we will be held accountable. Right now, we are building the Army of 2020 with the full knowledge that it will not be the Army we need in 2030" (Dempsey, 2011, p. 10). As their roles change, their military training is adjusting, which involves exploration of new training approaches that include new Modeling and Simulation (M&S) technologies and/or methods. The Department of Defense (DoD) published on 10 June 2003 the Training Transformation Implementation Plan that stated:

> To transform the total force and meet combatant commanders' needs in this new environment, we need to transform the way we conduct training. Training must now prepare the force to learn, improvise, and adapt to constantly changing threats in addition to executing doctrine to standards.

> (Office, Under Secretary of Defense, Personnel and Readiness Director, Readiness and Training Policy and Program, 2003, p. 1)

There are five key objectives in an updated Training Transformation Implementation Plan FY2006-FY2011 that the DoD Training Transformation program focused on when achieving its missions. Two of the objectives supporting the mission to enable the continuous, capabilities-based transformation of the DoD are: 1) Prepare forces for new warfighting concepts and capabilities, and 2) Develop individuals and organizations that improvise and adapt to emerging challenges (Office, Under Secretary of Defense, Personnel and Readiness Director, Readiness and Training Policy and Program, 2006, p. 1).

I/ITSEC's 2010 service keynote speaker, General Edward A. Rice, U.S. AF, remarked:

> History has shown us all to be poor judges of what future conflict might look like and where it will occur. We need your support in industry, and your ideas, in our efforts to produce better training and better training tools. Today's "digital generation" service members are "more technologically literate and computer savvy" than ever before. (Kaufman, 2010, p. 1)

Warfighting has changed not only because of the volatile global security environment but also due to the following challenges: 1) warfighter availability, 2) logistical constraints, 3) geographical distribution of personnel, and 4) limited resources precluding frequent field training (Alexander, et al., 2005). Consider simulators permeating every aspect of U.S. military training, as General Rice noted:

> While we tend to focus on simulators associated with our flying mission such as aircrew training, air traffic control and aircraft maintenance ... the fact is simulators permeate every aspect of qualification training in the United States Air Force, as well as the other military services. (Kaufman, 2010, 1)

Acquisition decision-makers are matching the training requirements to existing and proposed simulation training capability exercises. Although acquisition decision-makers are matching the training requirements to existing and proposed simulation training capability exercises (e.g. the new Infantry Immersion Trainer, Camp Pendleton, California (Garamone, 2008), the Naval Annual Emergency Response Training Exercise (Davis, 2011) and the U.S. Joint Forces Command exercise of a mock Afghan village setup at the Infantry Immersion Trainer in Camp Pendleton, CA (Miles, 2010)), the fundamental question of how do decision-makers defensively correlate military training requirements with either existing or proposed training simulators remains. Furthermore, is there a positive consistency in the decision-making process? These questions are addressed in the review of research section of this thesis but, first, the author addresses the thesis purpose followed by a definition of the problem statement and a description of the methods and procedures used to address the problem statement.

1.1 PROBLEM

During the planning process of military training, requirement versus capability preparations often involve additional training approaches that include new methods or techniques that are not currently conducted in military training simulations; therefore, it is of interest to utilize a systematic generalized framework, which includes performing comparison and sensitivity analysis on the different simulation training methods or techniques, to assist decision-makers in determining whether or not a proposed training approach is acceptable for a particular military training application.

1.2 PURPOSE

The purpose of this thesis is to gather data on military training for evaluation of a multi-criteria decision-making model in order to determine its efficacy for military training simulation selection(s); "efficacy" in the sense that the multi-criteria decision-making model under evaluation will have the power to accomplish a military training simulation selection. This thesis develops a prescriptive approach to decision making and considers elements related to the cognitive decision maker. The purpose of this thesis is neither to make any claims that any one training simulator indentified within this thesis is superior to another nor to claim ownership of any product or trademark referenced hereafter. The definition phase of military training and education is a very important activity to complete; however, the assumption of the author is that the military training and education requirements have been fully established prior to the utilization of a general methodological approach (and is thusly outside the scope of the thesis).

The benefits of having a general methodological approach for decision-makers to correlate military training requirements with either existing or proposed training simulators are (Bachman & Hester, 2012):

1. Obtaining decision cohesiveness between training requirements and training selections;
2. Promoting positive consistency in the decision-making process;
3. Affording a defensible argument for the simulation training selection;
4. Providing program cost effectiveness; and
5. Providing a medium to low level of effort.

An added benefit from this research, pending the development of a general methodological approach is for the method to be of use for as many of the five military branches as possible (Bachman, 2011). This encompasses the challenge of correlating the military training best practices and procedures of each branch within the U.S. military. In addition, follow-up research, such as validation studies, if deemed necessary, could be conducted to further enhance a generalized approach to multi-criteria decision-making with respect to military simulation training.

1.3 METHOD AND PROCEDURE

The solution approach for developing a general methodological decision-making approach shall include the following steps: 1) Conduct literature review and synthesis, 2) Identify components (i.e., non-inclusive list of attributes) used in simulation training transfer, 3) Determine training alternatives, 4) Select multi-criteria decision-making model via a model identification method, 5) Design experiment, 6) Conduct experiment, 7) Process data, 8) Perform data analysis on the model identified, 9) Conduct model sensitivity analysis where applicable, and 10) Formulate results and report findings.

The results from conducting a literature review and synthesis shall address the fundamental question, "How do decision-makers correlate military training requirements with either existing or proposed training simulators?" In addition, the literature review and synthesis results should provide insight as to whether or not it is of interest to develop a framework to assist decision-makers in determining whether or not a proposed training approach is acceptable for military training. Consider the following questions: 1) If there is a particular training approach, does it meet the associated training requirements, and 2) If a new training approach has to be selected, how does one maintain a defensible argument while cohesively deciding on the simulation training selection? The research should support model identification, experimental design, data collection, data analysis, reporting and briefing of the findings. Furthermore, guidance for attribute identification and training alternative determination should be gained through conducting the literature review.

The model identification method used to select a multi-criterion decision-making model under evaluation in the thesis test experimentation was based on criterion important to the purpose of the experimentation. A large portion of the experiment design was built upon the synthesis results from performing a literature review. Following the experiment design, the author obtained Human Subject Approval from the Old Dominion University Institutional Review Board (IRB) to conduct this study. After receiving IRB approval, the author contacted the candidate data collection locations for data collection approval and coordination. Once the data were collected and processed, they were entered into the model under evaluation. Following model data input, the author performed model execution and data analysis. The final step involved formulating the model execution results and documenting the findings from the model evaluation analysis. The solution approach considered: 1) the depth and breadth of its specific decision-making approach, 2) the necessary time spent in the front-end analysis of decision making, and 3) a mechanism for the analyst to place a training simulation candidate under the microscope.

CHAPTER 2

BACKGROUND OF THE STUDY

The literature explored for the background review of this study is identified in the review of research. All products and trademarks referenced in this thesis belong to their respective owner and it is not the intention of the author to make claims that one training simulator is better than another. Terminology used in this thesis is provided in the Nomenclature section to enhance the understanding of thesis content. Following the review of research section, the background of the study contains the experimental design and the data collection sections.

2.1 REVIEW OF RESEARCH

The literature review of research is categorized into the following groups: 1) simulation training history, 2) training alternatives and attributes, 3) decision-making models, 4) measurement concepts, 5) related studies, 6) model identification method, and 7) literature review summary.

2.1.1 Simulation Training History

In England, at least as early as 1910, two crude flight trainers called the "Sanders Teacher" and the "Eardly-Billing Oscillator" were used for flight training (Valverde, 1968). By 1917, a trainer based on a pivoted fuselage containing engine noise, rudder-aileron crossover, and a simple visual approach was developed in France (Ibid). In the years following World War I, Canada, Great Britain, and the United States continued the development of flight trainers. By 1929, in the United States, Edwin A. Link developed his first flight trainer, which became accepted and used extensively in civil aviation by the time World War II began (Ibid). Enhanced training simulators became a possibility with the advent of analog computers by the late 1940's. During World War II, the servo systems and components were in development, thus, because of the information derived from this technology, improvements were made to simulators (Ibid). Research in digital computers' speed and other characteristics was initiated in 1950 by the Moore School of Electrical Engineering at the University of Pennsylvania. This was jointly sponsored by the Air Force and Navy, who concluded that a digital computer of adequate capability for flight simulators did not exist at that time, leading the school staff to develop designs for an acceptable digital computer (Ibid). By 1960, under the sponsorship of the Air Force and Navy, the Sylvania Electric Products, Inc. developed a prototype system called the Universal Digital Operational Flight Trainer (UDOFT), which was based upon the Moore School of Engineering designs (Ibid). These historical facts tend to support Westbrook's position that he made in 1964:

> Those using research and development simulators can thank training simulator people for providing the motivation for and the development of the techniques and experiments necessary for what is used. Much of the literature on simulation in past years now relates to this area... (Ibid, p. 3)

The first virtual reality (VR) to be considered entering the field was in the 1950's. VR was used by displaying radar images across huge screens to support the military in various strategic planning activities (Sowndararajan, 2008). By the late 1960s, the concept of a head-mounted display depicting 3-D graphics was introduced by Sutherland (Brooks, 1999). This led to VR systems finding their way into not only movies and science fiction novels, but our theme parks as well (Sowndararajan, 2008). Frederick

Brooks, founder of the Computer Science Department at the University of North Carolina at Chapel Hill in 1964, further states that the four technologies crucial for good VR system are visual displays, "that immerse the user in the virtual world and that block out contradictory sensory impressions from the real world", graphics hardware/software system, tracking system, and database construction and maintenance system, which is "for building and maintaining detailed and realistic models of the virtual world" (1999, 16).

This thesis highlights a non-inclusive list of simulation trainers of which are categorized under the following fields: education, medical, and military. Education for the past several years has increased its use of M&S for training. The Science, Technology, Engineering, and Mathematics (STEM) efforts extend across the U.S. with a goal to encourage K-20 (i.e. kindergarten through graduate school) students to pursue a STEM career. Retired Rear Admiral Fred Lewis, president of the National Training and Simulation Association told the House Armed Services readiness subcommittee in July 2010 that "We have begun a journey into virtual worlds that don't just promise to blur the distinction between simulation and reality – they will soon actually remove it" (Walker, 2010, p. 6). Further, he stated:

> Alarm bells have been alerting us to the widening gap between the U.S. and most other developed countries in the science and technology skills of our young citizens. Perhaps no other industry is more dependent on a reliable supply of first-class scientists and engineers. (Ibid, p. 6)

He continued, "M&S could be a key to stimulating excitement and enthusiasm among American youth for science, Lewis said, because young people already immerse themselves in a type of simulation – video games" (Ibid, p. 6). STEM efforts, such as the

National Defense Education Program (NDEP) Virginia Demonstration Project (VDP) STEM Summer Academy, provide middle-age school students the opportunity to participate in a variety of STEM activities as well as learn about the variety of STEM careers (Bachman, Kota, & Kota, 2010). Students learn how to build a LEGO robot, what are the military purposes for robots, programming skills, team collaboration and test and evaluation skills using the M&S Tool, ROBOLAB™ of the LEGO Education – MINDSTORMS®. In addition, the Internet is instrumental in promoting on-line M&S tools that provide the educational opportunity for students in many areas of the country.

One recent military robotic training example occurred in June 2011, where U.S. Marines were trained for the first time with intelligent robotic targets during a foreign comparative testing and evaluation demonstration at the Marine Corps Base Quantico, VA. The Robotic Moving Target System (R-MTS) is available in two and four-wheeled variants of a 3-D based mannequin that moves autonomously on a Segway Robotic Mobility Platform. It is built by Australasian-based Marathon Targets. Lt. Col. Walt Yates commented on this type of training as being intended for Marines who have already obtained expert marksmanship skills. He remarked, "This is something where you would take the high-end shooters and make them better" (Quinn, 2011, p. 8). Yates continued, "Good training can be highly entertaining but it can also be useless if you don't remember what you came to the range for that day" (Ibid, p. 8).

The medical field has grown tremendously over the past two decades in utilizing simulations in their medical training programs. Two examples of using immersive simulation training in the medical field are: 1) training interns to make decisions in a trauma room situation, and 2) first responders training for mass casualty event.

Initial training for interns was accomplished by using textbooks and a dummy body that could simulate heart rate, blood pressure and a few vital signs in the classroom environment. VR was introduced as a means to offer as many training scenarios as the real world training could not (Sowndararajan, 2008). A VR system developed at Virginia Tech was built using a real time 3-D graphics engine that could render a realistically modeled 3-D trauma room (Ibid). The VR trauma room contained virtual characters to represent a nurse and a patient, as well as a vital sign monitor and x-ray machines. Medical professionals were consulted as subject matter experts (SMEs) for developing the decision trees built for scenario inclusion. The VR system added benefit is scalability, where the user is allowed to add as many scenarios as needed with just a few lines of code (Ibid).

Training first responders for a mass casualty event via VR was accomplished by using the Cave Automatic Virtual Environment (CAVE), where users entered wearing lightweight liquid crystal display (LCD) shutter glasses for stereoscopic viewing. Users were able to see their own hands and other participants or equipment brought into the CAVE, since the CAVE mode of operation is "see-through". The immersive VR was evaluated and concluded "to be a powerful tool for training first responders for high-acuity, low-frequency events" (Wilkerson, Avstreih, Gruppen, Beier, & Woolliscroft, 2008, p. 1158).

Regarding the military trainers, W. H. ("Dell") Lunceford Jr., director of the Army Model and Simulation Office in Arlington, Virginia noted, "The shift from live range training to computer-based training is fundamentally changing the way we prepare our soldiers for the future" (Macedonia, 2002, p. 33). "VR [military] training can provide realism not possible in classroom-based training, as well as higher flexibility and reduced cost compared to real-world exercises" (Bowman & McMahan, 2007, p. 37). As part of the Army's overall live, virtual, constructive integrated training environment, it purchased its first immersive, virtual simulation training system for dismounted soldiers (Quinn, 2011). "There's never really been a system fielded by the Army that really is focused on the dismounted soldier's training in the virtual environment," said John Foster, assistant project manager at Program Executive Office for Simulation, Training and Instrumentation (PEO STRI) for the Close Combat Tactical Trainer, which the dismounted soldier will fall under (Ibid, p. 9). These two systems, along with the Reconfigurable Vehicle Tactical Trainer, can be networked together. Through a helmet-mounted display, a ruggedized laptop worn on the soldier's back, sensors on the body, which provide motion tracking while allowing for 360-degrees of movement, a 10-by-10 area mat and a joy-stick on their weapon for controlling their locomotion in the virtual world, the system can link an entire squad. The intended use of the system is to augment live training and fill a gap by stressing soldiers mentally, said Foster (Ibid). For a further review within each service, the paragraphs below provide a snapshot of the following military trainers: 1) Internal Look, 2) Steele Beasts, 3) joint training efforts, 4) The Infantry Immersion Trainer, and 5) the Navy's submarine bridge trainer prototype.

Interestingly enough, there are correlations between the Gulf War and the game, Internal Look (Macedonia, 2002). General H. Norman Schwarzkopf wrote in his memoirs, *It Doesn't Take a Hero:*

> We played Internal Look in late July 1990, setting up a mock headquarters complete with computers and communication gear at Eglin Air Force Base in the Florida panhandle. As the exercise got under way, the movements of Iraq's real-world ground and air forces eerily paralleled the imaginary

> scenario of the game. We had envisioned a huge force—some 300,000 men, 3,200 tanks, and 640 combat planes—which would mass in southern Iraq and attack the Arabian Peninsula. Central Command's much smaller force was supposed to stop the invasion before it seized crucial Saudi oil fields, refineries, and ports. To make the drill more realistic, several weeks in advance I'd asked our message center to start sending a stream of fictional dispatches about military and political developments in Iraq to the headquarters of the Army, Navy, Air Force, and Marine units scheduled to participate. As the war game began, the message center also passed along routine intelligence bulletins about the *real* Middle East. Those concerning Iraq were so similar to the game dispatches that the message center ended up having to stamp the fictional reports with a prominent disclaimer: 'Exercise Only'. (Schwarzkopf & Petre, 1992, p. 337)

Over the two-week course of the exercise, U.S. Central Command staff, based at MacDill Air Force Base in Tampa, Fla., endured all the emotional highs and lows of battle—what virtual reality researchers call "presence" (Macedonia, 2002, p. 34). "Lessons learned from Internal Look shaped the defensive plan for Desert Shield, and drove home the power of computer simulation in preparing for war" (Ibid).

The next snapshot of one of the Army's training simulations was the commercial game called Steele Beasts. Shortly before 2002 the cadets at the U.S. Military Academy at West Point, N.Y. would only read about military strategy because war games in the field would occur following graduation (Macedonia, 2002). By 2002, battle and infantry were conducted by the academy cadets in virtual M1 tanks using this game. "The game lets them practice individually or in Internet-linked groups; they can face down a computer-simulated enemy or another squad of cadets" (Macedonia, 2002, p. 35). Although it never made it to the mainstream, the Army briefly experimented with Atari Inc.'s tank game Battlezone as far back as the early 1980s with the goal to enhance a gunner's eye-hand coordination (Ibid).

With respect to a snapshot of joint training efforts, in May 2007, it was released that by mid-2007, Australia planned to tap into the U.S. Joint National Training Center (JNTC) in Virginia via a newly established Joint Combined Training Centre (JCTC) near Sydney (Oliver, 2007). Urban warfare is the focus and it was noted that by 2010, 75 per cent of the world's population will live in large urban areas as well as cities that will most likely be the battlefields in the 21^{st} century (Ibid).

