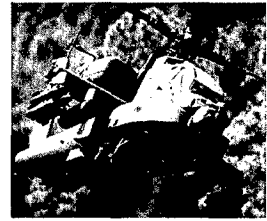


U.S. Army Research Institute
Special Report #56
May, 2003



Enhancing U.S. Army Aircrew Coordination Training

20030724 020



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Foreword

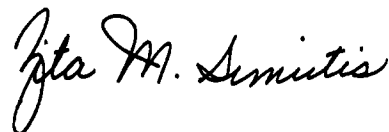
This special report describes objectives and outcomes of ongoing team training research and development (R&D) under the guidance of the U.S. Army Research Institute for the Behavioral and Social Sciences, Rotary-Wing Aviation Research Unit (ARI-RWARU) at Fort Rucker, Alabama. The Aircrew Coordination Training Enhancement (ACTE) program is an applied research project that employs experience, innovation, and technology to address the operational issue, "Can interactive multimedia courseware using web-based distribution provide the realism and relevance necessary for effective behavior-based team training and evaluation?"

The goal of the ACT Enhancement effort is to make available a web-delivered, interactive aircrew coordination training system that provides Army aircrews with the knowledge and skill-sets needed to increase flight safety and mission effectiveness in daily operations. Focus areas for the applied research were identified by Army leadership and the Aircrew Coordination Training Working Group. They emphasized —

- Current ACT program revitalization and enhancement without repeating previous research
- Automation and aircraft configuration issues
- Course length reductions
- Simplified assessment and evaluation procedures
- Adult learning-based presentation, feedback, and discussion

The products from the first phase of research are research reports on the development and evaluation of computer-based Aircrew Coordination Training. They include as attachments two interactive multimedia courses of instruction with supporting training, the ACTE Aircrew Course and the ACTE Instructor Course. Both courses contain a fully integrated Data Management System that tracks student demographics, provides graphic feedback displays during evaluation exercises, and facilitates electronic course critiques. User testing and validation results indicate high levels of acceptance for both the training and performance evaluation components. Initial testing of the prototype courseware on the Army's distance learning suite supports both the web-based and instructor facilitated delivery strategies. The products have been presented to the U.S. Army Aviation Center for consideration for Army-wide implementation.

Initial data suggest that web-delivered, interactive multimedia courseware provides effective realism and relevance for team training and evaluation. Ongoing ARI research activities include developing aircraft-specific training support packages and a program to meet the particular training needs of non-rated crewmembers. The ACTE serves as a model for adult learning-based training supported by distance learning technologies.



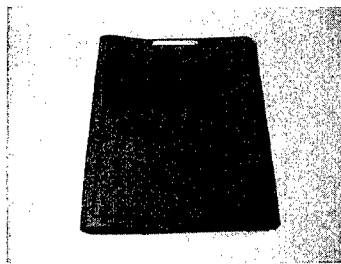
ZITA M. SIMUTIS
Director

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The Aircrew Coordination Training (ACT) Challenge

The crew of the UH-60 Black Hawk helicopter was conducting night training. The four-man crew was wearing night vision goggles in an extremely dusty environment. CW2 Stanley was a little nervous, having only 600 hours in this aircraft, but he was very aware that his Instructor Pilot (IP), CPT Fulford, had over 3,000 hours of flight time and was highly respected in the unit for his abilities. CPT Fulford was on the controls when they took off into a dust cloud. Stanley and both of the crew chiefs sitting in the back seat sensed that the aircraft was in a left turn, but none of them said anything, not wanting to question CPT Fulford. The aircraft had indeed been in a left turn, which changed a stiff right crosswind into a tailwind and prevented it from climbing out of the dust cloud. It contacted the ground, rolled over, and was destroyed.



The results of the Accident Review Board were conclusive. Crew error, specifically on the part of the instructor pilot, was the prime contributing cause of this accident. CPT Fulford allowed himself to exceed his capabilities by attempting to perform a maneuver that he had not performed in the aircraft for an extended period of time. But there was a deeper, more disturbing element present here as well. Three other crewmembers just sat there and let it occur. All sensed that something was not quite right, but they made no attempt to say anything during the maneuver that may have prevented the error that was about to occur.

