Technical Report 1303

Adaptive and Nonadaptive Training Technology for Small Unmanned Aerial System Employment

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14.ABSTRACT (*Maximum 200 words):*

The purpose of the research and development described here was to compare the effectiveness of adaptive and one-size-fits all technology-enabled training, holding all factors besides the adaptation constant. Adaptive features included selection of up-front instruction based on pretest performance, branching scenario-based decision making, and within-scenario remediation. The domain for the training was company and below employment of small unmanned aerial systems (SUAS). In particular, the training content was selected to provide leaders at company and below the knowledge required to integrate SUAS operation into their missions, conduct relevant troop leading procedures, and supervise execution of SUAS flights. There failed to be a significant difference in learning outcomes between the adaptive and the nonadaptive versions, when tested with 24 Soldiers; however, there were learning gains with both systems, and Soldiers appraised the training effectiveness of the adaptive system to be superior to that of the nonadaptive system.

15. SUBJECT TERMS

adaptive training, branching, learning objectives, learning outcomes, feedback, remediation, scenario, SUAS, technology, pretest, posttest

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ADAPTIVE AND NONADAPTIVE TRAINING TECHNOLOGY FOR SMALL UNMANNED AERIAL SYSTEM EMPLOYMENT

EXECUTIVE SUMMARY

Research Requirement:

The U.S. Army Learning Concept for 2015 (ALC 2015), TRADOC Pamphlet 525-8-2 (TRADOC, 2011) lays out a vision for how the Army will train and educate Soldiers to execute full-spectrum operations in an era of persistent conflict. Learning outside the classroom will play an increasingly key role. Innovative learning technologies and methods will be required to make self-directed learning effective and efficient. To accomplish this, it will be necessary to identify state-of-the-art adaptive training capabilities, and develop standards, protocols, and guidance on employing these capabilities in interactive multimedia instruction (IMI) modules. To this end, this report describes research comparing the effectiveness of two versions of a training system, one adaptive and the other nonadaptive (one-size-fits-all). The domain addressed was small unmanned aerial system (SUAS) employment aimed at leaders at company and below.

Procedure:

An adaptive training prototype system was developed to provide instruction and decision-making practice for the domain of employment of SUAS at company and below. In particular, the training content was selected to provide leaders at company and below the knowledge required to integrate SUAS operation into their missions, conduct relevant troop leading procedures, and supervise execution of SUAS flights. Adaptive features included selection of up-front instruction based on pretest performance, branching scenario-based decision making, and within-scenario remediation. A parallel nonadaptive training system was also developed. Twenty-four Soldiers were provided experience with one of the two versions and then took a post-training test, identical to the pretest. They also completed questionnaires on their opinions of the training experience.

Findings:

The posttest results were inconclusive with respect to the benefits of adaptation on training outcomes. There failed to be a significant difference in learning outcomes between the adaptive and the nonadaptive versions; however, there were learning gains with both systems, and Soldiers appraised the training effectiveness of the adaptive system to be superior to that of the nonadaptive system.

Utilization and Dissemination of Findings:

Although the results of the experiment examining learning outcomes after adaptive training vs. nonadaptive training were inconclusive, these results can only speak to the particular implementation of adaptive training tested. They do not necessarily indicate that adaptive training, in general, is not beneficial. Our implementation may have failed to produce the desired

results because during scenario-remediation consisted of abstract content rather than specific remediation related to the scenarios. Another possibility is that our learning outcome measure may have been insufficiently sensitive to detect differences in degree of learning.

Both versions of the training produced evidence of learning gains. Therefore, for purposes of actual training, there is the potential to utilize the training prototypes and/or to invest in their further development for purposes of training SUAS employment for leaders at company and below. Because Soldiers who experienced the adaptive training prototype rated it more positively than those who experienced the nonadaptive prototype, we recommend that any further development utilize that version.

Briefings on this work have been provided to the Future Force Integration Directorate, Fort Bliss, TX, and the Maneuver Center of Excellence Directorate of Combat Development, the SUAS School at Fort Benning, and the Institute for NCO Professional Development. Results relating to this work have been presented at the following conferences: Florida Artificial Intelligence and Research Society (May 2010), Applied Human Factors and Ergonomics Society (July 2010), Army Science Conference (December 2010), and ITEC 2011 (May, 2011).

ADAPTIVE AND NONADAPTIVE TRAINING TECHNOLOGY FOR SMALL UNMANNED AERIAL SYSTEM EMPLOYMENT

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ADAPTIVE AND NONADAPTIVE TRAINING TECHNOLOGY FOR SMALL UNMANNED AERIAL SYSTEM EMPLOYMENT

Introduction

The U.S. Army Learning Concept for 2015 (ALC 2015), TRADOC Pamphlet 525-8-2 (TRADOC, 2011) lays out a vision for how the Army will train and educate Soldiers to execute full-spectrum operations in an era of persistent conflict. Learning outside the classroom will play an increasingly key role. Innovative learning technologies and methods will be required to make self-directed learning effective and efficient. To accomplish this, it will be necessary to identify state-of-the-art adaptive training capabilities, and develop standards, protocols, and guidance on employing these capabilities in interactive multimedia instruction (IMI) modules. To this end, this report describes research comparing the effectiveness of two versions of a training system, one adaptive and the other nonadaptive (one-size-fits-all). The domain addressed was small unmanned aerial system (SUAS) employment aimed at leaders at company and below.

There is strong empirical support that one-on-one instruction by a human mentor is superior to traditional classroom-based approaches (e.g., Bausell, Moody & Walzl, 1972; Bloom, 1984). During one-on-one instruction, the mentor has the ability to adapt instructional content and style as deemed most suitable to the individual student. A classroom teacher, having to deal with a collection of individuals, rarely has this capability. It has been assumed that the ability of the mentor to adapt spontaneously to the student is one of the main reasons for the superiority of one-on-one instruction. By analogy, it has been assumed that for technology-based instruction, software that can adapt content or instructional style for each individual student should be superior to one-size-fits all methods. A human mentor has multiple methods of adapting to the student and can switch easily among them; however, for technology-based instruction, teaching methods and the rules for when to apply different methods need to be decided at design time. This is a challenge because there is a lack of causal evidence about what methods are most effective under different conditions (Durlach & Ray, 2011; Ohlsson, et al., 2007). Many different methods have been implemented, often in combination. Both Durlach and Ray (2011) and Vandervaetere, Desmet, and Clarebout (2011) reviewed adaptive instructional technologies, and found considerable variation in system design and sparse data related to empirical effectiveness with respect to enhancing learning outcomes.

One of the difficulties in evaluating whether automated adaptive techniques have the intended benefits on learning outcomes compared to nonadaptive technology-based approaches has been the lack of an appropriate baseline condition against which the adaptive system can be compared. Comparing learning outcomes from such a system with an entirely different form of instruction (e.g., classroom) is not adequate to answer this question, because the two methods differ in many ways besides the software-based adaptations. Two versions of the same technology-based instruction, which differ only in the adaptive techniques used, is what is required. The purpose of the research presented here was to design two parallel instructional prototypes that fit this requirement, and then to test their relative effects on learning.

A few experiments with analogous intentions already exist in the literature (Durlach & Ray, 2011). For example, Perrin, Dargue, and Banks (2003) conducted an experiment in which they compared nonadaptive training on export control rules with four different ways of implementing adaptive training. The training audience consisted of company employees taking a refresher course, having had training two years previous. In the Control (nonadaptive) condition, students went through multimedia instruction and practical exercises in a linear fashion. They were given intermittent assessments with feedback; but, their performance on these assessments did not affect their path through the material. Learners in this condition could initiate review of already presented information at their own discretion. In the Mastery Learning condition, students were not only required to go through the multimedia instruction; they were also required to review material related to items they got incorrect during the intermittent assessments. After this review, they were reassessed before being able to progress. A second adaptive condition, Loop-Back Remediation was similar to the Mastery Learning condition, but with an additional adaptation: incorrect use of previously mastered material led to required remedial review of that material. So, for example, if an error was made on an assessment, students not only had to review material relevant to the unchosen correct option, they also had to review material relevant to the chosen incorrect option. The third adaptive condition was the Pretest condition. Learners in this condition received the same treatment as the Loop-Back Condition; however, prior to training they took a knowledge test, which allowed them to skip initial multimedia content related to items passed on the pretest. Finally, the fourth condition, Advanced Placement, was also identical to the Loop-Back condition, except that the first phase of instruction (covering the first seven learning objectives) was simply omitted.

Learners in the Mastery Learning and the Loop-Back conditions performed significantly better on a training posttest, compared to the Control condition, confirming the prediction that adaptive training would be superior to nonadaptive training. However the scores for the Pretest and Advanced Placement conditions, also adaptive treatments, failed to be statistically superior to the Control condition. Thus, allowing students to skip instruction based on either assumed knowledge (Advanced Placement) or prior testing results (Pretest), turned out to interfere with the beneficial effects of the loop-back strategy. This was likely because the loop-back strategy was only applied to presented material. The Advanced Placement and Pretest conditions skipped some material (and assessments). Consequently, there was no opportunity to detect knowledge gaps that were attributed mistakenly as known until the posttest. For example, for the Pretest condition, lucky correct guesses on the pretest would allow the student to skip relevant didactic instruction (and its related assessment). Material on the same topic would not be tested again until the posttest. Thus, for the Advanced Placement and Pretest conditions, un-mastered learning objectives incorrectly assumed as mastered were never remediated.

In the present research, the adaptive condition allowed students to skip didactic instruction associated with pretest knowledge components answered correctly, just as in Perrin, Dargue, and Banks' (2003) Pretest condition; however, they subsequently went on to complete scenario-based exercises. Substandard performance during these exercises induced remediation. Thus, these scenario-based exercises could catch any knowledge that had been incorrectly inferred as known (as a result of lucky guessing on the pretest). In the nonadaptive condition, students also completed the pretest, but only for purposes of evaluation. They were required to review all the didactic instruction regardless of their pretest performance. They then went on to complete the scenario-based exercises. All trainees completed a posttest, which was identical to the pretest. The aim was to evaluate whether greater pretest to posttest learning gains would be observed in the adaptive condition compared with the nonadaptive condition, or whether equivalent gains would be observed but in less time in the adaptive condition compared with the nonadaptive condition.

Knowledge Domain

The domain covered by the training prototype was SUAS employment for Army leaders at company and below. Unmanned aerial systems are considered 'small' if they are man-portable and their employment does not require an established infrastructure (such as a runway or airport). It has been envisioned that SUAS will be operated by privates through sergeants (Office of the Secretary of Defense, 2002); but, more senior personnel will decide when and how to employ SUAS. These more senior members of the operator's unit will be the ones who plan and supervise SUAS missions. Consequently, company commanders, platoon leaders and platoon sergeants need training on the factors they ought to consider in the use of SUAS, including potential risks and benefits, and coordination with other users of the air space (Durlach, 2007). Thus, the focus of the training was on procedures of SUAS employment and principles of operation at company or troop level as part of a battalion or squadron mission. This includes synchronizing the use of the SUAS into the overall tactical plan in accordance with higher commander's intent, taking into account Mission, Enemy, Time, Terrain/Weather, Troops Available, and Civil Considerations (METT-TC). It also includes understanding air space coordination procedures: integration and synchronization of the SUAS mission within the constraints posed by other users of the air space.

Training Audience

The training audience was intended to include Maneuver Company Commanders (CO), Executive Officers (XO), Platoon Leaders (PL), Robotics noncommissioned officers (NCO) or SUAS Team Leaders (E6/E7); in other words, any personnel in charge of planning, preparing for, and/or supervising the execution of SUAS missions.

Domain Analysis

The domain analysis was conducted by two Boeing analysts. They gathered relevant reference materials and marshaled their own military experience to conduct a task analysis. Two primary sources were: *Leader's Guide to A2C2 at Brigade and Below* (Center for Army Lessons Learned, 2005), and a task analysis conducted under the Future Combat System project for the task Synchronize Planning of Air-Ground Operations for Company and Platoon. A comprehensive list of references is provided in Appendix A. The goal of the task analysis was to determine what the training audience must know in order to employ a SUAS, and then to create tactical scenarios employing SUAS assets requiring decision-making based on that knowledge. Decision points in the scenarios were designed to tap knowledge of generic SUAS tactics, techniques, and procedures (TTPs); technical information concerning the capabilities of a specific SUAS would be available in reference material if needed to make a decision. So for example, a decision might require knowledge that weather considerations are important; the specific weather conditions under which the particular SUAS could or could not fly were available as reference materials and were not part of what was to be learned.

The task analysis resulted in nine terminal learning objectives (TLOs). These are listed below, with their associated enabling learning objectives (ELOs).

1. SUAS Role in Operations: Understand the role of the SUAS in the overall tactical plan/operation.

- Attack, Defense, Security, Civil Operations
- Reconnaissance and Surveillance
- Target Acquisition and Battle Damage Assessment
- Security

2. Tactical Control Measures: Understand common company and battalion tactical control measures.

- Named area of interest
- Axis of advance
- Battle position
- Engagement area
- Attack by fire position
- Observation post

3. Procedural Airspace Controls: Understand the three types of procedural airspace separation.

- Lateral separation
- Temporal separation
- Vertical separation

4. SUAS Mission requests: understand the two types of mission requests and the three types of missions.

- Planned
- Immediate
- Dynamic

5. Importance of airspace coordination: Understand the importance of airspace coordination.

- Other unmanned aerial vehicles
- Manned aircraft
- Direct and indirect fires

6. Importance of coordination to support situational awareness: Understand the importance of coordinating with other units potentially affected by SUAS operations.