An innovative facility that combined live and virtual combat training is set to expand so that an increase in the number of Marines who receive the training can occur. The U.S. Marine Corps is planning the increase just two years after opening one (Lamothe, 2009). Marine officials say that the immersion trainers are important because "they give Marines a chance to experience a taste of combat before they actually deploy, to test themselves while hearing different languages in tense situations and discern who is the enemy" (Ibid, p. 52). On 16 November 2010, the Marine Corps unveiled an outdoor expansion of its Infantry Immersion Trainer at Camp Pendleton (Kovach, 2010). The Camp Pendleton's Infantry Immersion Trainer, a mixed reality simulator mimicking the chaos of war was remodeled in March to look like an Afghan village.

The next snapshot is of a virtual shipboard flight operation. Sailors on the East Coast used their imaginations to the art of launching helicopters from ships. They used wooden handheld models of aircraft. The West Coast sailors used a video game-like display. The drawback to the video game was that many of the details were incorrect. The Helicopter Sea Combat Squadron-3 in San Diego requested help from the Office of Naval Research's TechSolutions program. In three months, Lockheed Martin Corp.

engineers, leveraging off existing simulation code, developed the helicopter control officer tower trainer (Jean, 2009, p. 62).

2.1.2 Training Systems, Simulation Types and Transfer

There are several groups of people involved to some degree in the development or implementation of training systems. "A training system consists of the planned interaction of people, materials, and techniques, with the goal of improved human performance as measured by established criteria on the job" (Hays, 1992, p. 261). The types of people involved in a training system are: 1) trainees, 2) instructors (i.e. trainers), 3) course developers, 4) instructional administrators, 5) logistics managers, 6) SMEs, 7) training aid design engineers, 8) on-the-job supervisors, and 9) training system researchers (Ibid). Two types of simulations are tactical-decision simulations and social-process simulations. Both have a different focus. Tactical-decision simulations are "an evolving problem that depends on data interpretation and management for a solution"; whereas, social-process simulations are "the various human interactions involved in pursuing social or political goals" (Gredler, 1994, p. 21). Interestingly, tactical-decision simulations were first used for training in 1664, where the earliest examples were war games (Ibid, p. 18). Diagnostic simulations, crisis-management simulations, and data-management simulations are three types of tactical-decision simulations, each reflecting a particular type of data interpretation and management (Ibid).

Whether games, simulators, or real-world settings are used in training, they entail transfer (e.g. positive, negative, or nil) of lessons in the structured environment to the relatively unstructured atmosphere of real-world application (Alexander et al., 2005). "It is clear that high, positive transfer is desirable between a training system and real world operations (Ibid, p. 4)." Currently, there are three training alternatives to military training: 1) classroom education, 2) live training, and 3) computer-based training (Ibid). An increase in training transfer can be obtained by manipulating the constructs of fidelity, presence, immersion, and operator buy-in (Ibid). Alexander et al., posit that these four attributes drive training transfer and that the objective of training using games and simulators is "to achieve greater positive transfer than slower, more costly, or more dangerous training methods often relying on real-world technologies" (Ibid, p. 3).

2.1.3 Decision-making Models

Based on the benefits of having a general methodological approach for decision-makers to correlate military training requirements with either existing or proposed training simulators, decision making models have the potential to inform training decisions. The AHP, the Equipment Quantifying Usage Impact Process (EQUIP), the disjunctive decision-making approach, the Multi-Attribute Utility Theory (MAUT), the lexicographic approach, the elimination by aspects decision-making method, hierarchical task analysis and Lens decision making models are presented in the following paragraphs. This section of the literature search containing decision-making models shall be utilized in the model identification process.

The first model to address, the AHP, developed by Thomas L. Saaty (1980), is a multi-criteria decision method for investigating the decision making possibility of this problem domain (Anderson, Sweeney, Williams, & Martin, 2008). The AHP is a four-step process for determining the relative importance of each of several conflicting criteria. Figure 1 illustrates the AHP four-step process. The analyst uses the AHP model to make decisions in an intuitive manner using pair-wise comparisons "among the criteria and a series of pair-wise comparisons among the decision alternatives in order to arrive at a prioritized ranking of the decision alternatives" (Ibid, p. 651).

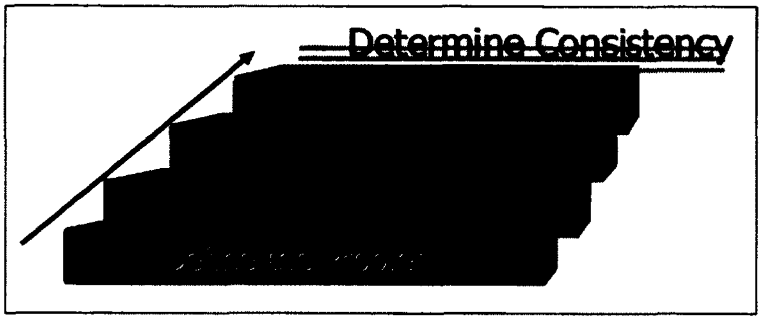

Figure 1: AHP Model Development Step Diagram.

Secondly, the Marine Corps Systems Command (MCSC) Marine Expeditionary Rifle Squad Program Office (PM-MERS) developed the EQUIP with a goal to provide the appropriate feedback for decision-makers involved in squad equipment selection for acquisition, planning, training, or deployment (see Figure 2 for EQUIP diagram).

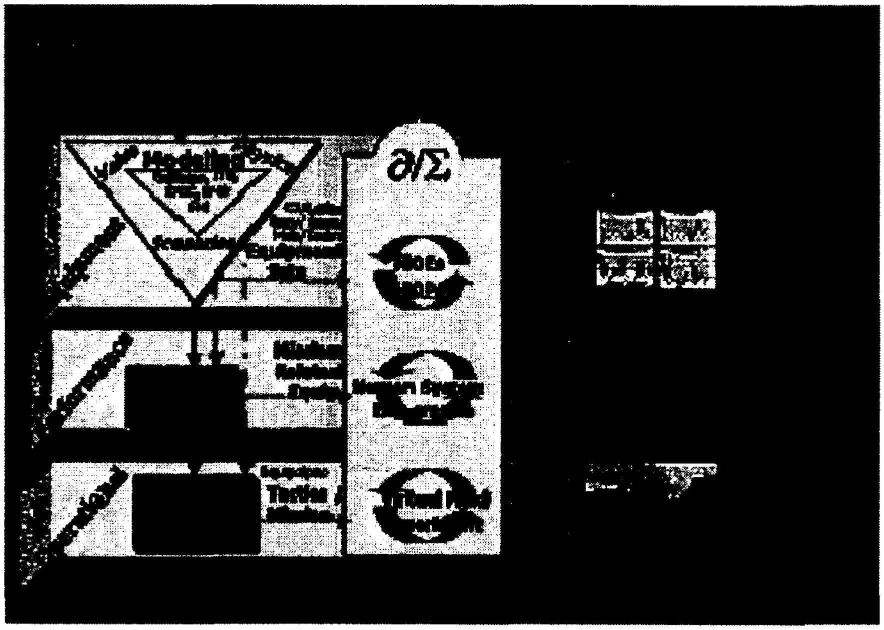

Figure 2: Equipment Quantifying Usage Impact Process (EQUIP) Diagram
(Bachman, Holland & Richter, 2006)

An earlier version of the PM-MERS M&S process focused on the following four M&S components: value modeling, scenario dependency, tactical simulation and human system integration (Holland, Richter, & Wright, 2004). By analyzing equipment impact on squad capability prior to any new technology acquisition, the PM-MERS M&S Process evolved into EQUIP (Bachman, Holland & Richter, 2006). Although it is not being recommended to use this methodology due to the specificity of its nature, there are key benefits worth highlighting from using this type of methodology: 1) it covers the depth and breadth of its specific decision-making approach, 2) it addresses the necessary time spent in the front-end of decision making, and 3) it provides a mechanism for the analyst to place a simulation selection under the microscope.

Thirdly, the disjunctive decision-making approach (Hastie and Dawes, 2001) is considered a low-pass filtering mechanism. It tends to select heterogeneous "specialists", where the alternatives excel at a particular attribute. Steps to the method are: 1) establish acceptable cut-offs for important attributes and 2) seek first alternatives that meet the cut-off criteria on any attribute (or the analyst selects a set of alternatives that are each good for a particular attribute). This approach is sensitive to list order.

Fourthly, the MAUT decision-making model (Keeney, 1974) weighs all attributes by their importance. It is considered a very high level of effort, compensatory, exhaustive, and alternative-based model; therefore, requiring significant time and effort. Equation 1 provides an example of computation of utility for a problem with three objectives being analyzed: 1) cost, 2) performance, and 3) expiration:

$$\begin{aligned} &Utility = (W_1 * Cost) + (W_2 * Performance) + \\ &(W_3 * Expiration) \end{aligned} \tag{1}$$

Fifthly, another attribute-based, non-exhaustive and medium level effort method is the lexicographic approach (Hastie and Dawes, 2001). Steps to this method are: 1) choose the most important attribute; 2) choose the best alternative on that attribute; 3) if several are tied, then move to the next most important attribute; and 4) repeat previous steps until one alternative remains. The negative side to this approach is that one could arrange the list such that a given alternative is chosen.

Finally, the elimination by aspects decision-making method (Ibid) is an attribute-based approach with medium effort. Steps to this method are: 1) select the first important attribute; however, not necessarily the top most important attribute, then select a cut-off value; 2) eliminate all non-conforming alternatives; 3) select the second important attribute and eliminate all non-conforming alternatives; and 4) continue this process until one alternative is remaining. This approach is subject to alternative order; especially since attributes are not ranked.

The last two decision models briefly addressed in this thesis are Hierarchical Task Analysis (HTA) and Lens. The HTA may be used to analyze any type of task in any domain, where 'tasks' are those objectives that the person is seeking to achieve and are essentially defined by 'goals' rather than actions (Annett & Stanton, 2000). An example application of linear models to the description of judgment behavior is the Brunswik's Lens Model (Bisantz, et al., 1997):

> The Lens Model provides dual, symmetric models of both the human judge and the environment. The judgments and the environmental criterion to be judged are described as linear combinations of environmental cues, or available information in the environment. In this way, both the judgment policy and the environmental structure in terms of cue-criterion relationships are captured. (p. 1)

2.1.4 Measurement Concepts

The DoD Training Transformation Program applies a modified version of the DoD spiral-development technique. "It uses a "build-a-little, test-a-little" approach to assess continuously the ways and means to achieve the policy end state, and then adjust as necessary within continuous transformation to adapt to new challenges" (Office, Under Secretary of Defense, Personnel and Readiness Director, Readiness and Training Policy and Program, 2006, p. 1).

According to an article in National Defense, experts say that many training tool buying decisions are based more on marketing than on empirical evidence; furthermore, it states that the "Defense Department has no consistent standards to measure the performance and the benefits of simulation-based training" (Jean, 2008, p. 46). There are limited discussions on how to quantify the benefits of immersion for learning; however, this resource is "driven towards exploring how VEs could be beneficial for memorization of a procedure" (Sowndararajan, 2008, p. 22).

Dan Gardner, director U.S. Office of the Secretary of Defense for Readiness and Training, Policy and Programs poses the question, "Our forces in Afghanistan are distributed in just this fashion – in small units. How do we train to be creative, adaptive and agile in decision-making in that environment? This is an education as well as a training challenge" (Mahon, 2009, p. 20). "Scouting" the exhibit floor for training innovations that step up to this challenge is what service delegations plan to do (Ibid).

Transfer of training formulas quantifying and comparing the transfer of training between control and experimental groups are illustrated in Equations 2 and 3 (Roscoe & Williges, 1980).

$$\textit{Percentage of transfer} = \frac{Y_c - Y_x}{Y_c} * 100 \qquad (2)$$

where:

Y_c = time, trials, or errors required by a control group to reach a performance criterion after zero training units on a prior or interpolated task; and

Y_x = corresponding value for an experimental transfer group having received X training units on a prior or interpolated task.

The percentage of transfer calculation does not include prior practice; therefore, it permits no conclusions about transfer effectiveness; whereas, the Cumulative Transfer Effectiveness Function (CTEF) can be used in those cases to determine the cost-effectiveness of specific types of training compared to others (Ibid).

$$\textit{Cumulative Transfer Effectiveness Function} = \frac{Y_c - Y_x}{X} \qquad (3)$$

where:

x = time, trials, or errors by an experimental transfer group during prior or interpolated practice on another task; *and all other variables are as before.*

Although researchers have yet to support these conclusions empirically, "Some instructors who have observed leaders during field exercises that followed training with games believe that the skills learned from games improved the decision-making and combat readiness of their leaders" (Beal, 2006, p. 9). Dr. Beal of the U.S. Army Research Institute in Fort Benning, Georgia points out that "two measures of training effectiveness and efficiency are based on how well tasks and skills learned during training games exercises transfer to mission rehearsals and to exercises that take place in the field" (Ibid).

The U.S. Army has selected as its official training game the "Virtual Battlespace 2" (VBS2) in December 2008 over the decade recruiting game, also used as a training tool in more than 20 Army programs, "America's Army 3 (AA3)". Unfortunately there are 33 selection criterion, which were not explicitly detailed other than stating that "VBS2 was chosen by a selection board overseen by PEO STRI in Orlando, FL [and that it] was based on requirements formulated by Training and Doctrine Command (TRADOC) Capability Manager for Gaming (TCM Gaming), the Army's office for gaming at Fort Leavenworth, Kansas" (Peck, 2009, p. 36). One of the requirements specified in the article noted that "the winning game be ready out of the box without further development" (Ibid). A recent article addresses the topic that training games are popular, but no one knows how well they work (Peck, 2012, p. 16). Peck states:

> Assessing the effectiveness of games is difficult. It's easy to determine whether Rifle A is better than Rifle B based upon how many rounds hit the

> target. But how do you measure the effectiveness of cognitive counterinsurgency training game like the Army's "Urbansim"? (Ibid)

Robert Bowen, chief of U.S. Army Training and Doctrine Command Capability Manager-Gaming (TCM-Gaming) noted the following: "VBS2 is used to perform so many tasks, it would be impossible to evaluate them all" (Ibid). Although research is still in progress, the article noted that Canadian researchers Paul Roman and Doug Brown concluded in a 2008 paper that "serious games work best when blended with live training" (Ibid).

Transitioning the aviation community's instrumented air combat maneuver range concept to those immersive environments expected to support the small units of the infantry fight is an application being addressed by the PM Training Systems (PM TRASYS) for conducting Enhanced Company Operations. Prior United States Marine Corps (USMC) training paradigms are established in the context of Live Virtual Constructive (LVC) yet a new training domain of mixed reality (MR) is being addressed (Smith et al., 2010). The approach is to highlight comprehensive after action reviews (AARs) as the need for mitigating the limitations associated with even the most capable immersive training capabilities envisioned (Ibid). Two sources provide training feedback to the training unit: 1) the perceived cause and effect the members of the unit experience during the event, and 2) the feedback received by the unit during the AAR (Ibid). In order to represent what the training unit should become "good at" upon completion of training, an Action Sequence Diagram (ASD) can act as a catalyst for defining the training system's requirements (Ibid). "Pairing high fidelity sensory stimuli that facilitates cognitive presence with the ability to collect and analyze objective performance data is essential to achieving the increased readiness and return on investment of next generation ground training systems" (Ibid, p. 9). The measurement concepts above provide some insight into potential considerations towards the problem solution approach; however, it is not all inclusive.

2.1.5 Related Studies

This section addresses a non-inclusive list of related studies from the U.S. Army, Air Force, and concluding with a review of study from the Marine Corps.

Dr. Beal addresses the question, "*How important to training game effectiveness is a clearly defined training objective?*" He notes that:

> Prior to the processes of training game software planning and development, it is important for instructors and developers to define the specific training objective the game is designed to meet. This is determined in large measure by the knowledge, skills and abilities of leaders who will use the game, standards of performance that leaders hope to achieve, the training conditions under which it will be used, and what leaders are expected to gain from the training experience. The definition phase is an important part of any game project because it determines the direction of subsequent planning, developing, implementing, evaluating, and modifying processes. (Beal, 2006, p. 5)

A team from the U.S. Air Force (USAF) Academy conducted a study addressing one of the questions facing researchers with respect to whether there were any performance differences between flight simulator training using a desktop computer and monitor versus training with a immersive virtual reality head-mounted display (HMD).

> The Desktop Display Group used a flight simulator workstation consisting of an AMD Athlon 64 FX53 processor running at 2.4GHz and 2GB memory. The HMD workstation consisted of a Dell 8400 with a Pentium IV processor running at 3.4GHz with 1GB memory, Virtual Research V8 HMD with 2D speakers, Intersense Inertia Cube head tracker, and CH Products Flight Sim Yoke and Pro Pedals. (McClernon, et al., 2006, p. 3)

Both workstations were running on the Microsoft Flight Simulator 2004 using the same aircraft (Cessna 172), time of day, and weather settings (Ibid). The team found no clearly defined explanations for why there were differences found in the performance between the two types of simulators. Their experiment, conducted in the Human Computer Interaction Lab at the U.S. Air Force Academy, measured the effects of different simulator displays on *simulator* performance as oppose to any advantages the simulator displays may have had on real flight performance.

