The Effect Of Immediate Feedback And After Action Reviews (AARS) On Learning, Retention And Transfer

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THE EFFECT OF IMMEDIATE FEEDBACK
AND AFTER-ACTION REVIEWS (AARS)
ON LEARNING, RETENTION AND TRANSFER

by

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ABSTRACT

An After Action Review (AAR) is the Army training system's performance feedback mechanism. The purpose of the AAR is to improve team (unit) and individual performance in order to increase organizational readiness. While a large body of knowledge exists that discusses instructional strategies, feedback and training systems, neither the AAR process nor the AAR systems have been examined in terms of learning effectiveness and efficiency for embedded trainers as part of a holistic training system. In this thesis, different feedback methods for embedded training are evaluated based on the timing and type of feedback used during and after training exercises. Those feedback methodologies include: providing Immediate Directive Feedback (IDF) only, the IDF Only feedback condition group; using Immediate Direct Feedback and delayed feedback with open ended prompts to elicit self-elaboration during the AAR, the IDF with AAR feedback condition group; and delaying feedback using opened ended prompts without any IDF, the AAR Only feedback condition group. The results of the experiment support the hypothesis that feedback timing and type do effect skill acquisition, retention and transfer in different ways. Immediate directive feedback has a significant effect in reducing the number of errors committed while acquiring new procedural skills during training. Delayed feedback, in the form of an AAR, has a significant effect on the acquisition, retention and transfer of higher order conceptual knowledge as well as procedural knowledge about a task. The combination of Immediate Directive Feedback with an After Action Review demonstrated the greatest degree of transfer on a transfer task.

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LIST OF ACRONYMS/ABBREVIATIONS

AAR After Action Review

C2 Command and Control

C2V Command and Control Vehicle

C4ISR Command, Control, Communications, Computers, Intelligence, Surveillance and Reconnaissance

CBT Computer Based Training

CGE Computer Generated Environment

CGF Computer Generated Force

DA Department of the Army

ET Embedded Training

FCS Future Combat System

FSM Finite State Machine

GCM Graphic Control Measure

GIG Global Information Grid

GOMS Goal-Operator-Method-Selection rule

IDF Immediate Directive Feedback

ILE Interactive Learning Environment

IMI Interactive Multimedia Instruction

ISR Intelligence, Surveillance and Reconnaissance

ITS Intelligent Tutoring System

I/O Instructor/Operator

ISR Intelligence, Surveillance and Reconnaissance

LVC Live, Virtual, and Constructive

NCO Non-Commissioned Officer

NRFTT Networked, Reconfigurable, Full Task Trainers

O/C Observer/Controller

OCU Operator Control Unit

OneSAF One Semi-Automated Forces

OTB OneSAF Testbed Baseline

SAF Semi-Automated Forces

STE Synthetic Training Environment

TRADOC Training and Doctrine Command

TTPs Tactics, Techniques, and Procedures

UA Unit of Action

UAV Unmanned Aerial Vehicle

UGV Unmanned Ground Vehicle

CHAPTER ONE: INTRODUCTION

“A balance of training and education is required to prepare Soldiers to perform their duties. Training prepares Soldiers and leaders to operate in relatively certain conditions, focusing on "what to think." Education prepares Soldiers and leaders to operate in uncertain conditions, focusing more on ‘how to think.’"

United States Army Posture Statement, 2005

The U.S. Army is changing into a new force called the Future Force. At the core of this new organization is the Future Combat System (FCS). FCS is composed of 24 major systems and organized around a brigade sized Unit of Action (UA). These 24 systems involve an array of manned and unmanned air and ground vehicles linked together through a wireless communication system called the Global Information Grid (GIG). The GIG will enable unprecedented situational awareness to military leaders through digital information technology (IT) systems. FCS will combine two separate operations, Command and Control (C2) and Intelligence, Surveillance and Reconnaissance (ISR), into a single process. The Army calls this unified process of gathering information, exchanging it, making decisions and sustaining the GIG the Command, Control, Communication, Computers, Intelligence, Surveillance and Reconnaissance (C4ISR) architecture (TRADOC, 2003a). A critical component for the success of the Future Force is training the C4ISR Robotics Non-Commissioned Officer (NCO) on the FCS equipped Command and Control Vehicle (C2V).

The training strategy for this Future Force calls for embedding training on a number of operational platforms. Embedded Training (ET) is defined as a training function that is hosted in hardware and/or software and integrated into the overall configuration of a piece of equipment. Currently, ET requirements will train the individual operators, crews and leaders from the lowest (Operational) to the highest (Organizational) levels on operational platforms instead of in simulators or simulation centers. ET will require the capability to support training across the Live, Virtual and Constructive (LVC) environments. The combining of any two of the three environments together for training is called the Synthetic Training Environment (STE). Training and educating soldiers and leader "How to Think" and not just "What to Think" is a critical component of the success of the Future Force's ET strategy (TRADOC, 2003b).

1.1 Future Force Training Requirements

Embedded Training will enable the following capabilities: individual and collective training; weapon & weapon effects simulation; sensor effects; target presentation and control; data collection, management, and analysis; and exercise control. Embedding these various capabilities into an operational weapon system turns the weapon system into a delivery method for Computer-Based Training (CBT) to enhance training and operations in the STE. Intelligent software will be required to monitor a trainee's actions in a simulated scenario, evaluate those actions against Tactics, Techniques, and Procedures (TTPs), and provide real-time, dynamic, one-on-one feedback to soldiers. An Intelligent Tutoring System (ITS) provides a method to accomplish this automatically.

Individual training is the training that all soldiers and leaders receive in institutions or at units, and includes both on the job training and self study. Individuals, both soldiers (operators) and leaders, in all training domains need to acquire skills, knowledge and attributes to perform tasks on digital systems that support specific operational requirements. Leaders must have the same skills as an operator, plus the understanding of how the system is integrated into the C4ISR network. Leaders supervise other operators and collect, synthesize and integrate information. Individual skill training will focus on both initial training and sustainment training and use Interactive Multimedia Instruction (IMI), CBT, and ITS technology.

Collective training is the training of soldiers arranged into hierarchical groups, called units, to perform assigned operational missions. Unit, or collective, training consists of performance oriented individual and collective training, with leader participation. Collective training tasks will also use CBT in the STE, allowing for drill and practice exercises, instructional games, and problem solving exercises.

The Army outlines its training philosophy in two references: Field Manual 25-100, Training the Force (FM 25-100) and Field Manual 25-101, Battle Focused Training (FM 25-101). FM 25-100 establishes the US Army's overarching training doctrine within the organization. It is centered on nine principles and these principles act as the framework for constructing all individual through collective training (DA, 1988). FM 25-101 provides a "how to" guide for leaders responsible for training and subdivides training into individual, crew and collective training tasks. Collective tasks are often linked to other collective tasks and it is the execution of individual tasks, drills and collective tasks which define a mission. Performance feedback and training outcomes are defined in these terms of individual tasks, drills and collective tasks (DA, 1990). Scenario based training provides a method for training individual tasks, drills and collective tasks simultaneously.

1.2 Intelligent Tutoring Systems

An Intelligent Tutoring System uses artificially intelligent software that seeks to replace or augment an instructor and provide a tailored, one-on-one tutoring experience for the student. Some ITSes use high-fidelity simulations to achieve training objectives without a human instructor present, by automating the process of monitoring student actions and providing feedback, either in real-time or in an After Action Review (AAR).

The major components of an ITS include: a cognitive model, an ideal student model or expert model, a student model, an overlay diagnosis or model tracing capability, and a database of curriculum, training scenarios and instructional strategies. The expert model is the method used by an expert to achieve a goal. The student model is the method that the student or trainee is currently using to achieve the goal. In model tracing, the ITS overlays the expert model on the student model to identify deviation from the norm (Williams, 2004).

In a scenario based ITS system, the model tracing component serves as the basis for the automated evaluation of student actions during a scenario exercise. The ideal student model would consist of the knowledge and skills required to successfully perform required tasks within each training scenario and are based on the Tactics, Techniques and Procedures (TTPs) identified for the trainee position. These models in some cases are based upon a Goals, Operators, Methods, and Selection Rules (GOMS) task analysis. Developed in 1983 by Card, Moran and Newell for constructing mental models of human computer interaction, it has been extended to develop production rules for cognitive task models executed by a production system as in Soar or ACT-R models. GOMS consists of four parts: (1) the Goal to be achieved, (2) the Operators or actions applied to achieve the goal, (3) the Method or sequencing of these operators, and (4) Selection Rules for applying a method if more than one method exists to accomplish a goal. Model tracing enables an ITS to determine when students incorrectly select or apply GOMS and serves as the basis for feedback.

The Army generally uses two types of feedback during training: immediate and delayed. Immediate feedback is often used when training novice operators and crews and involves the detection of errors coupled with directive feedback. Directive feedback provides fault correction feedback and requires trainees to correct their errors before continuance of the training procedure or task. Delayed feedback (AARs) are used when training crews and evaluating performance oriented training. Some authors argue that the timing of feedback effects learning and retention of knowledge. Dihoff, Brovisic, Epstein, & Cook (2004) and Kulik & Kulik (1988) found that learning and retention is enhanced by immediate feedback. Others, Clariana, Wagner, & Roher Murphy (2004) and Kulhavy and Anderson (1972) argue that learning and retention is best facilitated by delayed feedback. Still others argue that type of feedback, fault correcting directive feedback or elaborative feedback, promote better learning and retention. Moreno (2004) found that elaborative feedback promoted deeper understanding than corrective feedback alone. Anderson, Corbett, Koedinger & Pelletier (1995) found that directive feedback enhanced performance. The body of knowledge is diverse and often has conflicting findings depending upon the type of knowledge to be acquired, either procedural or conceptual/declarative. One method for implementing ET on operational platforms is to develop an ITS capable of training tasks for individual operators and evaluating how these individuals are performing as members of a crew executing collective tasks. A critical component of an ITS system is the type of feedback provided to the trainees during a variety of training sessions.

1.3 Research Question

It is in this context that the following research question emerges: *Does the timing of feedback and the type of feedback used in a training session effect the acquisition, retention and transfer of procedural knowledge and conceptual knowledge in a similar way?*

1.4 Research Purpose

The purpose of this research is to evaluate the types of feedback provided to a trainee from a tutor to determine if an optimal feedback strategy exists to facilitate the acquisition, retention and transfer of both procedural skills and conceptual knowledge. This knowledge can then be used in the development of an ITS system to support ET for the Future Force.

CHAPTER TWO: BACKGROUND LITERATURE

There are many factors which influence knowledge acquisition and retention. These factors include: feedback, reinforcement, drive reduction, repetition, juxtaposition of cues, degree of original learning, existing prior knowledge, interference and delay between learning trials, to mention a few (Anderson, 1993, 1995; Anderson and Lebiere, 1998; Ausubel, 1968, 2000; Tulving, 1983). Of all these factors, the two factors of concern for this study are feedback and prior knowledge. Although there is wide spread acknowledgement that learning is facilitated by feedback, there is little agreement as to whether the timing or type of feedback has the most impact on knowledge acquisition, retention and transfer (Anderson, Kulhavy & Andre, 1972; Clariana, Wagner, & Murphy, 2000; Dihoff, Brovisic, Epstein & Cook, 2004; Kulik & Kulik, 1988; Mathan & Koedinger, 2003; Moreno, 2004; Robin, 1978).

2.1 The Role of Feedback in Training

The Army has a rich tradition of conducting After Action Reviews (AARs). It started with S.L.A. Marshall's "after-action interview" during the Second World War and Vietnam as a method to gain the ground truth of a combat event for the historical record (Hackworth, 1967). AARs were researched extensively in the 1970s and 1980s by the Army Research Institute (Scott, 1984), and codified in the 1990s as an integral part of training with the publication of Training Circular (TC) 25-20, *A Leader's Guide to After-Action Reviews* (DA, 1993).

AARs are a method of providing feedback after individual and collective training by involving individuals in the training diagnostic process to increase and reinforce learning. AARs are facilitated by Instructor/Operators (IOs), for individual and crew training, and Observer/Controllers (OCs) for collective training (TRADOC, 2003b). The purpose of the AAR leader is to guide, or tutor, participants in identifying deficiencies and to develop solutions to correct these deficiencies. In theory, the AAR is arranged to answer three top level questions: What happened; Why it happened; and How to fix it. AAR leaders are to use open-ended prompts to promote discussion and lead participants through a problem-solving process so as to allow participants to discover for themselves the answers to these three questions (DA, 1990).

2.2 Elaboration as Feedback

Elaboration is the process of improving learning through the use of examples. Self-explanation is an elaboration technique often used in student-centered or tutor-student interactions. The elaboration technique of self-explanation focuses on the student's ability to generate explanations to oneself to clarify the worked out solution to a provided example. According to Graesser, Person and Magliano (1995), tutoring is a five step process that begins with a tutor prompting a student with a question, the student providing an answer, analyzing the answer for correctness with the tutor providing feedback, the tutor elaborating on the answer through a series of exchanges with the student, and finally, the tutor gauging the student's understanding of the principle or concept learned. In an AAR, the "What happened"; "Why it happened"; and "How to fix it" questions act as prompts to the trainee. The process of feedback and elaboration during the third and fourth steps of tutoring process as outlined by Graesser et al. (1995) help answer the what, why and how questions that make up the AAR.

VanLehn, Siler, Murray, Yamaguchi & Baggett (2003) conducted a study on the effects of human tutoring and learning on college students' ability to solve physics problems involving algebra and trigonometry. These students were neither novices, possessing no problem solving skills, nor advanced students simply improving previously acquired skills. VanLehn, et al. (2003) used a coached problem-solving approach which involves interaction between the tutor and the student while the student attempted to solve a problem. The results of this study found that impasses were strongly associated with learning, and that tutoring was more effective during these times of impasse. An impasse is defined as students getting stuck answering a problem, detecting an error, or by conducting an action correctly but expressing uncertainty about it. During an AAR, an impasse would most likely occur during the "Why it happened" and "How to fix it" questions. In the VanLehn et al. (2003) study, tutors always provided error detection feedback to the students and then provided explanatory feedback. VanLehn et al. (2003) propose that the best type of tutorial behavior is that which gets student to think, either because of student generated impasses, or open ended prompts.

Other studies have found that the elaboration process adds to learning through the depth of processing of information and the distinctiveness of information. Anderson and Reder (1979) assume that memory is a network of interconnected propositions and that through elaboration, new information is interconnected with existing assumptions, thus aiding in its recall by adding additional retrieval routes. They also note that it is the person's ability to generate and interpret elaborations with regard to their own experiences which is important. Hamilton (2004) suggests that elaboration activities which focus on distinctiveness, by focusing of internal differences in conceptual information, will produce stronger memories of conceptual information, thus effecting retention.

Studies have also been conducted on the effects of self-explanation in an Interactive Learning Environment (ILEs). In a study of self-explanation using natural language dialogue versus menu selection explanations using a geometry cognitive tutor, Aleven, Koedinger and Popesu (2003) found that students who used natural language dialog in self-explanation acquired better problem-solving skills than those who chose explanations from a menu. Conati and VanLehn (2000) explored a framework to provide computer support for self-explanation within Andes, a tutoring system for Newtonian physics that supports students during both examples studying and problem-solving. This framework explicitly coached the domain-general, meta-cognitive skill of self-elaboration during example studying. Rather than simply providing explanations, the tutor asks for self-explanation, and students are provided with immediate feedback on the correctness of their self-explanations. Although the results were not statistically significant, the self-explanation group performed better than the explanation only group on problem-solving tasks. These studies show that self-explanation within an ITS is a viable method to answer the "Why it happened" and "How to fix it" questions during tutoring.

2.3 Feedback Type: Directive versus Explanatory

The study of human tutoring is usually tutor-focused and generally involves the study of what tutors say and when they say it. In the third step of Graesser et al.'s (1995) tutoring model, student's answers are analyzed for correctness with the tutor providing feedback. Feedback type, directive or explanatory, occur during the error detection and correction phases of either human or machine tutoring. Directive feedback identifies student's errors and highlights the corrective action to be taken to achieve the appropriate response. Explanatory feedback provides a conceptual explanation as to why the appropriate response should be made. Directive feedback is almost always immediate, while explanatory feedback maybe immediate, delayed or a combination of immediate and delayed. A math tutor, giving a student the problem 2 x 3 = ? and receiving the answer, 16, using directive feedback would say something like "Incorrect; 2 x 3 = 6, 6 + 5 = 11". A tutor using explanatory feedback would say something like "Incorrect; you added 3 to 5 before multiplying by 2. The correct procedure is to multiply 2 x 3 first and then add 5. 2 x 3 = 6, 6 + 5 = 11". Studies on the effectiveness of directive or explanatory feedback are mixed, but there appears to be a correlation between the type of feedback and skill acquired, with directive feedback supporting procedural skill acquisition (Fredenburg, Lee, & Solomon, 2001) and explanatory feedback supporting conceptual knowledge acquisition (Moreno, 2004).

John R. Anderson developed his ACT-R theory based, in part, on his work in the 1980s involving the LISP tutor. The LISP tutor, a cognitive machine tutor used in learning computer programming, provided immediate feedback upon error detection, while allowing the student the opportunity to self-correct. With the LISP tutor, students either asked for an explanation of the error, or attempted to correct the error themselves. If unsuccessful, the LISP tutor provided directive feedback in the form of the correct next step, along with an explanation. Reflecting on the lessons learned in over 10 years of use with the LISP tutor, Anderson, Corbett, Koedinger & Pelletier (1995) found that the performance of students who received immediate, directive feedback was superior on post-test scores than when they did not receive feedback. Moreover, when the feedback was given immediately after an error, it reduced the amount of time students needed to reach a correct solution by half; however, it did not necessarily improve their post-test scores when compared to a delayed feedback group. In the delayed feedback group, the tutor did not provide feedback on errors unless it was demanded by the test subject and then the tutor provided the same feedback as the immediate feedback group.