- Other units (higher, lower, adjacent)
- Observations and reporting
- Battle Damage Assessment

7. Understand the airspace environment: Understand the risks in the airspace environment.

- Powerlines and manmade structures
- Communications interference
- Low altitude civilian aircraft
- Close combat attack aviation
- Terrain and line of sight
- Positive control and data links
- Enemy air defense
- Close air support
- Weather

8. Procedural controls: Understand the procedural control measures used in the airspace.

- Formal and informal airspace coordination areas
- Restrictive fire areas and lines, no fire areas
- Common reference system
- Air control point
- Air corridors
- Coordinating altitude
- Restricted operating zones and areas
- Minimum risk corridor

9. Brigade responsibilities: Understand the roles and responsibilities for airspace coordination at the brigade and battalion levels.

- Mission authorization
- Battalion staff responsibilities
- Company responsibilities
- Emergency procedures

Appendix B provides the linkage between these learning objectives and the source materials from which they were derived.

Scenario Development

The scenarios developed for the training prototype consisted of Plan, Prepare, and Execute phases. The goal in scenario development was to identify key decision points within each phase, which would require knowledge of the learning objectives. Generic scenario decision points for each of these phases are listed in Table 1. These decision points were used as a framework to develop two scenarios, an offense and a defense scenario.

Table 1. *Generic Decision Points for each Phase of a Scenario*

PLAN
• Decision Point #1 – Analysis of Commander's Intent in relation to SUAS operations • Decision Point #2 – Development of Flight Plan • Decision Point #3 – Development of Actions on Objective • Decision Point #4 – Development of Launch/Recovery/Next Operations Transition
PREPARE
• Decision Point #5 - Rehearsal • Decision Point #6 – Communications Checks/Contingency Plans for Positive Control • Decision Point #7 - Emergency Destruction Contingency/Change of Mission
EXECUTE
• Decision Point #8 – Synchronization of Fires and Maneuvers • Decision Point #9 – Support Changes to maneuver plan • Decision Point #10 – Avoid & Reduce SUAS fratricide • Decision Point #11 – Support Attack – High Payoff Targets – Target Acquisition

The two Boeing employees who conducted the task analysis also developed the scenarios. Both scenarios began by presenting the student with a description of the mission situation, with information relevant to commander's intent. For example, the offense scenario began with presentation of a tactical map and the following description:

> SITUATION: *Tm A/1-52 Inf: Mission is to attack and destroy an enemy platoon on the outskirts of a small village during limited visibility conditions (e.g. night). Bn Cdr Intent: The destruction of the enemy positioned (OBJ CROSS) near the village is vital to the overall battalion mission. The momentum of the attack to OBJ JAB (Bn's Objective) must not be slowed by enemy fires from OBJ CROSS. End State: After destruction of the enemy, TM A establishes a blocking position on the avenue of approach passing through the village. The Bn Cdr directs that reconnaissance plans be focused on identification of enemy anti-tank guided missiles positions.*

Each decision point in the scenario involved a situation update and a request for a decision. An ideal choice (according to existing doctrine) was decided during initial scenario development. Once this scenario "trunk" was developed, the scenario developers went back and created three alternative choices for each decision point. The aim was that each decision point have an optimal choice, two acceptable choices, and one unacceptable choice. For the adaptive version of the prototype, the acceptable choices allowed the student to deviate from the trunk and enter a scenario branch. For decision points on the branches, selecting an acceptable choice continued on the branch or returned the student to the trunk. This ability to return to the trunk allowed the degree of branching to be kept manageable. Figure 1 illustrates the branching structure for the offense scenario.

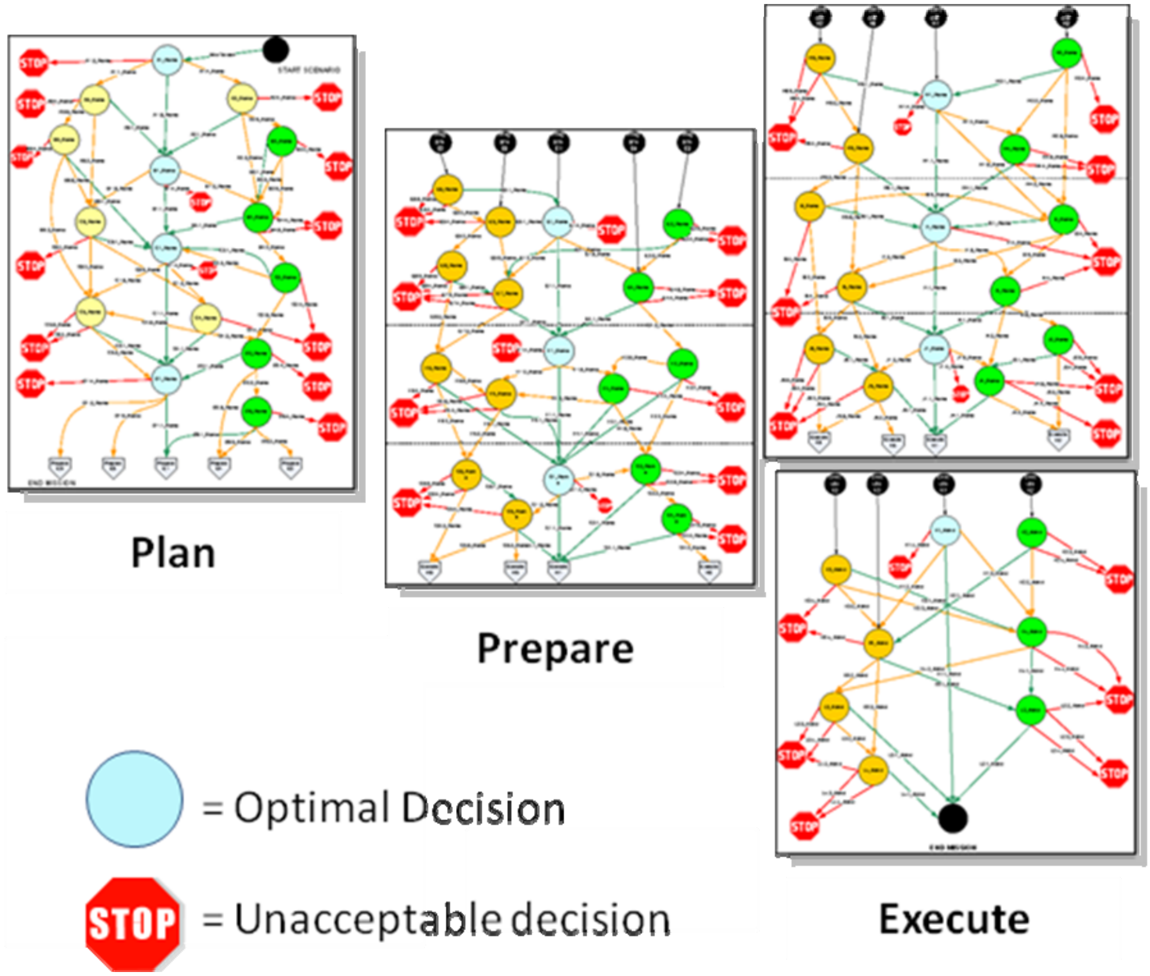

Figure 1. Illustration of the branching structure of the adaptive offense scenario. If the student chose an unacceptable option at a decision point, they were given feedback and were required to choose a different option. In the nonadaptive condition, students were kept on the optimal path (trunk), regardless of which decision they chose.

Table 2 provides an example decision point (the first decision point in the offense scenario). For each option, scenario developers also created a feedback message for each choice, also illustrated in Table 2. Feedback was accompanied by a green, yellow, or red graphic for optimal, acceptable, and unacceptable decisions, respectively.

For each decision, scenario authors created three levels of hints, also illustrated in Table 2. While making a decision a student (in either condition) could request the first hint, "for free." Requests for additional hints incurred a cost to their scores.

Table 2. *Textual Elements Contributing to a Decision Point, Using the First Decision Point in the Offense Scenario.Decision Points also Included a Graphic, Usually a Tactical Map*

SITUATION
Tm A/1-52 Inf: Mission is to attack and destroy an enemy platoon on the outskirts of a small village during limited visibility conditions (e.g. night). Bn Cdr Intent: The destruction of the enemy positioned (OBJ CROSS) near the village is vital to the overall battalion mission. The momentum of the attack to OBJ JAB (Bn's Objective) must not be slowed by enemy fires from OBJ CROSS. End State: After destruction of the enemy, TM A establishes a blocking position on the avenue of approach passing through the village. The Bn Cdr directs that reconnaissance plans be focused on identification of enemy anti-tank guided missiles positions.
QUESTION
You are the Company Cdr/XO. Based on Bn Cdr's intent for your assigned mission, what should be the primary task of the SUAS Team to support the attack at OBJ CROSS?
OPTION 1 (Optimal)
Primary Intent is Location of Enemy Weapons Locations
Feedback if Option 1 selected: The CDR's INTENT states the enemy must be destroyed. Enemy crew-served weapons are the key to the enemy defense. Knowledge of their location and destruction will neutralize the enemy's capability to defend. The Commander stresses this critical need in his reconnaissance guidance. SUAS execute the company reconnaissance plan.
OPTION 2 (leads to a branch)
Primary Intent is Identification of Enemy Activity
Feedback if Option 2 selected: Enemy activity often is indicative of enemy intent and capabilities; the responsiveness to the Cdr's Intent with respect to enemy locations should be considered.
OPTION 3 (leads to a branch)
Primary Intent is Location of Enemy Obstacles
Feedback if Option 3 selected: Knowledge of location of enemy obstacles aids in determining an enemy defensive plan. Enemy fires habitually cover obstacles so friendly forces are channeled into kill zones. Knowledge of obstacle locations is an indirect method of locating enemy weapons. After location of enemy weapons, location of obstacles is a secondary priority for offensive reconnaissance.
OPTION 4 (unacceptable)
Primary Intent is ID of Enemy Command Post
Feedback if Option 4 selected: CP location is useful intelligence. But it is not relevant intelligence needed for destruction of enemy weapons. Back up and choose another.
HINTS
Level 1: Who is the primary unit who needs the RSTA information and what information do they need?
Level 2: Why is the RSTA information important to the Battalion and Company missions?
Level 3: Who turns the sensor data into actionable intelligence?

The scenario developers determined how selection of any given decision choice should update student scores. Student scores were represented in an array with one number for each ELO. This array is the student model. The student model is updated immediately after each problem-solving decision, and therefore represents, at any point in time during the training, the student's estimated level of mastery on each of the ELOs. A one-to-many relationship was allowed between a decision choice and the ELO updates. In other words, a particular student response could cause updating of more than one ELO. For optimal choices, all related ELOs were impacted positively; and for unacceptable choices, all the related ELOs were impacted negatively. For acceptable, but non-optimal choices, some ELOs could be impacted positively, while others could be impacted negatively. The degree of impact each choice had on its related ELO scores was not necessarily equal. The positive or negative increment made to a particular ELO depended on how strongly the decision point was relevant to that ELO, according to the scenario author.

Implementation of the Adaptive Prototype

The adaptive training prototype was developed by Boeing, using a combination of commercial-off-the-shelf (e.g., Microsoft Excel), open source (e.g., AuthorPOINT, Mind On Sight Solo), and Boeing in-house tools. The prototype is fully conformant and compliant to SCORM 2004, and can be run in a web-based learning management system (LMS). The LMS used for prototype testing was an open source system called ILIAS (see http://www-ilias.cea.fr). Figure 2 gives an overview of the analysis, design and implementation processes, indicating where different tools were used in the various processes.

Scenario Flow

Scenario flow is fairly straight forward for a student who makes only optimal or acceptable choices and whose performance remains above threshold. As previously described, each scenario begins by presenting the student with a description of the mission situation, with information relevant to commander's intent. This is followed by a series of decision points, where each decision point provides a situation update and a request for a decision choice from among four options (one optimal, two acceptable, and one unacceptable). Before deciding, the student can ask to look at reference material (including a glossary, the scenario mission statement, and SUAS specifications), or request a hint. Asking for one hint has no effect; however asking for a second hint halves the positive ELO credits the student gets for a subsequent acceptable choice. If the student requests all three of the available hints, they get no credit for a subsequent choice. They also get a "strike" against the relevant TLO(s).

If the student has selected the optimal or an acceptable decision option, the system updates the student model (modulated by the number of hints requested) and provides the appropriate feedback. The student then advances to the next decision point. This continues until the student completes the scenario, at which point they are presented with a performance summary. Figure 3 illustrates the information provided in the performance summary.