Regarding a Marine Corps related study, the Analysts in the Training Simulation Interface Transfer (TSIT) study explored the comparison between the traditional desktop training approach and the immersive training approach. A case study of how, or even if, the results from a comparison analysis can be used to make a successful decision was conducted (Bachman & Hester, 2009). The authors concluded that in consideration of the model development process, parameters considered, review of sensitivity analysis, and review of the literature synthesis, the use of the AHP model could be beneficial as a decision-making tool for the end-user when multi-criteria decisions are involved. Although the comparison analysis paper focused on using the AHP as one method applied to the complex decisions in the TSIT study, additional analysis was conducted to focus on the AHP as one method to solve these complex decisions and to examine the case study utilizing AHP to evaluate the effectiveness of different computer software for education training purposes (Hester & Bachman, 2009). The authors concluded, in addition to the case study analysis conclusion, that it would be useful for engineering managers to consider the techniques of AHP when forced to make a complex decision (Ibid).

2.1.6 Model Identification Method

The author examined each candidate model using a list of criteria under consideration: filtering mechanism, level of effort and attribute order sensitivity. The list of candidate models reviewed were: 1) Analytical Hierarchy Process [AHP], 2) Disjunctive Approach [DA], 3) Multi-Attribute Utility Theory [MAUT], 4) Lexicographic Approach [Lex App], 5) Elimination by Aspects Method [Elim by Aspects], 6) Hierarchical Task Analysis [HTA], and 7) Lens. The criteria are the factors that the decision-maker considers relevant for evaluating each decision alternative (Anderson, Sweeney, Williams, & Martin, 2008, p. 665). The author identified that the type of filtering mechanism, that is how the candidate model filters its decision-making selections, is somewhat important to the model selection process. The level of effort criterion is the recognition of the amount of effort to conduct the model. Lastly, the author addressed how sensitive is the order in which the attributes are listed from each candidate model. The AHP was identified as the multi-criteria decision-making model selected for this thesis test experimentation based on how it met the criterion stated above. "Additive difference methods for decision making are very high effort, attribute-based (compare alternatives one attribute at a time), exhaustive (requiring perusal of all alternatives and attributes), compensatory (involving trade-offs) approaches to decision making" (Hester & Bachman, p. 1, 2009). In addition, "AHP is very popular for individuals who are not familiar with mathematical approaches to decision making (making it ideal for distribution among both technical and non-technical members of an organization)" (Ibid). Therefore, AHP met the criterion: filtering mechanism, level of effort and the attribute order of sensitivity. In a scenario where information is being elicited from individuals, the AHP is an ideal tool for handling the complex decision making. The AHP is best utilized when all of the decision alternatives are unambiguous prior to model execution, as is the case in this thesis test experimentation.

2.1.7 Literature Review Summary

Based on the aforementioned literature review of research, the fundamental question of how decision-makers defensively correlate military training requirements with either existing or proposed training simulators remains unexplored. Warfighting has been changed by the volatile global security environment, warfighter availability (e.g., Reserve or National Guard), by logistical challenges, by the geographical distribution of personnel, and by the limited resources precluding frequent field training (Alexander et al., 2005). Due to these challenges, warfighting training is changing (Ibid). It is of interest to decision-makers to utilize a repeatable framework to assist decision-makers in determining whether or not a proposed training approach is acceptable for a particular military training application. Upon reviewing and analyzing the candidate list of multiple attribute decision-making models in the decision-making model section of the literature review, the author proposes the selection of the AHP for the experimental design as the model of selection. AHP is best utilized when the judgments regarding the importance of the criteria and preference for the training alternatives using each criterion are recognized as valid by the user. Through the literature review findings, the author has justified the selection of three training alternatives and four training attributes in this experimentation upon the literature review findings of the Defense Advanced Research Projects Agency (DARPA) WARfighting trainer (DARWARS) Training Impact Group (Ibid).

2.2 EXPERIMENTAL DESIGN

The goal of the experimental design was to properly correlate training participant questions with several potential attributes that are used in a multi-criteria decision-making model. The end research goal was the development of a general methodology which can be used to make successful decisions in the selection of military training simulations. The approach utilized the AHP, a multi-criteria decision-making model, to evaluate the data collected from the test experiment in order to determine if the model has the efficacy for military training simulation selection. This section focuses on the experimental design for supporting simulation training transfer selections.

This section provides background material on the experiment, which includes: 1) training alternatives, 2) training attributes, 3) the AHP model, 4) hypothesis, 5) experimental purpose, 6) objective, 7) description, 8) participants, 9) devices, 10) procedures, 11) experimental data, 12) design attribute mapping, and 13) design summary.

2.2.1 Training Alternatives

The experimental design examined the use of all three training alternatives: classroom education, live, and computer-based. Definitions for these alternatives are provided to the trainee's completing the questionnaires. These three training alternatives were the independent variables of the experiment.

2.2.2 Training Attributes

The four factors (or constructs) included in this analysis were fidelity, presence, immersion, and operator buy-in. Definitions for the four attributes are provided to the trainee's completing the questionnaires. The author proposes the use of the definitions for fidelity, presence, immersion and operator buy-in provided in the nomenclature section of this thesis. These four attributes were used in the AHP model in an effort to evaluate the effectiveness of the model results and to determine if any increase in training transfer exists.

2.2.3 AHP Model

Preliminary work was conducted using the AHP on data from a simulation training case study, resulting in a favorable outcome for using the AHP as a candidate model (Bachman & Hester, 2009; Hester & Bachman, 2009). AHP was utilized to evaluate the data collected by way of the proposed experimental design to determine if the proposed model had the efficacy for military training simulation selection. This section provides the hierarchy development and priority establishment using the AHP.

Developing a graphical representation of the problem in terms of an 1) overall goal, 2) criteria, hereafter referred to as attributes, and 3) the training alternatives was the first step in the AHP model (see Figure 3 for illustration).

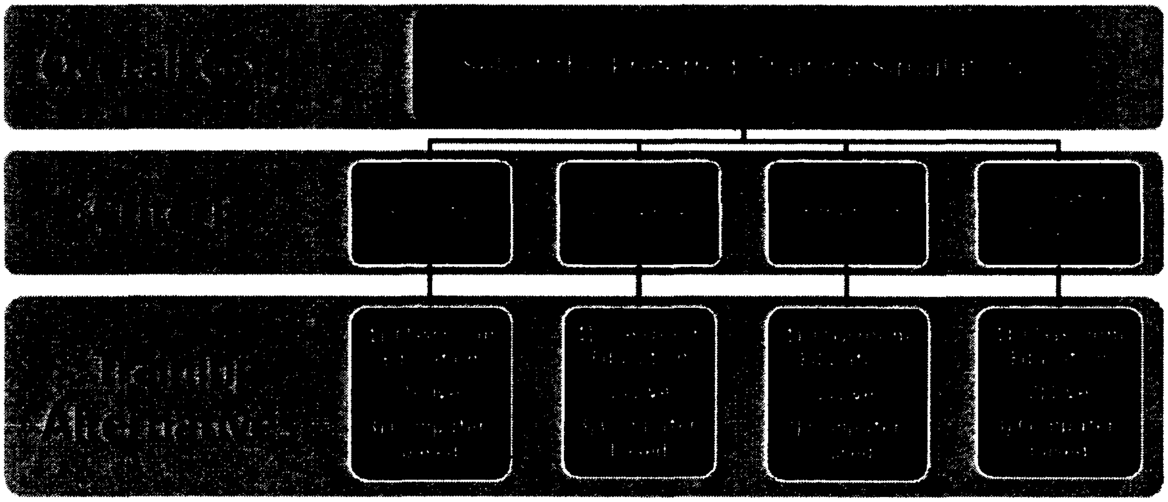

Figure 3: Hierarchy for the Military Simulation Training Selection Problem.

Next, the AHP determined priorities for each of the following:

1. How the four criteria contribute to the overall goal of selecting the preferred training simulation;
2. How the three training alternatives compare using the fidelity criterion;
3. How the three training alternatives compare using the presence criterion;
4. How the three training alternatives compare using the immersion criterion; and
5. How the three training alternatives compare using the operator buy-in criterion.

The above criteria were chosen based on the literature review findings from the DARPA WARfighting trainer (DARWARS) Training Impact Group (Alexander et al., 2005). Table 1 provides the pair-wise comparisons for determining how important each criterion is relative to each other criterion (when the criteria are compared two at a time, thus pair-wise).

Table 1: AHP Pair-wise Comparisons.

Criterion	Action	Criterion
Fidelity	compared to	Presence
Fidelity	compared to	Immersion
Fidelity	compared to	operator buy-in
Presence	compared to	Immersion
Presence	compared to	operator buy-in
Immersion	compared to	operator buy-in

Table 2 provides a nine-point scale for the importance of criteria using AHP (Anderson, Sweeney, Williams, & Martin, 2008, p. 673).

Table 2: Comparison Scale for the Importance of Criteria Using AHP.

Verbal Judgment	Numeric Rating
Extremely more important	9
	8
Very strongly more important	7
	6
Strongly more important	5
	4
Moderately more important	3
	2
Equally important	1

As an example, note that intermediate judgments such as "extremely more important" received a numerical rating of nine or an intermediate judgment such as "moderately more important" received a numerical rating of three. The two drawbacks of the AHP model are the choice of criteria and the relative importance of the criteria. The relative importance of the criteria is considered a drawback of the AHP model because the rating can be subjective. The author addressed the choice of criteria through the literature review results; however, the relative importance of the criteria (i.e. columns "More Important Criterion", How Much More Important" and Numerical Rating" initially denoted with TBD) was determined using the training participants' preferences from the Alpha study case. The pair-wise comparison entry for evaluating the AHP model in this thesis is accomplished by extracting the averages from the Alpha's data collection and using as insertions for the numerical rating. The author used the AHP consistency check method as a means to determine the consistency for the pair-wise comparisons. A five-step approximation of the consistency ratio was used where the consistency index, *RI*, is 0.90. The *RI* value was based upon the number of items being compared. There were four items being compared in this thesis, fidelity, presence, immersion and operator buy-in; therefore, the consistency ratio is 0.10.

Table 3: Initial Pair-wise Comparison Summary for the Alpha Study Case.

Pair-wise Comparison	**More Important Criterion**	**How Much More Important**	**Numerical Rating**
Fidelity-Presence	TBD[1]	TBD	TBD
Immersion-Fidelity	TBD	TBD	TBD
Operator buy-in-Fidelity	TBD	TBD	TBD
Presence-Immersion	TBD	TBD	TBD
Operator buy-in-Presence	TBD	TBD	TBD
Operator buy-in-Immersion	TBD	TBD	TBD

2.2.4 Hypothesis

If classroom education, live or computer-based is the selected training type, then it is feasible that fidelity, presence, immersion, and operator buy-in can be utilized in a

[1] In this table, TBD is "To Be Determined" from the data collection of the Alpha study case participants.

multi-criteria decision-making model to evaluate whether or not the model has the efficacy for military training simulation selections.

2.2.5 Experimental Purpose

The main purpose of the planned trainer and trainee questionnaires was to collect data in order to utilize a multi-criteria decision-making model to evaluate the data collected from the test experiment.

2.2.6 Objective

The experimental objective was to determine if the proposed AHP model had the desired efficacy for military training simulation selections.

2.2.7 Description

The approach of this study was to have participants complete questionnaires focused on capturing data with respect to training attributes following their training exercise. Questions were designed with an odd number of responses and no fill-in-the-blank questions, with the only exception being the questions for the trainer's and trainee's positions. The training instructor was asked to complete a questionnaire, called the trainer background questionnaire, which focused on gathering the background information of the training exercise. Participants were asked to complete an initial questionnaire, called trainee pre-training background questionnaire, which focused on gathering background information on their skill level. In addition, each participant in the training exercise completed a second questionnaire, called trainee post-training questionnaire. It focused was capturing data with respect to the training attributes. The second trainee questionnaire was completed following training. The Alpha study case used a modified version of the trainee post-training questionnaire. Further details regarding the questionnaires are discussed in later sections of this thesis.

2.2.8 Participants

Participants were from two training localities in Virginia, Dam Neck and Quantico. There were a total of 102 participants in the data collection process for this thesis. Two training classes presenting the same course topic participated from one trip to Dam Neck. This data collection was referred to as the "Alpha" study case. Three training classes participated from three trips to Quantico. The first Quantico data collection has the nomenclature of "Bravo", the second was referenced as "Charlie" and the third and final class was referred to as "Delta".

A total of two trainers and 19 participants were in the Alpha study case. There were 49 Bravo, five Charlie, 29 Delta participants and one trainer for each. Considering the three questionnaires, five trainers and 102 participants, a total of 2,712 data points were entered into a data collection tool (DCT). The purpose of the DCT was threefold: 1) the DCT provided the calculation required on the electronic data entries in preparation for the pair-wise comparisons' and the alternative comparisons' inputs into the AHP model, 2) the DCT provided the demographic results, and 3) it provided the results for the questionnaire assessment analysis.

2.2.9 Devices

The following material was provided to each participant during data collection: 1) two consent forms (see Appendix A), 2) three questionnaires (see Appendix B), 3) privacy act statement, 4) terminology list, 5) definitions list, 6) acronyms list, 7) pens and index cards. The privacy act statement, terminology list, definitions list, and acronyms list along with the participant number for the experimental informational materials package were contained in page protector sheets and bound for quick distribution. The experimental informational materials package was checked for completeness and reused for the next data collection event (see Appendix C for the experimental informational materials package). Equation 4 was applied to the Alpha study data collected from using the three questionnaires and the alpha (a measure of the internal consistency of a test) equaled 0.792, which resulted in passing the reliability instrument test.

$$\alpha = \left(\frac{k}{k-1}\right)\left(1 - \left(\frac{\sum_{i=1}^{k} var(S_i)}{var(\sum_{i=1}^{k} S_i)}\right)\right) \quad (4)$$

where:

k is the number of items in the instrument and S_i represents the score for item i (Cronbach, 1951).

The author provided a brief introduction and description of the data collection purpose to the candidate participants. Next, the author reviewed the informed consent and privacy act forms. Participants willing to participate had an opportunity to examine and sign forms of their own choosing. Once a participant signed the consent form, trainer and trainee background questionnaires were completed by the consenting participants. Up until this point, the data collection process took approximately 17 to 20 minutes. Following the training, the author returned to distribute the third and final questionnaire to the consenting participants. This generally took seven to ten minutes to complete.

2.2.10 Procedures

The experiment began by the associate investigator explaining the purpose of the study and the types of questionnaires that were given prior to the regularly scheduled military training event. All participants were given two consent forms (see Appendix A): 1) Informed Consent Form for Research and 2) Privacy Act Statement, wherein they were instructed that they are free to leave at any given time throughout the experiment without penalty. After signing the consent forms, participants were asked to complete a pre-training questionnaire (see Appendix B) to capture their demographic information (age, gender, job/Military Occupation Specialty (MOS), and experience with computers, gaming background and types of previous simulation training). This information was useful for understanding the findings from the post-training questionnaire and possibly determining the impact on the model evaluation; however, the questions were not formulated to connect questionnaires with a particular participant. Specifically, age, gender, and experience with computers were collected to help determine if the model results can provide any type of correlation between the training and the users with different levels of experience and preferences. Job/MOS information provided insight into the needs of those working in different jobs and specialties.

The associate investigator provided participants an experimental informational materials package, which contains participant number, privacy act description, the terminology and definitions list, and the acronyms and definitions list (found in Appendix C). The associate investigator instructed participants to not place their name on the questionnaires or their participant number on the consent forms; however, participants shall discover their participant number at the top right corner of the material package and write their number on the top of the pre and post-training questionnaires. This procedure was used to link the pre-training questionnaire with the post-training questionnaire in the likelihood that it is needed during AHP model analysis and evaluation.

Following the completion of the military training, the participant was given a post-training questionnaire (see Appendix B). The post-training questionnaire focused on capturing data with respect to the training attributes: fidelity, presence, immersion, and operator buy-in. The training instructor was asked to complete a trainer background questionnaire that is focused upon gathering the background information of the training exercise (see Appendix B). Questionnaires were developed with the lessons learned from a previous case study utilizing the AHP model (Bachman & Hester, 2009). The training background questionnaire was used to gather informational background on the type of training being conducted. This information proved important during the evaluation process of the multi-criteria decision-making model. Data collected from the trainee post-training questionnaire was used to run the model and analyze the model results along with examining the sensitivity in order to determine the efficacy of the model for military training simulation selections.

2.2.12 Experimental Data

All empirical data was collated by participant numbers. The names of participants were in no way connected to the data. In addition, the demographic forms were designed to be broad enough so that a participant should not be connected to a specific form. Participants completed a pre-training questionnaire containing ten questions regarding their simulation training background. After participants completed their military training session, they completed a post-training questionnaire containing sixteen questions regarding the training they just completed. There was no video recording conducted during the data collection. The questionnaires were used to collect data for insertion into the multi-criteria decision-making model. The model was evaluated for its efficacy for military training simulation selections.

2.2.13 Design Attribute Mapping

The author found it beneficial in the AHP model evaluation to have a mapping of the 16 questions to each of the attributes in the experimental design. The four attributes have four questions devised for each, totaling 16 questions for the post-training questionnaire. In Table 4, the 16 questions are mapped to one of the four attributes. This mapping was needed for entering the data collected into the AHP model. Each attribute type has one trainee 'expectation' question. The questions in the table are in the same order as they appear in the trainee's post-training questionnaire; however, the attributes were not denoted in the trainee's post-training questionnaire.