Moreno (2004) conducted a study to determine the effects of explanatory feedback versus directive feedback in a guided discovery, software agent-based, multimedia, computer environment that taught students fundamental botany principles. Moreno compared the use of learning with explanatory feedback versus directive feedback. Explanatory feedback consisted of the software agent providing feedback on the correctness of the student's answer, verbal explanations of why the students' answer was or was not correct, and then the correct answer. Directive feedback consisted of the software agent providing feedback on the correctness of the student's answer and then the correct answer. It did not provide any explanation as to why the student's answer was or was not correct. Moreno found that explanatory feedback promoted better retention and transfer than the use of directive feedback alone. Groups presented with the software agent's spoken explanatory feedback performed better on the problem-solving transfer task, producing fewer errors than the directive feedback groups. The problem-solving transfer task and retention tests were administered immediately after the training sessions.

A study of one-to-one tutoring effectiveness, found that tutors who provided generic and content specific prompts to students were as effective at teaching as when tutors provided explanatory feedback to students. Chi, Siler, Jeong, Yamauchi & Hausmann (2001) conducted two studies and offered three hypotheses for the effectiveness of tutoring strategies; tutor-centered, student-centered, or a blended, interactive style. The tutor-centered strategy focused on when and how the tutor delivered explanations to the student. The student-centered strategy involved tutors prompting students to self-correct mistakes or requesting explanations for the student's answer. In the interactive strategy, the tutor used both explanations and prompts to elicit responses from the student, while the student communicated to the tutor in response to the tutor's statements and questions. Both studies involved reading a page from a biology text, defining 21 terms about the human circulatory system, drawing and explaining the blood-path, and answering 70 questions on a post-test. Study 1 involved explanatory feedback and Study 2 involved prompted feedback. Study 2's interactive tutoring strategy used open-ended and content-free prompts, such as "Could you explain or put this in your own words?" or "What do you think?" There was no control group in either study. Both studies were conducted in three sessions involving a pre-test session, a tutoring session, and a post-test retention session following a one week delay. All tutoring sessions were recorded and analyzed for content. The researchers found evidence to support all three hypotheses and that a significant amount of learning occurred as a result of both tutor's explanations and tutor's prompts. In an earlier, tutor focused study of student-tutor interaction; Chi (1996) found that tutors provided three types of feedback to students: corrective, explanatory, and suggestive. Suggestive feedback is used when a student's answer is incomplete rather than wrong, and begins an iterative process known as scaffolding. Scaffolding is the process where the tutor provides a structure for the student and tutor to jointly construct knowledge and remove misconceptions of new knowledge.

Mathan and Koedinger (2003) investigated the guidance hypothesis to explain the role that error detection and error correction skills play in feedback. The guidance hypothesis (Schmidt, Young, Swinnen & Shapiro, 1989) suggests that immediate feedback promotes those skills needed to select and implement operators to accomplish a specific task, or problem solving skill. Receiving immediate feedback, however, comes at the cost of developing evaluative skills, or those skills needed to evaluate the effect of applying operators. According to Schmidt et al. (1989), evaluative skills promote transfer and retention. Mathan and Koedinger looked at the differences between an expert tutor and an intelligent novice tutor in teaching spreadsheet problem-solving skills. The expert tutor used immediate, directive feedback. The intelligent novice tutor used delayed, explanatory feedback, focusing on error detection and correction. The intelligent novice tutor's delayed feedback gave students the opportunity to develop evaluative skills while exercising error detection and correction skills. They found that test subjects using the intelligent novice spreadsheet tutor performed better on problem solving, conceptual understanding, transfer and retention (after a eight day retention interval) than those using the directive feedback expert tutor.

In a study of skill acquisition, Fredenburg, Lee, & Solmon (2001) explored the role that feedback played in improving performance on a motor-skill task. Test subject had to use 12 cups to create 3 pyramids. Feedback conditions included: no feedback, motivational feedback, task knowledge feedback, and motivational and task knowledge feedback. Motivational feedback offered encouragement to the test subject, "I know you can do this". Task knowledge feedback included operator statements needed for task accomplishment. The study found that type of feedback had no effect on the performance of simple motor skill tasks, 3 x 6 x 3 cup stack, but students receiving task knowledge (directive) feedback performed better on challenging motor-skill tasks, 1 x 10 x 1 cup stack.

Explanatory feedback is an integral part of answering the "Why it happened" and "How to fix it" questions during tutoring. These studies suggest that directive feedback promotes procedural skill acquisition and that explanatory feedback plays a role in the acquisition, retention and transfer of conceptual knowledge; therefore, both types of feedback can contribute in the development of an FCS ITS system.

2.4 Feedback Timing: Immediate versus Delayed

The timing of feedback debate involves the effectiveness of delayed feedback versus immediate feedback. Kulik & Kulik (1988) conducted a meta-analysis of 53 separate feedback timing and human verbal learning studies and found the effect of feedback differed depending on the type of material to be learned. They found that immediate feedback was superior to delayed feedback when measuring applied studies in a classroom using multiple choice exams. In experiments on acquisition of test content, delayed feedback proved superior to immediate feedback in multiple choice exams. They also noted that immediate feedback was more effective in list-learning experiments, but the results of list-learning experiments were highly variable.

Research studies have shown that immediate feedback allows students to learn more efficiently because they reduce unproductive floundering (Buzhardt & Semb, 2002; Kulik & Kulik, 1988; Mathan & Koedinger, 2003). Buzhardt and Semb (2002) studied immediate item-by-item (IBI) feedback versus delayed, end-of-test (EOT) feedback on a multiple choice, true or false tests. The feedback condition, regardless of timing, included the question (stimulus), the student's answer (response) and the correct answer. No distinction was made in the feedback between errors and correct responses. This study found no significant differences between IBI or EOT feedback in the rate of learning or retention; however, IBI feedback was significantly more efficient than EOT feedback when the cumulative time that a human tutor spent assisting a student was the measure of effectiveness. Kulik & Kulik (1988) found that the timing of feedback is dependent, in part, on the type of instruction used, either in applied studies with classroom quizzes and programmed materials, acquisition of test content, or list learning exercises. Delayed feedback is superior to immediate feedback in stimulus-response tests, especially when measured by delayed retention, while they found mixed results for immediate feedback in list-learning tests.

Dihoff, et al. (2004) found that immediate, self-correcting feedback, rather than delayed feedback, resulted in the increased ability to: identify correct responses, identify incorrect responses, enhanced performance on multiple choice exams, and promoted increased retention of factual knowledge. Interestingly, immediate feedback exerted a greater influence when interacting with the process of identification and recognition of identically worded questions between practice exams and the final exam than when interacting with the process of discrimination and generalization between questions presented during practice exams and represented in a slightly re-worded format during the final exam. Immediate feedback also reduced the likelihood of repeating errors on subsequent tests.

Studies of immediate feedback have also found that the providing immediate feedback after errors affected learning. Guthrie (1971) conducted a study of verbal learning, which required students to read a passage and then identify words that were deleted from learned sentences. He found that immediate feedback in the form of detecting and identifying errors to the student facilitated learning following wrong responses, but providing immediate feedback had no effect following correct responses during the learning session. Pashler, Cepeda, Wixted & Roher (2005) also studied verbal learning and conducted an experiment which involved recalling 20 matched word combinations. They found that directive feedback, identifying an error and supplying a correct answer, after an incorrect response from the student not only improved performance during learning sessions, but also increased retention when compared to feedback provided to students after only correct responses.

Schmidt and Bjork (1992) conducted an analysis of verbal and motor skill experiments and found that while providing immediate feedback during motor skill testing decreased the error rate during skill acquisition, delayed feedback actually promoted the retention of motor skills, with delayed feedback test subjects performing motor skill tasks with less error on retention tests than immediate feedback test subjects. Schmidt and Bjork argue that the effectiveness of training real-world tasks is revealed, and should be measured by, post training performance, or task retention.

Clariana, et al. (2000) studied the effect of delayed feedback, single-try immediate feedback, or multi-try immediate feedback on a computer-based lesson involving reading passages and answering multiple-choice questions, involving both verbatim and inferential questions. Feedback was provided on both correct and incorrect answers, with directive feedback provided in the form of the correct answer, depending on the assigned feedback condition protocol. This study found that the retention of new knowledge, after a one day delay, was greatest for delayed feedback rather than immediate feedback; but regardless of type, feedback, as a method for correcting errors, had its greatest effect with difficult lessons versus lessons with easy or mid-range difficulty.

One explanation for the effectiveness of delayed feedback is the Interference Preservation Hypothesis (IPH, Kulhavy and Anderson, 1972). IPH argues that initial errors and the immediate feedback provided correct response interfere with one another and prevent the acquisition of the correct response. Delayed feedback allows the student memory of the incorrect response to decay, thus there is less interference between the error and the delayed feedback provided correct response. These studies suggest that immediate, directive feedback facilitate learning motor skills and procedures

The Army's Embedded Training strategy will require an increasing reliance on intelligent tutoring systems capable of replicating human experts in the training of Reconnaissance, Surveillance, Target Acquisition (RSTA) operators and C2V crews. It is hypothesized that both feedback timing and type do have an overall effect of skill acquisition, retention and transfer. Immediate corrective and directive feedback should have an effect in reducing the number of errors committed while acquiring new procedural skills during training as well as retention of these procedural skills. Delayed feedback, in the form of an AAR which includes opened-ended prompts to foster elaboration, should have an effect on the acquisition, retention and transfer of higher order conceptual knowledge about a task. The blending of feedback timing and type together should show a significant difference in the retention and transfer of procedural knowledge about a task. Understanding the role that feedback plays in teaching, learning and retention will help the US Army to develop Intelligent Tutoring Systems and Embedded Training for soldiers in the FCS equipped Future Force.

CHAPTER THREE: METHODOLOGY

This research applied a methodology for extracting an expert's mental model of how a combat mission, Conduct a Tactical Reconnaissance, with its supporting collective, crew and individual tasks, is conducted. This method included a GOMS task analysis to identify the knowledge required to successfully perform the required tasks which are based on the TTPs identified for the Robotics NCO position in a FCS Command and Control Vehicle (C2V). This knowledge was then used to develop an ideal student model and to provide feedback on task performance during a simulation exercise. Scenarios, evaluation methods, and feedback mechanisms were all derived from the GOMS task analysis (See Appendix B). Simulation exercises were then presented to determine whether the timing of feedback, immediate or delayed, or the type of feedback, directive feedback or open-ended prompts, had an effect on the acquisition, retention and transfer of knowledge in the training of a robotics operator in a FCS C2V simulator.

This experiment was conducted in support of the US Army RDECOM Embedded Combined Arms Team Training and Mission Rehearsal (ECATT-MR) Science and Technology Objective (STO), located at the RDECOM Science and Training Technology Center (STTC) in Orlando, Florida. The goal of this STO effort was to investigate and implement several proof of concept demonstrations of the application of Intelligent Tutoring System (ITS) techniques and technology to embedded training in the domain of FCS robotic vehicle control.

3.1 Task

Test subjects where given a combination of human tutored and computer aided instructions while occupying the Robotics NCO crew station in a FCS equipped C2V Testbed simulator, located at STTC. This experiment required test subjects to learn both procedural and conceptual knowledge tasks in order to accomplish a tactical mission. Procedural knowledge tasks included the control of unmanned robotic assets in a virtual environment and learning the correct procedures for conducting: reconnaissance, surveillance and target acquisition tasks, two target engagement techniques, and submitting situation reports. Conceptual knowledge tasks included learning a defined set of the tactical principles associated with the planning and execution of a tactical reconnaissance mission and their associated supporting tasks. Test Subjects were given a timed tactical scenario which required them to perform a reconnaissance mission in order to demonstrate proficiency in the application of both procedural and conceptual knowledge.

3.2 Subjects

The available sample for this experiment included undergraduate students (n=45) from the College of Engineering & Computer Science and the College of Arts & Sciences at the University of Central Florida. A number of students chose not to participate, signed up for the experiment and did not show up, or their experiment timeslot was cancelled by the proctors due to adverse weather (Hurricane Jeanne!). Five test subjects were used in a pilot study, yielding a final sample size of 30 students (See Table 1 for descriptive statistics). The sample size consisted of 19 males and 11 females, ranging in age from 18 to 33 with 16 subjects pursuing a Bachelor of Arts degree and 14 subjects pursuing a Bachelor of Science degree. The average test subject was a 20 year old male pursuing a Bachelor of Arts degree and was self-assessed as having good computer experience with several types of software programs.

Ten test subjects were randomly assigned to one of three feedback condition groups: Immediate Directive Feedback (IDF) only; IDF, with AAR; and AAR Only. The IDF only feedback condition group included 7 males and 3 females, ranging in age from 18 to 33, with 5 pursing a Bachelor of Arts degree and 5 pursuing a Bachelor of Science degree. The IDF, with AAR feedback condition group included 5 males and 5 females, ranging in age from 18 to 22, with 6 pursing a Bachelor of Arts degree and 4 pursuing a Bachelor of Science degree. The AAR Only feedback condition group included 7 males and 3 females, ranging in age from 18 to 23, with 4 pursing a Bachelor of Arts degree and 6 pursuing a Bachelor of Science degree. Test subjects either received extra credit or monetary compensation for participating in the study. An ANOVA test was run on each of the feedback condition groups, $F_{(2, 27)}$ and $\alpha = .05$ and there was no significant difference between groups for Age (F=.628, p =.54), Gender (F=.537, p=.59), Degree (F=.90, p =.418) or Computer Experience (F=.917, p=.412).

Table 1. Test Subjects Descriptive Statistics from Demographic Survey

Factor	Treatment	n	*M*	*Mdn*	*Mode*	*SD*
Age	IDF Only	10	21.1	19.5	18	4.654
	IDF, with AAR	10	19.8	20	20	1.398
	AAR Only	10	19.8	19	18	1.814
	Combined	30	20.23	19.5	18	2.956
Gender (Male = 1)	IDF Only	10	.7	1	1	.483
	IDF, with AAR	10	.5	.5	1	.527
	AAR Only	10	.7	1	1	.483
	Combined	30	.633	1	1	.240
Degree (BA = 1)	IDF Only	10	.5	.5	0	.527
	IDF, with AAR	10	.7	1	1	.483
	AAR Only	10	.4	0	0	.516
	Combined	30	.533	1	1	.507
Computer Experience	IDF Only	10	2.9	3	3	.568
	IDF, with AAR	10	2.8	3	3	.919
	AAR Only	10	3.3	3	3	1.06
	Combined	30	3	3	3	.871

Computer Experience: 5= Can program in several languages and use several software packages; 4= Can program in one language and use several software packages; 3= Good with several software packages; 2= Good with one type of software package (such as word processing or slides); 1=Novice

3.3 Materials

The device used in this experiment was the Robotics' NCO crew station in a prototype FCS C2V (See Figure 1). The Robotics' NCO crew station consists of six, flat panel touch screens for visualization of and control of entities within the STE, haptic devices for the control of robotics assets (driver/gunners yokes, buttons, triggers, etc) speakers for audio output, a finite state machine (FSM) embedded simulation component for CGF behaviors, a tutoring-based feedback application system, and a data collection system.

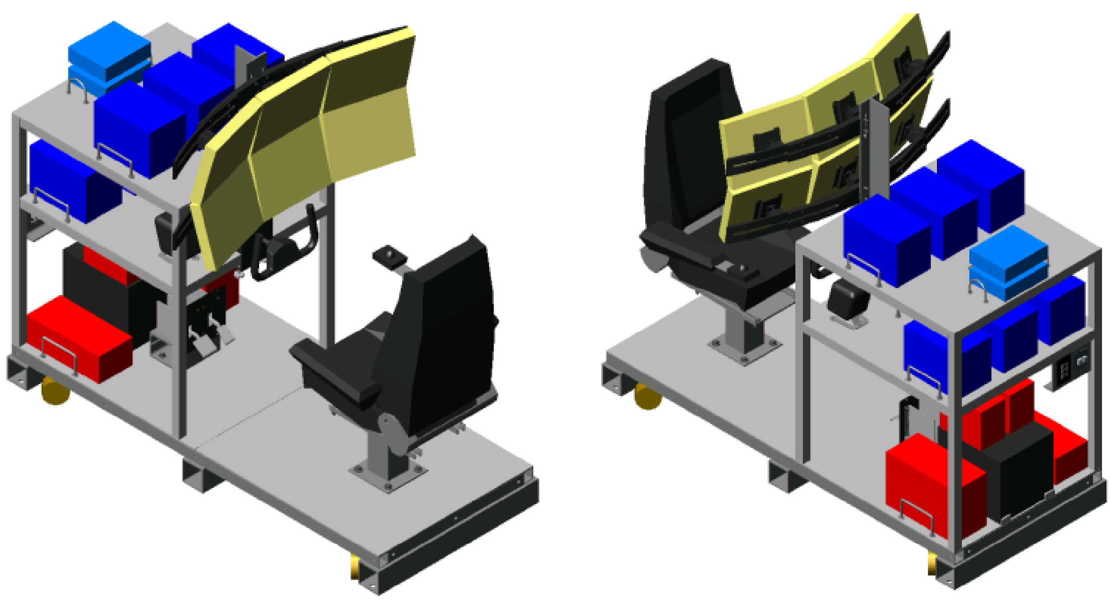

Figure 1. FCS C2V Robotics' NCO Crew Station

The top three flat panel screens display a three-dimensional view of the STE, each representing a different view from the robotic vehicles. The top left screen (See Figure 2) displays the view from the visual sensor mounted on the Unmanned Aerial Vehicle (UAV).

Figure 2. UAV Sensor view of the STE

The top center screen (See Figure 3) displays the driver's position view from the visual sensor mounted on the Unmanned Ground Vehicle (UGV).