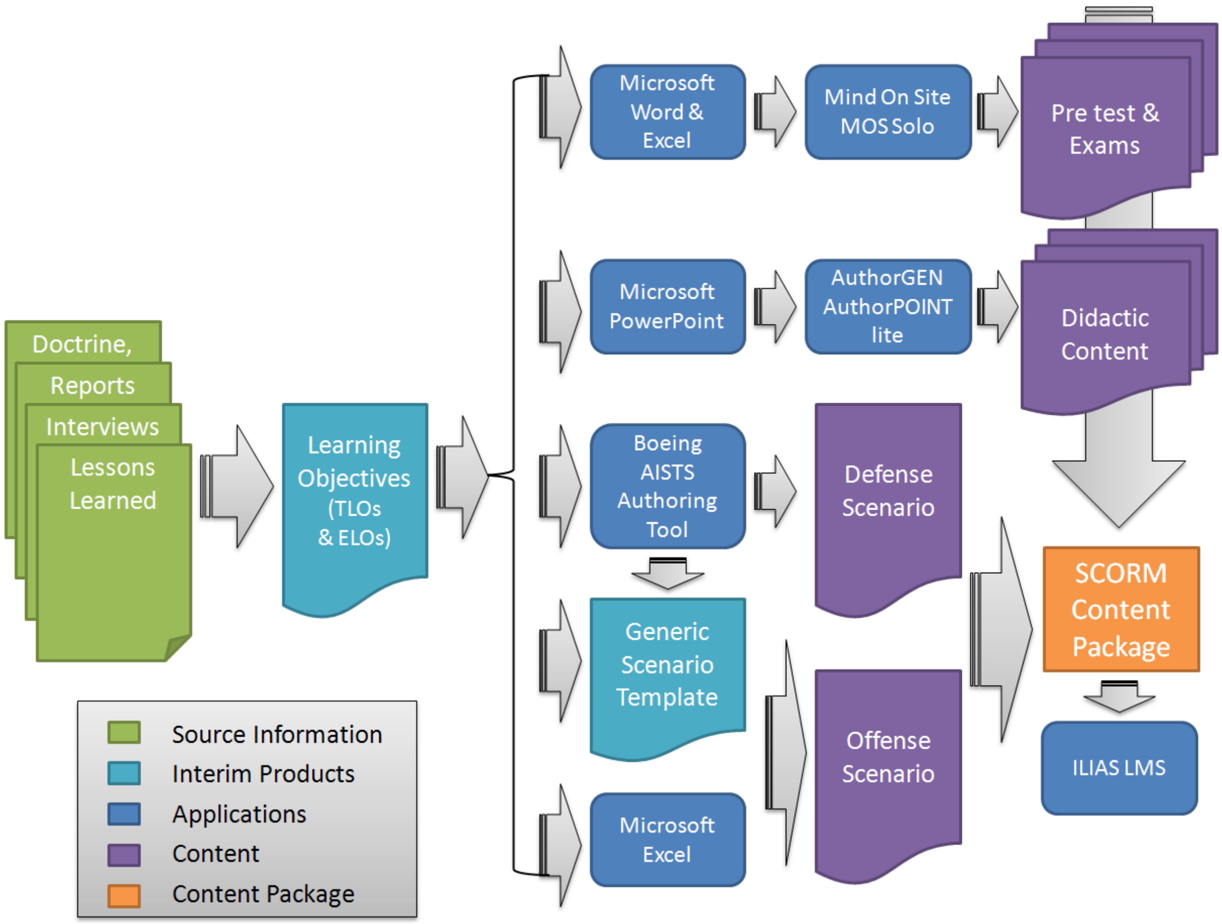

Figure 2. Overview of analysis, design, and implementation process.

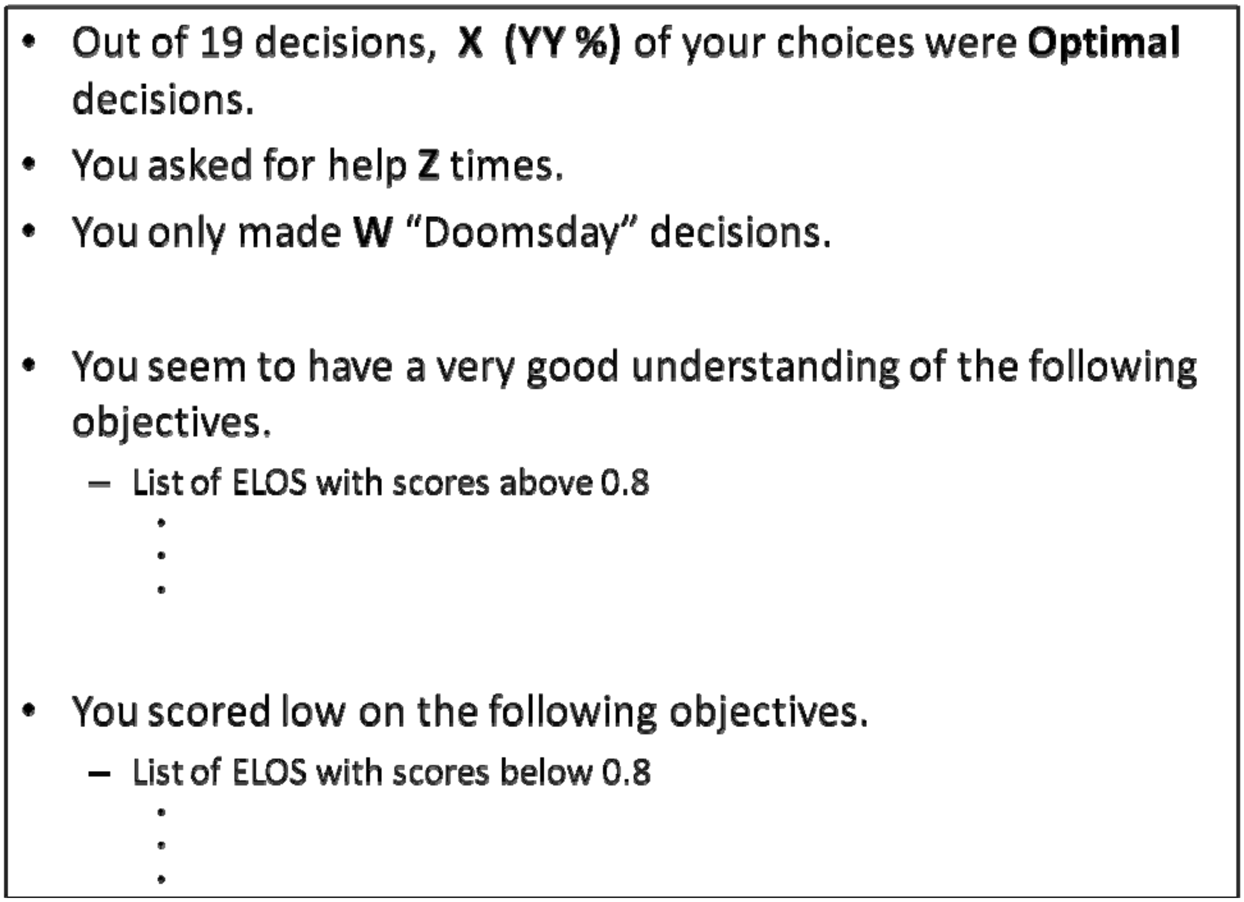

Figure 3. Schematized version of the performance summary provided after completion of a scenario.

If the student selects an unacceptable option, the system updates the student model, provides feedback, instructs the student to make a different choice, and presents the situation and options again. The student also incurs a "strike" against the relevant TLO(s). A schematic illustrating this flow is shown in Figure 4.

Remediation during Scenarios

If a student accumulates three strikes against any TLO, the scenario terminates, and the student is provided didactic remediation on ELOs related to their poor performance. As illustrated in Figure 5, this is where the phases (Plan, Prepare, and Execute) play a role. If the scenario is terminated for remediation, then subsequent to remediation, the student re-enters the scenario at the beginning of the phase they were in when they exited. In addition, at the end of each phase, the system evaluates the state of the student model, and if performance is below criterion on any ELO, the scenario is aborted and the student receives remediation. Like for the strikes, after remediation, the student returns to the start of the mission phase they had just failed.

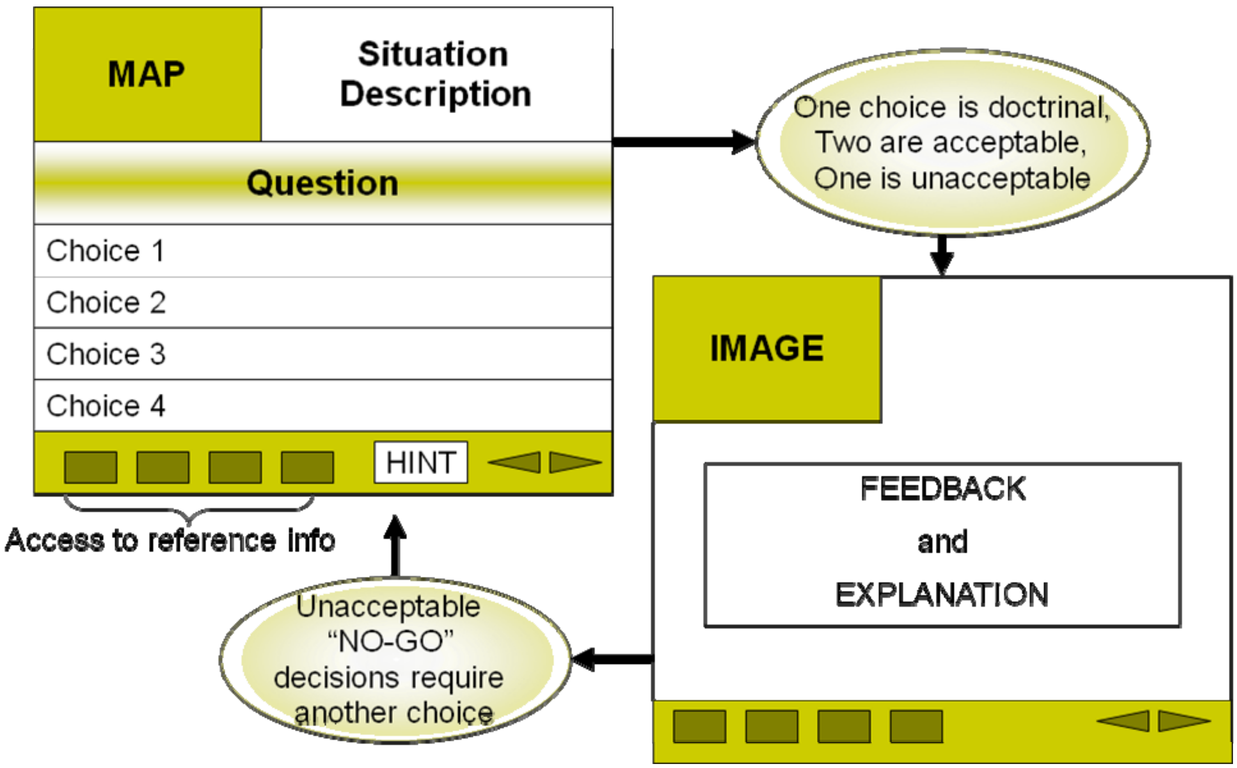

Figure 4. Illustration of scenario flow when the student selects an unacceptable (No-Go) decision.

Remediation materials were taken directly from reference sources used in the original task analysis (Appendix A). Each screen stated the ELO, cited the relevant references, and included information from the references, along with some relevant imagery. This was a potential weakness of the system, because the reference materials were not designed for instructional remediation, and did not refer specifically to the scenario decisions that the student had erred on. Rather, the content was relatively abstract, providing excerpts from handbooks and field manuals. Were more development on the prototype to occur, it is recommended that the remediation materials link back more specifically to the particular kinds of errors students committed, with reference to the scenario context. Such error-sensitive feedback has been shown to facilitate learning (Durlach & Ray, 2011).