Table 4: Trainee Question and Attribute Mapping.

Questions	Attributes
1) Rate your physical fidelity expectation (consider in terms of the visual displays, controls, and audio).	Fidelity
2) Rate your expectation of immersion.	Immersion
3) Rate your expectation level of involvement and immersion during this training exercise (i.e. your level of presence.)	Presence
4) Rate your level of expectation of others benefitting from this training exercise.	Operator buy-in
5) Was this training exercise realistic to live training?	Immersion

Questions	Attributes
6) Did you have to be trained to use the training system prior to conducting the training exercise?	Operator buy-in
7) Was the equipment used in the training exercise non-realistic (i.e. not normally used in live training)?	Presence
8) Did you ever get dizzy during the exercise?	Immersion
9) Did you ever experience an unrealistic anomaly (e.g. dying of unnatural causes such as brushing up against an object that unrealistically caused you to die)?	Fidelity
10) Have you used a training system similar to the training exercise conducted today?	Operator buy-in
11) Did you receive a written or verbal message of an event that was supposed to occur during the training exercise without actually experiencing the event?	Fidelity
12) Did you have to conduct a task during the training exercise that is not normally conducted during a live training exercise?	Presence
13) Rate your physical fidelity based on your experience in this training exercise to the degree to which the physical simulation looks, sounds, and feels like the operational environment (in terms of the visual displays, controls, and audio).	Fidelity
14) Rate your immersive experience (i.e. based on your perception of inclusion and/or interaction with the training environment.)	Immersion
15) Rate your level of involvement and immersion during this training exercise (i.e. your level of presence.)	Presence
16) Rate your recommendation for this type of training exercise.	Operator buy-in

Questions numbered 5 through 12 required 'yes', 'no' or non-applicable responses. Questions numbered 1 through 4 and 13 through 16 used a five-point Likert-type scale response. Each set of eight questions are evenly mapped to the attributes, i.e. there are two questions each for fidelity, immersion, presence, and operation buy-in.

2.2.14 Design Summary

An application for exempt research was submitted on 14 September 2011 and granted on 31 October 2011 by the IRB at Old Dominion University (ODU). Appendix D contains the IRB Documentation Appendix B ODU application for exempt research submitted by the author. Following questionnaire distribution and training simulation execution, the information from the questionnaires was collected, compiled and entered into one multi-criteria decision-making model, the AHP model, which is under evaluation. The main purpose and objective of the planned trainer and trainee questionnaires was to collect data to be utilized in a multi-criteria decision-making model. Such information was used to evaluate the data collected from the test experiment to determine if the model has the efficacy for military training simulation selections. The research was not intended to evaluate the instructor, students or the method of instruction. Throughout this process, the associate investigator maintained a thesis journal, capturing the process and observations relevant to the experimental design. In addition, the associate investigator conducted sensitivity analysis on the model, analyze and formulate the model results.

In summary, the experimental design has three questionnaires: 1) training background, which was given to the trainers; 2) participant background, which was given to the trainees prior to their training; and 3) the post-training questionnaire, given to the trainees following their training participation. The purpose of the training background questionnaire was to gather informational background or demographics on the type of training being conducted. The participant background questionnaire was to obtain training demographical information on each participant. The final questionnaire, post-training, collected information from the participant relative to the training attributes following the completion of their training. After analysis, the associate investigator determined whether or not the AHP model provides efficacy for military training simulation selections and what, if any, model results can be further addressed with respect to promoting military training simulation selection standards.

2.3 DATA COLLECTION

Data collection was categorized into the following groups: 1) Alpha study case background and definition; 2) Alpha study case objectives; and 3) Bravo, Charlie, and Delta experiment test definition. Data collection candidates were contacted by the associate investigator; hereafter referred to as the author, and provided the thesis background, approach, data collection process, and questionnaires. In addition, the author met with some data collection candidates face-to-face prior to data collection approval and provided a brief on the thesis background and data collection. The data collection brief is provided in Appendix E.

In the search for data collection opportunities, there was only one opportunity for creating a control group of participants that were afforded two training alternatives under the same course topic, referred to as the Alpha study case. Feedback was provided to refine the wording within the post-training questionnaire in order to accommodate the terminology used within the training environment; however, the post-training questionnaire modifications did not impede the original mapping of questions to the training attributes in the experimental design (see Appendix B Table B-4, Alpha study case: Trainee Post-training Questionnaire).

2.3.1 Alpha Study Case Background and Definition

The Alpha study case was the only control group where the participants experienced the same training topic in two different training alternatives: live (i.e., lab training) and computer-based training (i.e., simulation training). Each Alpha class divided the participants into two groups. Half of the participants began with the computer-based simulation training while the other half began with the lab training. At the end of the first half of training, the two groups exchanged the type of training to complete their training event. Only the Alpha study case was used to evaluate the model since it contained at least two of the three training alternatives and the same training topic.

The "training simulation" reference in the Alpha study case, also referred to as "Sim" in the data analysis, was correlated to the "computer-based" training alternative of the experimental design. The experimental design "live" training was correlated to the Alpha study case "lab training", also referred to as "Mount" in the data analysis section. The first objective in the Alpha study case was associated to the experimental design hypothesis. The second objective was associated to the Alpha study case hypothesis.

2.3.2 Alpha Study Case Objectives

There are two Alpha study case objectives: 1) evaluate the AHP model with the alpha data collection in order to determine if the model has the efficacy for military training simulation selection, and 2) examine how the AHP model evaluates the following case decision question. Which was the preferred sequence of training: a) training simulation first and then conduct lab training, or b) conduct lab training first and then simulation training last?

2.3.3 Bravo, Charlie and Delta Test Experiment Definition

The Bravo data collection experienced only computer-based training and the Charlie data collection experienced only classroom training. The Delta data collection were participants experiencing a hybrid military training on two class topics; the first class topic was conducted using the classroom education alternative and the second half was live training. The Bravo, Charlie and Delta data collections was used to evaluate the value of the eight questions and attribute mapping.

CHAPTER 3

MODEL EXECUTION AND RESULTS

Tom Lehrer, an American musician once said, "Think as you work, for in the final analysis, your worth to your company comes not only in solving problems, but also in anticipating them." The author first explains in this section the results from using the DCT, a tool for electronically entering the data collected, conducting initial calculations needed for AHP model input, and providing the mechanism for obtaining demographic results as well as the results for the questionnaire assessment analysis. Next, the model execution and results of the Alpha study case are discussed as well as an analysis of the attribute mapping. A comparison analysis between the two classes in the Alpha study case was explored. After that the author examines the sensitivity of the model results. Finally, an analysis of the demographic questions was conducted. Subsequent to the analysis of the data section, the AHP model evaluation and attribute mapping assessment are addressed in the results and discussion section. The attribute mapping assessment utilizes the data collected from the Bravo, Charlie and Delta experiments.

3.1 DCT EXECUTION AND RESULTS

Following thesis data collection and entry, DCT was used for an average and difference calculations of each attribute, which was then used for the pair-wise comparison entry in the AHP model. All non-applicable entries into the DCT were denoted as blanks so that the tool would not factor them in the average calculations. A linear transformation[2], illustrated in Equation 5, was applied for a five-point to a nine-point scale conversion. Figure 4 provides a "*xy*" table of results from applying Equation 5 and a diagram of the conversion from the old scale (five-point) to the new scale (nine-point). The old scale was zero to four; whereas, the new scale was one to nine.

$$2x + 1 \qquad (5)$$

where:

x = the difference between two attributes.

x	y
0	1
1	3
2	5
3	7
4	9

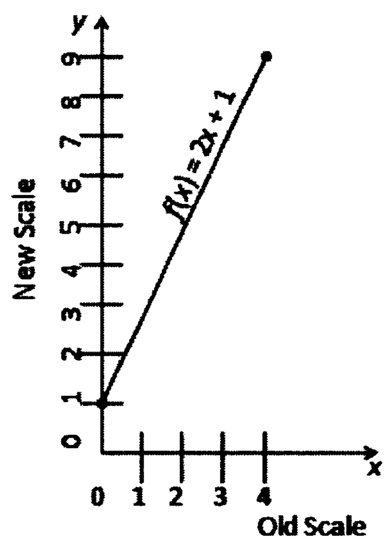

Figure 4: Scale Conversion Illustration.

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[2] Equation formulated by Lynda Hester, Math degree focus in statistics.

The next sections contain information regarding the data results from the DCT. Following model execution, a discussion of the AHP model results from the Alpha study case was provided.

3.1.1 Alpha DCT Analysis for Groups One and Two

The data collection for the Alpha study case was the result of two classes, hereafter referred to as group one and group two (see Figures 5 and 6 providing illustrations from DCT). The data collected for both groups was divided into two sub-groups. One sub-group would be trained initially using the Mount (Mount Totals), i.e. the lab environment first, while the other group would be trained using the simulation (Sim Totals). At the end of their initial training segment, the groups would switch training alternatives to complete the training class. Prior to the switch, participants completed the trainee post-training questionnaire (see Appendix B). The averages are calculated in DCT and displayed in the third row for both Mount and Sim totals in Figures 5 and 6. The fourth row under "Sim Totals" was the differences between the attributes found in Mount and Sim, i.e. group two's fidelity was subtracted from group one's fidelity and so forth. The fifth row of "Sim Totals" provides the results from applying the linear transformation (i.e. a five-point to a nine-point scale conversion). These values are entered into pair-wise comparison matrixes of the AHP model that show the preferences for the training alternatives using each criterion.

Group				1
	3.6666667		3.333333	3.42857
Group				1
	1.375		1.75	2.42857
	2.292	1.047	1.583	1
	5.584	3.094	4.166	3

Figure 5: Averages/Differences from Alpha Group One – DCT.

Group				2
	3		3.166667	3.5
Group				2
			2.5	3.1
	0.167	0.976	0.667	0.4
	1.334	2.952	2.334	1.8

Figure 6: Averages/Differences from Alpha Group Two – DCT.

The averages for the combination of Mount and Sim within each group are calculated in DCT (see the third row in Figures 7 and 8). The fourth row in both figures contains the averages rounded to the third decimal place. Combining Mount and Sim resulted in the attribute, presence, as having the highest average for group one and the attribute, operator buy-in, as having the highest average for group two.

Group				1
	2		2.42857	2.92857
	2	3.231	2.429	2.929

Figure 7: Alpha Group One Averages for Mount and Sim – DCT.

Group				2
	3.11111	2.413793	2.722222	
	3.111	2.414	2.722	3.278

Figure 8: Alpha Group Two Averages for Mount and Sim – DCT.

Next, each attribute was subtracted from the other to ascertain the difference between the two and to identify the most important criterion. This value was entered into the data entry section of the AHP within the row of the attribute with the most important criterion. Figure 9 contains the attribute differences from the DCT for each group's combination of Mount and Sim.

Group				1
Attributes				
	1			
	1.231	1	0.802	0.302
	0.429	1.246883	1	
	0.929		0.5	1
Group				2
Attributes				
	1	0.697	0.389	
		1		
		0.308	1	
	0.167	0.864	0.556	1

Figure 9: Alpha Groups One/Two Mount and Sim Differences – DCT.

This information completes Table 3 previously discussed in the AHP Model section (see Tables 5 and 6 for an update to Table 3). The numerical rating was rounded to the nearest whole number. The importance of completing the pair-wise comparison summary table with the data collected was that it addressed one the drawbacks of the AHP model, where it removes the author's preference by replacing with user preference, in this case the preferences of the training participants.

Table 5: Alpha Group 1 Pair-wise Comparison Summary.

Pair-wise Comparison	More Important Criterion	How Much More Important	Numerical Rating
Fidelity-Presence	Presence	Moderately more to strongly more	4
Immersion-Fidelity	Immersion	Very strongly	2
Operator buy-in-Fidelity	Operator Buy-in	Moderately more	3
Presence-Immersion	Presence	Moderately more	3
Operator buy-in-Presence	Presence	Equally to Moderately	2

Pair-wise Comparison	More Important Criterion	How Much More Important	Numerical Rating
Operator buy-in-Immersion	Operator Buy-in	Equally to Moderately	2

Table 6: Alpha Group 2 Pair-wise Comparison Summary.

Pair-wise Comparison	More Important Criterion	How Much More Important	Numerical Rating
Fidelity-Presence	Fidelity	Equally to Moderately	2
Immersion-Fidelity	Fidelity	Equally to Moderately	2
Operator buy-in-Fidelity	Operator Buy-in	Equally	1
Presence-Immersion	Immersion	Equally to Moderately	2
Operator buy-in-Presence	Operator Buy-in	Moderately more	3
Operator buy-in-Immersion	Operator Buy-in	Equally to Moderately	2

3.1.2 Alpha DCT Analysis for Groups Combined

A third approach was to analyze the available data by combining the two groups into one, where "Mount" participants from both groups are combined and "Sim" participants from both groups are combined. The averages for the group combination of Mount and Sim are calculated in DCT (see the fourth row under "Sim Totals" in Figure 10). Presence has the highest average in both Mount and Sim; however, the highest average difference was immersion.

Groups				1 & 2
	3.2222		3.25	3.466667
Groups				1 & 2
	2.45		2.2	2.823529
	0.772	0.929	1.050	0.643
	2.544	2.858	3.1	2.286

Figure 10: Combined Alpha Group Averages/Differences – DCT.

Figure 11 provides an illustration from the DCT for combining the two groups and formulating the attribute differences that were entered into the data entry section of the AHP model. The highest combined group average was presence. Figure 12 provides a DCT illustration of the difference between the Mount and Sim within the combined groups and also identifies the most important criterion. These values are entered into the data entry section of the AHP within the row of the attribute with the most important criterion. The important criterion was noted by the value entered on the attribute's row. For example, presence was more important than fidelity, immersion and operator buy-in (see Figure 11).

Groups				1 & 2
	2.6896552		2.59375	3.125
	2.69	3.406	2.594	3.125

Figure 11: Combined Alpha Group Averages for Mount and Sim – DCT.

Groups				1 & 2
Attributes				
	1		0.096	
	0.716	1	0.812	0.281
			1	
	0.435		0.531	1

Figure 12: Combined Alpha Group Mount and Sim Differences – DCT.

The pair-wise comparison summary for the combined group was displayed in Table 7. Figure 12 and Table 7 should be related with respect to the "more important criterion" of the pair-wise comparison. For example, the row for immersion in Figure 12 does not show this attribute as important; hence, "immersion" does not appear in the "more important criterion" column of Table 7. This table's second and fourth columns are completed as discussed earlier for groups one and two.

Table 7: Combined Alpha Group Pair-wise Comparison Summary.

Pair-wise Comparison	**More Important Criterion**	**How Much More Important**	**Numerical Rating**
Fidelity-Presence	Presence	Equally to Moderately	2
Immersion-Fidelity	Fidelity	Equally	1
Operator buy-in-Fidelity	Operator Buy-in	Equally to Moderately	2
Presence-Immersion	Presence	Moderately more	3
Operator buy-in-Presence	Presence	Equally to Moderately	2
Operator buy-in-Immersion	Operator Buy-in	Equally to Moderately	2

3.2 MODEL EXECUTION AND RESULTS

Prior to running the AHP model on data obtained for the purposes of this thesis, the AHP model was developed and validated against known data to verify formula accuracy within the model (Bachman & Hester, 2009). The author enters the attribute differences for a group retrieved from the DCT into the AHP model (see Figure 13 for an illustration of group one's entry). Equation 5 was applied to the data entries to compile the pair-wise comparisons matrix (see Figure 14 for an illustration of group one's pair-wise comparisons matrix).

Attributes	Fidelity	Presence	Immersion	Operator buy-in
Fidelity	1.00			
Presence	1.231	1.00	0.802	0.302
Immersion	0.429		1.00	
Operator buy-in	0.929		0.500	1.00

Figure 13: Data Entry Illustration in AHP.

Attributes	Fidelity	Presence	Immersion	Operator buy-in
Fidelity	1.00	0.29	0.54	0.35
Presence	3.46	1.00	2.60	1.60
Immersion	1.86	0.38	1.00	0.50
Operator buy-in	2.86	0.62	2.00	1.00

Figure 14: Pair-wise Comparisons Matrix Illustration in AHP.

The second and final AHP model input from the author was illustrated in Figure 15, where the author retrieves the DCT values representing the preferences for the training alternatives using each criterion. The shaded portion in Figures 14 and 15 are the data entry points and the white portion opposite the diagonal ones was the reciprocal calculation, in accordance with AHP.

[illegible]

Alternatives	Live	Classroom Education	Computer-based
Live	1	5.584	5.584
Classroom Education	0.18	1	5.584
Computer-based	0.18	0.18	1

[illegible]

Alternatives	Live	Classroom Education	Computer-based
Live	1	3.094	3.094
Classroom Education	0.323	1	3.094
Computer-based	0.323	0.323	1

[illegible]

Alternatives	Live	Classroom Education	Computer-based
Live	1	4.166	4.166
Classroom	0.2400384	1	4.166
Computer-based	0.2400384	0.24003841	1

[illegible]

Alternatives	Live	Classroom Education	Computer-based
Live	1	3	3
Classroom Education	0.333	1	3
Computer-based	0.333	0.333	1

Figure 15: Alternative Comparisons Illustration in AHP.