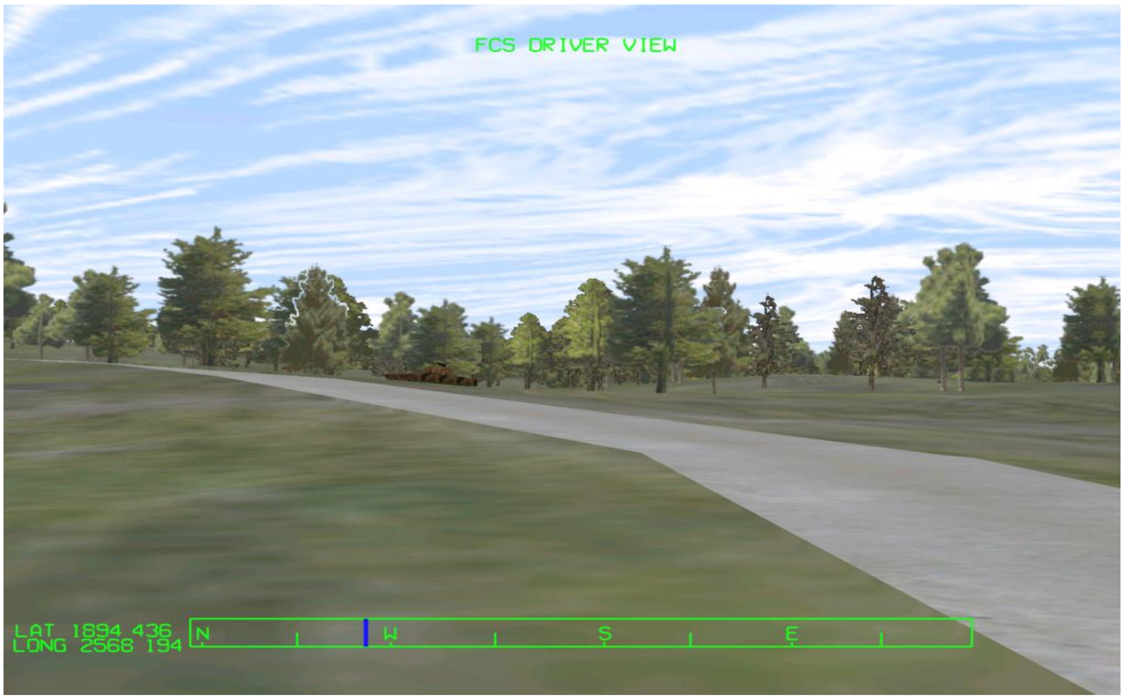

Figure 3. UGV Sensor view of the STE (Driver's Position)

The top right screen (See Figure 4) displays the view seen by the visual sensor from the gunner's position in the turret. When displayed, feedback prompts also appear on this screen.

Figure 4. UGV Sensor view of the STE (Gunner's Position)

The primary control environment that the test subjects used is called an Operator Control Unit (OCU) and is displayed on the bottom center screen (See Figure 5). The OCU functions as the control interface for networked robotic vehicles under the test subject's command. The OCU operates directly with the OneSAF Testbed Baseline (OTB) to control and monitor status for robotic entities under the test subject's control. It also provides situational awareness to the test subject, providing a map, scenario defined graphic control measures (GCM), and icon tracking & locations.

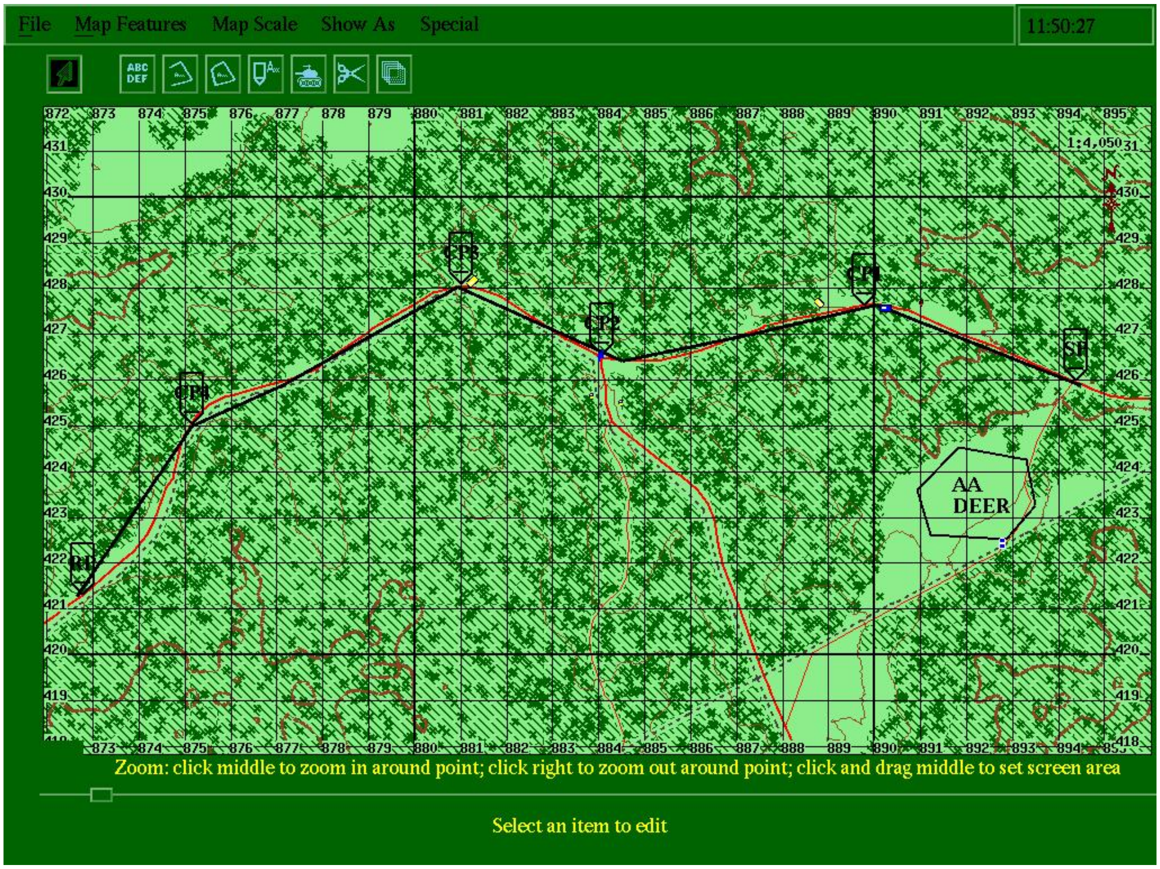

Figure 5. OCU/Situational Awareness Map

An additional user interface, called the Robotic Assets/Mission Status Tool provides a high level control user interface both for seeing the status of the unmanned vehicles under the control of the operator, for initiating commands to the vehicle entities, submitting reports, and acknowledging targets. It is located on the lower left screen (See Figure 6), and the test subjects touch the screen to activate the appropriate buttons

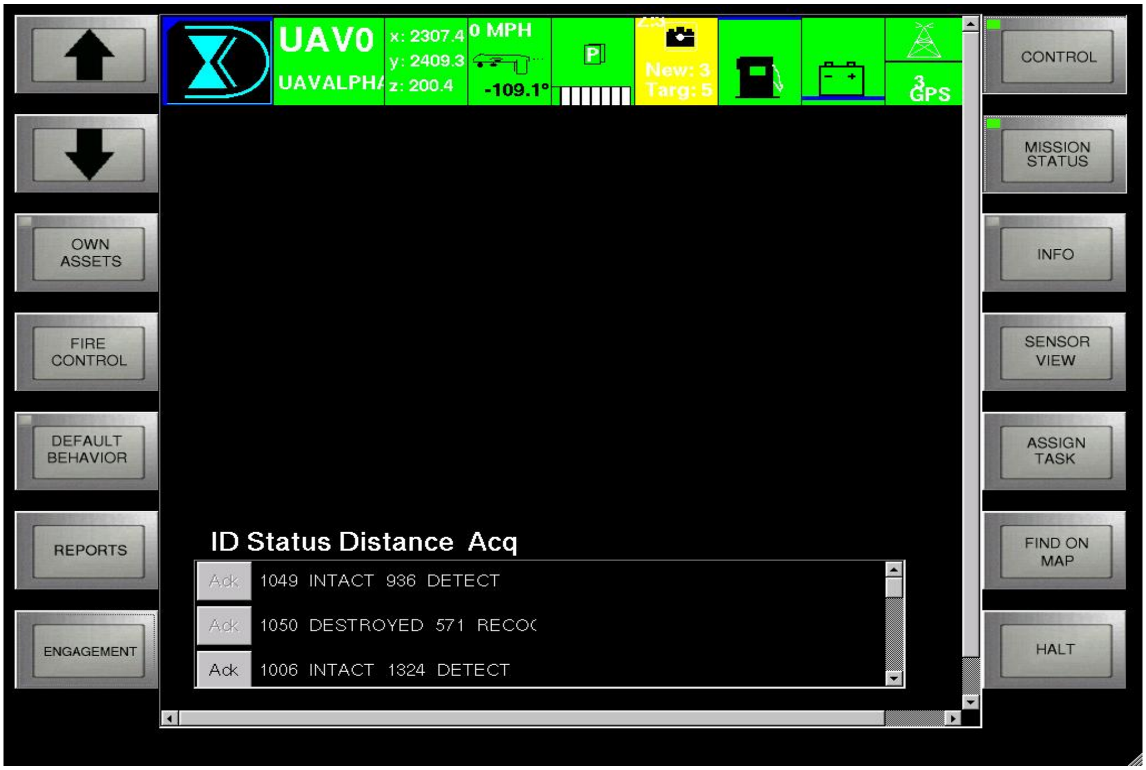

Figure 6. Robotic Assets/Mission Status Tool

The lower right screen is yet another user interface, called the Tele-Operation Asset Tool (See Figure 7) and it provides a high level control user interface both for seeing the status of the Tele-Op UGV vehicle under the control of the operator and issuing commands.

Figure 7. Tele-Operation Asset Tool

The embedded simulation component includes OTB as the driver for computer generated forces. OTB is a scalable, composable simulation which provides physical and behavioral models for computer generated forces in a CGE. OTB is part of the US Army Program Executive Office for Simulation, Training & Instrumentation's (PEO STRI) ongoing effort to develop One Semi-Automated Forces (OneSAF) for use throughout the US Army.

The machine tutoring-based application system for this experiment was provided by Stottler Henke Associates, Inc. and involved the development of a correct solution for each scenario and compared the test subjects' actions with a subject matter expert's defined solution. Stottler Henke developed a FSM model for automated evaluation and feedback. In this approach, every action executed within the scenario is evaluated to determine if it is the correct response to the current situation. If the response is incorrect, immediate feedback is provided in the form of an error message provided to the test subject. No immediate feedback was provided for following correct procedures. The three types of immediate feedback included: battlefield heuristic feedback, “Conduct a sensor scan before beginning movement”; error detection and directive feedback, “Submit a report anytime there is a change to the tactical situation”; or directive feedback, “You have failed to correctly submit a SITREP. The correct procedure is . . .”. (See Appendix C for a complete list of Error Prompt Messages). Immediate Directive Feedback prompts (See Figure 8) were triggered either when a test subject failed to take an appropriate action, after receiving an error detection prompt, or conducted a procedure incorrectly.

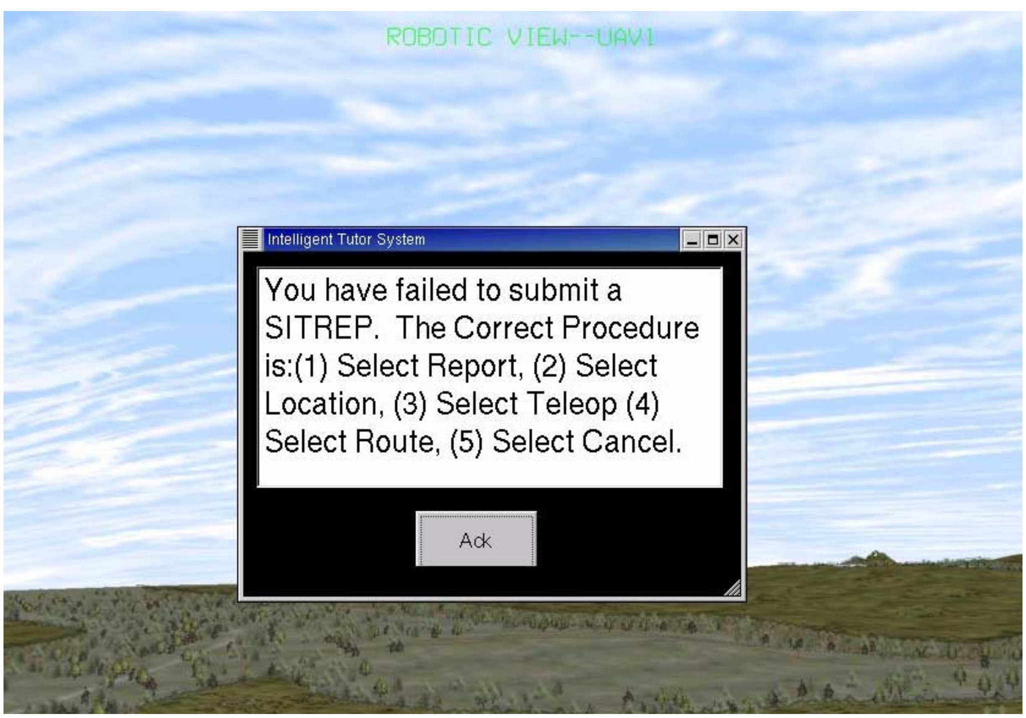

Figure 8. Immediate Directive Feedback (Procedural Error Prompt).

Human tutoring on both Procedural Knowledge and Conceptual Knowledge used open-ended prompts during the AAR to elicit elaboration and self-explanation from the trainees. The AAR protocol used (See Appendix I) followed a typical Army After Action Review format as outlined in TC 25-20, *A Leader's Guide to After-Action Reviews* (DA, 1993) and focused on answering three top level questions: What happened; Why it happened; and How to fix it. It is during the review of tactical principles and "The How to fix it" portion of the AAR that the tutor focuses on Conceptual Knowledge. Conceptual Knowledge includes general tactical principles and definitions of concepts which provide a framework for Procedural Knowledge. For example, Conceptual Knowledge includes understanding the tactical principles of reconnaissance, the various methods for engaging a target, and the purpose for submitting reports; Procedural Knowledge is the following the sequential steps to actually engage a target.

During the AAR, test subjects were required to review both concepts and procedures and then asked open- ended, content neutral prompts to elicit elaboration and feedback. For example, one measure of Conceptual Knowledge required the test subject to define the term "Cooperative Engagement" and give an example. As part of the AAR, the test subject reviewed the definition of Cooperative Engagement and was asked the following questions: "Can you explain this concept in simple terms?"; "Can you give an example?"; and "When have you done something like this?". If, in answering these questions, the test subject provided an incorrect answer, the tutor identified the answer as incorrect and asked the test subject to try again.

Automated data collection, scenario play back and feedback report formats were provided by General Dynamics' S2 Focus™. S2 Focus™ is a simulation management tool that allows for simulation exercise management, monitoring, and analysis. The Recorder, Analyzer & AAR tools were adapted for use to capture and record CGF data generated by each training trial run, analyze the data, and provide scenario playback during the AAR. Event data was stored in Microsoft Access® Database which allowed the data analysis tool to generate user defined reports for use during the AAR (See Appendix D).

3.4 Procedures

The experiment was conducted on 30 test subjects during two testing periods, separated by seven days, between October and December 2004. Phase one consisted of a one hour administration period and three, one hour training periods. Phase two consisted of two half hour periods. Test subjects were required to fill out a Test Subject Demographic Survey and sign an Informed Consent form before participating in the experiment (See Appendix F). All test subjects were administered an un-timed paper and pencil pre-test to establish a baseline of subject knowledge (See Appendix G). Each subject knowledge test consisted of 10 procedural knowledge questions and 10 conceptual knowledge questions. Procedural knowledge questions included skill acquisition tasks and asked the test subjects to write down the steps to accomplish a procedural task, i.e. "What is the correct procedure for Submitting a SITREP?" Conceptual knowledge questions included general tactical principles and definitions of concepts, i.e. “What are the tactical principles for reconnaissance?” and “Define a Line of Sight Engagement”. Test subjects had to provide the answers to each question, were instructed not to guess, and write “I do not know” after each question if they could not answer the question.

Test subjects occupied the Robotics NCO crew station in a FCS equipped C2V simulator and received an orientation to the simulator. Each training trial began with a review of the procedures and training tasks to be accomplished during the training exercise (See Appendix H). After this review, each test subject executed a 30 minute timed training scenario that measured their ability to correctly apply these concepts and conduct these procedures in a manned simulator. At the end of each training trial, the test subjects assigned to the IDF Only feedback condition group conducted a self-paced review of the concepts and procedures located in Appendix H and completed a subject knowledge test. The IDF Only feedback condition group received no delayed feedback in the form of an AAR. Test subjects assigned to the IDF, with AAR and the AAR Only feedback condition groups received a human facilitated AAR (See Appendix I) and then completed a subject knowledge test. Four tests were developed (See Appendix J), Subject Knowledge Test Alpha, Bravo, Charlie, and Delta with the same 10 procedural and 10 concept knowledge questions from the pre-test presented in a random order for each test. Each test subject was randomly assigned one of four different subject knowledge tests upon completion of each training trial. Tests were not timed. All three training trial scenarios were identical, with no change to the tactical scenario occurring between iterations.

During phase two, a randomly assigned, un-timed subject knowledge paper and pencil test was administered to measure retention of knowledge. Test subjects were then given a transfer task which was identical to the previously learned concepts about the task, Conduct a Route Reconnaissance, and included the same goal, constraints and options for completing the tasks, but the terrain was different than the terrain used during the training tasks. Test subjects had to plan a route on a paper map (See Appendix K) and identify concepts and procedures when answering questions about the task (See Appendix L). Test subjects then re-occupied the FCS C2V simulator and executed the transfer task on a proctor provided scenario.