Aircrew Coordination Training Defined

The US Army defines aircrew coordination as a set of principles, attitudes, procedures, and techniques that transforms individuals into an effective crew. The stated objective of Aircrew Coordination Training (ACT) is to provide aircrews the knowledge, skills and attitudes necessary to increase their mission effectiveness, while decreasing the errors that lead to accidents.

ACT and Crew/Cockpit Resource Management (CRM) programs were instituted in the 1980's, first in commercial aviation and later in military aviation, to address adverse mishap rate trends that showed the inability of many aviators to work well together in periods of high stress or workload (Helmreich, Merritt, & Wilhelm, 1999). Minor aircraft malfunctions were resulting in fatal accidents with alarming frequency. While aviators generally displayed excellent knowledge and understanding of aircraft systems, operating procedures, rules and regulations and other technical information, they often displayed a glaring inability to communicate effectively, distribute workload, maintain or regain situational awareness and make sound decisions. Military aviation took note of the success of CRM in the civilian sector and instituted similar training programs (Orlady & Foushee, 1987).

ACT/CRM programs have been structured in various ways and continue to evolve as the perspective changes as to what constitutes effective team coordination training. Most programs include the following basic elements:

- A discussion of the core behaviors or basic skill sets that make up ACT. Each program structures these core behaviors differently, but all contain common elements.
- An examination of the applicability of ACT behaviors in the “real world.” This typically takes the form of one or more case studies of real-world incidents or accidents and includes an analysis of where or when proper ACT behaviors could have been employed.
- Some type of role-playing or practice of ACT behaviors in a simulated mission setting, e.g., line-oriented flight training (LOFT) or its equivalent.
- Some form of assessment of the learning or changes in attitudes and behaviors that have taken place as a result of the training, and the evaluation of the training by the students.

During fiscal years 1984-1989, crew coordination failures identified by the Army Safety Center directly contributed to the loss of 147 lives and \$292 million in aviation accident costs. In 1990, Army leadership directed the Army Aviation Center to focus its aviation training and evaluation on crew performance.

Beginning in 1988, the US Army Research Institute (ARI) began conducting a program of training research that responded to the Army need for better crew coordination training. This program of research conducted in close cooperation with the US Army Aviation Center (USAAVNC) in support of the effort to revise aviation training standards to incorporate increased emphasis on crew-level performance. To assist in the effort to refocus aircrew training on the crew level of performance, ARI contracted with Dynamics Research Corporation (DRC) for a two-phase research effort. First, develop and test measures of crew coordination, then develop and validate an Aircrew Coordination Training course using field aviators. Evaluation testing of aircrew coordination measures by unit aviators produced favorable results (Pawlik, Simon, Risser, & Zeller, 1990). The US Army Aviation Center then formed an Aircrew Coordination Working Group (ACWG) to review measures, research results, and companion training and evaluation materials. The ACWG revised the behavior-based training and evaluation designs for development and validation testing of an aircrew coordination course.

ARI worked closely with Army aviation training, evaluation, and safety personnel to develop, validate, and field an ACT Exportable Training Package. The test bed demonstrated and validated the program for training and evaluating crew coordination skills. Test results showed that the crews performed their missions significantly more effectively and safely after the training than before the training (Simon & Grubb, 1993).

The Army ACT program suite of methods and measures included behaviors and performance (see Table 1). Results of the Army ACT validation test showed significant improvement in aircrews' overall mission effectiveness between pre- and post-training evaluation scenarios. During this test, all aircrews made errors in completing the complex, tactical simulator missions. Pre- to post-

training results improved markedly for navigation, instrument flight recovery, and mission-threatening error performance measures. Like the mission effectiveness increases, results of the Army ACT validation test showed significant improvement in aircrew flying safety between pre- and post-training evaluation scenarios.

Table 1. 1992 ACT Validation Test.

Methods and Measures	
ACT behaviors or Basic Qualities evaluated with supporting behaviorally anchored rating scales	
Aircrew Training Manual task performance	
Mission performance of two flight simulator scenarios similar in difficulty in terms of time stress, navigational demands, quantity and capabilities of simulated threat	
Mission Effectiveness Results	
Overall mission effectiveness	+20%
Navigation accuracy	+38%
Mission objectives	+44%
Error Management Results	
Course deviations	-45%
Arrive at correct landing zone	+38%
No early descent below minimums	+32%
Manage mission threatening error	+27%
Flying Safety Results	
Unexpected weather recovery	+25%
Emergency detection	+38%
Number of aircraft crashes	-43%

Instructor evaluators rated crew performance of the set of 13 Army ACT behaviors (called Basic Qualities) during each test mission. There was improvement between the pre-training and post-training evaluations in every Basic Quality with statistically significant improvements on 12 of 13.