3.2.1 Alpha Study Case Results

The Alpha study case results are provided in Table 8. Group one references the first class of participants and group two represents the second class of participants. The results in Table 8 are a product from executing the AHP model three times using the averages of data collected from group one, group two and the combination of the two groups. The consistency checks met the less than 0.10 criteria in all three categories. The preferred choice from all three categories was "live" training.

Table 8: Alpha Study Case Utility Values.

Training Alternative	AHP Nine-point Scale		
	Group 1	Group 2	Groups Combined
Live	0.60	0.47	0.55
Computer-based	0.13	0.22	0.16

Training Alternative	AHP Nine-point Scale		
	Group 1	**Group 2**	**Groups Combined**
Preferred Choice	Live	Live	Live
Consistency Check	0.007	0.003	0.002

3.3 BETA, CHARLIE AND DELTA ANALYSIS

Obtaining participants that received training in all three alternatives (classroom education, live, and computer-based) for one course topic was difficult to achieve. Data was collected, totaling 83 participants, in the following training alternatives: 1) computer-based; 2) classroom education; and 3) hybrid training class, where the first segment of the class was classroom education and the second half of the class was live training; although the same class participants, each segment contained a different class topic. The computer-based experiment was denoted by "Bravo". The classification for the classroom education experiment was "Charlie" and the hybrid training class has the nomenclature of "Delta" for its data collected.

3.3.1 Background

The data collection for these remaining test experiments were utilized to assess the type of eight questions provided on the trainee post-questionnaire and to evaluate the validity of the attribute mapping conducted in the experimental design; however, this data collection was not utilized in the AHP model evaluation. The remaining sections provide the results for each experiment by exploring the status of the following inquiries: 1) how many applicable, neutral, poor and excellent responses were noted? 2) per question, how many times was it not answered? and 3) what was the average for each question?

3.3.2 Bravo DCT Results

The data collection for the Bravo experiment consisted of 49 participants. Table 9 displays the DCT results from evaluating Bravo responses to the questionnaire. The averages are rounded to two decimal places.

Table 9: Bravo Results –DCT.

Question ID #	Attribute Mapped	Average	N/A Count	Poor Count	Neutral Count	Excellent Count	No Response
1	Fidelity	3.39	0	1	25	6	0
2	Immersion	3.49	0	1	25	5	0
3	Presence	3.73	0	0	15	8	0
4	Operator buy-in	3.90	1	1	10	12	0
13	Fidelity	3.06	1	4	19	1	0
14	Immersion	3.49	0	1	19	3	0
15	Presence	3.63	0	2	19	9	0
16	Operator buy-in	4.16	0	1	2	15	0
Totals		3.61	2	11	134	59	0

All 49 participants answered the eight questions under assessment. A total of two non-applicable responses were received for: 1) the Operator buy-in question: "Rate your level of expectation of others benefitting from this training exercise." and 2) the fidelity question: "Rate your physical fidelity based on your experience in this training exercise to the degree to which the physical simulation looks, sounds, and feels like the operational environment (in terms of the visual displays, controls, and audio)." The second operator buy-in inquiry, "Rate your recommendation for this type of training exercise", received the least amount of "neutral" responses.

Figure 16 illustrates the averages of the attribute questions. The operator buy-in attribute received the highest average.

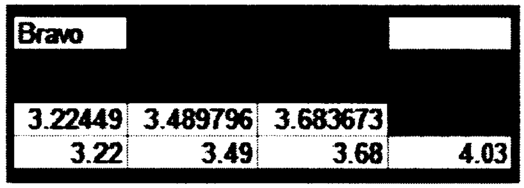

Figure 16: Bravo Experiment Test Averages – DCT.

3.3.3 Charlie DCT Results

The data collection for the Charlie experiment encompassed five participants. Table 10 displays the DCT results from evaluating Charlie responses to the questionnaire.

Table 10: Charlie Question Assessment Results.

Question ID #	Attribute Mapped	Average	N/A Count	Poor Count	Neutral Count	Excellent Count	No Response
1	Fidelity	3.60	1	0	0	2	0
2	Immersion	4.00	0	0	1	1	0
3	Presence	3.80	0	0	3	2	0
4	Operator buy-in	4.20	0	0	1	2	0
13	Fidelity	0.20	4	1	0	0	0
14	Immersion	3.00	1	0	1	2	0
15	Presence	2.80	2	0	0	2	0
16	Operator buy-in	3.40	0	0	2	1	0
Totals		3.13	8	1	8	12	0

All five participants answered the eight questions under assessment. A total of eight non-applicable responses were received. Only one participant found the fidelity question: "Rate your physical fidelity based on your experience in this training exercise to the degree to which the physical simulation looks, sounds, and feels like the operational environment (in terms of the visual displays, controls, and audio)" as being applicable. It was the only questions to not receive a response of "excellent."

Figure 17 illustrates the averages of the attribute questions. The operator buy-in attribute received the highest average.

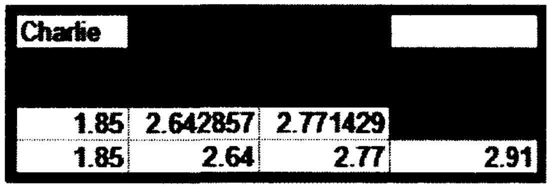

Figure 17: Charlie Experiment Test Averages – DCT.

3.3.4 Delta DCT Results

The data collection for the Delta experiment included 29 participants. Table 11 displays the DCT results from evaluating Delta responses to the questionnaire.

Table 11: Delta Question Assessment Results.

Question ID #	Attribute Mapped	Average	N/A Count	Poor Count	Neutral Count	Excellent Count	No Response
1	Fidelity	3.24	1	0	16	0	0
2	Immersion	3.52	0	0	14	2	0
3	Presence	3.83	0	0	9	4	0
4	Operator buy-in	3.59	0	1	10	3	0
13	Fidelity	3.21	2	0	15	2	0
14	Immersion	3.38	1	0	15	3	0
15	Presence	3.79	0	0	12	6	0
16	Operator buy-in	3.79	0	1	8	5	0
Totals		3.54	4	2	99	25	0

All 29 participants answered the eight questions under assessment. A total of four non-applicable responses were received; three of which covered both fidelity questions. The two questions receiving a "poor" response were both for the operator buy-in questions and came from the same participant. All questions received at least two "excellent" responses except for the fidelity: "Rate your physical fidelity expectation (consider in terms of the visual displays, controls, and audio", which received none.

Figure 18 illustrates the averages of the attribute questions. The immersion attribute received the highest average.

Delta			
3.13083	3.261663		3.452333
3.13	3.26	3.55	3.45

Figure 18: Delta Experiment Test Averages – DCT.

3.4 COMPARISON ANALYSIS

The author first examined the comparison of the averages and differences results between groups one and two as well as between the groups' two sub-groups within the Alpha study case. Secondly, a comparison analysis was conducted between group one, group two and the combination of the two groups. Finally, the author conducted a comparison analysis between Bravo, Charlie and Delta results.

3.4.1 Alpha Study Case

There are two user inputs into the AHP model, preferences for the training alternatives using each criterion and the most important criterion. In conducting a comparison of the values to be entered into the pair-wise comparison matrixes for recognizing the user's preferences for the training alternatives using each criterion, one obvious similarity between group one and group two was that both have their highest attribute average for "presence." Only group two's sub-group, Sim, had two attributes with the highest average, "fidelity" and "presence." The largest difference in group one was "fidelity", yet group two's largest difference was "presence." Group one's preferences are greater for "fidelity" by 4.25, for "presence" by 0.14, for "immersion" by 1.83 and for "operator buy-in" by 1.20.

In comparing the most important criterion between groups one and two, "presence" was more important when paired with the other three criterions in group one; however, group two rated it least important when compared to the other three criterions. "Presence" has a numerical rating of four, the highest in all three pair-wise comparison summaries. "Operator buy-in" was the second highest in group one but was most important in group two with the numerical rating of three. "Immersion" was more important than "fidelity" in group one and more important than "presence" in group two.

A comparison of the preferences for the training alternatives using each criterion by combining the two groups shows that "presence" received the highest average with "immersion" receiving the highest preference score of 3.1. "Presence" was the more important criterion for the pair-wise comparison matrix when paired with the other three attributes. It has the highest numerical rating of the three. "Immersion" does not rate and "fidelity" rates only once with a numerical rating of one.

In summary, there are two comparison cases involving two user inputs into the AHP model. The two inputs are: 1) preferences for the training alternatives using each criterion, and 2) more important criterion. The two comparison cases are: 1) between group one and group two, and 2) between group one, group two and the combination of the two groups. Table 12 provides the comparison results for both cases. It was interesting to discover that the more important criteria for group one happens to be the least important criterion for group two. Nonetheless, both groups individually and combined found the highest preference for the training alternatives using each criterion as "presence."

Table 12: AHP Input and Group Comparison Results.

AHP User Input Type	Group		
	One	Two	Combined
Highest preference for the training alternatives using each criterion	Presence	Presence	Presence
Largest difference of preference for the training alternatives using each criterion	Fidelity	Presence	Immersion
More important criterion	Presence	Operator buy-in	Presence
Least important criterion	Fidelity	Presence	Immersion

3.4.2 Beta, Charlie and Delta Test Experiment Comparisons

The author compared the results from Beta, Charlie and Delta questionnaire assessments (see Table 13). Table 14 provides the comparison summary of the questionnaire assessment.

Table 13: Questionnaire Assessment Comparison Results

Question ID #	Attribute Mapped	Highest Average	Lowest Average	Highest N/A Count	Highest Poor Count	Highest Neutral Count	Highest Excellent Count
1	Fidelity	Charlie = 3.60	Delta = 3.24	Charlie and Delta = 1	Bravo = 1	Bravo = 25	Bravo = 6
2	Immersion	Charlie = 4.00	Bravo = 3.49	All = 0	Bravo = 1	Bravo = 25	Bravo = 5
3	Presence	Delta = 3.83	Bravo = 3.73	All = 0	All = 0	Bravo = 15	Bravo = 8
4	Operator buy-in	Charlie = 4.20	Delta = 3.59	Bravo = 1	Bravo and Delta = 1	Bravo and Delta = 10	Bravo = 12
13	Fidelity	Delta = 3.21	Charlie = 0.20	Charlie = 4	Charlie = 1	Bravo = 19	Delta = 2
14	Immersion	Bravo = 3.49	Charlie = 3.00	Charlie and Delta = 1	Bravo = 1	Bravo = 19	Bravo = 3
15	Presence	Delta = 3.79	Charlie = 2.80	Charlie = 2	Bravo = 2	Bravo = 19	Bravo = 9
16	Operator buy-in	Bravo = 4.16	Charlie = 3.40	All = 0	Bravo and Delta = 1	Delta = 8	Bravo = 15

Question number 13, "Rate your physical fidelity based on your experience in this training exercise to the degree to which the physical simulation looks, sounds, and feels like the operational environment (in terms of the visual displays, controls, and audio)", a fidelity question received the most non-applicable responses. Upon verifying the data collection, there were a total of five participants in a classroom education training event; therefore, it makes sense for the classroom education training participants to respond to this question with non-applicable. The group with the most neutral count was Bravo. The Bravo class was computer-based training, hence the author found it interesting that the 49 participants overall were neutral to all but the sixteenth question mapped as an operator buy-in: "Rate your recommendation for this type of training exercise." Since a response of neutral was more prevalent than others, especially from computer-based participants, the author examines further the set of questions (see Table 14).

Table 14: Questionnaire Assessment on Neutral Responses.

Question ID #	**Question**	**Attribute**	**Highest Neutral Count**	**Ratio of Neutral Responses**
1	Rate your physical fidelity expectation (consider in terms of the visual displays, controls, and audio).	Fidelity	Bravo = 25	51%
2	Rate your expectation of immersion.	Immersion	Bravo = 25	51%
3	Rate your expectation level of involvement and immersion during this training exercise (i.e. your level of presence.)	Presence	Bravo = 15	31%
4	Rate your level of expectation of others benefitting from this training exercise.	Operator buy-in	Bravo and Delta = 10	Bravo = 20% Delta = 34%
13	Rate your physical fidelity based on your experience in this training exercise to the degree to which the physical simulation looks, sounds, and feels like the operational environment (in terms of the visual displays, controls, and audio).	Fidelity	Bravo = 19	39%
14	Rate your immersive experience (i.e. based on your perception of inclusion and/or interaction with the training environment.)	Immersion	Bravo = 19	39%
15	Rate your level of involvement and immersion during this training exercise (i.e. your level of presence.)	Presence	Bravo = 19	39%
16	Rate your recommendation for this type of training exercise.	Operator buy-in	Delta = 8	16%

Both questions for "fidelity" and "presence" received very high percentage rates from the Bravo participants responding as neutral for questions with neutral responses (referencing questions identified as numbers 1, 2, 13, and 15). Only one Bravo participant answered all four questions of these questions as neutral.

3.5 SENSITIVITY ANALYSIS

None of the averages from the questionnaires resulted in a value of nine; therefore three additional runs of the AHP model were conducted. For each of those runs, the groups were combined, the nine-point scale was used and an alternating attribute was changed to nine with the remaining attributes set to the original data collection results. Since "immersion" was not identified as one of the most important criterion, only three runs were needed. The results from all three runs are provided in Table 15.

Table 15: Alpha Sensitivity Analysis Results.

Combined Alpha Groups Using Nine-point Scale			
Rank = 9	**Live**	**Computer-based**	**Consistency Check**
Fidelity	0.60	0.13	0.24 = Not Met
Immersion	Not applicable since immersion was not identified as one of the most important criterion.		
Presence	0.68	0.08	0.02 = Met
Operator buy-in	0.65	0.10	0.14 = Not Met

The largest significant difference when comparing each attribute among the two alternatives was "presence." There was 0.60 of a difference between the two alternatives. The least difference when comparing each attribute among the two alternatives was "fidelity". The attribute resulting as the most sensitive under live alternative was "presence" and the least sensitive was "fidelity"; whereas, under computer-based, the most sensitive attribute was "fidelity" and the least sensitive was "presence." Although the other two attributes did not meet the consistency check, "Operator buy-in" was only four percent above the threshold, while "fidelity" was 14 percent above the consistency check. Finally, out of the three runs, only the run for "presence" resulted in meeting the consistency check required of AHP of less than ten percent.

3.6 DEMOGRAPHICS ANALYSIS

A pre-questionnaire was developed to capture demographic data that may or may not provide additional insight into the process for AHP model evaluation. The author discusses the findings in the following sections. The training and trainee background sections each address the Alpha study case and the Bravo, Charlie and Delta test experiment.

3.6.1 Alpha Training Background

The Alpha study contained a total of 19 participants, 15 males and four females as illustrated in Figures 19 and 20. Figure 20 reveals that most participants are within the 19 to 24 age range. The second highest age range was 25 through 30.

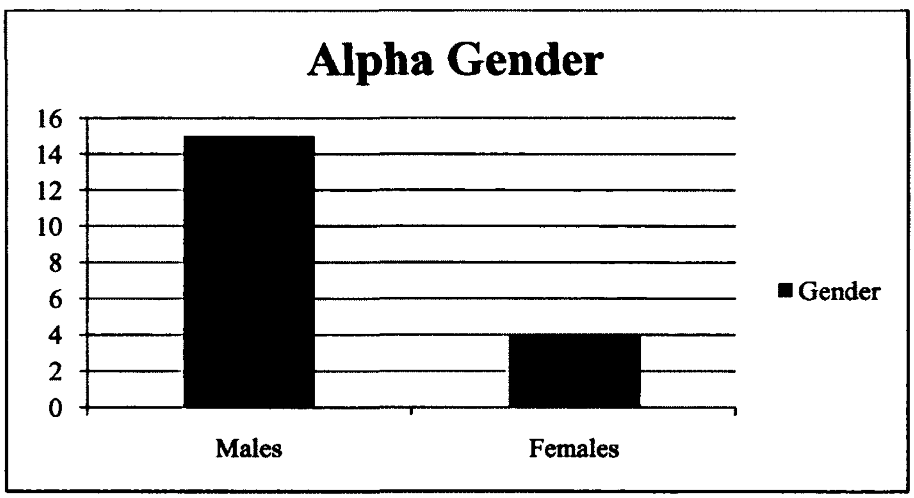

Figure 19: Gender for the Alpha Study Group.

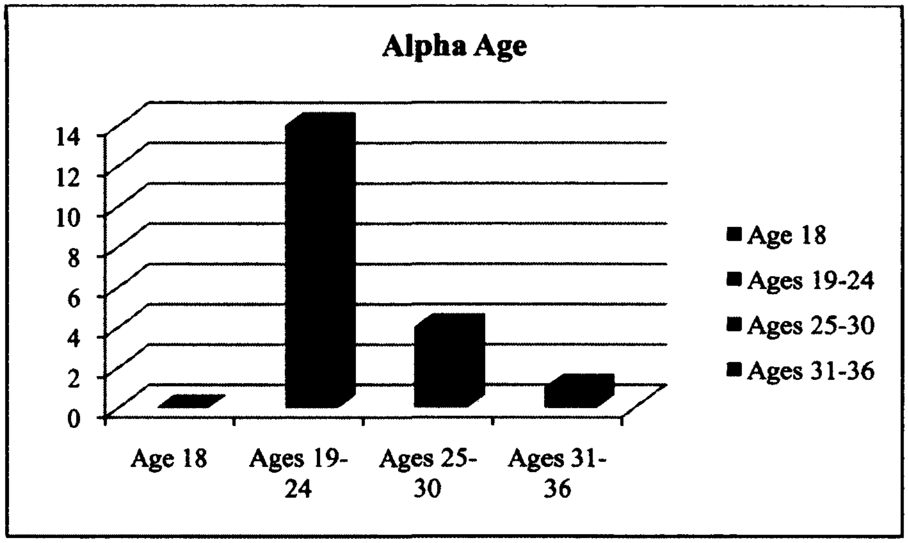

Figure 20: Age for the Alpha Study Group.