3.5 Experimental Design

The experiment utilized a 1 between and 1 within subjects mixed ANOVA design. The between subject factor was feedback condition and the within subject factors was training trials. Measures of Procedural Knowledge and Conceptual Knowledge were obtained from a paper and pencil test. The numbers of directive feedback messages were also recorded as a measure of procedural knowledge during the performance of a test subject on each training trial (See Appendix C). A one-factor design ANOVA was conducted to assess both retention of knowledge and knowledge transfer. The retention test for the between subjects factor for both measures was type of treatment. Measures of transfer and retention consisted of knowledge from three separate areas: route planning, concept identification, and procedures identification following a one week hiatus after the last training trial (Appendix K). Route planning consisted of drawing and naming the correct graphic control measure symbols required to conduct the route reconnaissance mission on the transfer task. Concept identification and procedure identification required the naming of the appropriate concept or procedure required for the execution of the transfer task and writing a mission statement (Appendix L). Directive Feedback messages of error detection and corrective action generated by the tutoring system during the execution of the mission in the transfer scenario was also recorded as a measure of the transfer of Procedural Knowledge.

Three proctors administered the test protocols. Proctor 1 was an Army Captain, 34 years of age with 11 years of military service. Military experience included 18 months as a Platoon Leader and 23 months as a Company Commander, directly responsible for the training of over 500 soldiers. Additional training experiences included a 12 month assignment as the operations officer for a 235 man aviation company, responsible for scheduling and monitoring all flight related training and allocating resources to ensure mission accomplishment. Proctor 2 was an Army Captain, 35 years of age with 12 years of military service. Military experience included 4 years as a Platoon Leader and Company Commander, directly responsible for the training of over 700 soldiers. Additional training experiences included the development of training plans to ensure a forward deployed Military Police Battalion made up of companies from various battalions throughout Germany was prepared to efficiently operate all of their communication assets. These plans ensured successful support of the first phases of the Task Force Eagle and Falcon deployments to the austere environments of Albania and Kosovo. Proctor 3 was an Army Lieutenant Colonel, 42 years of age with 19 years of military service. Military experience included 5 years as a Platoon Leader and Company

Commander, directly responsible for the training of over 240 soldiers. Additional training experiences included 4 ½ years as an Observer/Controller at the Joint Readiness Training Center.

To control for bias, Proctor 2 graded all written tests and did not directly participate in any of the experiments. Proctor 1 administered the training protocol for the IDF Only feedback condition group and administered the paper and pencil post-tests after each training trial and the transfer task. To control for bias in the test subjects' administrative instruction and orientation period, Proctor 3 conducted the administrative portion of the experiment, administered all pre-tests and conducted the orientation for all test subjects on the C2V simulator. Proctor 3 administered the training protocol for the IDF, with AAR and AAR Only feedback condition groups and administered the paper and pencil post-tests after each training trial. Proctor 3 also administered the transfer tasks.

CHAPTER FOUR: DATA ANALYSIS

The overall results of the experiment support the hypothesis that the timing and type of feedback received during training does effect the acquisition, retention and transfer of both procedural and conceptual knowledge. Significant differences did exist in individual measures, suggesting that immediate directive feedback has a significant effect in reducing the number of errors committed while acquiring new procedural skills during training as well as retention of these procedural skills. Also, delayed feedback, in the form of an AAR which includes opened-ended prompts to foster elaboration, has a significant effect on the acquisition, retention and transfer of higher order conceptual knowledge about a task as well as procedural knowledge about a task. A blended feedback approach, like that used in the IDF with AAR feedback condition group, produced statistically significant results in the application of conceptual and procedural knowledge on a transfer task.

4.1 Analysis of Pre-Test Scores

Two test subjects, Test Subject 14 & 45, answered, respectively, one and two pre-test questions correctly. Test Subject 14 answered one conceptual knowledge question and Test Subject 45 answered one conceptual knowledge and one procedural knowledge question on the pre-test. A one-way ANOVA was conducted on the pre-test scores to test the Hypothesis that all groups baseline of knowledge were equal. We failed to reject the Hypothesis and therefore concluded that there was no significant difference between the feedback condition groups means with $F_{(2,27)} = .100$ and $p > .05$ (see Table 2).

Table 2. ANOVA on Pre Test Total Scores

Effect	df	F	p-level
Feedback Condition	2	.100	.556
S/Feedback Condition	27	(.167)	

Note. Values enclosed in parentheses represents mean square error. $p>.05$.

4.2 Analysis of Training Trial Test Scores

A one between and one within factor ANOVA was conducted on the Conceptual Knowledge questions answered correctly after each training trial. The between subjects factor was feedback condition, IDF Only, IDF with AAR, and AAR Only, and the within subject factor was training trials. The dependent measure was the number of Conceptual Knowledge questions answered correctly on the paper and pencil post-test. Conceptual Knowledge questions required the identification of tactical principles and asked for the definitions of higher level tactical concepts. The results of the ANOVA found a significant main effect for Feedback Condition ($F_{(2,27)} = 5.78$), Training Trials ($F_{(2,54)} = 21.62$), and Feedback Conditions x Training Trials ($F_{(4,54)} = 2.97$), $p < .05$ (see Table 3).

Table 3. One Between x One Within ANOVA on Conceptual Knowledge Scores

Effect	df	F	p-level
	Between subjects		
Feedback Condition (F)	2	5.78*	< .05
S/F	27	(8.19)	
	Within subjects		
Trials (T)	2	21.62*	< .05
T x F	4	2.97*	< .05
S x T/F	54	(1.08)	

Note. Feedback Conditions are: Immediate Directive Feedback only; Immediate Directive Feedback, with AAR; and AAR only, respectively. Values enclosed in parentheses represent mean square errors. Values enclosed in parentheses represent mean square errors. S = subjects. $*p<.05$.

In order to locate the source of the effect, pairwise contrasts were conducted, using the Fisher-Hayter Test for family wise error. The effect for Feedback Condition came from the AAR Only feedback condition group (M = 5.80, SD = 1.864) versus the IDF Only feedback condition group (M = 3.30, SD = 1.664) ($t_{(2,19)} = 3.383$) with the greatest effect for Feedback Condition being the AAR Only feedback condition group. The effect for trials came from two comparisons, Trial 3 (M=5.40, SD=2.253) versus Trial 1 (M=3.67, SD=2.090) ($t_{(2,38)} = 6.474$) and Trial 2 (M=4.80, SD=1.972) versus Trial 1 (M=3.67, SD=2.090) ($t_{(2,38)} = 4.233$), with the greatest effect for Training Trials occurring between Trial 3 versus Trial 1, $p < .05$ (See Table 5). An effects analysis

(Cohen, 1988) found large effects sizes for Feedback Condition ($\hat{f}_F$ = .5645), and Training Trials ($\hat{f}_T$ =.6769), with a slightly larger effect for trials than feedback condition.

Table 4. Pairwise Contrasts for Conceptual Knowledge ANOVA

Comparisons	q	t	p-level
	Between Feedback Conditions		
AAR Only (M = 5.80) versus IDF Only (M = 3.30)	2.96	3.383*	< .05
IDF, with AAR (M = 4.77) versus IDF Only (M = 3.30)	2.96	1.985	> .05
AAR Only (M = 5.80) versus IDF, with AAR (M = 4.77)	2.96	1.398	> .05
	Between Training Trials		
Trial 3 (M = 5.40) versus Trial 1 (M = 3.67)	2.86	6.474*	< .05
Trial 2 (M = 4.80) versus Trial 1 (M = 3.67)	2.86	4.233*	< .05
Trial 3 (M = 5.40) versus Trial 2 (M = 4.80)	2.86	2.241	> .05

Note. FWE = .05, q .05 (2,19) = 2.96, q .05 (2,38) = 2.86, *p<.05.

Figure 9 shows the interaction between Feedback Conditions and Training Trials. The IDF Only feedback condition group consistently shows the smallest mean scores for

Conceptual Knowledge after each training trial. The AAR Only feedback condition group shows a shallow increase in Conceptual Knowledge between Trial 1 and Trial 2, then a large gain at Trial 3. The IDF, with AAR feedback condition group accounts for the most dramatic single effect between Feedback Condition and Training Trials, with the major gain in Conceptual Knowledge occurring at Trial 2 and then leveling at Trial 3. All three feedback condition groups show an upwards trend over trials.

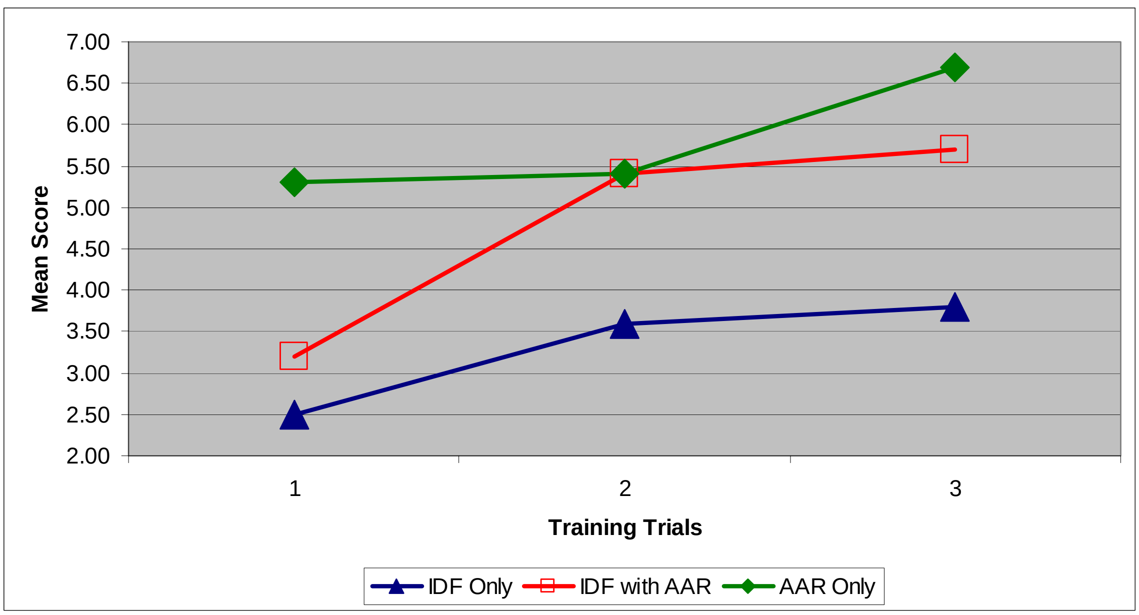

Figure 9. Plot of means for the 2-way interaction of Feedback Conditions x Training Trials on Conceptual Knowledge score

A one between and one within factor ANOVA was conducted on the Procedural Knowledge questions answered correctly after each training trial. Again, the between subjects factor was Feedback Condition, IDF Only, IDF with AAR, and AAR Only, and the within subject factor was Training Trials. The dependent measure was the number of

Procedural Knowledge questions answered correctly on the paper and pencil post-test. Procedural Knowledge questions involved the proper sequencing of steps to accomplish critical procedures within the simulator. The results of the ANOVA found a significant main effect for Training Trials ($F_{(2,54)} = 18.59$), with a $p < .05$, but not for Feedback Condition (See Table 5).

Table 5. One Between x One Within ANOVA on Procedural Knowledge Scores

Effect	df	F	p-level
	Between subjects		
Feedback Condition (F)	2	.19	>.05
S/F	27	(7.17)	
	Within subjects		
Trials (T)	2	18.59*	<.05
T x F	4	1.38	>.05
S x T/F	54	(1.41)	

Note. Feedback Conditions are: Immediate Directive Feedback only; Immediate Directive Feedback, with AAR; and AAR only, respectively. Values enclosed in parentheses represent mean square errors. Values enclosed in parentheses represent mean square errors. S = subjects. *p<.05.

Pairwise contrasts were conducted, using the Fisher-Hayter Test for family wise error to identify the source of the effect. The effect for trials came from all three comparisons, with the greatest effect for trial occurring between Trial 3 (M = 5.50, SD = 1.592) versus Trial 1 (M = 3.63, SD = 1.771) ($t_{(2,38)}$ =6.097), followed by Trial 3 (M = 5.50, SD = 1.592) versus Trial 2 (M = 4.53, SD = 1.995) ($t_{(2,38)}$ =3.157), and then Trial 2 (M = 4.53, SD = 1.995 versus Trial 1 (M = 3.63, SD = 1.771) ($t_{(2,38)}$ = 2.939), with $p < .05$ (See Table 6). An effects analysis (Cohen, 1988) found a large effects size for Training Trials ($\hat{f}_T$ =.6253),

Table 6. Pairwise Contrasts for Procedural Knowledge ANOVA

Comparisons	q	t	p-level
	Between Training Trials		
Trial 3 (M = 5.50) versus Trial 1 (M = 3.63)	2.86	6.097*	< .05
Trial 2 (M = 4.53) versus Trial 1 (M = 3.63)	2.86	2.939*	< .05
Trial 3 (M = 5.50) versus Trial 2 (M = 4.53)	2.86	3.157*	< .05

Note. FWE = .05, q .05 (2,19) = 2.96, q .05 (2,38) = 2.86, *p<.05.

4.3 Analysis of Training Trial Performance Scores

A one between and one within factor ANOVA was conducted on the performance task, Conduct a Route Reconnaissance, during each training trial. The between subjects factor was Feedback Condition, IDF Only, IDF with AAR, and AAR Only, and the within subject factor was Training Trials. The dependent measure was the number of Immediate Directive Feedback prompts triggered during the execution of the reconnaissance mission. IDF prompts were triggered whenever trainees failed to execute a procedure correctly. The ANOVA was conducted to determine if the mean number of IDF prompts triggered was equal across all Feedback Conditions. Table 7 shows that the ANOVA found a significant main effect for Feedback Conditions ($F_{(2,27)} = 7.65$), and Training Trials ($F_{(2,54)} = 5.03$), with a $p < .05$.

Table 7. One Between x One Within ANOVA on Immediate Directive Feedback Prompts for Procedural Knowledge

Effect	df	F	p-level
	Between subjects		
Feedback Condition (F)	2	7.65*	< .05
S/F	27	(117.39)	
	Within subjects		
Trials (T)	2	5.03*	< .05
T x F	4	2.49	> .05
S x T/F	54	(101.74)	

Note. Feedback Conditions are: Immediate Directive Feedback only; Immediate Directive Feedback, with AAR; and AAR only, respectively. Values enclosed in parentheses represent mean square errors. S = subjects. *p<.05.

In order to locate the source of the effect, pairwise contrasts were conducted, using the Fisher-Hayter Test for family wise error. The effect for Feedback Condition came from the AAR Only (M = 29.63, SD = 13.760) versus the IDF Only (M = 18.83, SD = 9.649) feedback condition group ($t_{(2,19)} = 3.861$, $p < .05$) with the most IDF prompts triggered by the AAR Only feedback condition group. The effect for Training Trials came from Trial 3 (M = 20.73, SD = 10.508) versus Trial 1 (M = 28.43, SD = 14.593) ($t_{(2,38)} = 2.957$, $p < .05$). An effect size analysis (Cohen, 1988) found a large effects size for Feedback Condition ($\hat{f}_F = .666$), and medium for Training Trials ($\hat{f}_T = .2991$).

Table 8. Pairwise Contrasts for Immediate Directive Feedback Prompts for Procedural Knowledge ANOVA

Comparisons	q	t	p-level
Between Feedback Conditions			
AAR Only (M = 29.63) versus IDF Only (M = 18.83)	2.96	3.861*	< .05
IDF, with AAR (M = 22.70) versus IDF Only (M = 18.83)	2.96	1.382	> .05
AAR Only (M = 29.63) versus IDF, with AAR (M = 22.70)	2.96	2.478	> .05
Between Training Trials			
Trial 3 (M = 20.70) versus Trial 1 (M = 28.43)	2.86	2.957*	< .05
Trial 2 (M = 22.00) versus Trial 1 (M = 28.43)	2.86	2.470	> .05
Trial 3 (M = 20.73) versus Trial 2 (M = 22.00)	2.86	0.486	> .05

Note. FWE = .05, q .05 (2,19) = 2.96, q .05 (2,38) = 2.86, *p<.05.

4.4 Analysis of Post-Test Scores, Retention

A completely randomized, one factor design ANOVA was conducted on the post test scores to measure retention of Conceptual Knowledge. The single factor was type of Feedback Condition; IDF Only, IDF with AAR, and AAR Only, and the dependent measure was the number of Conceptual Knowledge questions answered correctly on the paper and pencil retention test. The results of the ANOVA found a significant main effect for Feedback Condition ($F_{(2,27)} = 3.816$), with a $p < .05$ (see Table 9).

Table 9. Conceptual Knowledge Retention Scores ANOVA

Effect	df	F	p-level
Feedback Condition	2	3.816*	<.017
S/Feedback Condition	27	(3.485)	

*Note.*Values enclosed in parentheses represents mean square error. *p<.017.

Pairwise contrasts were conducted, using the Fisher-Hayter Test for family wise error to identify the source of the effect. The effect for Feedback Condition came from the AAR Only (M = 5.60, SD = 2.119) versus the IDF Only (M = 3.10, SD = 2.025) feedback condition group ($t_{(2,6)} = 3.760$, $p < .05$), with the greatest effect for Feedback Condition being No IDF with AAR feedback condition group (See Table 10).

Table 10. Pairwise Contrasts for Conceptual Knowledge Retention ANOVA

Comparisons	q	t	p-level
	Between Feedback Condition		
AAR Only (M = 5.60) versus IDF Only (M = 3.10)	3.46	3.760*	< .05
IDF, with AAR (M = 5.0) versus IDF Only (M = 3.10)	3.46	2.860	> .05
AAR Only (M = 5.60) versus IDF with AAR (M = 5.0)	3.46	.900	> .05

Note. FWE = .05, q .05 (2,6) = 3.46, *p<.05.