The USAAVNC approved the Aircrew Coordination Exportable Training Package (ETP) (Pawlik, Simon, Grubb, & Zeller, 1992) late in 1992, and formed a training cadre in August, 1993. This cadre, made up of attack, cargo, observation, and utility subject matter experts (SMEs), was tasked to field the training and evaluation system to both the Army Active and Reserve Components by the end of May 1995 (Pawlik, Simon, Grubb, & Zeller, 1993).

Aircrew Training Program

The Army's Aircrew Training Program (ATP) specifies that aircrew coordination be emphasized during readiness level progressions and will be evaluated during all evaluation flights. The inclusion of aircrew coordination in Aircrew Training Manual (ATM) task descriptions reflects the "crew concept" philosophy that generally no task is an individual undertaking. Each task can be performed more effectively and safely by the coordinated efforts of the entire crew. ATM revisions will include crew actions in the task descriptions, as appropriate. Crew actions define responsibilities, whether individual or crew, by describing the parts of a task that an individual or group of crewmembers will perform. Knowledge of the crew actions for tasks being performed will help crewmembers perform their individual actions more effectively and enhance crew coordination.

Research and studies conducted by USAAVNC, ARI, and the US Army Safety Center (USASC) show the importance of good aircrew coordination. A 1990 analysis of US Army aviation accidents revealed that a significant percentage of these accidents resulted from one or more crew coordination errors committed before or during the flight. Often an accident was the result of a sequence of undetected crew errors that combined to produce a catastrophic result. Additional research by ARI showed that even when accidents are avoided, these same errors can result in degraded performance. A systematic analysis of these error patterns identified specific areas where crew-level training could reduce the occurrence of such errors and break the error chains leading to accidents and poor performance (Peusch & Hicks, 2001).

Broadly defined, aircrew coordination is the interaction of crewmembers necessary for the safe, efficient, and effective performance of tasks. Working with this definition, the USAAVNC and ARI translated crew coordination concepts into a set of 5 crew coordination objectives and 13 Basic Qualities (see Appendix A). Crew coordination objectives are the on-going crew mission responsibilities that form the organizing structure for aircrew coordination training and evaluation behaviors. Basic Qualities are the behaviors and skills that can be trained, observed, and evaluated relative to crew coordination performance. Both Crew Coordination Objectives and Basic Qualities have been incorporated into the USAAVNC Aircrew Coordination ETP. Each basic quality is defined in terms of observable behaviors that represent superior, satisfactory, or unsatisfactory levels of crew coordination. These Basic Qualities and goals are summarized in each aircraft ATM. The Aircrew Coordination ETP contains detailed guidance and performance descriptions for use by commanders to evaluate ACT performance and qualify crewmembers.

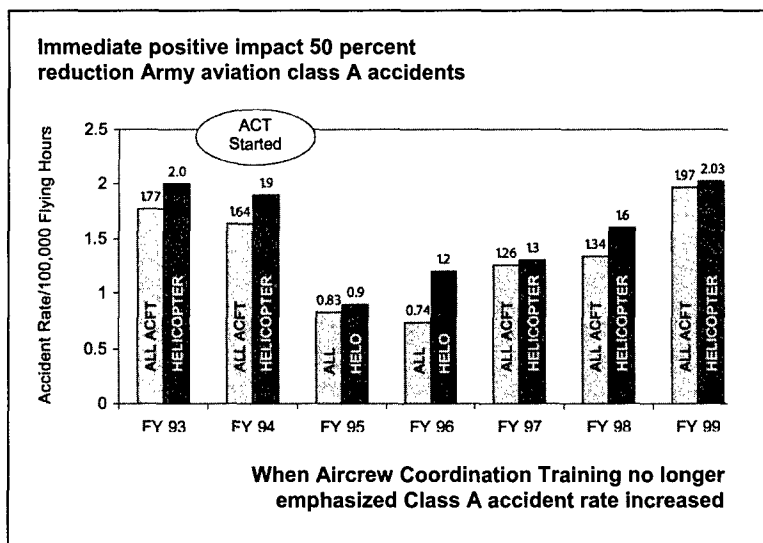
Description of the Initial Army ACT Program

The U.S. Army implemented its version of ACT in 1994 (Department of the Army, 1992). As a result of the initial ACT training program, Army aircrews learned behavioral skills and team coordination techniques that helped them to remain focused and ready to deal with emergencies and unforeseen problems so they were able to better concentrate on mission objectives.