The Alpha group's background in gaming was illustrated in Figure 21. In response to the three gaming background questions, only five participants comprising of 26 percent, responded positively to having experience with 'Serious' gaming. A rate of 63 percent of the participants responded positively to having gaming background experience with video and online games. Figure 22 illustrates the participants' response to the type of training background that they have experienced. None of the participants responded with only selecting classroom education as the sole training alternative. Fifty-three percent of the participants chose a selection of all three types of background experiences. One participant did not respond to this question.

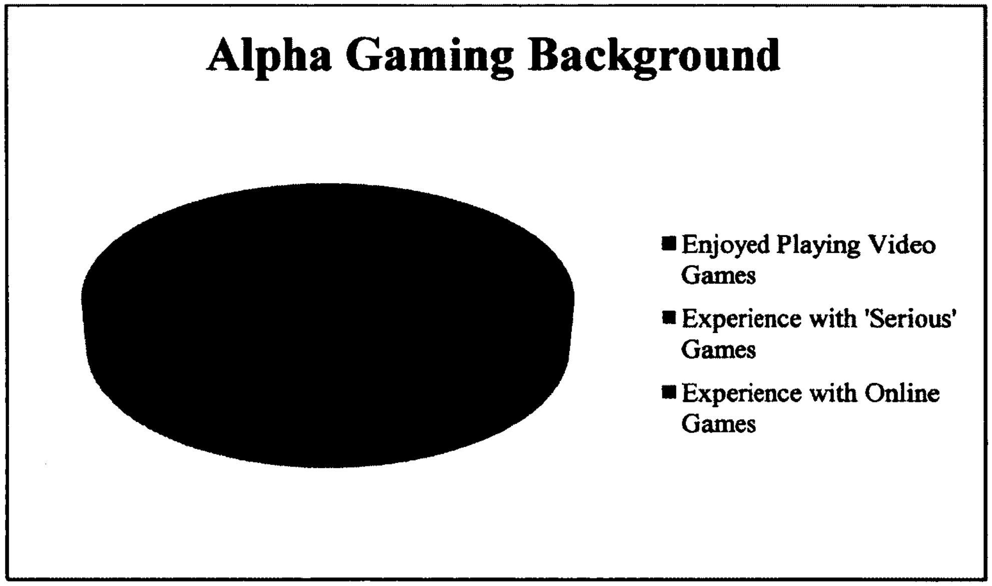

Figure 21: Gaming Background for the Alpha Study Group.

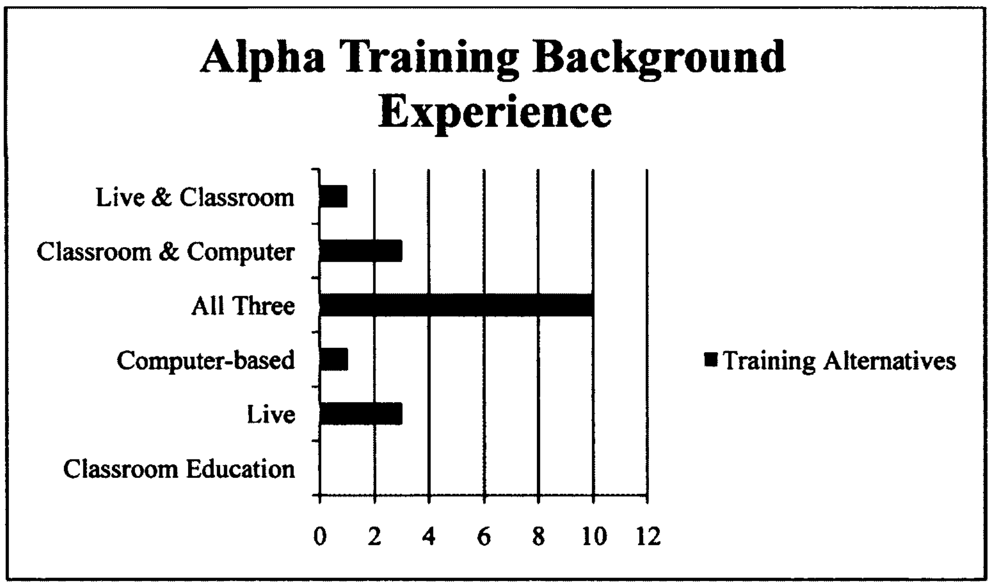

Figure 22: Training Background for the Alpha Study Group.

In summary, there were no inconsistencies between the Alpha Study group's responses in the pre-questionnaire and the post-questionnaire.

3.6.2 Bravo, Charlie and Delta Background

The demographics for the experiment test, consisting of Bravo, Charlie and Delta data collections, are combined for the following graphs. Figure 23 provides the gender. A significant observation regarding the experiment test was that out of the 83 participants, all were male except for one. In addition, the age range of 19-24 contained 84 percent of the participants (see Figure 24).

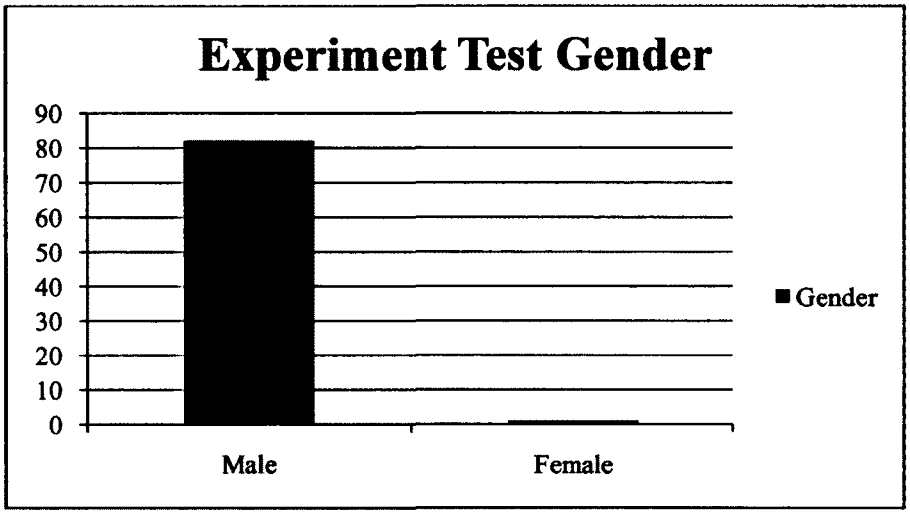

Figure 23: Gender for the Experiment Test.

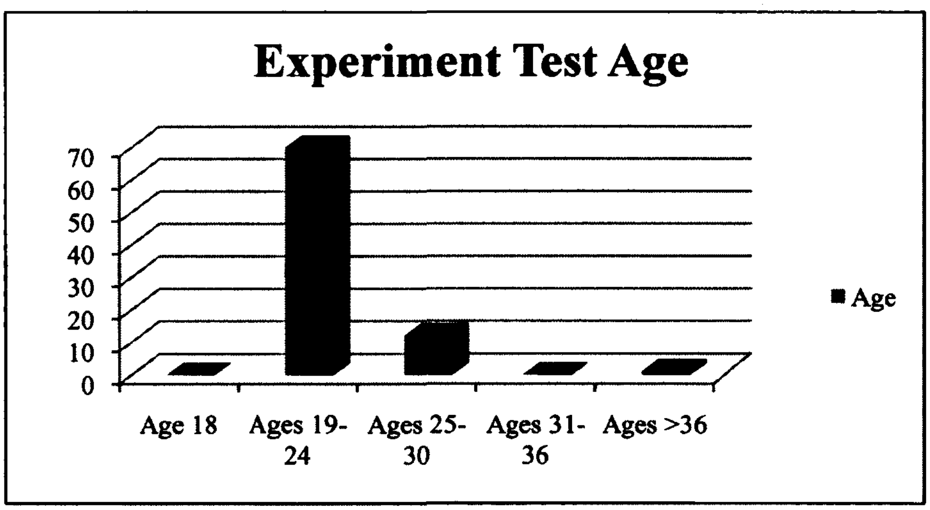

Figure 24: Age for Experiment Test.

Figure 25 illustrates the gaming background of the participants. Eighty-three percent of participants' responded that they enjoyed playing video games. The second highest response rate was for experience with online games, 70 percent of the participants have experience with online games. Participants responding affirmative to experience with 'serious' games was 57 percent. Only one instance of a non-response occurred and that involved the playing video games question; nonetheless, the participant answered that the rate of their playing video games was one step above their rating themselves as a novice and three steps below an advanced video game player.

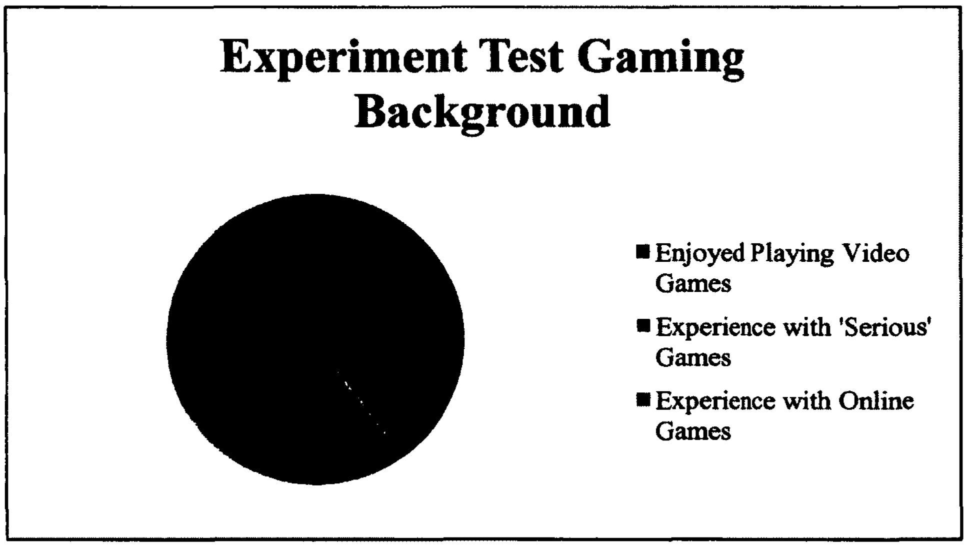

Figure 25: Gaming Background for the Experiment Test.

The Experiment Test participants' response to the type of training background that they have experienced is illustrated in Figure 26. Ninety-two percent of the participants responded with a selection of all three training alternatives for their background experience. None of the participants selected one of the combinations of either computer-based, classroom and computer-based or live and computer-based when responding to the background experience question.

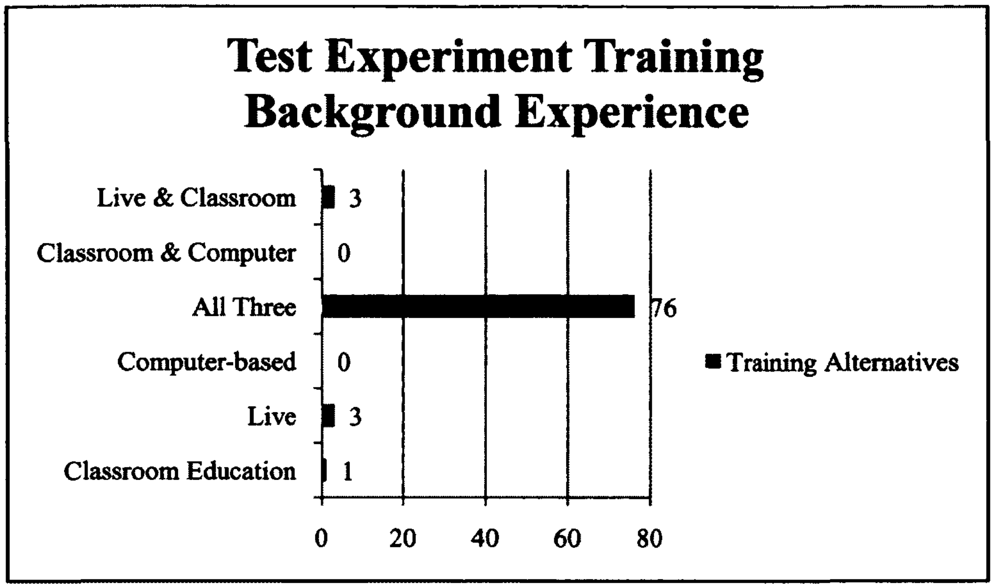

Figure 26: Training Background for the Experiment Test.

In conclusion, the author recognized an interesting observation from how the participants handled skip logic. There were 12 participants in the test experiment that responded to a follow-on question even though they had selected a 'no' response. With respect to the Alpha study case, there were six participants that responded in the same manner as well. The Author may reconsider the future use of skip logic in survey questions. Considering a comparison of the demographics between the Alpha study case and the experiment test case, both cases have the highest number of participants as male, in the 19 to 24 age range, and the majority responded with a selection of all three training alternatives for their background experience.

CHAPTER 4

RESULTS AND DISCUSSION

The benefit of good foresight was that it avoids hindsight coming up and biting you in the rear. Two of the main drawbacks to utilizing the AHP model are the choice of criteria and the relative importance of the criteria. The author addressed the first drawback by justifying the selection of three training alternatives and four training attributes in this experimentation upon the literature review findings of the DARWARS Training Impact Group (Alexander et al., 2005). The second drawback was addressed by the author as a result of replacing the author's preferences with training participants' preferences, where data regarding the participant's (i.e. the trainee's) experience from the same course but through two training alternatives was used as input for the relative importance of the criteria.

Based upon the evaluation of the Alpha study case results, the AHP model displays promise in providing effectiveness and the proper influence for military training simulation selections. On the negative side, assembling the information and data needed to establish the input for the AHP model was not a low-level of effort. The author discovered that "presence" was the highest preference for the training alternatives using each criterion from the Alpha study case. The author was pleased with the training attributes selected for this thesis and based on the evaluation of the types of questions posed for each attribute, and as a result of the Bravo, Charlie and Delta analysis, no evidence was found to neither disqualify the eight attribute questions nor the attribute mapping. All three of the Alpha study case AHP model executions (see Table 8) met the consistency check of AHP, which indicates that the consistency of the pair-wise comparisons was considered reasonable. In addition to meeting the consistency check, the Bravo, Charlie and Delta analysis indicated that an approach has been developed which was consistent across groups and displays strong alternative preferences that are consistent. The next section concludes the findings for this thesis.

CHAPTER 5

CONCLUSIONS

Based upon the results of the literature review performed for this thesis, the author concluded that the fundamental question of how do decision-makers defensively correlate military training requirements with either existing or proposed training simulators remains unexplored. Moreover, it is of the acquisition and training planners (decision-makers) interest to develop and utilize a framework to assist decision-makers in determining whether or not the proposed training approach is acceptable for a particular military training application. Warfighting has been changed by the volatile global security environment, warfighter availability (e.g., Reserve or National Guard), by logistical challenges, by the geographical distribution of personnel, and by the limited resources precluding frequent field training (Alexander et al., 2005). In December 2008, The Army released its "Training for Full Spectrum Operations" field manual and a few months later, work had already begun on revisions of the document (Magnuson, 2009, p. 46). Magnuson reported in an Army training and simulation article:

> The increasingly complex battlefield is prompting the service to rethink the way it trains for war. Troops can find themselves conducting offensive operations, defending against an attack or carrying out stability operations – building schools, meeting with local tribal leaders to help improve citizens' conditions – all in the course of one day. (Ibid, p. 46)

Consider the following example for needing a general methodological framework. The training requirement is to use combat scenarios for improving performance of decision-making for fire engagements. The current training method utilizes a computer-based simulation, which contains no immersion, to meet the above training requirement. The question posed: Do we transfer our combat scenario simulation training from computer-based to live training or do we upgrade the current computer-based training to an enhanced immersive simulation training capability? Three training alternatives evolve: remain the same, transfer to live training or upgrade to an enhanced immersion capability. In addition to the these benefits of a cohesive, defensible argument; leading to consistency in making acquisition decisions for having a general methodological framework supporting simulation training selections, are the benefits of providing cost effectiveness and a medium-to-low level of effort in the process. Although there are advantages to having a low level of effort, Abraham Lincoln once said, "Give me six hours to chop down a tree and I will spend the first four sharpening the axe." Preparation to overcome the drawbacks of the AHP model is an important effort as well as how sound you plan the time-to-complete.

The purpose of this thesis was to explore and assess a multi-criteria decision-making model to distinguish if it has the power to assist decision-makers, acquisition and training planners, in determining whether or not a proposed training approach is acceptable for a particular military training application. The AHP was the multi-criteria decision-making model identified. An experimental design was developed to utilize the AHP and evaluate the data collected from the test experiment for determination of the model's efficacy for military training simulation selections. The Alpha study passed the reliability instrument test as well as the AHP model's consistency check. User preference by the trainees was used as input into the AHP. Hayes noted that R. J. Biersner "found that trainees, who rated training devices higher, performed better on the devices" (Hayes, 1992, p. 263). The evidence suggests that the AHP model could be utilized as a decision-making tool for not only the acquisition planner but also the training planner when multi-criteria decisions are involved. This is not without cost; however, it is recommended that trainers plan for a medium level of effort up front (i.e. the preparation time for developing the AHP hierarchy; however, remembering that there are two kinds of input needed for the AHP model). Nevertheless, this preparation drawback is outweighed by the defensibility, consistency and cohesiveness afforded an organization by using a prescriptive model for training simulation selections.