A completely randomized, one factor design ANOVA was conducted on the post test scores to measure retention of Procedural Knowledge. The single factor was Feedback Condition; IDF Only, IDF with AAR, and AAR Only, and the dependent measure was the number of Procedural Knowledge questions answered correctly on the paper and pencil retention test. The results of the ANOVA found no significant main effect for Feedback Condition ($F_{(2,27)} = .913$), with a $p > .05$ (see Table 11). Feedback timing or type had no effect on the retention of procedural knowledge.

Table 11. Procedural Knowledge Retention Scores ANOVA

Effect	df	F	p-level
Feedback Condition	2	.913	.413
S/Feedback Condition	27	(4.052)	

Note. Values enclosed in parentheses represents mean square error.

4.5 Analysis of Transfer Task Test Scores

A completely randomized, one factor design ANOVA was conducted on the application of concepts and procedures on a transfer task. The single factor was type of Feedback Condition, IDF only, IDF with AAR, and AAR only, and the dependent measure was the number of concepts, procedures, and graphic control measures, learned during previous training trials, correctly identified and applied on the transfer task, planning a route reconnaissance mission. The results of the ANOVA found a significant main effect for Feedback Condition ($F_{(2,27)} = 3.663$), with a $p < .05$ (see Table 12).

Table 12. Knowledge Transfer Task Scores ANOVA

Effect	df	F	p-level
Feedback Condition	2	3.663*	.039
S/Feedback Condition	27	(14.00)	

*Note.*Values enclosed in parentheses represents mean square error. *p<.05.

In order to locate the source of the effect, pairwise contrasts were conducted, using the Fisher-Hayter Test for family wise error. The effect for feedback condition came from the IDF, AAR (M = 17.20, SD = 3.225) versus the IDF Only (M = 13.90, SD = 3.985) feedback condition group ($t_{(2,6)} = 3.803$, $p < .05$), with the greatest effect for feedback condition being IDF w/AAR (See Table 13).

Table 13. Pairwise Contrasts for Knowledge Transfer Task ANOVA

Comparisons	q	t	p-level
	Between Feedback Condition		
AAR Only (M = 15.40) versus IDF Only (M = 13.90)	3.46	2.282	> .05
IDF with AAR (M = 17.20) versus IDF Only (M = 13.90)	3.46	3.803*	< .05
AAR Only (M = 15.40) versus IDF with AAR (M = 17.20)	3.46	1.521	> .05

Note. FWE = .05, q .05 (2,6) = 3.46, *p<.05.

4.6 Analysis of Transfer Task Performance Scores

A completely randomized, one factor design ANOVA was conducted on the performance task, Conduct a Route Reconnaissance, during the transfer task. The between subject factor was type of Feedback Condition, IDF only, IDF with AAR, and AAR only, and the dependent measure was the number of Immediate Directive Feedback prompts triggered during the execution of the reconnaissance mission. The ANOVA was conducted to determine if the mean number of IDF prompts generated was equal across all feedback conditions. The results of the ANOVA found a significant main effect for Feedback Condition ($F_{(2,27)} = 3.636$), with a $p < .05$ (see Table 14).

Table 14. Immediate Directive Feedback Prompts for Procedural Knowledge Transfer Task ANOVA

Effect	df	F	p-level
Feedback Condition	2	3.636*	.040
S/Feedback Condition	27	(11.944)	

Note. Values enclosed in parentheses represents mean square error.

Pairwise contrasts were conducted, using the Fisher-Hayter Test for family wise error to identify the source of the effect. The effect for Feedback Condition came from the AAR Only (M = 13.70, SD = 4.029) versus the IDF Only (M = 9.60, SD = 2.988) feedback condition group ($t_{(2,6)} = 3.751$, $p < .05$), with the most IDF prompts generated by the AAR Only feedback condition group (See Table 15).

Table 15. Pairwise Contrasts for Immediate Directive Feedback Prompts for Procedural Knowledge Transfer Task ANOVA

Comparisons	q	t	p-level
Between Feedback Condition			
AAR Only (M = 15.40) versus			
IDF Only (M = 13.90)	3.46	3.751*	< .05
IDF with AAR (M = 11.0) versus			
IDF Only (M = 13.90)	3.46	1.281	> .05
AAR Only (M = 15.40) versus			
IDF with AAR (M = 11.0)	3.46	2.470	> .05

Note. FWE = .05, q .05 (2,6) = 3.46, *p<.05.

CHAPTER FIVE: CONCLUSION

The results of this experiment show that the timing of feedback, immediate and delayed, and the type of feedback, directive and explanatory, has an impact on the acquisition, retention and transfer of knowledge. Immediate feedback that detects errors and provides directive feedback to correct the error promoted skill acquisition, retention and transfer for procedures. Providing feedback on procedures, whether immediate or delayed, resulted in improvement; however, providing Immediate Directive Feedback significantly reduced the amount of procedural errors committed during training. Delayed feedback, in the form of an AAR which used opened ended prompts to foster self-elaboration and tie new knowledge to meaningful pre-existing knowledge, promoted retention of new conceptual knowledge and its application and transfer to new tasks. The combination of immediate directive feedback with delayed feedback in the form of an AAR resulted in a significant improvement in the transfer of knowledge to a new but related task. Providing feedback on performance, whether immediate or delayed, directive or explanatory, resulted in improvements in the acquisition, retention and transfer of knowledge. These results should prove useful to the Army as it continues its development of its ET strategy for the Future Force.

5.1 Discussion

The results of the Conceptual Knowledge ANOVA and Pairwise Contrasts for Conceptual Knowledge ANOVA suggest that feedback conditions containing AARs which used content neutral, open-ended prompts to elicit self-explanation focusing on the

“Why it happened” and “How to Fix it” questions, significantly influenced the acquisition of Conceptual Knowledge. Pairwise contrasts between Feedback Conditions found a significant difference between the IDF Only and the AAR Only feedback condition groups on Conceptual Knowledge scores. There was not a significant difference between the IDF with AAR versus the IDF Only feedback condition groups or the IDF with AAR versus the AAR Only feedback condition groups over all training trials. One would expect that the IDF Only versus the IDF with AAR feedback condition would be significant if the AAR is reinforcing conceptual knowledge. This was the case during Trial 2 and Trail 3 but not for Trial 1 and is demonstrated by the Feedback Condition x Training Trial interaction. Given the large effect size for feedback condition ($\hat{f}_F = .5645$), we concluded that the type of feedback relative to Conceptual Knowledge provided by AARs reinforced the acquisition of Conceptual Knowledge.

The results of the ANOVA conducted on knowledge for procedure showed that not surprisingly Training Trials had an effect on the acquisition of procedures. The timing of feedback however, did not influence the acquisition of these procedures. All conditions provided feedback on Conceptual Knowledge and knowledge of procedures equally well.

The results of the analysis of variance of feedback prompts triggered for each of the feedback conditions demonstrated that procedural skill is better acquired and transferred with Immediate Directive Feedback rather than delayed feedback. Pairwise contrasts between Feedback Conditions found a significant difference between the number of error prompts triggered by the ITS between the IDF Only versus the AAR

Only feedback condition groups for both learning and transfer. The significantly lower number of error prompts triggered during the execution of the training scenario and the large effect size for feedback condition, $\hat{f}_F = .666$, demonstrates that the IDF Only Feedback Condition had a significant effect on the acquisition and transfer of the performance of procedures. This supports the earlier studies cited on the benefits of immediate and directive feedback (Anderson, et al., 1995; Buzhardt and Semb, 2002: Dihoff et al., 2004; Guthrie, 1971: Kulik & Kulik, 1998).

Analysis of the Conceptual Knowledge Retention Scores ANOVA and the Knowledge of Procedures Retention Scores ANOVA demonstrated that the Feedback Condition effects across the retention interval were consistent with those across Training Trials.

The results of the Knowledge Transfer Task Scores ANOVA and the Pairwise Contrasts for Knowledge Transfer Task ANOVA show that the IDF with AAR feedback condition group had the greatest effect for the application of both Conceptual Knowledge and Procedural Knowledge on the transfer task. While IDF promotes skill acquisition and delayed feedback promotes the acquisition and retention of conceptual knowledge, a blended approach is needed when transferring this knowledge to new tasks; therefore, the FCS ITS should be capable of supporting both immediate directive feedback for the instruction of procedures and delayed feedback using elaboration and self-explanation for conceptual knowledge.

5.2 Areas for Further Research

The varying effects of feedback condition and trials on the performance measures selected to measure training effectiveness argue for additional research and experimentation. Individual findings of significance between feedback condition measures within trials and the effect of within feedback condition measures between trials suggest that feedback timing and type does have an overall effect. Significant differences did exist in individual measures, suggesting that immediate error detection and directive feedback has a significant effect in reducing the number of errors committed while acquiring new procedural skills during training as well as retention of these procedural skills. Also, delayed feedback, in the form of an AAR which includes opened-ended prompts to foster elaboration, has a significant effect on the acquisition, retention and transfer of higher order conceptual knowledge about a task. Therefore, the following recommendations for future research in the area of feedback and ITS systems for FCS are included:

1. Update the capabilities within the FCS C2V simulator to include a freeze option to allow trainees an opportunity to freeze the scenario while attending to error detection and directive feedback. Enhance the procedural fidelity by preventing actions from occurring within the STE if proper procedures are not followed.
2. Automate the AAR protocol to remove humans completely from the feedback process. Include support for trainee self-elaboration during the AAR.

3. Refine the feedback condition categories and effectiveness measures to reflect updated capabilities with the C2V simulator. The mixed feedback condition should focus immediate feedback on procedural errors and delayed feedback on conceptual knowledge. Extend the length of time for retention, and manipulate the variables to determine is the linear association between highest levels of training achieved impact retention.
4. Continue the refinement of the scenario development process described in Appendix B. Expand the focus to include the additional FCS C2V crew members' individual tasks, the crew tasks and platoon level collective tasks. Develop and standardize scenarios for use as digitized situational training exercises.

APPENDIX A: FUTURE FORCE TRAINING PRINCIPLES

Future Force Training Requirements

By 2035, the US Army will be “transformed” into the Future Force, capable of operating as part of a joint, inter-agency, or multi-national force while providing the majority of the land forces available. The Army’s transformation effort is organized around the following seven functional domains: Doctrine, Organization, Training and Education, Material, Leadership, Personnel and Facilities (DOTMLPF). The Army plans on organizing and equipping these UAs using an 84 month Unit Set Fielding (USF) model to modernize the force and deliver a total organizational warfighting capability, rather than simply delivering individual systems to units. Preplanned technology inserts, including software and hardware upgrades to existing systems, will occur every 18-24 months. This cyclical fielding of improved capabilities will require routine retraining. This new Future Force training strategy calls for the embedding of Individual, Crew and Collective training tasks into a single platform, capable of supporting training across the Live, Virtual and Constructive (LVC) environment. The combining of any two of the three environments together for training is called the Synthetic Training Environment (STE) (TRADOC, 2003b)

Individual training is the training that all soldiers and leaders receive in institutions or at units, and includes both on the job training and self study. Individuals, both soldiers (operators) and leaders, are found in all training domains who need to acquire skills, knowledge and attributes to perform function tasks on digital systems that support specific operational requirements. Leaders must have the same skills as an operator, plus the understanding of how the system is vertically and horizontally integrated into the command, control, communications, computers, intelligence, surveillance, and reconnaissance (C4ISR) network. Leaders supervise other operators and collect, synthesize and integrate information. Individual skill training will focus on both initial training and sustainment training and use Interactive Multimedia Instruction (IMI) and CBT.

Collective training is the training of soldiers into hierarchically arranged groups, called units, to perform assigned operational missions. Unit, or collective, training consists of performance oriented individual and collective training, with leader participation. Collective training tasks will also use CBT in the STE, allowing for drill and practice exercises, instructional games, and problem solving exercises.

The Army outlines it's training philosophy in two references – Field Manual 25-100, Training the Force, (FM 25-100) and FM 25-101, Battle Focused Training (FM 25-101). FM 25-100 establishes the US Army's overarching training doctrine within the organization. It is centered on nine principles and these principles act as the framework for constructing all individual through collective training. These principles are: (1) Train as a combined arms and service teams, (2) Train as you fight, (3) Use appropriate doctrine, (4) Use performance-oriented training, (5) Train to challenge, (6) Train to sustain proficiency, (7) Train using multi-echelon techniques, (8) Train to maintain, (9) Make commanders the primary trainers (DA, 1988).

The three most critical training principles are: Use appropriate doctrine, Use performance-oriented training, and Train using multi-echelon techniques.

Use appropriate doctrine – this provides a common framework in which to plan, prepare and execute operations. Applying doctrinal principles correctly ensures that units can apply standard procedures to minimize reaction times. This principle requires the understanding and application of conceptual knowledge at multiple echelons and ensures that individuals and units are executing tasks from the same playbook.

Use performance-oriented training – this is a hands-on approach which emphasizes the repeated practice of critical skills, tasks and missions that soldiers and units will be required to execute in combat. This principle requires the learning and demonstration of procedural knowledge for both individuals and units.

Train using multi-echelon techniques – this principle calls for training on different levels simultaneously. This technique trains individuals, crews, sub-units and leaders within a single organization and maximizes the efficiency of training for individual and collective tasks associated with a specific task or mission. This principle blends the application of conceptual knowledge with the demonstration of procedural knowledge. larger units

FM25-101 provides a "how to" guide for leaders responsible for training and subdivides training into individual, crew and collective training tasks. Each task is composed of specified qualitative and quantitative measures and their associated execution standards. Individual tasks are divided into soldier and leader tasks, and these are combined with procedures, called drills, to form collective tasks. Drills are procedures in which individual tasks must be accomplished in a set sequence. Collective tasks generally do not require that individual tasks and drills to be performed in a set sequence, but involve leaders making tactical decisions about the sequencing of the tasks. Collective tasks are often nested to other collective tasks and it is the execution of these individual tasks, drills and collective tasks which define a mission. Performance feedback and training outcomes are defined in these terms (DA, 1990).

The Army provides training feedback to individuals and units through the use of an After Action Review (AAR). AARs are a method of providing delayed feedback to units by involving individuals in the training diagnostic process to increase and reinforce learning. AARs are facilitated by Instructor/Operators (IOs), for individual and crew training, and Observer/Controllers (OCs) for collective training. IOs provide feedback through instructor critiques while OCs are required to use a form of guided (or tutored) learning technique. The AAR leader guides participants in identifying deficiencies and seeking solutions (TRADOC, 2003a)

The Synthetic Training Environment

"Everything is simulation except combat"

Defense Science Board, 1993

The US Army groups simulation training into three broad categories: Live, Virtual and Constructive. Live simulation involves the training of soldiers, crews and units physically conducting training with their organic equipment in as close to "real" conditions (terrain, weather, limited visibility, etc) as possible. It emphasizes an individuals and units abilities to practice tactics, techniques and procedures while training on individual and collective tasks.

Virtual simulation immerses individuals, crews and units into a realistic, computer generated environment (CGE). Trainees interact in this environment through simulators which replicate combat vehicles or weapon systems. The trainees actions cause the simulator to interact in the virtual environment. Virtual simulators generally concentrate on individual and crew collective tasks. Networked virtual simulators train small unit collective tasks. The Unit Conduct of Fire Trainer (UCOFT) and the Simulation Networking Trainer (SIMNET) are examples of a crew virtual trainer and virtual network, respectively (TRADOC, 2003b).

Constructive simulations involve the use of CGEs but include complex stochastic or deterministic computer driven models to train commanders and their staffs on collective training tasks. Various algorithms simulate the actions of real units in the CGE. Trainees are isolated from the CGE and computer operators input information into the CGE. Constructive simulations generate information and reports which the computer operator relays the training audience. Janus and the Battlaion/Brigade Battle Simulation (BBS) are widely used Army Constructive Simulations tools for staff training (TRADOC, 2003b).

Embedded Training in the Future Force

The ET concept establishes four broad functional categories for tasks: Driver and Vehicle Maintenance Training; Weapon/Crew Training, Control and employment of unmanned vehicles {Reconnaissance, Surveillance, Target Acquisition (RSTA)}; Battle Command Training. All collective training tasks fall into either crew training or Battle Command training. ET will include IMI and CBT. CBT uses the computer as a focal point for instruction and will include the following teaching modes: Computer Assisted Instruction, Learning and Testing, Computer Based Instruction, Web Based Training, Intelligent Tutoring Systems (ITS), and Intelligent Computer Assisted Instruction (ICAI). ICAI is similar to ITS and uses computer based instructional dialogue using artificial intelligence. This System of Systems (SoS) training architecture will include three types of training support packages (TSPs): Interactive Electronic Technical manuals (IETMs) for procedural training; Simulation-based LVC exercises for crew, unit, leader and staff training in a stand alone mode or linked to external simulations; and Interactive Multimedia Instruction. Collective training applications will also include progressive training matrices. Each manned ground vehicle will have a "basic load" of electronic TSPs and tools to modify them as required. The vehicles organic command and control system will provide a "reach back" capability to distributed knowledge centers (HSOCs or Army Knowledge Enterprise System) to gain access to additional training products as required. Manned FCS platforms will include ET management services, as well a common After Action Review (AAR) interface and standardized AAR data formats. Objective OneSAF (OOS) will be the on-board computer generated forces (CGF) driver for all simulation-based training. (TRADOC, 2003b)

APPENDIX B: TASK ANALYSES AND PROBLEM SPACE IDENTIFICATION

Task analysis began with a four step training systems engineering approach: Needs and Organizational Assessment, Task Analysis, Delivery System Characteristics, and Experimental Design (Williams, 2004). The first step included a full review of the current Future Combat System (FCS) documents, the FCS Operational Requirements Document (ORD), the United States Army Objective Force Operational and Organizational Plan Maneuver Unit of Action, 30 June 2003 (UA O&O), and the Army Future Combat Systems Unit of Action Systems Book, version 3.0 dated 22 May 2003. This step identified the critical systems and organizations at each level that could impact on the training scenario. It also identified the operational concepts under development and demonstrated how these new FCS systems, conceptually, would be employed in the future.