Testing-In to Upfront Instruction

The same materials that were prepared for during-scenario remediation were also used for upfront instruction. The scenario developers created a knowledge test (multiple choice) covering the ELOs. Performance on this knowledge test was used to tailor upfront instruction. Only instruction related to ELOs for questions missed was presented. The student began the first scenario after reviewing this material. In an authentic training situation, students would receive

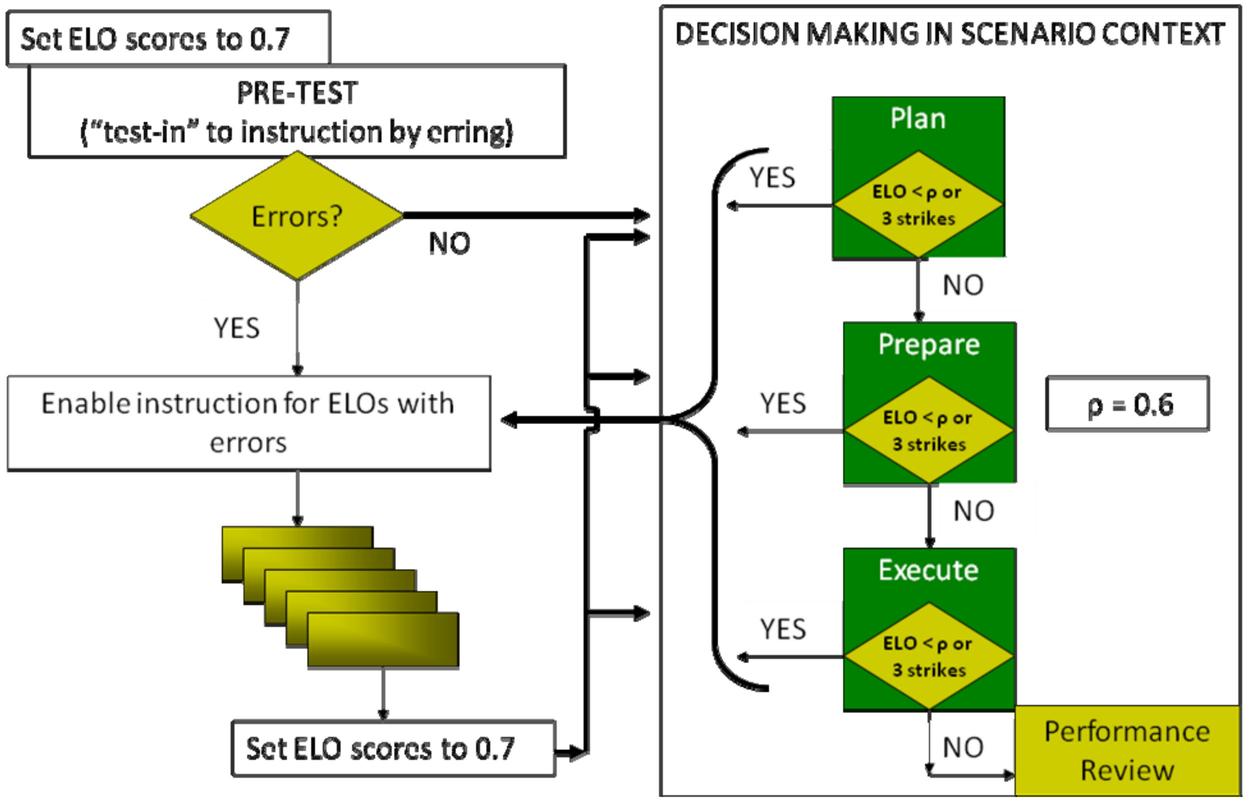

Figure 5. Overview of the flow of the adaptive training system. Students are assumed to have some incoming knowledge, and to gain knowledge by reviewing the instruction ($\rho = 0.7$). This value is decremented (on an ELO basis) according to errors committed on the pretest or less than optimal choices selected during decision making. Students initially take a pretest. Instruction is provided on any ELOs for which errors were made. After this, the student begins the decision making phase of training. This scenario-based phase can be interrupted with remedial instruction if student model scores on any ELO fall below the criterion threshold ($\rho = 0.6$) or if three strikes accumulate. This remediation is followed by a return to the decision making context, at the start of the phase that had been interrupted. $\rho = 0.8$ or above on all ELOs was set as the pass criterion. After completing a scenario, if students did not meet this criterion, they were required to repeat the scenario (for a maximum of three repetitions).

corrective feedback on their test answers; however, for purposes of evaluating the adaptive prototype vs. a nonadaptive version, corrective feedback was not given. Students did receive a performance summary (percent correct).

The original version of the pretest included 42 questions and covered all the ELOs thoroughly. Pilot testing indicated that Soldiers took almost an hour to complete this test, however. Rather than devoting so much time to pretesting, the test was reviewed by the scenario authors and shortened to 22 questions. This meant that a few of the ELOs did not have an associated question, and no ELOs were covered by multiple questions. This compromise reduced the test's sensitivity, but took about half the time to complete.

Parametric Decisions

Implementation of the prototype required several parametric decisions, which were somewhat arbitrary and largely based on developer intuition. The scenario developers decided the weights used to update ELO scores for each decision option. The system developers decided that each decision would have three hints and how hint requests would affect updating the student model (e.g., that full credit would be given with one hint, half credit with two hints, and no credit with three hints). They decided that ELO scores could range from – 1 to + 1. They set criteria for when to abort a scenario and send the student to remediation (e.g., three strikes or any ELO below 0.6 at the end of a phase). Another parameter selected was how to update the student model after students reviewed didactic material. Assuming that students gained some knowledge by reviewing the upfront instruction or remedial slides, the ELO scores associated with that material were updated to 0.7 after review. Finally, 0.8 or above on all ELOs was set as the pass criterion. After completing a scenario, if students did not meet this criterion, they were required to repeat the scenario (for a maximum of three repetitions).

Subject Matter Expert Feedback

Instructors and other available personnel associated with the Raven Operator School at Fort Benning, Georgia generously spent time with the development team over a two-day period, examining an early version of the prototype and providing feedback. This included the chief of an in-theater mobile training team, experienced in SUAS unit operations. Our goals were to assess system usability, obtain expert feedback on our content, and gain additional content knowledge about current TTPs from hands-on users of SUAS. Raven school personnel took the knowledge test (original version), completed one or both scenarios (depending on their available time), reviewed a sample of the instructional materials, and provided feedback on all these components. Participants were generally approving of the prototype, concurred with our TLOs, and thought that it would be a valuable component of a leader's course on SUAS employment, were one to be developed. We learned from them about current TTPs, which did not necessarily concur with written doctrine. We also learned about training deficiencies that instructors thought existed in their current curricula, and areas that were unaddressed due to the inability of the school to keep pace with the evolution of SUAS employment in-theater. We subsequently injected this information into the system. Particularly useful was their input on current but non-doctrinal TTPs. This was used to help fashion the acceptable, but non-doctrinal decision options.

Implementation of the Nonadaptive Prototype

Were we developing a nonadaptive prototype for actual training purposes, we would have developed an event flow as depicted on the left side of Figure 6; however, we were designing the nonadaptive version in order to conduct an experiment, which would compare training outcomes for the adaptive and nonadaptive versions. To that end, certain modifications were made to the authentic flow. This is depicted on the left side of Figure 6. Specifically, an authentic version, would present a block of instruction, followed by check on learning questions with corrective feedback, followed by the practical exercises (scenarios). The problem with this is that, for the experiment, we wanted to give all students the knowledge test as a pretest prior to any instruction. This would allow us to examine knowledge gains by comparing performance on a pretest with that of a posttest. If we used the authentic flow, students in the nonadaptive condition would have to complete both the pretest and the check on learning questions. Not only would this take more time, the check on learning questions would give the nonadaptive condition additional test questions. It is known that testing improves retention (Carpenter & DeLosh, 2005; Kornell, Hays, & Bjork, 2009; Pyc & Rawson, 2010), and so we did not want to give different amounts of testing in the two conditions. Consequently, we implemented the flow illustrated on the right of Figure 6. Students would first take the pretest, then review all the didactic instruction (regardless of pretest performance), and then go on to complete the scenarios.

Scenario flow for the nonadaptive version of the training is illustrated in Figure 7. All aspects of scenario decision making were the same in the adaptive and nonadaptive prototypes, except that the nonadaptive scenario did not branch, and it did not adaptively remediate. Regardless of whether the optimal or one of the acceptable answers was chosen, feedback was given, followed by the next situation on the trunk. If the unacceptable answer was selected, like for the adaptive condition, the student would be given feedback and instructed to select another option. The nonadaptive version provided the same access to hints and reference materials as did the adaptive version. At the end of a scenario, students had the option to review the instructional materials relevant to their weaknesses (pointed out in the performance summary), by selecting items from a list.

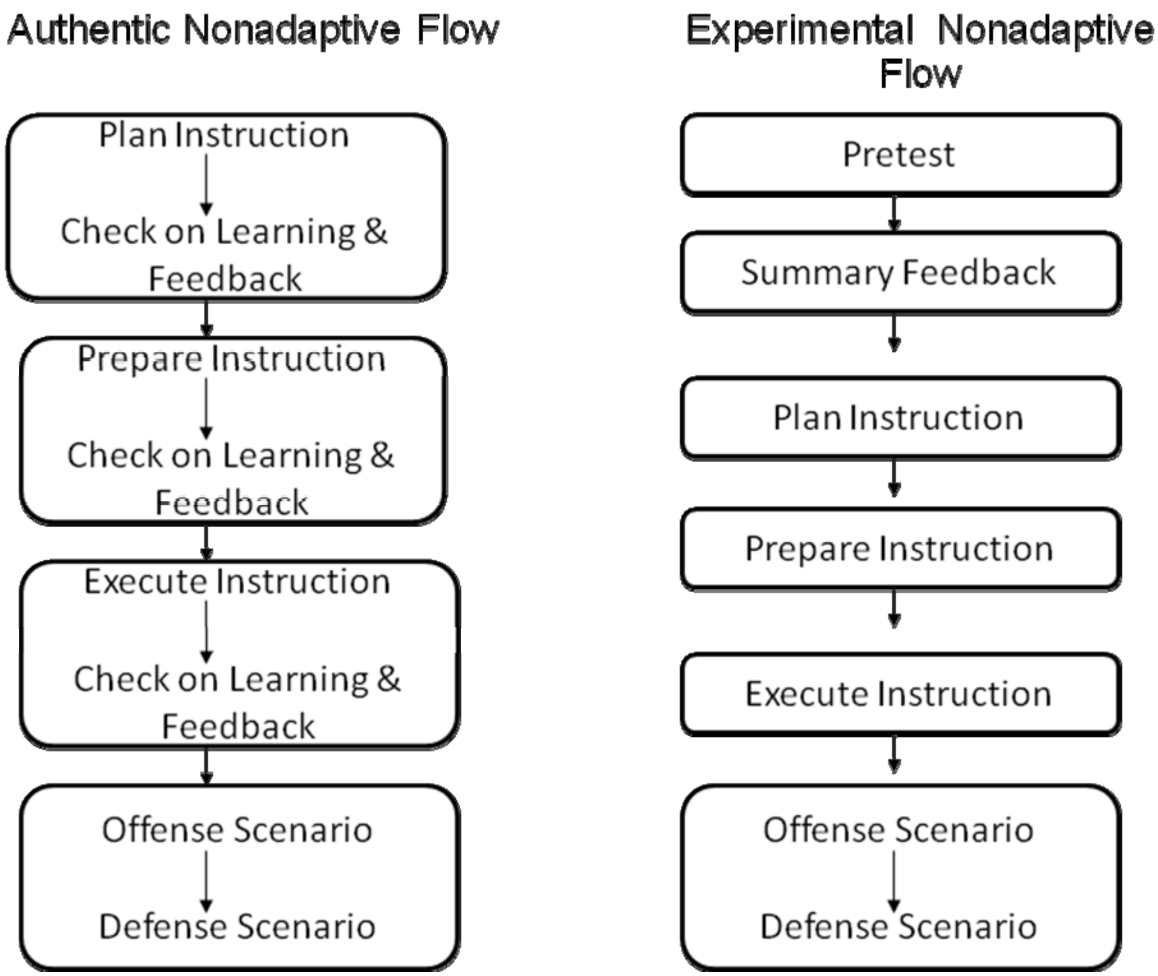

Figure 6. Comparison of a potential training flow for an authentic nonadaptive training system (left) and the actual flow of the nonadaptive training system used for experimentation (right).

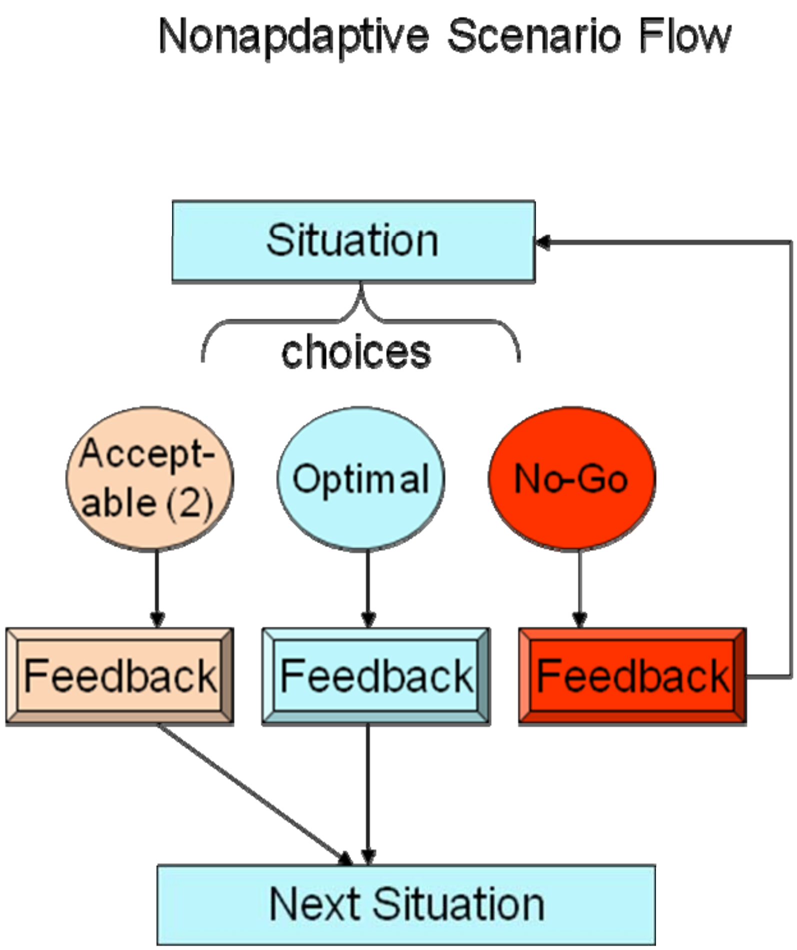

Figure 7. Illustration of scenario flow during decision making in the nonadaptive version.