In considering future work, the author recommends conducting a study case where training participants are afforded all three training alternatives under the same training course topic for further validation of this model. In addition, contemplation with regards to what if the decision-maker is exploring future training exercises may be value-added. Since this thesis addresses the model as a backward-looking tool, i.e., correlating military training requirements with existing training simulators versus proposed training simulators, what about the training exercises that do not exist but only in concept, how well does the AHP model support alternatives when they are all conceptual? For this general framework to be beneficial to each branch within the U.S. military, how each military's training best practices and procedures will be correlated within the framework needs further investigation. In addition, follow-up research, such as validation studies, could be conducted to further enhance a generalized approach to multi-criteria decision-making with respect to military simulation training.

Consideration of more types of people recommended for use in training system design should have their input included into the general framework (i.e. as model input;

importance of criteria). Hayes noted, "It is vital that individuals understand that the goals of other groups may conflict with their own and that these conflicts must be resolved if the training system is to be optimally effective" (Ibid, p. 261). He further expands:

> Many new technological and instructional developments hold the promise of improved training effectiveness (e.g. multimedia, digital video, distance learning). However, to achieve this goal, the individuals responsible for training systems development need to be aware of activities and viewpoints outside of their own subsystem and gear their activities to reduce intersystem conflicts. (Ibid, p. 264)

Although acquisition decision-makers are matching their training requirements to existing and proposed simulation training capability exercises, the decision approaches uncovered in the literature review indicate that no general methodological framework that promotes a cohesive and defensible argument, leading to consistency in making acquisition decisions, exists. The author concludes that the findings from this thesis work afford a foundation for furthering the goal of developing a general methodological approach to training simulation selections.

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APPENDIX A: CONSENT FORMS

INFORMED CONSENT FORM FOR RESEARCH: Using Decision-making Techniques in Support of Simulation Training Transfer Selections

1. Introduction:

You are being asked to voluntarily participate in a thesis entitled *"Using Decision-making Techniques in Support of Simulation Training Transfer Selections"*. The main objective of this form is to assure that you are informed of the risks and benefits of this research and that your participation is voluntary.

2. Purpose of the study: The purpose of the study is to assess a multi-criteria decision-making model in order to determine the efficacy for military training simulation selection.

3. Procedures to be followed
The experiment will begin by having the participants complete a pre-training questionnaire to capture their age, gender, job/Military Occupation Specialty (MOS), and experience with computers, gaming background and types of previous simulation training. Following the completion of the military training, the participant will be given a post-training questionnaire. The post-training questionnaire focuses on capturing data with respect to the training attributes. The training instructor is asked to complete a questionnaire that is focused upon gathering the background information of the training exercise.

4. Discomforts and Risks: This study poses no more than minimal risk.

5. Benefits: The benefits to society and me are described below:

(a) Benefits to Me: No direct benefits other than knowing that your input will be applied toward a multi-criteria decision-making model under evaluation for military training simulation selections.

(b) Potential Benefits to Society: The results of this data collection will be applied toward the model evaluation, which will benefit the greater simulation training community. In addition, these are the benefits of having a general methodological approach for decision-makers to correlate military training requirements with either existing or proposed training simulators: 1) require a medium to low level of effort, 2) promote positive consistency in the decision-making process, 3) obtain decision cohesiveness between training requirements and training selections, 4) afford a defensible argument for the simulation training selection, and 5) provide program cost effectiveness.

6. Duration/Time of the Procedures and Study:

The data collection may be no more than a total of seventeen minutes per participant. This time is dependent on question comprehension speed and the time it takes to respond to the question.

7. Alternative Procedures that Could be Utilized: N/A

8. Statement of Confidentiality:

All records are kept confidential by assigning a coded identification number, which means your name will not be directly associated with any data. The confidentiality of the information related to my participation in this research will be ensured by maintaining records only coded by identification numbers. Research studies occasionally are evaluated by Institutional Review Boards (IRB) and other oversight agencies (i.e., Department of Navy Human Research Protection Program or Office of Naval Research) to determine that the study was conducted properly. If such an evaluation is requested for this study they may have a need to inspect my research record from this study, in order to fulfill their responsibilities.

9. Right to Ask Questions
You have a right to ask questions at any time before, during, or after the test. Please contact the Principal Investigator, one of the Associate Investigators, or the Institutional Review Board (IRB) chairman at any time with questions, complaints or concerns about the research. They are:

Principle Investigator: Patrick Thomas Hester, 757-683-5205, pthester@odu.edu

Associate Investigator: Jane T. Bachman, 540.653.7570, jane.bachman@navy.mil

10. Payment for Participation: N/A

11. Cost of Participating: N/A

12. Voluntary Participation: Your participation is voluntary and you may request to withdraw or stop the study at any time without free of reprisal or penalties.

13. Injury Clause: N/A

14. Participation Requirements: There are no requirements for the participants.

If you agree to take part in this research study and the information outlined above, please sign your name and indicate the date below. By signing below, you are also certifying that you have been informed of the information above and that your participation in this study is voluntary. You will be given a copy of this signed and dated consent form for your records.

Participants Name **Participants signature** **Date**

Investigator's Name **Investigator's signature**

PRIVACY ACT STATEMENT

I understand that all personal information will be kept confidential and will be reported in an anonymous fashion. This includes, but is not limited to, my name, rate, rank, years of experience, and performance during this study. I further understand that disclosure of personal information is voluntary, and I may withdraw this consent at any time without penalty.

______________________________ _______________

Participant's Signature Date

______________________________ _______________

Principal Investigator's Signature Date

APPENDIX B: QUESTIONNAIRES

The three experimental design questionnaires used in the experimental test are provided in Tables B-1 through B-3. The Alpha study case uses Tables B-1 and B-2; however, Table B-4 illustrates the changes made to Table B-3 to accommodate the exercise of the Alpha study case in the AHP model evaluation.

B.1 Experimental Design Questionnaires

Table B-1: Trainer Background Questionnaire #1.

Instructor ID#	*(circle one or fill in a blank)*
1) Age (years):	< 26 26-31 32-37 38-43 >43
2) Gender:	M F
3) What is your current job title?	Officer Technician TechOp Operator MOS__________ Other____________________
4) Does this training include after action review (AAR)?	No Yes
5) How many scenarios are run for this training session?	0 1 2 3 >3
6) What is the type of training conducted?	Live Classroom education Computer-based
7) Is this training using a simulator?	No Yes
8) Is this training using a video game on a desktop or laptop?	No Yes
9) Is this immersive training?	No Yes
10) Is this a combination? (Please circle all that apply.)	(Desktop video game) (Immersive video game) (Avatars) (Simulator i.e. air trainer, helo, tank, sub, etc.) (live actors)
11) If there was a previous training method used for this training requirement, please circle all that apply.	(Desktop video game) (Immersive video game) (Live) (Legacy Simulator now updated) (Classroom education)

Instructor ID#	*(circle one or fill in a blank)*
12) How long for this training objective have you been using this training technique?	< 1 year up to 3 years up to 6 years 6-10 >10

Table B-2: Trainee Pre-Training Background Questionnaire #2.

Participant ID#	*(circle only one or fill in a blank for each question)*
1) Age (years):	18 19-24 25-30 31-36 >36
2) Gender:	M F
3) What is your current job title?	Officer Technician TechOp Operator MOS__________ Other______________________
4) Circle the types of training that you have previously participated?	Live Classroom education Computer-based
5) Do you enjoy playing video games?	No Yes
6) If yes, rate your video game skill level.	1=Novice 2 3 4 5=Advanced
7) Do you have experience with 'serious' games (i.e. games used in military training?)	No Yes
8) If yes, rate your serious game skill.	1=Novice 2 3 4 5=Advanced
9) Do you have experience with online games?	No Yes
10) If yes, rate your online game skill.	1=Novice 2 3 4 5=Advanced

Table B-3: Trainee Post-Training Questionnaire #3.

Participant ID#	*(circle only one for each question)*
1) Rate your physical fidelity <u>expectation</u> (consider in terms of the visual displays, controls, and audio).	0=N/A 1=Poor 2 3=Neutral 4 5=Excellent
2) Rate your <u>expectation</u> of immersion.	0=N/A 1=Poor 2 3=Neutral 4 5=Excellent
3) Rate your <u>expectation</u> level of involvement and immersion during this training exercise (i.e. your level of presence.)	0=N/A 1=Poor 2 3=Neutral 4 5=Excellent
4) Rate your level of <u>expectation</u> of others benefitting from this training exercise.	0=N/A 1=Poor 2 3=Neutral 4 5=Excellent
5) Was this training exercise realistic to live training?	No Yes N/A - i.e. it was a live training exercise.
6) Did you have to be trained to use the training system prior to conducting the training exercise?	No Yes N/A
7) Was the equipment used in the training exercise non-realistic (i.e. not normally used in live training)?	No Yes N/A
8) Did you ever get dizzy during the exercise?	No Yes N/A
9) Did you ever experience an unrealistic anomaly (e.g. dying of unnatural causes such as brushing up against an object that unrealistically caused you to die)?	No Yes N/A
10) Have you used a training system similar to the training exercise conducted today?	No Yes N/A
11) Did you receive a written or verbal message of an event that was supposed to occur during the training exercise without actually experiencing the event?	No Yes N/A
12) Did you have to conduct a task during the training exercise that is not normally conducted during a live training exercise?	No Yes N/A

Participant ID#	*(circle only one for each question)*
13) Rate your physical fidelity based on your experience in this training exercise to the degree to which the physical simulation looks, sounds, and feels like the operational environment (in terms of the visual displays, controls, and audio).	0=N/A 1=Poor 2 3=Neutral 4 5=Excellent
14) Rate your immersive experience (i.e. based on your perception of inclusion and/or interaction with the training environment.)	0=N/A 1=Poor 2 3=Neutral 4 5=Excellent
15) Rate your level of involvement and immersion during this training exercise (i.e. your level of presence.)	0=N/A 1=Poor 2 3=Neutral 4 5=Excellent
16) Rate your recommendation for this type of training exercise.	0=N/A 1=Poor 2 3=Neutral 4 5=Excellent

B.2 Alpha Study Case Questionnaire

Table B-4: Alpha Study Case: Trainee Post-Training Questionnaire #3.

Instructor ID:	(circle one or fill in a blank)
1) Age (years):	< 26 26-31 32-37 38-43 >43
2) Gender:	M F
3) What is your current job title?	Officer Technician TechOp Operator MOS__________ Other____________________
4) Does this training include after action review (AAR)?	No Yes
5) How many scenarios are run for this training session?	0 1 2 3 >3
6) What is the type of training conducted?	Live Classroom education Computer-based
7) Is this training using a simulator?	No Yes
9) Is this immersive training?	No Yes
10) Is this a combination? (Please circle all that apply.)	(Desktop video game) (Immersive video game) (Avatars) (Simulator i.e. air trainer, helo, tank, sub, etc.) (live actors)
11) If there was a previous training method used for this training requirement, please circle all that apply.	(Desktop video game) (Immersive video game) (Live) (Legacy Simulator now updated) (Classroom education)
12) How long for this training objective have you been using this training technique?	< 1 year up to 3 years up to 6 years 6-10 >10

APPENDIX C: EXPERIMENTAL INFORMATIONAL MATERIALS PACKAGE

The informed consent page for the privacy act statement is the first page of the experimental informational package. Package consisted of three pages inserted into page protectors, each package having its individual participant number located top right corner of the privacy act statement. Table C-4 is the second page in the package, which provides a list of acronyms referenced in the questionnaires and their respective meaning. Table C-5, page three of the package, provides terminology referenced in the questionnaires and their respective definitions.

Informed Consent

PRIVACY ACT STATEMENT

1. Authority. 5 U.S.C. 301

2. Purpose. Information will be collected for a Modeling and Simulation thesis titled ***Using Decision-making Techniques in Support of Simulation Training Transfer Selections***. The purpose of this thesis is to gather data on military training for evaluation of a multi-criteria decision-making model in order to determination its efficacy for military training simulation selection(s).

3. Routine Uses. The data collected will be used for model analyses and thesis work conducted for a Master's of Science in Modeling and Simulation at Old Dominion University. Additional use of the information may be granted to non-Government agencies or individuals by the Navy Surgeon General following the provisions of the Freedom of Information Act or contracts and agreements. I voluntarily agree to its disclosure to the agencies or individuals identified above, and I have been informed that failure to agree to this disclosure may make the research less useful.

4. Voluntary Disclosure. Provision of information is voluntary. Failure to provide the requested information may result in failure to be accepted as a research volunteer in an experiment or removal from the program.

Table C-1: Experimental Informational Materials Package: Acronyms.

Name	*Definition*
A	
AAR	After Action Review
AHP	Analytic Hierarchy Process
F	
F	Female
H	
HW	Hardware
I	
ID	Identification
IRB	Institutional Review Board
J	
JFCOM	Joint Forces Command
M	
M	Male
MAUT	Multiple Attribute Utility Theory
M&S	Modeling and Simulation
N	
N/A	Non-applicable
O	
ODU	Old Dominion University
P	
POC	Point of Contact
S	
SW	Software

Table C-2: Experimental Informational Materials Package: Definitions.

Term	*Definition*
C	
Classroom education	"Provides valuable declarative knowledge to warfighters" (Alexander, Brunye, Sidman, & Weil, 2005, 1)
Computer-based	"Computer-based training systems, sometimes referred to as "lightweight simulations," are web or PC-based systems designed to provide individual instruction on specific mission skills (Ibid, 1).
F	
Fidelity	It is the level of detail. "Simulation fidelity is an umbrella term defined as the extent to which the simulation replicates the actual environment" (Vincenzi, Wise, Mouloua, & Hancock, 2009, 62).
I	
Immersion	Defined as the trainee's perception that s/he was included and interacting within an environment unlike their current physical one.
L	
Live Training	"Practice applying the complex skills [warfighters] study, and practicing them to proficiency" (Alexander, et al., 2005, 1).
N	
Negative Transfer	"Negative transfer occurs when existing knowledge and skills (from previous experiences) impedes proper performance in a different task or environment" (Vincenzi, Wise, Mouloua, & Hancock, 2009, 50).
O	
Operator buy-in	Operator buy-in is the user acceptance, i.e. "buy-in refers to the degree to which a person recognizes that an experience or event is useful for training" (Alexander, et al., 2005, 8).
P	
Positive Transfer	Positive transfer occurs when an individual "correctly applies knowledge, skills, and abilities learned in one environment (e.g. in simulation) to a different setting" (Vincenzi, et al., 2009, 50).
Presence	In the trainee's opinion, s/he believes that they were provided the experience of being involved within an environment other than the one that they were physically trained. "Both involvement and immersion are necessary for experience presence" (Witmer & Singer, 1998, 225).
S	
Simulation	"The imitation of the operation of a real-world process or system over time" (Banks, 1998, 3).
Simulators	"Systems that emulate visual stimuli and physical controls from the operational environment" (Alexander, et al., 2005, 1).

APPENDIX D: IRB DOCUMENTATION

Proposal Number:__________
(To Be Assigned by the College Committee or IRB)

APPENDIX B
OLD DOMINION UNIVERSITY
APPLICATION FOR EXEMPT RESEARCH

Note: For research projects regulated by or supported by the Federal Government, submit 10 copies of this application to the Institutional Review Board. Otherwise, submit to your college human subjects committee.

[redacted]

First Name: Patrick	Middle Initial: Thomas	Last Name: Hester
Telephone: 757-683-5205	Fax Number: 683-4912	E-mail: pthester@odu.edu
Office Address: Room 242C, Kaufman Hall		
City: Norfolk	State: VA	Zip: 23529
Department: Department of Engineering Management and Systems Engineering	College: BCET	
Complete Title of Research Project: Using Decision-making Techniques in Support of Simulation Training Transfer Selections		Code Name (One word):

[redacted]

First Name: Jane	Middle Initial: T.	Last Name: Bachman
Telephone: 540.653.7570	Fax Number: 540.653.3607	Email: jbach005@odu.edu Jane.bachman@navy.mil
Office Address: 18444 Frontage Road		
City: Dahlgren	State: VA	Zip: 22448
Affiliation: _Faculty _X Graduate Student __Undergraduate Student _Staff _Other ______		
First Name:	Middle Initial:	Last Name:
Telephone:	Fax Number:	Email:
Office Address:		
City:	State:	Zip:
Affiliation: _Faculty _Graduate Student __Undergraduate Student _Staff _Other ______		
List additional investigators on attachment and check here: _		

[redacted]

Proposal Number:___________
(To Be Assigned by the College Committee or IRB)

1. This study is being conducted as part of (check all that apply):

_ Faculty Research
_ Doctoral Dissertation
X Masters Thesis
_ Non-Thesis Graduate Student Research
_ Honors or Individual Problems Project
_ Other_______________

2. Is this research project externally funded or contracted for by an agency or institution which is independent of the university? Remember, if the project receives ANY federal support, then the project CANNOT be reviewed by a College Committee and MUST be reviewed by the University's Institutional Review Board (IRB).