Task analysis highlighted the functional objectives for each system (Command and Control Vehicle [C2V], Unmanned Aerial Vehicle [UAV], Unmanned Ground Vehicle [UGV], Armed Reconnaissance Vehicle –Assault [ARV-A], etc) and guided the process of task development.

Task development included the identification of a proposed mission (Route Reconnaissance) and a decomposition of tasks needed to support this goal. This task decomposition process included the identification of conditions under which the tasks would be accomplished and the development of measures of performance and effectiveness. This methodology included the identification of subordinate goals (tasks) needed to achieve the higher level goal. If more than one method presented itself to goal attainment, or multiple tasks were needed to achieve a higher level goal, then all other tasks (variables) were frozen while each method was fully decomposed. After all subordinate tasks were identified, then this just completed variable was frozen and a previously identified method was explored. The review of the Delivery System Characteristics included the use of the CBI system, the system platforms (including virtual models, simulators, and real world systems) and a review of the environment (Live, Virtual and Constructive). The experimental design phase included a revalidation of the hypothesis, measures of effectiveness and performance, and a refinement of conditions under which the experiment/training would occur.

The desired outcome was the training of the robotics operator of the Future Combat System (FCS) Company Level Command and Control Vehicle (C2V) within a Combined Arms Unit of Action (UA). This was a subordinate task embedded within the larger task of training of the FCS C2V crew, with a focus on the robotics operator; therefore, the primary training audience was the Robotics NCO and his interaction with the company Executive Officer, as well as the Driver and Vehicle Commander, whose secondary duties include the operation of robotic vehicles within the company.

Task decomposition focused on the common functional capabilities of the FCS C2V, unmanned robotic vehicles and fires systems organic to either the Infantry or Mounted Combat System (MCS) Company levels. Additional fires platforms organic to the CA Bn were included in this functional capabilities review, as well as aviation assets, although aviation assets were quickly eliminated to reduce the scope of the evaluation set. Information dominance is a cornerstone of the Future Force, so sensor fusion became the focus of the task analysis. The O&O defines fusion as "the combining or blending of data and information from single or multiple sources into information." This fusion provides the FCS-equipped UA the "Quality of Firsts" which enables it to dominate the battlefield. This battlefield dominance centers on the coupling of new lethality concepts (conceptual engagement types) and methods of receiving targeting information. Lethality modes include the traditional Line of Sight (LOS) and Beyond Line of Sight (BLOS) engagements (direct fire) and Non-Line of Sight (NLOS) (indirect fire). BLOS is an extension of the traditional direct fire engagement because the shooter "sees" the target through a sensor that has a sensor-to-shooter link. Cooperative Engagement is an engagement method where the sensor and shooter are not together in a single platform. Point and Shoot is a subset of Cooperative Engagement and allows a platform to designate a target for engagement by a different platform. Point and Shoot requires highly responsive effect (5 seconds or less) but occurs within the same tactical echelon. (TRADOC, 2003a).

According to the UA O&O, the Infantry and MCS Company share five common tasks:

- Conduct reconnaissance and surveillance operations (zone, area, route)
- Execute fire and maneuver before contact, in contact, and during assault to close with and destroy the enemy
- Provide mutual support in overwatch and cooperative engagements
- Conduct offensive, defensive, stability and support operations in all terrain and weather
- Conduct security operations (counter-reconnaissance)

Of the listed tasks, each subsequent task relied heavily on the successful completion of the first task listed; therefore the scenario was built around the reconnaissance task. Each Infantry or MCS Company is equipped one C2V in the Company Headquarters. The C2V platform provides the company with the embedded decision making tools and planning aids necessary to plan, coordinate with higher, lower and adjacent units, conduct rehearsals and then execute the plan. The FCS C2V became the critical node for training during this analysis process. An initial review of the C2V functions allowed for the development of crew collective tasks. Functions, training objectives, and crew duties were refined as a result of the formal task decomposition process and resulted in the following:

C2V Functions/Training Objectives:

- Battle Tracking
- Manage C4ISR network
- Conduct RSTA operations (zone, area, route)
- Conduct Cooperative Engagements
- Dynamically task unmanned assets to/from higher and lower control nodes through the battle command network
- Perform Battle Command on the Move

C2V Crew Duties

- Maintain Situational Awareness
- Scan Sectors
- Update COP
- Employ Organic Unmanned Aerial and Ground Vehicles (Autonomous and Tele-operations modes)
- Dynamic re-tasking of unmanned vehicles
- Manage C4ISR network
- Support Mission Planning (Routes)
- Engage Targets using LOS/BLOS/NLOS assets

C2V C4ISR Operator Controlled

- Cl II Unmanned Aerial Vehicle (UAV) {Tele-Operation (TO) & Semi-Autonomous Navigation (SA-N)}
- Armed Robotics Vehicle-Reconnaissance, Surveillance, and Target Acquisition (ARV-RSTA) {TO,SA-N, & SA-Follower (SA-F)}
- ARV-Assault (ARV-A) and ARV-A (Light) {TO, SA-N & SA-F}
- Multifunction Utility/Logistics Equipment Vehicle (MULE) w/Ground Standoff Mine Detection System (GSMDIS) {TO, SA-N & SA-F}

C2V C4ISR Operator Tasking Authority

- ICV Small Unmanned Ground Vehicle (SUGV) {TO}
- ICV Unattended Ground Sensor
- ICV Cl I UAV{TO & SA-N}
- UA Cl IV UAV {TO & SA-N}
- NLOS/BLOS Fires {SA-F}

After reviewing the training objective and operational concepts, the next step in the process was task decomposition. Using a GOMS model for identifying goals and sub-goals, this critical step allowed for the development of subordinate tasks, conditions and standards for small unit collective tasks, as well as identifying the skills, knowledge and attributes required by the robotics operator. Figure 10 below shows a partial task decomposition.

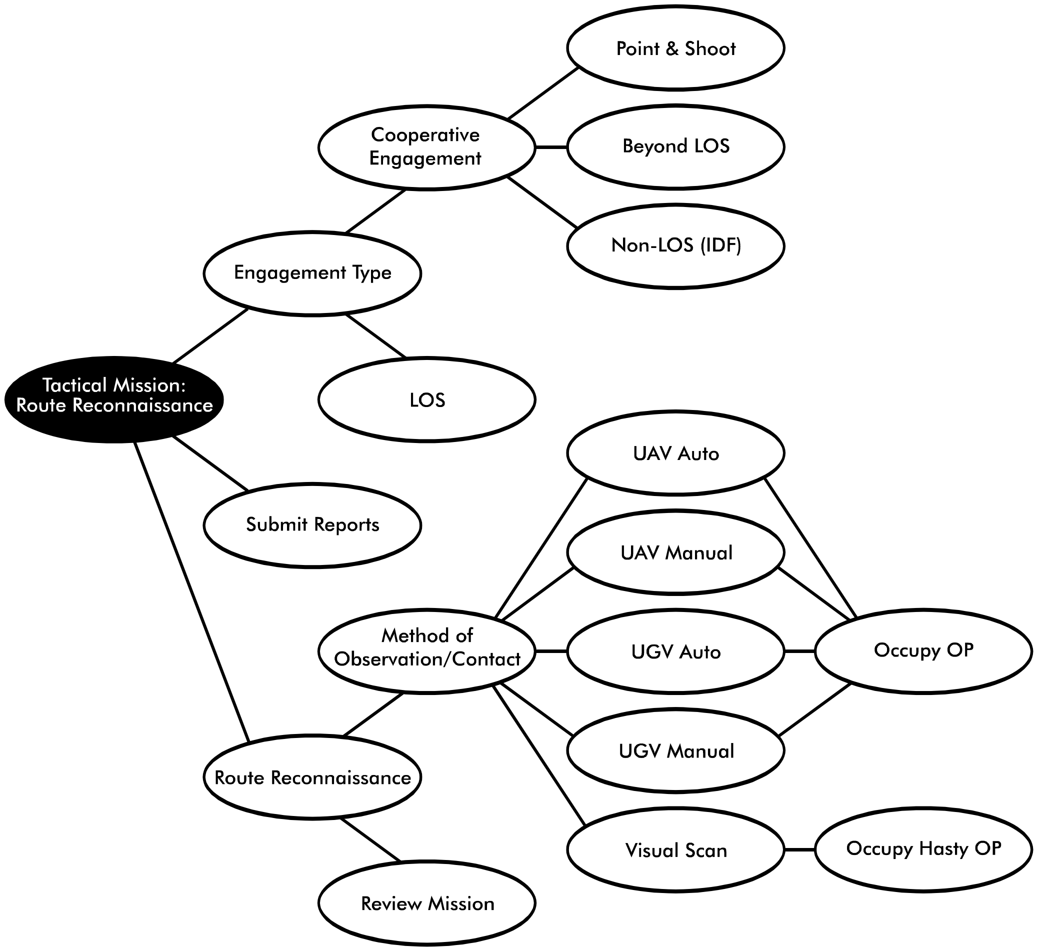

Figure 10. Partial Task Decomposition

The diagram above shows how the tactical mission, Conduct a Route Reconnaissance, can be decomposed into its major supporting tasks. The first major subgoal was the Route Recon tasks itself. This task immediately triggered a concurrent task, Submit Reports. The Submit Report Sub Task is a recurrent task which is triggered anytime there is a change state (Beginning movement, launching an Unmanned Vehicle, Engaging the enemy, etc). The Route Recon task required two major sub tasks; Review the Mission and selection of a Method of Observation. Method of Observation included five principles techniques (variables) and each of these techniques were defined and refined, one technique at a time. This task refinement yielded conditions and standards for each technique. After all five techniques were defined separately; they were again refined to work in conjunction with one another. This entire process yielded Tasks, Conditions, and Standards for each task and subtask. It also identified tasks and actions that other crew members were required to perform to support the Robotics Operator, and additional conditions for the execution of the training scenario. For example, once a target was detected, the Robotics NCO was required to select an engagement type, generally consisting of a subset of tasks within the Cooperative Engagement technique. Permission to engage targets would generally flow from the Commanding Officer to the XO. Requests for engagement authority and permission to engage were simplified into a single action, Call for Fire, and automatically handled within the simulation. This identified a needed precondition for the training scenario, authority to engage, a concept to be understood, Cooperative Engagement, a procedure to be trained, Call for Fire, and identified an area for future experimentation, the handling of calls for fire.

C2V Engagement Types

ENGAGEMENT TYPES

POINT & SHOOT

- *LOS Unguided**
- LOS Guided Autonomous & Designate

COOPERATIVE POINT & SHOOT

- Avenge Kill
- *LOS Unguided**
- *LOS Guided Autonomous & Designate**
- *BLOS Autonomous & Designate**

COOPERATIVE ENGAGEMENT

- BLOS Autonomous
- *BLOS Designate**
- *Off-The-COP**

WAYS OF RECEIVING TARGETING INFORMATION

SLEW-TO-QUE (ORGANIC SENSORS)

- Sensor-to-Shooter (UAV, SUGV)

NON-ORGANIC SUPPORTED SENSORS

- Sensor-to-Shooter
- Sensor-to-Decider
- Sensor-to-Analysis

OFF-THE-COP

2

C2V C4ISR Operator Control Issues

C2V C4ISR Operator Controlled

- Cl II Unmanned Aerial Vehicle (UAV) {Tele-Operation (TO) & Semi-Autonomous Navigation (SA-N)}
- Armed Robotics Vehicle-Reconnaissance, Surveillance, and Target Acquisition (ARV-RSTA) {TO,SA-N, & SA-Follower (SA-F)}
- ARV-Assault (ARV-A) and ARV-A (Light) {TO, SA-N & SA-F}
- Multifunction Utility/Logistics Equipment Vehicle (MULE) w/Ground Standoff Mine Detection System (GSMDIS) {TO, SA-N & SA-F}

C2V C4ISR Operator Tasking Authority

- ICV Small Unmanned Ground Vehicle (SUGV) {TO}
- ICV Unattended Ground Sensor
- ICV Cl I UAV{TO & SA-N}
- UA Cl IV UAV {TO & SA-N}
- NLOS/BLOS Fires {SA-F}

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APPENDIX C: ERROR PROMPT MESSAGES

1. Review your mission.
2. Review your route assignments.
3. You need to control a vehicle before performing tasks.
4. Select an entity, then click on Control.
5. You should click on Mission Status to see acquired targets.
6. You need to issue a HOVER command to get your UAV airborne before issuing a FLY command.
7. You can deploy your UAV by clicking Assign Task, then Hover.
8. Conduct a scan of the route before beginning movement.
9. Select Sensor View to conduct scan.
10. You should have deployed your UAV by this time.
11. Use UAV as the primary method for conducting a reconnaissance.
12. Conduct a scan of the route before beginning movement.
13. Select Sensor View to conduct scan.
14. You should have deployed your UAV by this time.
15. You can deploy your UAV by clicking Assign Task, then Hover.
16. UAV should fly the route using sequential checkpoints, starting with the Start Point and ending at the Release Point.
17. Report location when you reach a Graphic Control Measure (GCM).
18. You have left a Graphic Control Measure without reporting your location.
19. Submit SITREP anytime there is a change to the tactical situation, based on the movement or contact with enemy.
20. You have failed to submit a SITREP. The Correct Procedure is: (1) Select Report, (2) Select Location, (3) Select UAV/UGV (4) Select Start Point, (5) Select Cancel.
21. You have failed to submit a SITREP. The Correct Procedure is: (1) Select Report, (2) Select Location, (3) Select Tele-Op (4) Select Start Point , (5) Select Cancel
22. You have failed to submit a SITREP. The Correct Procedure is:(1) Select Report, (2) Select Location, (3) Select UAV/UGV (4) Select Route , (5) Select Cancel

23. You have failed to submit a SITREP. The Correct Procedure is: (1) Select Report, (2) Select Location, (3) Select Tele-Op (4) Select Route, (5) Select Cancel

24. You have failed to submit a SITREP. The Correct Procedure is: (1) Select Report, (2) Select Location, (3) Select UAV/UGV (4) Select Check Point, (5) Select Cancel

25. You have failed to submit a SITREP. The Correct Procedure is:(1) Select Report, (2) Select Location, (3) Select Tele-Op (4) Check Point, (5) Select Cancel

26. You have failed to submit a SITREP. The Correct Procedure is: (1) Select Report, (2) Select Location, (3) Select UAV/UGV (4) Select Release Point, (5) Select Cancel

27. You have failed to submit a SITREP. The Correct Procedure is:(1) Select Report, (2) Select Location, (3) Select Tele-Op (4) Release Point, (5) Select Cancel

28. Maintain 1 GCM separation between unmanned assets during movement

29. You have engaged a target (Cooperative Engagement) without first lazing the Target. The correct procedure is: (1) Scan to Target, (2) Laze Target, (3) Confirm Spot Report Number and Acknowledge, (4) Submit SITREP

30. You have engaged a target (Cooperative Engagement) without first acknowledging the Target. The correct procedure is: (1) Scan to Target, (2) Laze Target, (3) Confirm Spot Report Number and Acknowledge, (4) Submit SITREP

31. You have engaged a target (Line of Sight) without first lazing the Target. The correct procedure is: (1) Acquire Target, (2) Laze, (3) Engage, (4) Submit SITREP.

32. Once a target has been acquired, engage targets using any available means.

33. You have acknowledged a target without following the correct procedure. The correct procedure is: (1) Scan to Target, (2) Laze Target, (3) Confirm Spot Report Number and Acknowledge, (4) Submit SITREP.

34. You have submitted a SITREP without following the correct procedure. The correct procedure is: (1) Scan to Target, (2) Laze Target, (3) Confirm Spot Report Number and Acknowledge, (4) Submit SITREP.

35. Remember to submit a report after an engagement, even if the enemy is not destroyed.

36. Submit SITREP anytime there is a change to the tactical situation, based on movement or contact with the enemy.

37. You have failed to submit a SITREP. The Correct Procedure is: (1) Select Report, (2) Select Contact, (3) Select UAV/UGV (4) Select dismount observed.

38. Is 'dismount observed' the correct report for what you lazed?

39. You have failed to submit a SITREP. The Correct Procedure is: (1) Select Report, (2) Select Contact, (3) Select UAV/UGV (4) Select dismount destroyed.

40. Is 'dismount destroyed' the correct report?

41. You have failed to submit a SITREP. The Correct Procedure is: (1) Select Report, (2) Select Contact, (3) Select UAV/UGV (4) Select vehicle observed.

42. Is 'vehicle observed' the correct report for what you lazed?

43. You have failed to submit a SITREP. The Correct Procedure is: (1) Select Report, (2) Select Contact, (3) Select UAV/UGV (4) Select vehicle destroyed.

44. Is 'vehicle destroyed' the correct report?

45. You have failed to submit a SITREP. The Correct Procedure is: (1) Select Report, (2) Select Contact, (3) Select Tele-Op (4) Select dismount observed.

46. You have failed to submit a SITREP. The Correct Procedure is: (1) Select Report, (2) Select Contact, (3) Select Tele-Op (4) Select dismount destroyed.

47. You have failed to submit a SITREP. The Correct Procedure is: (1) Select Report, (2) Select Contact, (3) Select Tele-Op (4) Select vehicle observed.

48. You have failed to submit a SITREP. The Correct Procedure is: (1) Select Report, (2) Select Contact, (3) Select Tele-Op (4) Select vehicle destroyed.