Evaluating the Adaptive vs. the Nonadaptive Training Prototypes

Participants

In order to compare the effectiveness of the adaptive and nonadaptive versions, we sought the participation of Soldiers at two different Army posts. Soldiers all gave informed consent, and were randomly assigned to conditions. We requested 12 each: company commanders (Captains), platoon leaders (Lieutenants), and noncommissioned officers (Staff Sergeants or Sergeants First Class), from maneuver units (infantry and armor). The actual Soldiers tested were two Captains, 12 Lieutenants, four Staff Sergeants, and 13 Sergeants First Class, and came from nine different branches (e.g., infantry, artillery, military police, etc.). Overall, 16 Soldiers completed the adaptive version, and 15 the nonadaptive version; however, data from seven of the participants were excluded from the analysis due to malfunctioning of the software during their training sessions. This resulted in data for 13 Soldiers in the adaptive version, and 11 in the nonadaptive version.

Equipment and materials

Four laptop computers were used for the training. Two of the laptops were loaded with the adaptive version of the training software and two with the nonadaptive version. The research was conducted in a well-lit room with a large table with two laptops on either side. Up to four Soldiers, one per laptop, could participate simultaneously. Soldiers were asked to complete one paper questionnaire prior to training, which asked about experience and background, and another after training, which asked about reactions to and opinions of the training. The pretest and posttest were completed on the laptops.

Procedure

Each Soldier participated for about half a day (9:00 – 12:30 or 13:30 -17:00). Upon arriving at the testing location, Soldiers were randomly assigned to a computer, and asked to look over information about the research, including information about informed consent and their rights of privacy. If they agreed to participate (all did) they signed an informed consent form and were assigned a participant code, which would be used to identify their data. After completing the background questionnaire, the Soldiers were shown how to log into the training system using their code, and then completed training at their own pace. They were told to ask questions if they ran into any difficulties or had any confusion about the system. They were also told our estimate of how long the session would take, and that they were free to take short breaks at their own discretion.

For both the adaptive and nonadaptive versions, the computer session started and concluded with the knowledge test, consisting of 22 questions, which covered 84% of the ELOs.

Following the pretest, Soldiers doing the adaptive version read through a personalized set of instructional materials, which were selected on the basis of errors made on the pretest. Once they completed this instruction, they completed the offensive scenario, and then the defensive scenario, according to the procedures described in the adaptive scenario section above. Following the pretest, Soldiers doing the nonadaptive version read through all the instructional materials. Once they completed this, they completed the offensive and defensive scenarios (described in the adaptive implementation section above). All Soldiers concluded the session by completing the posttest, and two questionnaires, one on system usability, and one on their opinions concerning the training.

Results and Discussion

Soldiers completed the pretest (without feedback) prior to training and an identical posttest after training. On average, test scores increased from pretest (48.3%) to posttest (61.7%). A mixed analysis of variance using these test scores as the repeated factor and condition as the between-group factor indicated a significant effect of training (pretest vs. posttest), $F(1, 22) = 18.06$, $p < .001$, with an effect size (partial eta-squared) of 0.49. There failed to be a significant two-way interaction between test time and condition, as would be expected if the adaptive version produced better learning outcomes than the nonadaptive version. Mean pretest and posttest scores were 46.3% and 60.7% respectively, in the nonadaptive condition, and were 50.3% and 62.6% respectively, in the adaptive condition.

Soldiers in both conditions spent, on average, about the same amount of time to complete their training sessions. The mean was 94.0 minutes for the nonadaptive condition, and 102.9 minutes for the adaptive condition. The range of times varied widely, however; the fastest Soldier completed the session in about 41 minutes, whereas five Soldiers took three hours. Figure 8 shows that Soldiers who took more than 85 minutes (the median) to complete the session increased more from pretest to posttest than those who took less than 85 minutes to complete the session, $F(1, 20) = 11.24$, $p < .01$. There was no interaction of time-to-complete with condition, however ($F < 1$).

Relevance of the training to the Soldiers' branch and duties during their last deployment also affected test scores. Those for whom the training domain was more relevant scored higher on both the pretest and the posttest (51.6% and 68.2%, respectively), than those for whom the training domain was relatively less relevant (44.3% and 52.5%, respectively), $F(1, 20) = 11.34$; $p < .01$, effect size partial eta-squared = 0.36. See Appendix C for assignment of Soldiers to these conditions. The effect of relevance failed to interact with condition ($F < 1$).

After training, Soldiers responded to eight questions about the usability of the training system. A detailed summary of the questions and responses can be found in Appendix D. On the whole, responses were moderately positive, but indicated that the system or the introductory instructions could be improved. For example, only about 70% of Soldiers agreed or strongly agreed that they understood the "knobology" and/or felt confident they could explain how the system worked to a friend. We failed to detect any differences in responses according to condition.

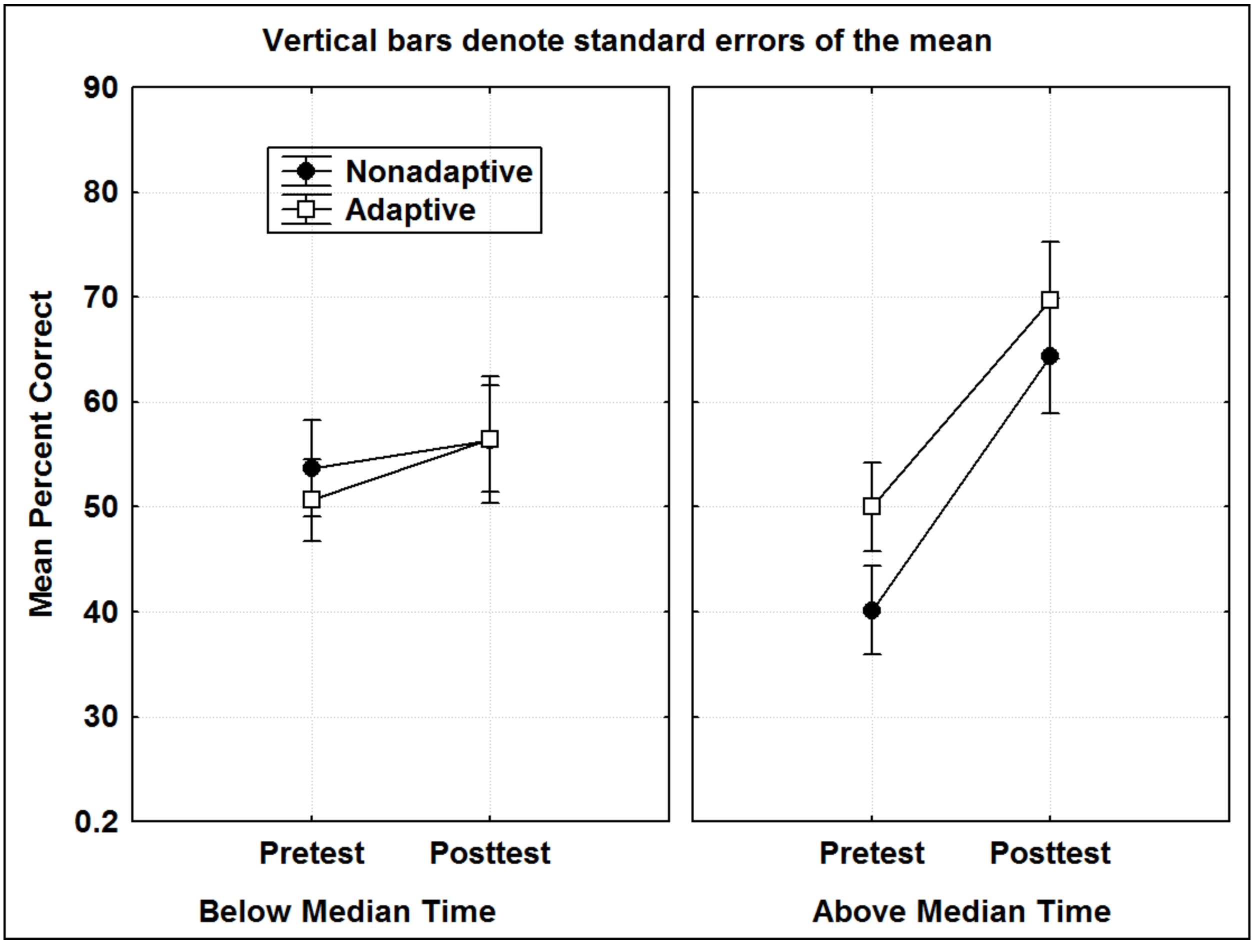

Figure 8. Mean percent correct on the pretest and posttest, according to time on task. The left panel shows the data for participants who spent less than the median amount of time on task and the right panel shows the data for participants who spent more than the median amount of time on task.

After training, Soldiers also responded to 14 questions concerning their opinions about the training effectiveness of their experience. A detailed summary of the questions and the modal responses can be found in Appendix E. Overall, the responses were more favorable in the adaptive condition than the nonadaptive condition. The modal responses for eight of the 14 questions favored the adaptive condition. For the remaining questions, the modal responses were the same. This comparison represents a significantly more favorable appraisal by those taking the adaptive version, Wilcoxon T = 0, $p < .05$. Examining each question individually using Mann-Whitney U tests, there were three questions for which the adaptive condition responded significantly more positively than the nonadaptive condition. These questions were

- Experiencing actual situations that might arise during the employment of an SUAS. Adjusted $z = 2.39$, $p < .05$.
- The scenario(s) I worked on were realistic. Adjusted $z = 2.10$, $p < .05$.
- The hints available during the scenarios were helpful. Adjusted $z = 3.01$, $p < .01$. [Note that both conditions had the same hints available].

A summary of the Soldier's session logs are presented in Appendix F. Inspection of the log data reveals that performance on the second (Defense) scenario was somewhat worse than the Offense scenario, $\chi^2 = 10.08$, $p < .01$. Only two Soldiers failed to pass the Offense scenario, while 12 failed to pass the Defense scenario. Six of these were in the adaptive condition, where Soldiers were allowed three attempts at the scenario. It may be that the Defense scenario was more difficult than the Offense scenario; or it may be that Soldiers were simply growing tired by this time, and rushing to finish. The time spent on the Defense scenario (first attempt for the adaptive condition) was significantly lower (mean 7.4 minutes) than on the Offense scenario (mean 15.5 minutes), $F(1, 22) = 17.3$; $p < .001$. Soldiers also took significantly less time to complete the posttest than the pretest, spending on average 12.0 minutes on the pretest, but only 7.1 min on the posttest, $F(1.22) =20.66$; $p < .001$.This could be because Soldiers found the posttest easier than the pretest (having gone through the training); but, it could also could be because Soldiers just wanted to finish the session as quickly as possible, and so deliberated less on each question. The possibility that Soldiers tended to rush through the latter part of the session (including the posttest) may have undermined our ability to evaluate the relative effectiveness of the two training versions, by adding substantial noise to the posttest data.

Conclusions and Lessons Learned

Soldier's test scores increased significantly from pretest to posttest; however, the results failed to demonstrate significantly greater learning from the adaptive vs. the nonadaptive training prototype. As with all failures to find an effect, we should not necessarily conclude there is no difference in the effectiveness of the prototypes, because there are multiple possible reasons for a failure to find an effect. It may be that our pretest and posttest were insufficiently sensitive to detect differences in amounts of learning. We shortened our test to 22 questions because pilot testing indicated that Soldiers could take more than an hour to complete the longer (42-item) test. However, a longer test with multiple items related to each LO would have provided a more sensitive measure, less prone to noisy data resulting from guessing or haste.

Soldiers varied widely in the amount of time they took on each phase of the training. In general, Soldiers who took more time tended to have larger increases between pretest and posttest scores (Figure 8). Amount of time spent on each succeeding phase tended to decrease. Soldiers, on average, spent about twice as much time on the pretest than the posttest. This likely reflected combination of decreasing interest over time (resulting in a rush to complete) and an increase in knowledge (resulting in the need for less deliberation over each question). Perhaps it was unrealistic to conduct the amount of training we did in a single session.

Even if we accept the conclusion that the adaptive and nonadaptive conditions failed to affect learning differently, that conclusion must be specific to the particular implementation of the training software tested here. The present results do not rule out the possibility that different parameters or different methods of adaptation might be more effective. In the present implementation, we gave Soldiers in the adaptive condition up to three tries at each scenario. Nevertheless, five Soldiers in this condition did not successfully complete one or both scenarios. Consequently, our intention to enforce a mastery criterion was not actualized in their cases.

Requiring mastery should improve posttest scores (Durlach & Ray, 2011), so increasing this limit might produce better learning outcomes.