__Yes (If yes, indicate the granting or contracting agency and provide identifying information.)
_X_No

Agency Name:
Mailing Address:
Point of Contact:
Telephone:

3a. Date you wish to start research (MM/DD/YY) _Date of IRB Approval__
3b. Date you wish to end research (MM/DD/YY) _04_/_01_/_12_

4. Has this project been reviewed by any other committee (university, governmental, private sector) for the protection of human research participants?
__Yes
_X_No

4a. If yes, is ODU conducting the primary review?
_Yes
_No (If no go to 4b)

4b. Who is conducting the primary review?
Jane T. Bachman, ODU student working on a thesis for a master of science degree in Modeling and Simulation.

Proposal Number:__________
(To Be Assigned by the College Committee or IRB)

5. Attach a description of the following items:

_X_ Description of the Proposed Study
__Research Protocol
__References
_X_ Any Letters, Flyers, Questionnaires, etc. which will be distributed to the study subjects or other study participants
__If the research is part of a research proposal submitted for federal, state or external funding, submit a copy of the FULL proposal

Note: The description should be in sufficient detail to allow the Human Subjects Review Committee to determine if the study can be classified as EXEMPT under Federal Regulations 45CFR46.101(b).

6. Identify which of the 6 federal exemption categories below applies to your research proposal and explain why the proposed research meets the category. Federal law 45 CFR 46.101(b) identifies the following EXEMPT categories. Check all that apply and provide comments.

SPECIAL NOTE: The exemptions at 45 CFR 46.101(b) do not apply to research involving prisoners, fetuses, pregnant women, or human in vitro fertilization. The exemption at 45 CFR 46.101(b)(2), for research involving survey or interview procedures or observation of public behavior, does not apply to research with children, except for research involving observations of public behavior when the investigator(s) do not participate in the activities being observed.

___(6.1) Research conducted in established or commonly accepted educational settings, involving normal educational practices, such as (i) research on regular and special education instructional strategies, or (ii) research on the effectiveness of or the comparison among instructional techniques, curricula, or classroom management methods.
Comments:

_X_(6.2) Research involving the use of educational tests (cognitive, diagnostic, aptitude, achievement), survey procedures, interview procedures or observation of public behavior, unless: (i) information obtained is recorded in such a manner that human subjects can be identified, directly or through identifiers linked to the subjects; AND (ii) any disclosure of the human subjects' responses outside the research could reasonably place the subjects at risk of criminal or civil liability or be damaging to the subjects' financial standing, employability, or reputation.
Comments:

The main purposes/objectives of the planned trainer and trainee questionnaires is to collect data in order to utilize a multi-criteria decision-making model to evaluate the data collected from the test experiment in order to determine if the model has the efficacy for military training simulation selection. The research is not to evaluate the instructor, students or the instruction.

Proposal Number:__________
(To Be Assigned by the College Committee or IRB)

___(6.3) Research involving the use of educational tests (cognitive, diagnostic, aptitude, achievement), survey procedures, interview procedures, or observation of public behavior that is not exempt under paragraph (b)(2) of this section, if:
(i) The human subjects are elected or appointed public officials or candidates for public office; or (ii) federal statute(s) require(s) without exception that the confidentiality of the personally identifiable information will be maintained throughout the research and thereafter.
Comments:

___(6.4) Research, involving the collection or study of existing data, documents, records, pathological specimens, or diagnostic specimens, if these sources are publicly available or if the information is recorded by the investigator in such a manner that subjects cannot be identified, directly or through identifiers linked to the subjects.
Comments:

___ (6.5) Does not apply to the university setting; do not use it

___(6.6) Taste and food quality evaluation and consumer acceptance studies, (i) if wholesome foods without additives are consumed or (ii) if a food is consumed that contains a food ingredient at or below the level and for a use found to be safe, or agricultural chemical or environmental contaminant at or below the level found to be safe, by the Food and Drug Administration or approved by the Environmental Protection Agency or the Food Safety and Inspection Service of the U.S. Department of Agriculture.
Comments:

PLEASE NOTE:

1. You may begin research when the College Committee or Institutional Review Board gives notice of its approval.
2. You MUST inform the College Committee or Institutional Review Board of ANY changes in method or procedure that may conceivably alter the exempt status of the project.

Responsible Project Investigator Patrick T. Hester **Date 9/13/2011**

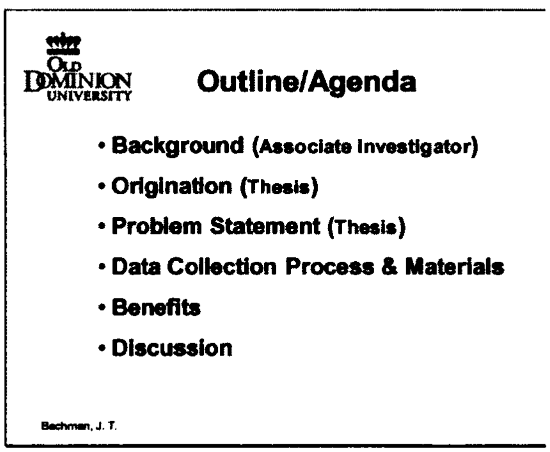
APPENDIX E: DATA COLLECTION BRIEF

The data collection brief was used for discussion of thesis purpose and the data collection efforts and procedures when seeking data collection sites. The informational slides are illustrated below.

Slide 1

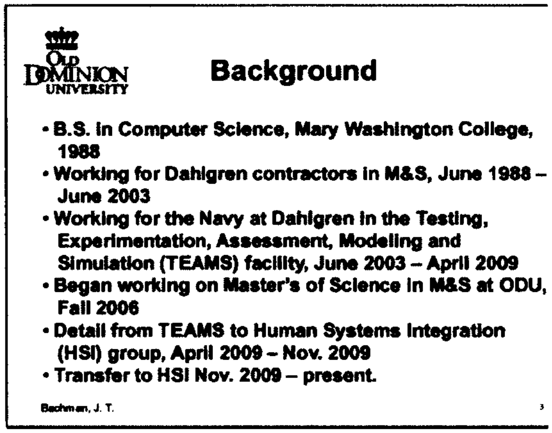
Jane T. Bachman
540.653.7570 (work)
jane.bachman@navy.mil
jbach006@odu.edu

Slide 2



This brief is used to provide information when seeking data collection opportunities for
Thesis work titled: "*Using Decision-making Techniques in Support of Simulation Training Transfer Selections*"

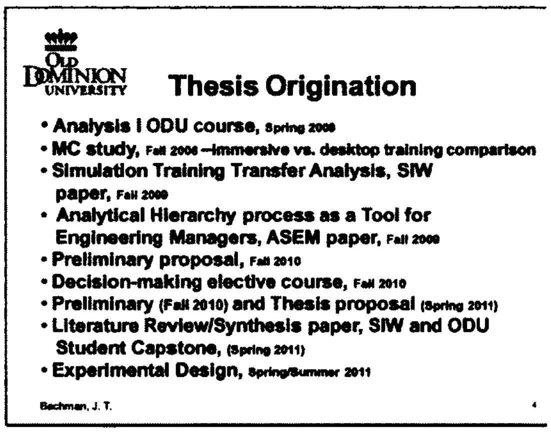
Slide 3



Old Dominion University (ODU)

Background on Associate Investigator, Jane T. Bachman

Slide 4

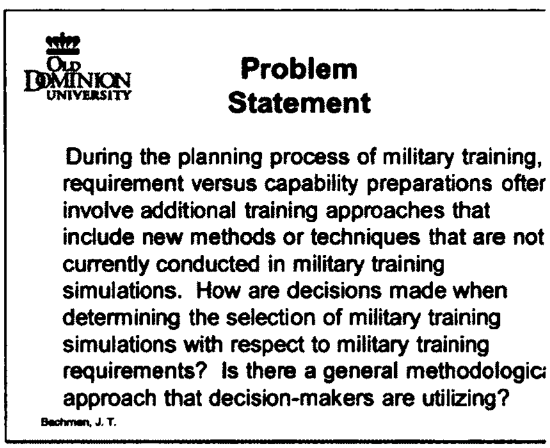


Marine Corps (MC)

Annual Society of Engineering Managers (ASEM)

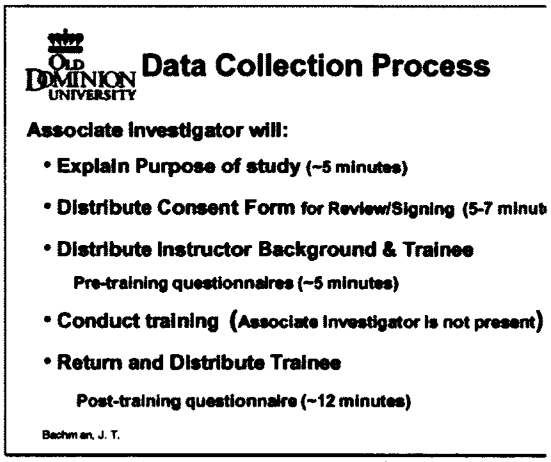
Simulation Interoperability Workshop (SIW)

Slide 5



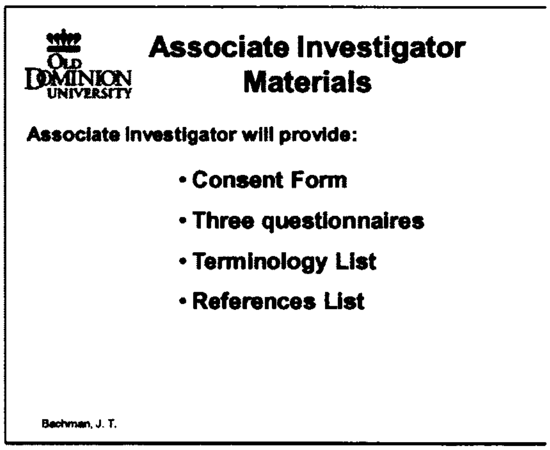
Bachman's thesis problem statement

Slide 6



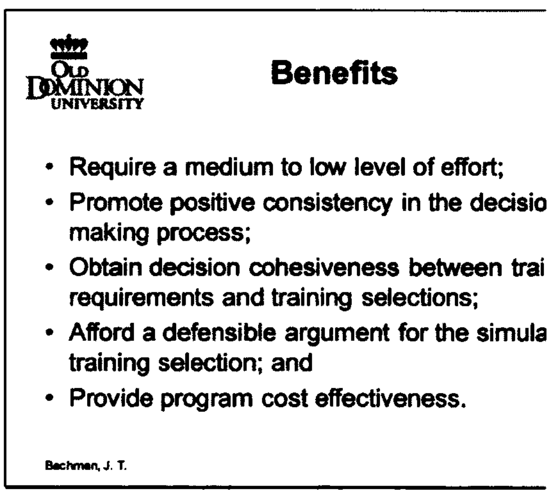
Steps taken in collecting the data for thesis work.

Slide 7



Materials provided by the associate investigator.

Slide 8



These are the benefits of having a general methodological approach for decision-makers to correlate military training requirements with either existing or proposed training simulators.

Slide 9

Discussion

Questions/Comments

Bachman, J. T.

APPENDIX F: THESIS TTAMs

Tools, Techniques, Approaches and Methods[3] (TTAMs) used in this thesis are identified and briefly described in the following table.

Table F-1: Thesis TTAMs.

Type	Description
Approach	To determine if multi-criteria decision-making AHP model under evaluation will have the power to accomplish a military training simulation selection.
Method	AHP model used to execute the data collection from the experimental design.
Method	Consistency check provided by the AHP model to be used in measuring the degree of consistency among the pair-wise comparisons provided by the decision maker.
Method	Journal to capture notes and observations during data collection.
Technique	Linear transformation equation used to convert a five-point scale to a nine-point scale.
Technique	Experimental Informational Materials Package used to provide quick distribution and easy access for participant's completing questionnaires.
Tool	Literature Review Tracking tool used for maintaining and tracing literature reviewed for the thesis.
Tool	Data Collection Tool (DCT) used to analyze the data collected from the experimental design.
Tool	MS PowerPoint used to generate a brief used to solicit data collection sites and defend thesis.

[3] TTAMs coined by Dr. Nita Lewis Shattuck, NPS, Operations Research Department.

Type	Description
Tool	MS Excel used to create the Literature Review, DCT and AHP model.
Tool	MS Word used to generate the thesis document.

APPENDIX G: ACRONYMS

Acronyms and their meaning used in this thesis are identified and briefly described in Table G-8.

Table G-1: Thesis Acronyms.

Acronym	Meaning
2D	Two Dimensional
3-D	Three Dimensional
AA3	America's Army 3
AAR	After Action Review
AHP	Analytic Hierarchy Process
ASD	Action Sequence Diagram
CAVE	Cave Automatic Virtual Environment
CBT	Computer-based Training
CTEF	Cumulative Transfer Effectiveness Function
DA	Disjunctive Approach
DARPA	Defense Advanced Research Projects Agency
DARWARS	DARPA WARfighting trainer
DCGS-MC	Distributed Combat Ground Station/Systems of the Marine Corps
DCT	Data Collection Tool
DoD	Department of Defense
DoDD	DoD Directive
DVTE	Deployable Virtual Training Environment

Acronym	Meaning
EQUIP	Equipment Quantifying Usage Impact Process
GB	Gigabyte
GHz	Gigahertz
GUI	Graphical User Interface
F	Female
HMD	Helmet-mounted or Head-mounted Display
HTA	Hierarchical Task Analysis
HW	Hardware
HSI	Human Systems Integration
ID	Identification
IRB	Institutional Review Board
IEEE	Institute of Electrical and Electronics Engineers
I/ITSEC	Interservice/Industry Training, Simulation and Education Conference
JCTC	Joint Combined Training Centre
JNTC	Joint National Training Center
K-20	Kindergarten through Scholar Programs
LCD	Liquid Crystal Display
LVC	Live Virtual Constructive
M	Male
M&S	Modeling and Simulation
MAUT	Multi-Attribute Utility Theory
MC	Marine Corps

Acronym	Meaning
MCSC	Marine Corps Systems Command
MOS	Military Occupation Specialty
MR	Mixed Reality
MS	Microsoft
NDEP	National Defense Education Program
NDIA	National Defense Industry Association
NPS	Naval Post-graduate School
NSWCDD	Naval Surface Warfare Center Dahlgren Division
ODU	Old Dominion University
PC	Personal Computer
PEO STRI	Program Executive Office for Simulation, Training and Instrumentation
PM-MERS	Marine Expeditionary Rifle Squad Program Office
POC	Point of Contact
R-MTS	Robotic Moving Target System
PM TRASYS	PM Training Systems
RPI	Responsible Project Investigator
SE	Synthetic Environment
SISO	Simulation Interoperability Standards Organization
SME	Subject Matter Expert
STEM	Science, Technology, Engineering, and Mathematics
SW	Software
TTAMs	Tools, Techniques, Approaches and Methods

Acronym	Meaning
TCM Gaming	TRADOC Capability Manager for Gaming
TRADOC	Training and Doctrine Command
TSIT	Training Simulation Interface Transfer
TSJ	Training Simulation Journal
UAV	Unmanned Aerial Vehicles
UDOFT	Universal Digital Operational Flight Trainer
USMC	United States Marine Corps
U.S.	United States
USAF	United States Air Force
VBS2	Virtual Battlespace 2
VDP	Virginia Demonstration Project
VR	Virtual Reality

VITA

Jane Taylor Bachman

Old Dominion University
1200 E.V. Williams Engineering and Computational Sciences Building
Norfolk, VA 23529

B.S. Computer Science, Mary Washington College, May 1988.

Mrs. Bachman is Lead Scientist performing simulation and software engineering for the Human Systems Integration (HSI) group at the Naval Surface Warfare Center Dahlgren Division (NSWCDD), Dahlgren, VA. She has 24 years of experience in modeling and simulation (M&S), consisting of simulation software development and application, 3-D Visualization, graphical user interface (GUI) tool development, and composability. Currently, Mrs. Bachman is Lead HSI Engineer on the Distributed Common Ground/Surface System - Marine Corps (DCGS-MC) program, group lead for the National Defense Education Program (NDEP) Virginia Demonstration Project (VDP) Science, Technology, Engineering, and Mathematics (STEM), serving as Virginia Module Coordinator, NDEP VDP STEM Dahlgren Summer Academy Director and Dahlgren Site Coordinator for NDEP FIRST grants. In addition, she provides a hybrid support of M&S and HSI on Aggregate Techniques, Tactics and Procedures (TTPs) and on a Systems Engineering, Interoperability, Architectures & Technology (SIAT) projects. She is a member of IEEE, National Defense Industry Association (NDIA), Simulation Interoperability Standards Organization (SISO), an elected member of SISO's Executive committee serving as secretary, and an inductee of the Golden Key International Honour Society.

Publications:

1) Bachman, J.T. & Hester, P.T. (2012). Experimental Design in Support of Simulation training Transfer Selection. *Proceedings of the Spring 2012 Simulation Interoperability Workshop Conference*, Orlando, FL, March 26-30.
2) Bachman, J.T. (2011). Using Decision-making Techniques in Support of Simulation Training Transfer. *Proceedings of the Spring 2011 Simulation Interoperability Workshop Conference*, Boston, MA, April 04-08.
3) Bachman, J. and Hester, P.T. (2011). Using Decision-making techniques in support of simulation training transfer. *Proceedings of the 2011 Modeling, Simulation, & Gaming Student Capstone Conference*, Suffolk, VA, April 14.
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