49. Remember to submit a report after an engagement, even if the enemy is not destroyed.

50. Submit SITREP anytime there is a change to the tactical situation, based on movement or contact with the enemy.

APPENDIX D: S2 FOCUS™ USER DEFINED REPORT

AAR Scenario Overview	***Duration:***	30 ***minutes*** 20 ***seconds***
Number of Targets Lased:		5
Number of Location Reports:		4
Number of Contact Reports:		9
Number of ITS Prompts:		26
Number of Distinct ITS Prompts:		17

ITS Display Prompt Summary

Prompt	***Prompt Count***
Conduct a scan of the route before beginning movement.	1
Maintain 1 GCM separation between unmanned assets duringmovement	1
Remember to submit a report after an engagement.	3
Report location when you reach a Graphic Control Measure	1
Review your mission.	1
Review your route assignments.	1
Select Sensor View to conduct scan.	1
Submit SITREP (ROUTE) anytime there is a change to the tactical situation, based on the movement or contact with	2
Submit SITREP anytime there is a change to the tactical situation, based on movement or contact with the enemy.	2
UAVersus should fly the route using sequential checkpoints, starting with the Start Point and ending at the Release Point.	2
You have acknowledged a target without following the correct procedure.	2
You have engaged a target (Cooperative Engagement) without first acknowledging the Target. The correct procedure	4

You have engaged a target (Cooperative Engagement) without first lazing the Target. The correct procedure is:	1
You have failed to submit a SITREP.	1
You have left a Graphic Control Measure without reporting your location.	1
You have submitted a SITREP without following the correct procedure.	1
You should click on Mission Status to see acquired targets.	1

Page 1 of 1

APPENDIX E: INSTITUTIONAL REVIEW BOARD APPROVAL LETTER

University of Central Florida

Office of Research

August 5, 2004

LTC Mike Sanders
University of Central Florida
Engineering & Management Systems
Orlando, FL 32816-2993

Dear Mr. Sanders:

With reference to your protocol entitled, "Training and Performance Assessment in the Control of Multiple Simulated Robotic Vehicles," I am enclosing for your records the approved, expedited document of the UCFIRB Form you had submitted to our office.

Please be advised that this approval is given for one year. Should there be any addendums or administrative changes to the already approved protocol, they must also be submitted to the Board. Changes should not be initiated until written IRB approval is received. Adverse events should be reported to the IRB as they occur. Further, should there be a need to extend this protocol, a renewal form must be submitted for approval at least one month prior to the anniversary date of the most recent approval and is the responsibility of the investigator (UCF).

Should you have any questions, please do not hesitate to call me at 823-2901.

Please accept our best wishes for the success of your endeavors.

Cordially,

Barbara Ward

Barbara Ward, CIM
Institutional Review Board (IRB)

Copies: Dr. Kent Williams, Industrial Engineering & Management Systems, Room 427
IRB File

12443 Research Parkway • Suite 207 • Orlando, FL 32826-3252 • 407-823-3778 • Fax 407-823-3299

APPENDIX F: DEMOGRAPHIC SURVEY & INFORMED CONSENT FORMS

Appendix C

Informed Consent (Procedural Information)

Please read this consent document carefully before you decide to participate in this study.

Project title: Human Robot Interaction Study

Purpose of the research study: The goal of this research is to examine the ways human operators interact with unmanned robotic vehicles.

What you will be asked to do in this study: On each trial in the study, you will be asked to control a number of unmanned robotic vehicles and perform some assigned tasks. You will be tele-operating one robotic vehicle, monitoring/controlling other robotic vehicles, and performing the assigned tasks such as reconnaissance of enemy vehicles and fixing system malfunctions of your own robotic essets.

Time required: Approximately four hours in total. You are free to terminate participation in this experiment at any time without bias. You will receive course credit for the amount of time you participate or at least one hour.

Risks: There is no known risk of physical discomfort for working on simulators such as the one used in this study for such short duration as under 4 hours.

Benefits/Compensation: Your participation will help the military training community better understand how people interact with robotic vehicles in the military environment. You will receive course credit for research requirement, extra course credit (if offered by their instructor), or a combination of both.

Confidentiality: Your identity will be kept confidential to the extent provided by law. Your information will be assigned a code number. The list connecting your name to this number will be kept in a locked file in the principal investigator's office. When the study is completed and the data have been analyzed, the list will be destroyed. Your name will not be used in any report.

Voluntary participation: Your participation in this study is voluntary. There is no penalty for not participating.

Right to withdraw from the study: You have the right to withdraw from the study at any time without consequences.

Whom to contact if you have questions about the study: LTC Mike Sanders or CPT Jared Sloan, Dept. of Industrial Engineering, University of Central Florida, Orlando, FL 32816; phone: 407-405-3387; e-mail: mike.sanders@us.army.mil

Whom to contact about your rights in the study: **UCFIRB Office, University of Central Florida Office of Research, Orlando Tech Center, 12443 Research Parkway, Suite 207, Orlando, FL 32826**

Appendix D

Consent Form and Voluntary Agreement

I, ________________________(please print your full name), having full capacity to consent, do hereby volunteer to participate in research entitled Training and performance assessment in the control of multiple simulated robotic vehicles under supervision of the U.S. Army Research Laboratory. The implications of my voluntary participation and the nature, duration, and purpose of the research, and the method and means by which it is to be conducted are contained on the second page of this consent packet. I have been given an opportunity to read and keep a copy of this Agreement and to ask questions concerning this research. Any such questions have been answered to my full and complete satisfaction. Should any further questions arise, I will be able to contact LTC Mike Sanders at (407) 405-3387 or mike.sanders@us.army.mil, or CPT Jared Sloan at 407-719-0256 or j-ksloan@mindspring.com. I understand that I may at any time during this research revoke my consent and withdraw from the test without prejudice, and I will receive credit for the amount of time I participate or at least one hour. I also understand that the rate of credit per hour (if applicable) will be determined by the instructor of the course for which the credit is to be applied.

________________________________ ______________

Signature **Date**

____

Course Number and Section

Note: If you believe you have been injured during participation in this research project, you may file a claim against the State of Florida by filing a claim with the University of Central Florida's Insurance Coordinator, Purchasing Department, 4000 Central Florida Boulevard, Suite 360, Orlando, Fl 32816, (407) 823-2661. University of Central Florida is an agency of the State of Florida and that the university's and the state's liability for personal injury or property damage is extremely limited under Florida law. Accordingly, the university's and the state's ability to compensate you for any personal injury or property damage suffered during this research project is very limited. Information regarding your rights as a research volunteer may be obtained from:

Ms. Barbara Ward
Institutional Review Board (IRB)
University of Central Florida (UCF)
12443 Research Parkway, Suite 207
Orlando, Florida 32826-3252
Telephone: (407) 823-2901

APPROVED BY
University of Central Florida
Institutional Review Board
SFD 2 Aug 2004
CHAIRMAN

Demographic Questionnaire Date ______

Participant # _______ Age ______ Major ________________ Gender ________

1. What is the <u>highest</u> level of education you have had?

Less than 4 yrs of college ____ Completed 4 yrs of college ____ Other ____

2. When did you use computers in your education? (*<u>Circle all that apply</u>*)

Grade School	Jr. High	High School
Technical School	College	Did Not Use

3. Where do you currently use a computer? (*<u>Circle all that apply</u>*)

Home Work Library Other________ Do Not Use

4. For each of the following questions, <u>circle</u> the response that best describes you.

How often do you:

Use a mouse? Daily, Weekly, Monthly, Once every few months, Rarely, Never

Use a joystick? Daily, Weekly, Monthly, Once every few months, Rarely, Never

Use a touch screen? Daily, Weekly, Monthly, Once every few months, Rarely, Never

Use icon-based programs/software?

Daily, Weekly, Monthly, Once every few months, Rarely, Never

Use programs/software with pull-down menus?

Daily, Weekly, Monthly, Once every few months, Rarely, Never

Use graphics/drawing features in software packages?

Daily, Weekly, Monthly, Once every few months, Rarely, Never

Use E-mail? Daily, Weekly, Monthly, Once every few months, Rarely, Never

Operate a radio controlled vehicle (car, boat, or plane)?

Daily, Weekly, Monthly, Once every few months, Rarely, Never

Play computer/video games?

Daily, Weekly, Monthly, Once every few months, Rarely, Never

5. Which type(s) of computer/video games do you most often play if you play at least once every few months?

6. Which of the following best describes your expertise with computer? (check √ one)

_____ Novice
_____ Good with one type of software package (such as word processing or slides)
_____ Good with several software packages
_____ Can program in one language and use several software packages
_____ Can program in several languages and use several software packages

7. Are you in your usual state of health physically? YES NO

If NO, please briefly explain:

8. How many hours of sleep did you get last night? ______ hours

9. Do you have normal color vision? YES NO

10. Do you have prior military service? YES NO If Yes, how long _____

APPENDIX G: SUBJECT KNOWLEDGE PRE-TEST

This is a test of your subject area knowledge. Do not guess. If you don't know the answer, write "I do not know".

1. What is the correct procedure for Engaging Targets using the Line of Sight (LOS) technique?

2. Name three important Robotics NCO Training Tasks

3. Define Line of Sight (LOS) Engagement and give an example:

4. What is the correct procedure for correcting a signal fault with a UAV?

5. Name three tasks you are required to perform when supervising Unmanned Vehicle RSTA Operations:

6. What techniques do you use to engage targets?

7. What is the correct procedure for initially gaining control of the UAV?

8. What is the correct procedure for Engaging Targets once the target survey has been conducted (Cooperative Engagement)?

9. What is the method for Conducting a Target Survey (Acknowledging a Spot Report) with a UAV?

10. Identify four Graphic Control Measures.

11. When do you engage targets?

12. What are the Tactical Principles for Reconnaissance?

13. How do you laze a target with a UGV?

14. Define Graphic Control Measure (GCM)

15. How do you gain control of the UGV Turret?

16. When do you submit reports?

17. What is the correct procedure for Submitting a SITREP?

18. How do you conduct a sensor scan with a UAV?

19. How do you assign a task after you have gained control of the UAV?

20. Define Cooperative Engagement and give an example:

APPENDIX H: TRAINING TASKS

Robotic NCO Training Tasks

- Supervise Unmanned Vehicle Reconnaissance, Surveillance & Target Acquisition (RSTA) Operations
  - Ensure reconnaissance area is properly marked with Graphic Control Measures
  - Ensure that the entire area has been surveyed during the reconnaissance mission and at least 1 ground vehicle has driven the route.
  - Ensure that all targets have been surveyed during the target acquisition process
- Submit Reports
  - Any time there is a change to the tactical situation, based on movement or contact with the enemy. This includes the results of any engagements with the enemy.
- Engage Targets
  - Once a target has been acquired, engage targets using one of two methods: Line of Sight (LOS) or Cooperative Engagement Techniques

Tactical Principles of Reconnaissance

- Find the Enemy
- Avoid Detection
- Make contact with the smallest element possible

Procedures

- **Conduct a Target Survey (Acknowledge Spot Reports).**
  - Scan to Target
  - Laze Target
  - Confirm Spot Report Number and Acknowledge
  - Submit SITREP

- **Submit Situation Report (SITREP)**
  - Select Reports
  - Select Report Type
  - Select Sensor Type
  - Select Appropriate Action

Procedures

Engage Targets using Cooperative Engagement (Call For Fire).

- Select Engagement Button
- Select CFF button
- Await results
- Submit SITREP.

- **Engage Targets using LOS.**
  - Acquire Target
  - Laze Target
  - Engage
  - Submit SITREP

Definitions

- GCM ~ Graphic Control Measure
  - Map Symbol used to assign responsibilities, coordinate fires and maneuver, and control combat operations. Examples are: Assembly Area, Route, Start Point, Release Point, Check Points.
- LOS ~ Line Of Sight
  - LOS is the traditional form of a direct fire engagement used by assaulting elements. The target in a LOS engagement is not masked from the firing platform or soldier and the sensor and shooter are located on the same platform
- Cooperative Engagement
  - Cooperative Engagements are collaborative attacks of a target by two or more platforms, in which the sensor and the shooter are not resident on the same platform or echelon
- UAV ~ Unmanned Aerial Vehicle
  - Type of unmanned platform which carries visual sensors, but no weapons (shooter)
- UGV ~ Unmanned Ground Vehicle
  - Type of unmanned platform which carries visual sensors and weapons (shooter)

Mission

You are the Robotics NCO in a company Command and Control Vehicle (C2V). Your mission is to conduct a route reconnaissance to ensure that it is clear of all enemy forces. You are operating in the enemy's zone and there are no friendly units along the route. You are free to engage the enemy once they are sighted. You have 30 minutes to complete this task.

Mission success is defined as completion of the route reconnaissance, the identification and destruction of enemy elements along the route within 30 minutes.

APPENDIX I: AFTER ACTION REVIEW PROTOCOL

IDF with AAR and AAR Only Feedback Condition groups

1. Time Management ~ 25% of available Time on *What Happened*, 25% of available time on *Why It Happened* and 50% of available time on *How To Fix It*

2. AAR Format:
    a. Review Task/Condition/Standards for Mission (Para 3) & Mission Statement
    b. Review Plan/Tactical Principles (Para 4)
    c. Review *What Happened* and include OPFOR actions
    d. Review *Why It Happened* (Prompts came up because of not executing procedures correctly, selecting ineffective engagement technique, failure to submit reports, etc).
    e. Discuss Key Issues (*How To Fix*)
        i. Procedures for correcting bad practices (3 Items)
        ii. Reinforce good practices (3 Items)
    f. Summarize Standards, Concepts & Key Lessons Learned

3. Robotics NCO Training Tasks:
    a. Supervise Unmanned Vehicle RSTA Operations
        i. Ensure reconnaissance area is properly marked with Graphic Control Measures
        ii. Ensure that the entire area has been surveyed during the reconnaissance mission and at least 1 ground vehicle has driven the route.
        iii. Ensure that all targets have been surveyed during the target acquisition process
    b. Submit Reports
        i. Any time there is a change to the tactical situation, based on movement or contact with the enemy. This includes the results of any engagements with the enemy.
    c. Engage Targets
        i. Once a target has been acquired, engage targets using one of two methods: Line of Sight (LOS) or Cooperative Engagement Techniques

4. Tactical Principles for Reconnaissance
        i. Find the Enemy
        ii. Avoid Detection
        iii. Make contact with the smallest element possible

5. Procedural Knowledge

    a. Submit Situation Report (SITREP): Select Reports, Select Sensor Type, Select Report Type, Select Appropriate Action.
    b. Conduct a Target Survey (Acknowledge Spot Reports): Scan to Target, Laze Target, Confirm Spot Report Number and Acknowledge, Submit SITREP
    c. Engage Targets using Cooperative Engagement (Call For Fire): Select Engagement Button, Select CFF button, await results, submit SITREP.
    d. Engage Targets using LOS: Acquire Target, Laze Target, Engage, Submit SITREP

6. Conceptual Knowledge

    a. Graphic Control Measure (GCM). Map Symbol used to assign responsibilities, coordinate fires and maneuver, and control combat operations. Examples are: Assembly Area, Route, Start Point, Release Point, Check Points.
    b. Line of Sight (LOS) Engagement and give an example ~ LOS is the traditional form of a direct fire engagement used by assaulting elements. The target in a LOS engagement is not masked from the firing platform or soldier and the sensor and shooter are located on the same platform. *Engaging target with the UGV*
    c. Cooperative Engagement and give example ~ Cooperative engagements are collaborative attacks of a target by two or more platforms, in which the sensor and the shooter are not resident on the same platform or echelon. *Engaging target using Call for Fire procedure with the UAV*

7. Script

    a. Review Task/Condition/Standards for Mission (¶ 3 above) & Mission

        i. Supervise RSTA Ops ~
            1. *Could you explain the concept of this idea?*
            2. *What does this remind you of?*

        ii. Submit Reports ~
            1. *What does this mean?*
            2. *What have you done that is similar to this?*

        iii. Engage Targets ~
            1. *Why don't you explain what this sentence means*
            2. *When have you done something like this?*

        iv. Mission ~
            1. *What are the main points of this paragraph?*
            2. *When have you done something like this?*

b. Review Plan/Tactical Principles (¶ 4 above)

   i. *What are you thinking about?*
   ii. *When have you done something like this?*

c. Review *What Happened* and include OPFOR actions
   i. *What does this remind you of?*

d. Review *Why It Happened*
   i. Procedural Knowledge (¶ 5 above)
      1. Conduct a Target Survey (Acknowledge Spot Reports). ~
         a. *Could you explain this procedure in simple terms?*
         b. *When have you done something like this?*
      2. Submit Situation Report (SITREP) ~
         a. *Could you explain this procedure in simple terms?*
         b. *When have you done something like this?*
      3. Engage Targets using Cooperative Engagement (Call For Fire). ~
         a. *What is this related to?*
         b. *When have you done something like this?*
      4. Engage Targets using LOS. ~
         a. *What is this related to?*
         b. *When have you done something like this?*

   ii. Conceptual Knowledge (¶ 6 above)
      1. Graphic Control Measure (GCM). ~
         a. *What does this paragraph mean?*
         b. *What does this remind you of?*
      2. Line of Sight (LOS) Engagement. ~
         a. *What does this mean?*
         b. *Can you give an example?*
         c. *When have you done something like this?*
      3. Cooperative Engagement~
         a. *Can you explain this concept in simple terms?*
         b. *Can you give an example?*
         c. *When have you done something like this?*

APPENDIX J: SUBJECT KNOWLEDGE POST TESTS

Subject Knowledge Post Test Alpha   Test Subject ___________

This is a test of your subject area knowledge. Do not guess. If you don't know the answer, write "I do not know".