Another aspect of our adaptive implementation that could be improved was the method of remediation. We used materials taken from the upfront instruction to provide remediation. These consisted of excerpts from handbooks and other doctrinal sources, combined together; but these materials were not specifically designed for instruction or the particular scenario situations that would instigate the remediation. A review of the learning sciences literature (Durlach & Ray, 2011) suggests that our adaptive remediation strategy could have been more effective if we had used error-sensitive remediation. Error-sensitive remediation would address not only that a student erred, but also the way in which they erred. Instead of using abstract conceptual materials for remediation during scenario-based decision making, error-sensitive remediation would address the error made with direct reference to the scenario context. Not using this strategy likely accounts for why five Soldiers could not complete the scenarios successfully with the remediation provided.

Reviewing the research literature, Durlach and Ray (2011) did identify some experiments in which learning outcomes were superior for an adaptive system vs. a parallel nonadaptive system (e.g., Perrin, Dargue, & Banks, 2003); but, they also discovered several experiments, like this one, which failed to find any outcome differences. They concluded that there can be learning benefits from adaptive approaches over nonadaptive approaches; but, that the benefits are not guaranteed. Designing adaptive training technology may need to be an iterative process, where cycles of development, testing, and refinement may be required to ensure that the potential benefits are realized. Current heuristic guidance on how to implement adaptive strategies in software are not specific enough to ensure that the first version of any particular implementation will be beneficial (compared with a nonadaptive implementation). Systematic documentation of the iterative process and comparison of the effectiveness of different implementations is required to transform vague heuristic guidelines into more specific implementation recommendations. When engineering a system, it is tempting (and common) to make multiple refinements at one time, in order to get to the final version more quickly. Unfortunately, this works against developing an understanding concerning the relative contributions of the various changes to system effectiveness, and in turn undermines development of a systematic understanding that will take us beyond mere design heuristics.

Despite our failure to find learning differences, Soldiers' provided more positive appraisals of the training effectiveness of the adaptive version over the nonadaptive version. The current adaptive version may provide the basis for the development of improved training on SUAS employment at company and below.

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Appendix A

Task Analysis Sources

Main sources

- **Leader's Guide to A2C2 at Brigade and Below**. No. 05-25, Center for Army Lessons Learned (CALL), June 05.
- **FM 3-52. Army Airspace Command and Control in a Combat Zone** (FM 100-103), Field Manual. Headquarters, Department of the Army, Washington, DC, 1 August 2002.
- **FMI 3-04.155. Army Unmanned Aircraft System Operation.** Field Manual Interim Headquarters No. 3-04.155 Department of the Army. Washington, DC, 4 April 2006 Expires 4 April 2008.
- **Joint Concept of Operations for Unmanned Aircraft Systems.** Creech Air Force Base, Indian Springs, NV. First Edition, March 2007.

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- FM 3-06. Urban Operations. 1 June 2003.
- FM 3-20.95. Cavalry Operations. (Final Draft) 2004.
- FM 3-21.21. Risk Management and Fratricide Avoidance. 31 July 2003.
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- FM 3-90.6. The Brigade Unit of Action. (Draft TBD). 15 March 2005.
- FM 3-90.XX. UA Fires and Effects.
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- FMI 3-04.155, Army Unmanned Aircraft Systems Operations, April 2006.
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- FM 3-52 (FM 100-103) .*ARMY AIRSPACE COMMAND AND CONTROL IN A COMBAT ZONE.*
- JP 3-52 *JOINT DOCTRINE FOR AIRSPACE CONTROL IN THE COMBAT ZONE.*
- JP 3-55.1, *Joint Unmanned Aerial Vehicle Regulation*, 27 August 1993.
- AR 95-23. *Unmanned Aerial Vehicle Flight Regulations*. 14 May 2004.
- ARTEP 34-117-30-MTP. *Mission Training Plan for the Surveillance Troop of the*
- *Stryker Brigade Combat Team*. 28 June 2005.
- ARTEP 34-387-10-DRILL. *Crew Drills for the Shadow 200 Tactical Unmanned*
- *Vehicle (TUAV)*. 20 November 2005.
- ARTEP 34-387-30-MTP. *Mission Training Plan for the Direct Support Military*
- *Intelligence Company (Digitized)*. 30 September 2004.
- ARTEP 34-414-10-DRILL. *Crew Drills for the Hunter Tactical Unmanned Aerial*
- *Vehicle (TUAV)*. 21 February 2006.
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- *Company (Aerial Exploitation) (Corps)*. 2 December 2002.

Additional Resources were consulted from AKO and Other Internet sources. The following were most useful:

- NFTF - MAJ Chris Barra. Airspace Command and Control at the Brigade Level. June 2005
- SAMS Monograph. Rise of the unmanned aerial vehicle and its effect on manned tactical aviation. MAJ James Meger. US Army Command and General Staff College,1 Reynolds Ave.,Fort Leavenworth, KS. June 2006.

Most joint publications can be found at http://www.dtic.mil/doctrine/index.html.

Most Army publications are available at https://akocomm.us.army.mil/usapa/doctrine/index.html.

Appendix B

Relation Among Learning Objectives and Source Data

LO ID		Objective	Source Data
1_SUASROLE		Understand the role of the SUAS in the overall tactical plan/operation.	5-25 CALL HB; Appendix B; FM 3-04.15 Ch II or IV.
	SUAS Tactical Basics	**Objective of Didactic Training:** Understand the SUAS is used for RSTA, Security, and Battle Damage Assessment. At the SUAS it is not an attack platform. Understand that the performance of these missions RSTA, Security, and BDA requires airspace coordination and ground coordination to support the overall tactical plan. Be exposed to the doctrinally correct definitions and a visual representation of a SUAS in the appropriate context (e.g. R&S mission with airspace coordination implications displayed).	
1A_SUAS-OPN	Attack, Defense, Security, Civil Operations	Understand the role of the SUAS in the **major Army operations (Attack, Defense, Security, Civil Operations).**	FM 3-90 Chapter 2 (pp. 2-1 thru 2-39; FM 3-04.15, Ch 1 (Man-portable SUAS focus); Summarize FM 3-04.15 para 6. a, b.c.d. (p. I-7& I-8) and FM 3-90 p. 2-1 and p. 2-2 Include Figure 2-1. Capture content of Par 2-1 thru 2-3 (p. 2-1 thru 2-2) See FCS IMI Lsn 3, frame 73-75.

1B_SUAS-R&S	R&S	Know the essential elements and concepts of **Reconnaissance and Surveillance (R&S)** SAUS missions.	FM 3-90, Ch. 12 focused on Company Level , FM 3-20.98 Chapter 3 & Chap 3:Sec II, FM 3-04.15 Ch IV (Specifics:Intro - Recon- Definition in FM3-04.15 in Glossary p. 9 followed by Fig IV-1 then section on Route Recon -para 2.a.(1). (a) and (b),pp. IV-1thru IV-2); then Zone Recon para 2.b. (1), (2), (3) p. IV-3); Area Recon- para 2.c.(1), (2),(3),(4), p. IV-4) Surveillance - Definitiion, p.9 of Glossary, FM3-04.14 put copy of DDForm 1975 to illustrate, and then Summary of para 3.a.,b.,c.,d.,e. (make sure you write out all terms like SPINS (Special Instructions) by going to Glossary), p. IV-4 thru IV-5.
1C_SUAS-TA	T&A & BDA	Know the essential elements and concepts of **Target Acquistion** (TA) and **Battle Damage Assessment (BDA)** SAUS missions.	FM 3-04.15, Chapter IV (Specifics- Intro Definition in Gloassary, FM3-04.15, p.Glossary-9, Summarize para. 4. a. AI. (3)only then 4. b. with emphasis on (2)&(5) with emphasis on Fire Support Coordination Measures & MRR.

1D_SUAS-SEC	Security	Know the essential elements and concepts of **Security in** SAUS missions. Focus on **Screen** and **Force Protection**.	FM 3-90, Ch. 12 focused on Company Level See also FM 3-90.98. See also FM3.04.15 Ch IV.(Specifics: Definition in FM3-04.15 in Glossary p. 9 Define: Security mission of Screen, Guard, and Cover then define Force Protection (FP) see FM 3-04.15 p.7 in Glossary and the go to FMI3-04.155 and summarize par 3-38 thru 3-41(p. 3-10) omitting technical data but focusing on mission and objectives. See also para 4-135 & 4-136 on p. 4-25of FMI3-04.155 emphasizing the situation awareness SUAS gives the Cdr for FP a sensor to mitigate risk against certain threats. Really force protection is like a screen but in a "non combat" mode. FM3-04.155 para 5-122 third bullet is a good summary force protection.
1E_SUAS_BDA	BDA	Know the essential elements and concepts of **Battle Damage Assessment** SAUS **missions**.	Know FM 3-04.15 Par 6 a. & b.(p.IV-14) A part of Combat Assessment (See FM 3-04.15 Glossary 5). See also FM3-04.155 par B-41 (p.B-7)

			and para.5-54 (p.5-13) and CALL HB 5-25 p.29 as a primary mission of SUAS.
2_TACTCONT		Understand common company and battalion tactical control measures.	FM 3-90 & FM 3-52
	SUAS Bn & Comp Tac Control Measures	**Objective of this Didactic Training:** Be able to apply the definitions and graphical symbols associated with basic offense and defensive Army battalion operations and understand their basic implications. The following are not all inclusive of the basic tactical control measures but are essential to this given training. This section should be designed to be expanded to accomodate other control measures like Limit of Advance (LOA) FM 3-90 (p.3-7). Others like Line of Departure (LD) are assumed to be understood by the student as they are basic Army terminology.	
2A_TACT_NAI	NAI	Understand the importance of positive control during observation of **Named Area of Interest (NAI)**.	FM 3-90, p. 2-33; FM 3-52 sec 5-43 thru 5-47 p. 5-11.
2B_TACT-AA	Axis of Advance	Understand the concepts of **Axis of Advance**	FM 3-90, p. 3-5; FM 3-52 sec 4-16 (p.4-7)
2C_TACT-BP	Battle Position	Understand the concepts of **Battle Position**	FM 3-90, p. 8-7; FM 3-52 sec 4-18, p.4-7.
2D_TACT-EA	Engagement Area	Understand the concepts of **Engagement Area**	FM 3-90, p. 2-21; FM 3-52 sec 4-19, p. 4-7.
2E_TACT-ABF	Attack by Fire Position	Understand the concepts of **Attack by Fire Position**	FM 3-90, p.3-5; FM 3-52 sec 4-21, p.4-8.
2F_TACT-OP	Observation Post	Understand the concepts of **Observation Post**	FM 3-90, p. 12-5 thru 12-10; FM 3-52 sec 4-22; p.4-8.
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3_PRO-SEPC		Understand and know the three types of separation used in manned and unmanned aircraft. (5-25 CALL, p.4; FM 3-52, p. 4-12)	5-25 CALL, p.4; FM 3-52, p. 4-12. See FM 3.04.15 Chapter II. See FM3-04.15 Chap II, par 5.a, e.f, g. h, i., j.; FM3-52, p.4-20 thru 4-11 para. 4-32 and 4-34. Maybe use Figure 4-9 with SUAS added.
	Airspace Methods of Separation - Procedural Controls - Separation	**Objective of Didactic Training:** This should/could be a adaptation of the FCS IMI Lsn 2 ELO 4 Identify Employment Considerations for UAS Airspace Deconfliction Requirements This ELO focuses on information for company/platoon leadership on conducting airspace deconfliction for the Class 1 UAS (Blk 0), to include the following: -- Operations in the vicinity of other UAS, and manned aircraft -- Operations in the vicinity of friendly fires	
3A_PRO-LAT	Lateral	Understand and know **Lateral separation**	5-25 CALL HB, p.4; FM3-04.155 B-16, p.B-3
3B_PRO-TIM	Time	Understand and know **Time separation**	5-25 CALL HB, p.4; FM3-04.155 B-17, p.B-3
3C_PRO-VET	Vertical	Understand and know **Vertical separation**	5-25 CALL HB, p.4; FM3-04.155 B-18, p.B-3
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4_MIS-REQ		Understand the two types of airspace **mission requests and three types of missions**	5-25 CALL HB Ch 2 (pp.10-13)

	Mission Types and Mission Requests	**Objective of Didactic Training:** Know the definitions of mission requests and the general format of a immediate SUAS mission request. ***See the RAVEN POI 11-2 LSA 4 Airspace Management pdf pp. 11-18 for essential information to capture.*** See also ***Lsn 2 FCS Planning Consideration IMI frame 84-99*** (see frame 93 for immediate mission request format. Summary of SUAS mission request types : Planned -- Done during Planning phase (more than 72 hrs prior to LD) - PLANNED REQUEST Immediate -- done during the Prepare phase (less than 72 hrs but before LD) - IMMEDIATE REQUEST Dynamic -- done during Execute phase (after LD) - IMMEDIATE REQUEST per UNIT SOP All types can be planned for and trained for as they are variants of the same procedure as are OPLANs, OPORDs, and FRAGOs.	** See John Sanders for this TLO as he has an excellent simplification. The FCS frames are also well done for didactic training.
4A_MIS-PLAN	Planned	Understand the considerations and coordination required for a **planned** SUAS mission request. (more than 72 hrs prior to mission start)	5-25 CALL HB Ch 2 (pp.12); p.25-26;
4B_MIS-IMMD	Immediate	Understand the considerations and coordination required for an **immediate** SUAS mission request. (done less than 72 hrs prior to mission start but not after mission start)	5-25 CALL HB Ch 2 (pp.12-13); p.27
4C_MIS-DYNAMIC	Dynamic	Understand the considerations and coordination required for a ***dynamic re-tasking*** SUAS mission request. FM 3-04.15 p. II-5 thru II-7. Dynamic flight occurs anytime a platform deviates from its planned mission—	FM 3-04.15 pp. II-5 thru II-8. See IMI Lsn 2 pp. 62-82.

		a common occurrence during combat operations (done during a mission execution (after Line of Departure). Use immediate SUAS mission request format modified and adapted if required.	
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5_DECON-O		Understand the importance of **deconfliction in airspace coordination**	5-25 CALL HB, p.4 & Ch. 4 (14-20), FM 3-04.15 Ch I & III.
	SUAS and Deconfliction	**Objective of this Didactic Training:** This section is the practical applications of airspace management. These are the major types of aircraft (manned and unmanned/Army) and fires that the SUAS must not adversely impact but complement. The emphasis whould be show visual examples of the need to deconflict via diagrams from doctrinal literature or POI. **See and Use FCS IMI Lsn 2 ELO 4 pp. 83-94.** Include some information of deconflicting communications for UAVs, Manned Aircraft, and direct/indirect fires (see FM 3-04.15 pp. III-1 thru III-3 (Section 1. para b & c.)	
5A_DECON-UM	Other SUAS/UAVs	Understand the importance and coordination necessary to **deconflict other UAV** operations.	5-25 CALL HB, p.4 & Ch. 4 (14-20);FM 3-04.15 pp. III-1 thru III-3 (Section 1. para b & c
5B_DECON-MA	Manned Aircraft	Understand the importance and coordination necessary to **deconflict other Manned Aircraft** operations.	5-25 CALL HB, p.4 & Ch. 4 (14-20);FM 3-04.15 pp. III-1 thru III-3 (Section 1. para b & c
5C_DECON-IND	Direct and Indirect Fires	Understand the importance and coordination necessary to deconflict with **direct and indirect** fires.	5-25 CALL HB, p.4 & Ch. 4 (14-20);FM 3-04.15 pp. III-1 thru III-3 (Section 1. para b & c

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6_SA-OPN		Understand the **needs** and **necessity of coordination** with other units affected by SUAS operations to **support situational awareness**. See HB CALL 5-25 para 1, p. 11.	
	SUAS Staff Coordination and Situation Awareness Considerations	**Objective of Didactic Training**: The SUAS commander/operator must coordinate below, above, and to their left and right to ensure the SUAS flight and operations are synchronized. This section **could be an adaptation of FCS IMI Lsn 1 pg 53-71**. Also it could be summary of Figure III-1 and III-2 UAS C2 in FM 3-04.15. FM 3-04.155 Appendix B Figure B-6, pp. B-14.	
6A_SA-INFO	Other Units (Above, below, adjointing)	Understand the importance of **sharing information between units and higher echelons** as part of mission planning. (5-25 CALL, p.7-11)	5-25 CALL HB, p.7-11, p. 21
6B_SA-OBS	Observation Posts concepts for Situational Awareness (SA)	Know the essential elements and **concepts of Observation** to support situational awareness SAUS missions.(5-25-,CALL,p.11)	5-25 CALL HB, p.11,p. 21. See also FM 3-90, p. 12-7 and others. Summarize FM 3-04.15 Ch IV, section 3, pp. IV-4thru IV-5 on Surveillance with a focus on Brigade and below applications.
6C_SA-BDA	Battle Damage Assessment	Know the essential **elements and concepts of Battle Damage Assessment** dissemination during SAUS missions. (5-25 CALL, p.11) This is the same as 1E. Use the same didactic training.	5-25 CALL HB, p.11, Summarize Sec 6 of Ch IV of FM 3-04.15 (pp. IV-14)
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7_RISK-ENT		Understand the risks and likelihood in the **Airspace Environment**. (FM3-04.155, Appendix A) **In my research for this objective there are usually 'operational considerations' for employment of SUAS e.g. wind*	FM3-04.155, Appendix A&B, FM 3-04.15 Ch II,p. II-16 Sec 8 (Environmental Considerations in Mission

		speed. I have attempted to document the likely risks which a Skill Level 2 up to Company Grade officer should be aware.	Planning), 5-25 CALL HB Ch 1.
	SUAS Airspace Environment and Threats/Risks	**Objective of Didactic Training:** The SUAS commander/operator should understand the potential "obstacles" in the airspace - natural, man-made, and account for their presence in planning and operations. This section encompasses the majority of **ELO 5 from FCS IMI Lsn 2 pg 100-107** and FM 3-04.155 and FM 3-04.15 extracts. Specifics follow.	Selected sections from Appendix A and B of FM 3-04.155 and FM 3-04.15 sections.
7A_RISK-PL	PowerLines & Commo Interference	Understand the risks and likelihood of **Overhead Power Lines** and **Communications interference** in the Airspace Environment.	FM3-04.155,Table A-1:UAS mission planning checklist-Communication Plan section ; FM3-04.15 Ch III.
7B+C_RISK-TOW	Man-made Structures	Understand the risks and likelihood of **Man-made structures (Buildings, Towers, etc.)** in the Airspace Environment.	FM3-04.155, Chapter 4, section 4-27-29, p.4-4 Terrain& Weather section
7D_RISK-LAF	Low altitude civilian aircraft	Understand the risks and likelihood of **Low altitude civilian aircraft** in the Airspace Environment.	FM 3-04.155 Sec II, Appendix B B-42-B-44 (p.B-7)
7E_RISK-ART	Close Combat Attack Aviation (Apache Hel - AH-64)	Understand the risks and likelihood of **Artillery projectiles and effects** in the Airspace Environment.	FM3-04.155,Section IV p. 5-24 thru 5-25 par 5-93thru 5-97; FM3-52, Glossary p.7 (CFL ,RFL, Definition)
7G_RISK-TER	Terrain and Line of Sight	Understand the risks and likelihood of **Intervening Terrain** and **Line of Sight implications** in the Airspace Environment. (FM3-04.155, Section 4-140 Terrain, p. 4-25)	(FM3-04.155, Section 4-140 Terrain, p. 4-25)
7G_RISK-TER	Positive Control and Data Links	Understand the importance of planning, preparing, and executing to maintain positive control of SUAS assets.	CALL HB 5-25, pp 1-3;

7I_RISK-ABN	Close Combat Attack Aviation (Apache Hel - AH-64)	Understand the risks and likelihood of **Army Aviation (Close Combat Attack) operations** in the Airspace Environment.	FM3-04.15 CCA Handover Vignette until par g. pp. IV-20-IV-21 then through IV-22 where CCA is topic.
7J_RISK-ADA	Enemy Air Defense	Understand the risks and likelihood of **Enemy air defenses (primarily small arms fire)** in the Airspace Environment.	FM3-04.155, Chapter 4, section 4-34 (p. 4-5) and 4-43 (4-7) and 5-44 (p.5-11)
7K_RISK-HAF	CAS	Understand the risks and likelihood of **Close Airs Support (CAS) aircraft** in the Airspace Environment.	FM3-04.15 pp. IV-9 thru IV-10 (Begin para.b. Close Air Support through para b.(5)).
7_L_M_N_F_RISK-WEA	Weather	Understand the risks and likelihood of **Weather (Precipitation, winds, tempature, fog, icing, etc.)** in the Airspace Environment. (FM3-04.155, Chapter 4, section 4-31-34)	FM 3-04.155 Chapter 4, section 4-31-34.
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8_CONT-PRO		Understand the **procedural control measures** used for battalion and below operations as they apply to SUAS operations (FM 3-52, 1-6, **Ch 4**)	FM 3-52, p.1-6, **Ch 4;** 5-25CALL HB 5-25 pp 2-3

	SUAS Opns & Procedural Controls Measures	**Objective of Didactic Training**: Objective is for the Soldier to have a knowledge of the basic fire support and airspace **procedural measures** at a conceptual level of understanding. Know the defintion and several possible uses of the control measure. Soldier needs to know conceptually the difference between Formal Airspace Coordination Area and Informal Airspace Coordination area (FM 3-52) Soldier needs to know common airspace control measures of FM 3-52 (para 4-4, p.4-2, FM 3-52) -- Coordinating Altitude (para.4-5, p.4-2,FM 3-52) -- Minimum Risk Route (para 4-7, p.4-3, FM 3-52) -- Restricted Operation (para 4-8, p.4-4, FM 3-52) -- Army Airspace Control Measures SOPs (para 4-14 thru 4-22), p. 4-5-4-7, FM 3-52)...Air Corridor, Air Control Point, Communication Checkpoint (ACP) Soldier need to know major Fire Support Coordination Measures used at Brigade/Battalion/Company/Platoon -- Permissive FSCMs par 4-28 thru par 4-31, p 4-9 thru 4-10, FM 3-52. -- Restrictive FSCMs par 4-32 thru 4-27, p.4-10 thru 4-12, FM 3-52 Soldier needs to know uses of Army Air Control Points (FM 3-52) Soldier needs to know uses of Air Corridors, Air Corridors, ROZ/ROAs, and Minimum Risk Corridors.	Summary information for incorporation throughout at FM 3-05.15 para (5),Airspace Control Measures p. IV-10.

		(FM 3-52)	
8A_CONT-FAC	Formal Airspace Coord Area	Know the purpose of **Formal Airspace Coordination Area**. (FM 3-52)	FM 3-52 para 4-33, p. 4-10 & 4-11 & FM 3-04.155 par 4-95 thru 4-103 (p.4-17thru 4-18).
8B_CONT-IAC	Informal Airspace Coord Area	Know the purpose of **Informal Airspace Coordination Area**. (FM 3-52)	FM 3-52,para. 4-34, p. 4-11 para 4-33, p. 4-10 & 4-11 & FM 3-04.155 par 4-95 thru 4-103 (p.4-17thru 4-18).
8C_CONT-RFL+ 8D_CONT-RFA + 8D_CONT-NFA	RFL & RFA & NFA	Know the military graphical control for the Restrictive Fire [Control] Line **(RFL) and** Restrictive Fire Area (RFA**)**and understand its purpose. Know the military	FM 3-52, para 4-35 thru 4-37,(p.4-11 thru 4-12);

		graphical control for the **No Fire Area (NFA)** and understand its purpose. Know the military graphical control for the **Restrictive Fire Area (RFA)** and understand its purpose.(FM 3-52)	
	CRS	Know the defintion of a **Common Reference System** (CRS).	FM 3-52, para 4-40, p. 4-12 and Glossary p. 6.
8E_CONT-ACP & 8F_CONT-RCP & 8G_CONT-CCP	ACP	Know the military graphical control symbol for **Air Control Point (ACP)** and when it is appropriate to use. Know that **Air Control Point (ACP)** use can rapidly facilitate rapid restructuring of routes. Know that **communications checkpoints can be ACP**s(FM 3-52).	FM 3-52, p. 4-7. See Glossary pg. 1 for definition. FM 3-52, p.4-8, See Glossary pg 6 for communication checkpoint. FM 3-52, p.4-8, See Glossary pg 6 for communication checkpoint. See FCS IMI Lsn 2, frames 88-89. See also FCS IMI, Lsn 2, frame 88-89.
		TBD	TBD
		TBD	TBD
8H_CONT-AC	Air Corridors	Know the military graphical control symbol of **Air Corridors** and when it is appropriate to use. (5-25 CALL, p.2, FM 3-52, p.4-6).	5-25 CALL, p.2; FM 3-52, par a 4-16, p.4-6 and Glossary p. 1; also called flight corridor
8I_CONT-CCA	AGL	Know that the air altitudes in an air corridor cannot exceed the **coordinating altitude**.	FM 3-52, p. 4-6
8J_CONT-CCA	AGL	Know where to find **Coordinating Altitude** procedural airspace control information in a Brigade/Battalion/Company OPLAN/OPORD. (FM 3-52, p.4-2)	FM 3-52, para. 4-5, p.4-2 and Glossary p. 7; See FM 3-52 Figure 4-1 pon p. 4-3. Emphasis on para 3-72,p. 3-15, FM3-52.
8K_CONT-ROZ	ROZ/ROA	Know the military graphical symbols for **Restricted Operating Zones/Areas (ROZ/ROA)** and when it is	FM 3-52, para 4-8 or para 4-9, p.4-4

		appropriate to use. (FM 3-52, p.4-4)	
8L_CONT-MRC	Minimum Risk Corridor	Know the definition of **Minimum Risk Corridor** procedural airspace. (FM 3-52, p.4-3)'	FM 3-52, para 4-7 and Fig 4-2, p.4-3 Glossary p. 15.
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9_RESP		Know roles and responsibilities of BCT Airspace coordination teams and Emergency Procedures	
	SUAS BCT Airspace Coordination Team	**Objective of Didactic Training:** This section should essential roles and tasks of ADAM/BAE,Bn S3/Bn S3Air,and Company/SUAS team for Airspace coordination Below is doctrinal summarizations: ADAM/BAE - Summarize FM3-04.155 Appendix B Section B-23 thru B-26, p.B-4 Bn S3/Bn S3Air - Summarize FM3-04.155 Appendix B Section B-28 and B-29 p. B-5 Company Responsibilities - Summarize SUAS Mission Planning Flow in CAL HB 5-25, pp. 7-9 with emphasis on company part of this process. Recovery/Destruction/Abort/Emergency Procedures - Summarize Appendix E,. Sec II- Raven Recovery, FM 3-05.155. Summarize par E-22-24. This should be generalized for all SUAS.	
9A_RESP-BAE	ADAM/BAE	No SUAS flies without prior airspace coordination through the **ADAM/BAE**.	CALL HB 5-25, pp 4-6;
9B_RESP-BnS	Bn S3/BnS3Air	**Understand Bn S-3 and Bn S-3 Air staff responsibilies tom manage SUAS airspace coordination. "S3 Air" within S3 has staff responsibility for ALL SAUS operations. (5-25 CALL, p. 6)**	(CALL HB 5-25, p. 6 and FM3-04.155 par 4-59 and 4-60 on p. 4-10.