1. What is the correct procedure for Engaging Targets using the Line of Sight (LOS) technique?

2. Name three important Robotics NCO Training Tasks

3. Define Line of Sight (LOS) Engagement and give an example:

4. What is the correct procedure for correcting a signal fault with a UAV?

5. Name three tasks you are required to perform when supervising Unmanned Vehicle RSTA Operations:

6. When do you submit reports?

7. What is the correct procedure for Submitting a SITREP?

8. How do you conduct a sensor scan with a UAV?

9. How do you assign a task after you have gained control of the UAV?

10. Define Cooperative Engagement and give an example:

11. What techniques do you use to engage targets?

12. What is the correct procedure for initially gaining control of the UAV?

13. What is the correct procedure for Engaging Targets once the target survey has been conducted (Cooperative Engagement)?

14. What is the method for Conducting a Target Survey (Acknowledging a Spot Report) with a UAV?

15. Identify four Graphic Control Measures.

16. When do you engage targets?

17. What are the Tactical Principles for Reconnaissance?

18. How do you laze a target with a UGV?

19. Define Graphic Control Measure (GCM)

20. How do you gain control of the UGV Turret?

Subject Knowledge Post Test Bravo **Test Subject _________**

This is a test of your subject area knowledge. Do not guess. If you don't know the answer, write "I do not know".

1. Name three tasks you are required to perform when supervising Unmanned Vehicle RSTA Operations.

2. How do you gain control of the UGV turret?

3. Identify four graphic control measures (GCMs).

4. When do you submit reports?

5. What techniques do you use to engage targets?

6. What is the correct procedure for Engaging Targets (LOS)?

7. After gaining control of the UAV, how do you assign it a task?

8. What is the correct procedure for Engaging Targets once the target survey has been conducted (Cooperative Engagement)?

9. Define Line of Sight (LOS) and give an example:

10. What is the correct procedure for Conducting a Target Survey (Ackowledging a Spot Report) with a UAV?

11. When do you engage targets?

12. How do you submit a SITREP?

13. Define Cooperative Engagement and give an example:

14. What is the correct procedure for initially gaining control of the UAV?

15. How do you laze a target with a UGV?

16. Name the Tactical Principles for Reconnaissance.

17. How do you conduct a sensor scan with a UAV?

18. What is the correct procedure for correcting a signal fault with a UAV?

19. Define Graphic Control Measure (GCM)

20. Name three important Robotics NCO Training Tasks.

Subject Knowledge Post Test Charlie **Test Subject________**

This is a test of your subject area knowledge. Do not guess. If you don't know the answer, write "I do not know".

1. What techniques do you use to engage targets?

2. What is the correct procedure for correcting a signal fault with a UAV?

3. How do you gain control of the UGV Turret?

4. What are the Tactical Principles for Reconnaissance?

5. How do you laze a target with a UGV?

6. Define Line of Sight (LOS) Engagement and give an example:

7. Define Graphic Control Measure (GCM)

8. What is the correct procedure for Engaging Targets using the Line of Sight (LOS) technique?

9. Name three important Robotics NCO Training Tasks

10. Name three tasks you are required to perform when supervising Unmanned Vehicle RSTA Operations:

11. How do you conduct a sensor scan with a UAV?

12. What is the correct procedure for Submitting a SITREP?

13. When do you submit reports?

14. How do you assign a task after you have gained control of the UAV?

15. Define Cooperative Engagement and give an example:

16. What is the correct procedure for initially gaining control of the UAV?

17. What is the correct procedure for Engaging Targets once the target survey has been conducted (Cooperative Engagement)?

18. What is the method for Conducting a Target Survey (Acknowledging a Spot Report) with a UAV?

19. Identify four Graphic Control Measures.

20. When do you engage targets?

Subject Knowledge Post Test Delta **Test Subject _________**

This is a test of your subject area knowledge. Do not guess. If you don't know the answer, write "I do not know".

1. Name three tasks you are required to perform when supervising Unmanned Vehicle RSTA Operations:

2. What is the correct procedure for Conducting a Target Survey (Acknowledging a Spot Report) with a UAV?

3. What are the Tactical Principles for Reconnaissance?

4. What is the correct procedure for initially gaining control of the UAV?

5. What is the correct procedure for correcting a signal fault with a UAV?

6. When do you submit reports?

7. How do you conduct a sensor scan with a UAV?

8. What is the correct method for Engaging Targets (LOS)?

9. When do you engage targets?

10. Identify four Graphic Control Measures.

11. Define Cooperative Engagement and give an example:

12. What techniques do you use to engage targets?

1. Name three important Robotics NCO Training Tasks:

14. What is the correct procedure for Engaging Targets once the target survey has been conducted (Cooperative Engagement)?

15. Define Line of Sight (LOS) Engagement and give an example:

16. How do you gain control of the UGV Turret?

17. Define Graphic Control Measure (GCM)

18. What is the correct procedure for Submitting a SITREP?

19. How do you physically laze a target with a UGV?

20. How do you assign a task after you have gained control of the UAV?

Correct Answers for all Subject Knowledge Tests

1. ***Procedural Knowledge (PK)*** What is the correct procedure for Engaging Targets using the Line of Sight (LOS) technique?

    - Acquire Target, Laze Target, Engage, Submit SITREP

2. ***Conceptual Knowledge (CK)*** Name three important Robotics NCO Training Tasks

    - Supervise (Unmanned Vehicle) RSTA Operations, Submit Reports, Engage Targets

3. ***(CK)*** Define Line of Sight (LOS) Engagement and give an example:

    - LOS is the traditional form of a direct fire engagement used by assaulting elements. The target in a LOS engagement is not masked from the firing platform or soldier and the sensor and shooter are located on the same platform. *Engaging target with the UGV*

4. ***(PK)*** What is the correct procedure for correcting a signal fault with a UAV?

    - Touch UAV Camera symbol on screen twice

5. ***(CK)*** Name three tasks you are required to perform when supervising Unmanned Vehicle RSTA Operations:

    - Ensure reconnaissance area is properly marked with Graphic Control Measures, Ensure that the entire area has been surveyed during the reconnaissance mission and at least 1 ground vehicle has driven the route, Ensure all targets have been surveyed during the target acquisition process

6. ***(CK)*** When do you submit reports?

    - Any time there is a change to the tactical situation, based on movement or contact with the enemy. This includes the results of any engagements with the enemy.

7. ***(PK)*** What is the correct procedure for Submitting a SITREP?
    - Select Reports, Select Sensor Type, Select Report Type, Select Appropriate Action.
        - Examples
            - Touch "Reports" , "UAV", "Location" and "Check Point" buttons
            - Touch "Reports" , "Tele-Op", "Activity" and "Veh Obs" buttons

8. ***(PK)*** How do you conduct a sensor scan with a UAV?

    - Select "sensor view" button and manipulate the view using directional buttons.

9. ***(PK)*** How do you assign a task after you have gained control of the UAV?

    - Touch "assign task" button and assign an appropriate task (fly, hover, land)

10. ***(CK)*** Define Cooperative Engagement and give an example:

    - Cooperative engagements are collaborative attacks of a target by two or more platforms, in which the sensor and the shooter are not resident on the same platform or echelon. *Engaging target using Call for Fire procedure with the UAV*

11. ***(CK)*** What techniques do you use to engage targets?

    - Line of Sight and Cooperative Engagement

12. ***(PK)*** What is the correct procedure for initially gaining control of the UAV?

    - Touch the UAV Symbol on left bottom screen and then touch "control" button

13. ***(PK)*** What is the correct procedure for Engaging Targets once the target survey has been conducted (Cooperative Engagement)?

    - Select "Engagement" button, select "CFF" button, await results, submit SITREP. **OR**
    - Call For Fire, await results, submit SITREP

14. ***(PK)*** What is the method for Conducting a Target Survey (Acknowledging a Spot Report) with a UAV?

    - Scan to Target, Laze Target, Confirm Spot Report Number and Acknowledge, Submit SITREP

15. ***(CK)*** Identify four Graphic Control Measures.

- Assembly Area, Start Point , Release Point, Route, Check Points

16. ***(CK)*** When do you engage targets?

- Once a target has been acquired or
- Once you have acknowledged the target or
- After scanning, lazing, acknowledging and submitting a SITREP

17. ***(CK)*** What are the Tactical Principles for Reconnaissance?

- Find the Enemy, Avoid Detection, Make contact with the smallest element possible

18. ***(PK)*** How do you laze a target with a UGV?

- Align cross hairs (reticle sight) on the target and depress "Laze" button on the operator's yoke

19. ***(CK)*** Define Graphic Control Measure (GCM)

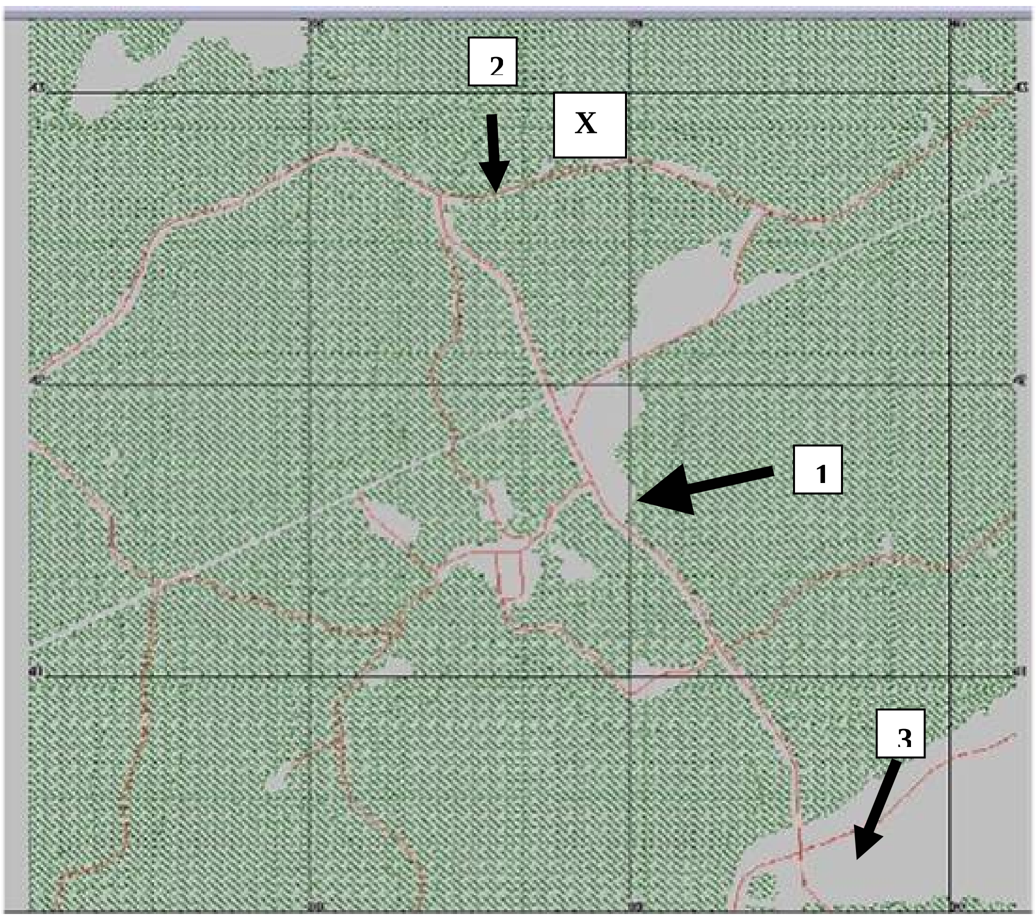
- Directives given by Commanders to subordinate commands to assign responsibilities, coordinate fires and maneuver, and control combat operations. Anything dealing with the control of movement

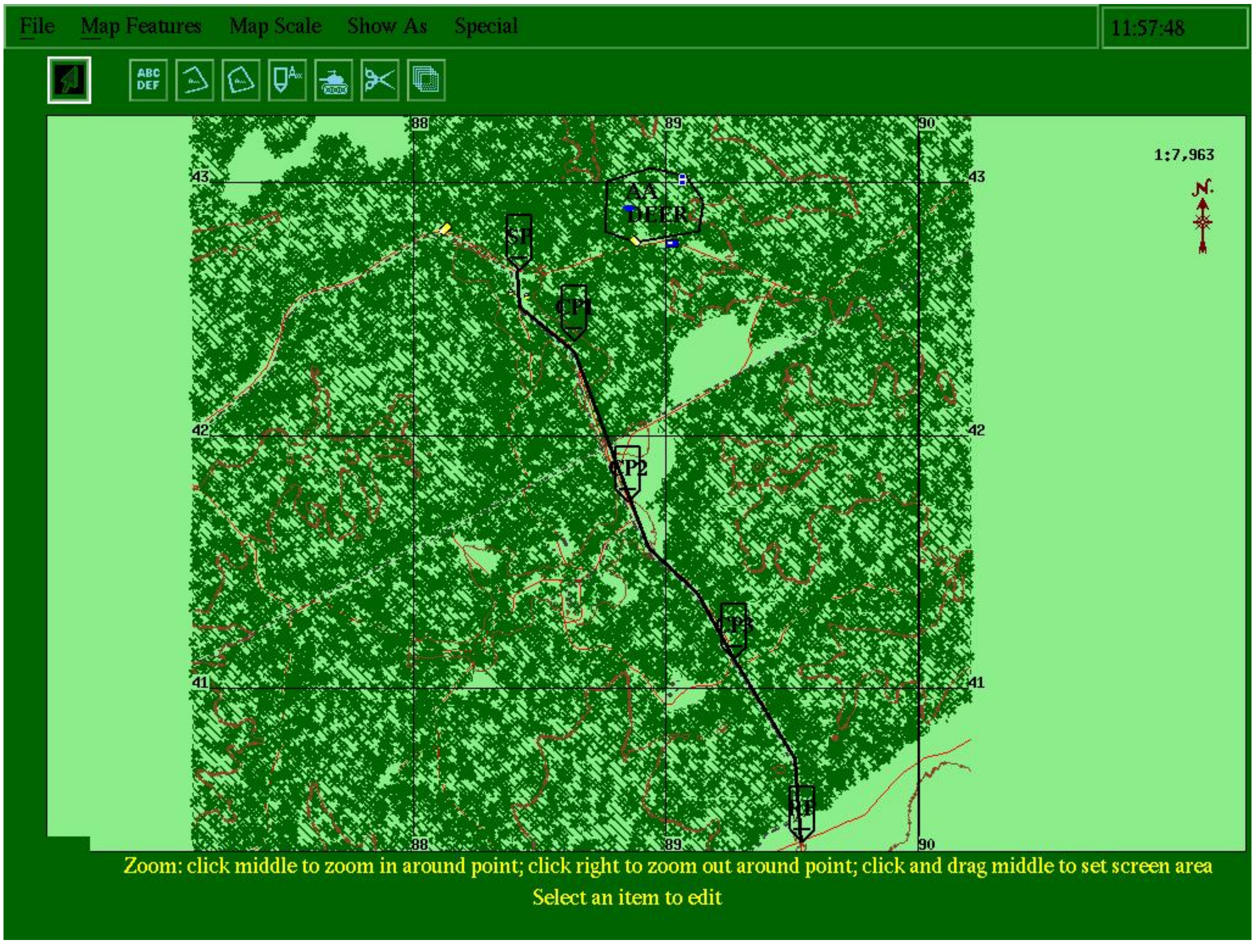
20. ***(PK)*** How do you gain control of the UGV Turret?

- Depress palm grips on the operator's yoke.

APPENDIX K: TRANSFER TASK PLANNING

Your task is to plan a reconnaissance of this road (1 ~ Major North-South road on map) from this road intersection (2 ~ East-West Road in North with North-South Road) to this road intersection (3 ~ East-West Road in South with North-South Road). You have two robotic assets, and they are generally located in this area (North and East of 1st road intersection ~ X marks the spot). Use the appropriate Graphic Control Measures, map symbols, when you plan your reconnaissance. Name the Graphic Control Measures, either by spelling them out or using the appropriate abbreviations. Do you have any questions?





This Transfer Task (Map) was evaluated using the following scale: one point for the correct use of the GCM symbol type (five points), one point for the correct naming of each GCM symbol type (five points) for a total possible score of 10 points.

APPENDIX L: TRANSFER TASK QUESTIONS

1. What type of graphic control measures did you use as you planned your route? What Tactical Principles of Reconnaissance or Training Tasks were involved in your planning?

2. **You have 30 minutes to conduct a Route Reconnaissance. Write a mission statement.** What is your mission? How do you know that you have successfully completed the mission?

3. What would you do if you found enemy forces along this route? What Procedures, Techniques or actions would you take?

Answer Key for Transfer Questions

1. (Concept Knowledge Application). What type of graphic control measures did you use as you planned your route? What Tactical Principles of Reconnaissance or Training Tasks were involved in your planning? (11 points possible)

- Assembly Area, Start Point, Check Point(s), Release Point, Route (5 x 1 point = 5 points)
- Find the Enemy, Avoid Detection, Make Contact with the smallest element possible (3 x 1 point = 3 points)
- Supervise (Unmanned Vehicle) RSTA Operations, Submit Reports, Engage Targets (3 x 1point = 3 points)

2. (Concept Knowledge Application). You have 30 minutes to conduct a Route Reconnaissance. Write a mission statement. What is your mission? How do you know that you have successfully completed the mission? (5 points possible)

- Conduct a Route Reconnaissance within 30 minutes (1 Point)
- Ensure that the route is properly marked with GCMs; Ensure that the entire area has been surveyed and at least 1 ground vehicle has driven the route; Ensure all targets within the recon area have been surveyed (identified) during the target acquisition process (3 x 1 point = 3 points)
- All identified targets have been destroyed (1 point)

3. **(Procedural Knowledge Application).** What would you do if you found enemy forces along this route? What Procedures, Techniques or actions would you take? (6 points possible)

- Scan to Target (find), Laze Target, Confirm Spot Report , Submit SITREP (4 x 1 point = 4 points)
- Engage targets using any of the following methods: Line of Sight or Cooperative Engagement (2 x 1 point = 2 points)

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