9C_RESP-Tm	Company/Trp/Team	Understand Company/SUAS team responsibilities in airspace coordination. Know that improper coordination may result in catastrophic damage to aircraft and Soldiers.	CALL HB 5-25, pp 7 & appendix A
9D_DESTRY	Emergency Opns	Understand **Destruction/Abort and Emergency Procedures for SUAS flight planning and operations.**	para. E-22 thru E-24 of Section II,Appendex E, FM 3-04.155, ppE-6 & for context JUAS CONOPS, pp II-16thru II-17 (3) Mission Planning para a & b.

Appendix C

Categorization of Soldiers according to relevance of the training domain to their last duty position while deployed.

More Relevant		**Less Relevant**	
Branch	**Duty Position**	**Branch**	**Duty Position**
Armor	Platoon Leader	Aviation	Aviation Mechanic
Armor	Troop XO	Aviation	Shop Tech
Aviation	Flight Platoon Leader	Engineer	PL
FieldArtillery	BN targeting NCO	FieldArtillery	CBRN NOIC
FieldArtillery	Plt Sgt	Military Police	Human Resources Sgt
Infantry	Platoon Leader/ASST S3	Ordnance	Shop foreman
Infantry	SquadLeader	Ordnance	(not given)
Infantry	Platoon Leader	Signal	PLT SGT(E7)
Infantry	SquadLeader	Transportation	BG Transportation NCO
Military Intelligence	SignitPlatoon Leader	Transportation	TruckDriver
Military Police	Battle Captain		
Signal	Platoon Leader		
Signal	Co XO		
(not given)	Squad Leader		

Appendix D

System Usability Questionnaire

For each question, Soldiers were asked to rate their level of agreement with the given statement as Strongly Agree, Agree, Neutral, Disagree, Strongly Disagree. For purposes of analysis these answers were recoded as 2, 1, 0, -1, and -2, respectively. No statistically significant relationships were found between the training outcomes and the opinions provided.

Percent of Soldier Responses

	Strongly agree	Agree	Neutral	Disagree	Strongly disagree
1. I felt I understood the "knobology" of the system (how to make it work), <u>during the instructional and testing phases</u>.	29.2	41.7	16.7	12.5	0
2. I felt I understood the "knobology" of the training system (how to make it work), <u>during the scenario phases</u>.	20.8	50.0	16.7	12.5	0
3. I was aware that I could ask for hints during the scenario phases.	62.5	25.0	8.3	4.2	0
4. I was aware that there were reference materials about the SUAS system that I could access during the scenario phases.	29.2	33.3	20.8	16.7	0
5. I was aware that there was a glossary that I could reference during the scenario phases.	33.3	20.8	20.8	20.8	4.2
6. The effort needed to operate the training system was manageable.	29.2	66.7	4.2	0	0
7. I am confident that I could explain to a friend how to use this system.	25.0	45.8	25.0	0	4.2
8.The training system was clear about what it thought I needed to learn.	12.5	70.8	16.7	0	0

Appendix E

Training Evaluation Questionnaire

Modal Responses for each condition for each question

Thinking about the training prototype you worked with today, please rate it on how you think it would compare in effectiveness to conventional classroom training on each of the following:	ADAPTIVE	NONADAPTIVE
1. Providing knowledge background on employment of SUAS	Better	Just as good
2. Getting exposure to the kind of decisions leaders will need to make about actual SUAS employment	Multiple: Just as good & Better	Just as good
3. Experiencing actual situations that might arise during the employment of an SUAS	Better	Just as good
4. Applying tactical knowledge and skills to the employment of SUAS	Better	Just as good
5. Identifying gaps in your knowledge about employment of SUAS	Better	Just as good
6. Which of the following best describes how you felt about the initial instruction about SUAS employment?	I was unfamiliar with a lot of the material and really found it informative	I was unfamiliar with a lot of the material and really found it informative
7. The instruction I was presented with held my attention.	Multiple: Neutral & Strongly Agree & Strongly Disagree	Multiple: Neutral & Strongly Disagree
8. I felt that the instruction provided was helpful in my subsequent ability to complete the scenario(s).	Agree	Agree
9. Which of the following best described how you felt about the scenario(s) you completed?	It was the right level of challenge for me	It was the right level of challenge for me
10. The scenario(s) I worked on were realistic	Agree	Multiple: Neutral & Agree
11. The scenario(s) I worked on held my attention	Agree	Agree
12. The feedback given during the scenarios was helpful	Agree	Agree
13. The hints available during the scenarios were helpful	Agree	Neutral
14. I think this would make a good training system for leaders at company and below with organic SUAS	Agree	Multiple: Neutral & Agree & Strongly Agree

Appendix F

SESSION LOG SUMMARIES

✓ indicates scenario was completed successfully
✗ indicates that scenario was not completed successfully
E in Soldier ID indicates NCO
O in Soldier ID indicates officer
Steps during scenario attempts represent the number of decisions made
min = minutes

Adaptive Condition

Soldier ID	*E1*	*E2*	*O3*	*O4*
Pretest - % correct (min)	*45.4% (15.7)*	*36.3% (9.8)*	*63.6% (18.9)*	*45.4% (9.3)*
Upfront Instruction - # of ELOs (min)	*11 (39.5)*	*10 (17.9)*	*7 (13.4)*	*11 (22.5)*
Offense Scenario Try 1 - steps (min)	✓*12 (12.2)*	*2 (2.1)*	✓*12 (16.2)*	✓*12 (11.8)*
Remediation - # of ELOs (min)		*4 (1.0)*		
Offense Scenario Try 2 - steps (min)		*5 (1.2)*		
Remediation - # of ELOs (min)		*2 (0.6)*		
Offense Scenario Try 3 - steps (min)		✗*4 (0.3)*		
Remediation - # of ELOs (min)		*3 (1.0)*		
Defense Scenario Try 1 - steps (min)	✓*11 (15.8)*	*1 (0.3)*	✓*11 (18.27)*	✓*11 (12.5)*
Remediation - # of ELOs (min)		*2 (0.6)*		
Defense Scenario Try 2 - steps (min)		*7 (0.9)*		
Remediation - # of ELOs (min)		*1 (0.3)*		
Defense Scenario Try 3 - steps (min)		✗*2 (0.3)*		
Remediation - # of ELOs (min)		*3 (0.6)*		
Posttest - % correct (min)	*54.5% (12)*	*63.6% (9.5)*	*72.7% (13.8)*	*81.8% (5.7)*

Soldier ID	*E6*	*O7*	*O8*	*O9*
Pretest - % correct (min)	*54.5% (13.8)*	*59.1% (10.2)*	*59.0% (8.2)*	*54.5% (13.41)*
Upfront Instruction - # of ELOs (min)	*12 (24.1)*	*10 (38.1)*	*10 (11.5)*	
Offense Scenario Try 1 - steps (min)	*6 (5.1)*	*11 (28.2)*	*11 (14.8)*	✓*11 (50.4)*
Remediation - # of ELOs (min)	*1 (1.6)*	*1 (1.6)*	*1 (0.4)*	
Offense Scenario Try 2 - steps (min)	✓*5 (1.9)*	✓*4 (1.3)*	*5 (2.3)*	
Remediation - # of ELOs (min)			*2 (0.5)*	
Offense Scenario Try 3 - steps (min)			✓*5 (1.2)*	
Remediation - # of ELOs (min)				
Defense Scenario Try 1 - steps (min)	*4 (2.65)*	*11 (4.7)*	✓*11 (6.4)*	✓*11 (18.7)*
Remediation - # of ELOs (min)	*2 (4.1)*	*4 (2.0)*		
Defense Scenario Try 2 - steps (min)	*4 (.9)*	*4 (6.3)*		
Remediation - # of ELOs (min)	*2 (.8)*	*3 (1.1)*		
Defense Scenario Try 3 - steps (min)	✗*4 (.8)*	✓*4 (1.5)*		
Remediation - # of ELOs (min)	*2 (3.18)*			
Posttest - % correct (min)	*36.4% (6.6)*	*86.4% (6.8)*	*81.8% (4.6)*	*50 % (8.2)*

Soldier ID	*O11*	*O12*	*E13*	*O13*
Pretest - % correct (min)	*63.6% (8.9)*	*50% (31.6)*	*45.4 % (19.6)*	*45.4% (11.4)*
Upfront Instruction - # of ELOs (min)	*7 (28.3)*	*10 (48.6)*	*10 (8.6)*	*9 (46.4)*
Offense Scenario Try 1 - steps (min)	✓*12 (20.3)*	*7 (26.7)*	✓*11 (22.0)*	✓*12 (12.8)*
Remediation - # of ELOs (min)		*1 (1.2)*		
Offense Scenario Try 2 - steps (min)		*4 (2.4)*		
Remediation - # of ELOs (min)		*1 (0.6)*		
Offense Scenario Try 3 - steps (min)		✓*4 (2.2)*		
Remediation - # of ELOs (min)				
Defense Scenario Try 1 - steps (min)	✓*11 (7.3)*	*11 (8.0)*	*6 (8.0)*	*11 (7.6)*
Remediation - # of ELOs (min)		*2 (0.9)*	*1 (.63)*	*1 (0.2)*
Defense Scenario Try 2 - steps (min)		*4 (2.9)*	*6 (3.8)*	✓*4 (1.0)*
Remediation - # of ELOs (min)		*1 (0.6)*	*1 (1.9)*	
Defense Scenario Try 3 - steps (min)		✗*4 (1.1)*	✗*3 (3.6)*	
Remediation - # of ELOs (min)		*1 (0.4)*	*2 (0.3)*	
Posttest - % correct (min)	*72.7 % (1.9)*	*68% (5.4)*	*45.4 % (7.0)*	*59.1% (4.1)*

Soldier ID	E5
Pretest - % correct (min)	31.8% (15.4)
Upfront Instruction - # of ELOs (min)	9 (4.7)
Offense Scenario Try 1 - steps (min)	✓11 (41.2)
Remediation - # of ELOs (min)	
Offense Scenario Try 2 - steps (min)	
Remediation - # of ELOs (min)	
Offense Scenario Try 3 - steps (min)	
Remediation - # of ELOs (min)	
Defense Scenario Try 1 - steps (min)	4 (8.2)
Remediation - # of ELOs (min)	1 (1.4)
Defense Scenario Try 2 - steps (min)	7 (7.5)
Remediation - # of ELOs (min)	1 (1.6)
Defense Scenario Try 3 - steps (min)	✗3 (2.7)
Remediation - # of ELOs (min)	1 (0.4)
Posttest - % correct (min)	40.9% (8.6)

Nonadaptive Condition

Soldier ID	Pretest % correct (minutes)	Upfront Instruction minutes	Offense Scenario - minutes	Defense Scenario - minutes	Posttest % correct (minutes)
EC10	59.1% (7.3)	18.0	✓19.7	✓7.9	68.2% (4.6)
EC2	36.4% (7.0)	35.6	✗ 2.6	✗ 2.0	36.6% (6.6)
EC3	63.6% (12.0)	9.2	✓ 7.6	✗ 4.9	59.1% (5.7)
EC4	40.9% (10.1)	67.6	✓ 2.7	✗ 7.8	68.2% (5.6)
EC5	45.4% (12.0)	34.5	✓19.0	✓11.0	59.1% (6.8)
EC6	31.8% (12.3)	38.6	✓11.8	✗ 7.2	63.6% (9.7)
EC9	27.3% (10.3)	92.6	✓ 8.7	✗6.1	77.3% (5.6)
OC1	40.9% (9.8)	10.9	✓ 8.2	✓ 4.5	50.0% (7.2)
OC11	50.0% (7.9)	38.6	✓11.6	✓6.2	59.1% (11.8)
OC7	54.5% (6.3)	51.4	✓15.8	✓ 4.7	68.2% (4.3)
OC8	59.1% (11.7)	13.2	✓ 1.0	✓ 0.9	59.1% (6.3)

Appendix G

ACRONYMS

BN	Battalion
CO	Company Commander
ELO	Enabling Learning Objective
IMI	Interactive Multimedia Instruction
LMS	Learning Management System
METT-TC	Mission, Enemy, Time, Terrain/Weather, Troops Available, and Civil
NCO	Noncommissioned Officer
OBJ	Objective
PL	Platoon Leader
SUAS	Small Unmanned Aerial System
TLO	Terminal Learning Objective
TTPs	Tactics, Techniques, and Procedures
XO	Executive Officer