Implementation

Crew coordination training provides the knowledge, skills, and attitudes to aircrews that increase their mission effectiveness, while decreasing the cockpit errors that contribute to accidents. Following the implementation of the initial Army ACT in the mid-nineties, the Class A accident rate dramatically dropped (see Figure 1). Army ACT was presented as “one-time training” without annual continuation or sustainment training. Though other variables may have contributed to the decrease, the Class A aviation accident rate increased when ACT was no longer emphasized.

Figure 1. Impact on accident rate.



Commanders and aircrews alike acknowledged the benefit of the mandatory, one-time training that was received by all aviators within the Army aviation community. The initial program did not address sustainment issues and did not package the training in a program that would facilitate such training. Therefore, sufficient funds were not provided for developing a program to sustain this important training. Funding issues notwithstanding, significant personnel turbulence associated with downsizing the force since the 1994 program inception has potentially resulted in an erosion of the safety gains initially realized as a result of ACT. Finally, the atrophy of skills and the decline of experience levels that occurred during successive years of limited defense funding coincided with a sharp increase in accident and incident rates (Allman, 2002).

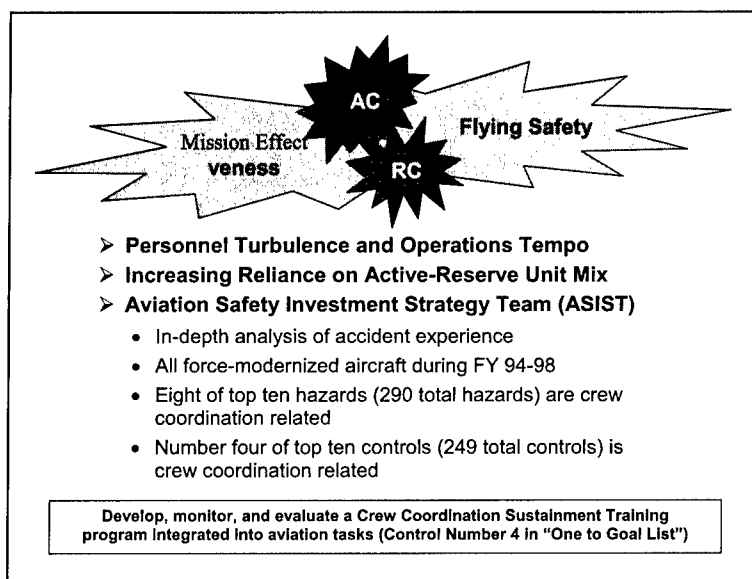
Lack of effective aircrew coordination continues to be cited as a definite or suspected contributing factor in aviation flight accidents, and it is a factor limiting attainment of the full mission effectiveness of Army aviation. For example, the Director of Army Safety reported in the December 1999 issue of *Flightfax*, “In fact, FY99 produced Army aviation’s worst safety performance since Desert Shield/Desert Storm.” The ACT program has not been updated since its original introduction. Currently, ACT is conducted in the classroom via eight hours of instruction, with no mandatory follow on training. Instructors responsible for evaluating and reinforcing this academic training receive four hours of academic training with no exam to determine competency. Temporary measures such as awareness videos, assistance visits, safety newsletter articles, and a web-based training support package have been ineffective substitutes for focused ACT training.

Enhancing Behavior-based Training and Evaluation

Aviation Safety Investment Strategy Team (ASIST)

Lack of effective aircrew coordination continues to be cited as a definite or suspected contributing factor in aviation flight accidents, and it is a factor limiting attainment of the full mission effectiveness of Army aviation. The Aviation Safety Investment Strategy Team (see Figure 2) was chartered in 1994 to define measurable accident prevention goals and identify the most important Army-wide investments needed to achieve them. The ASIST study reported that a crew coordination sustainment-training program would help attain the Army accident reduction goals at the least investment cost (Hicks & Peusch, 2000).

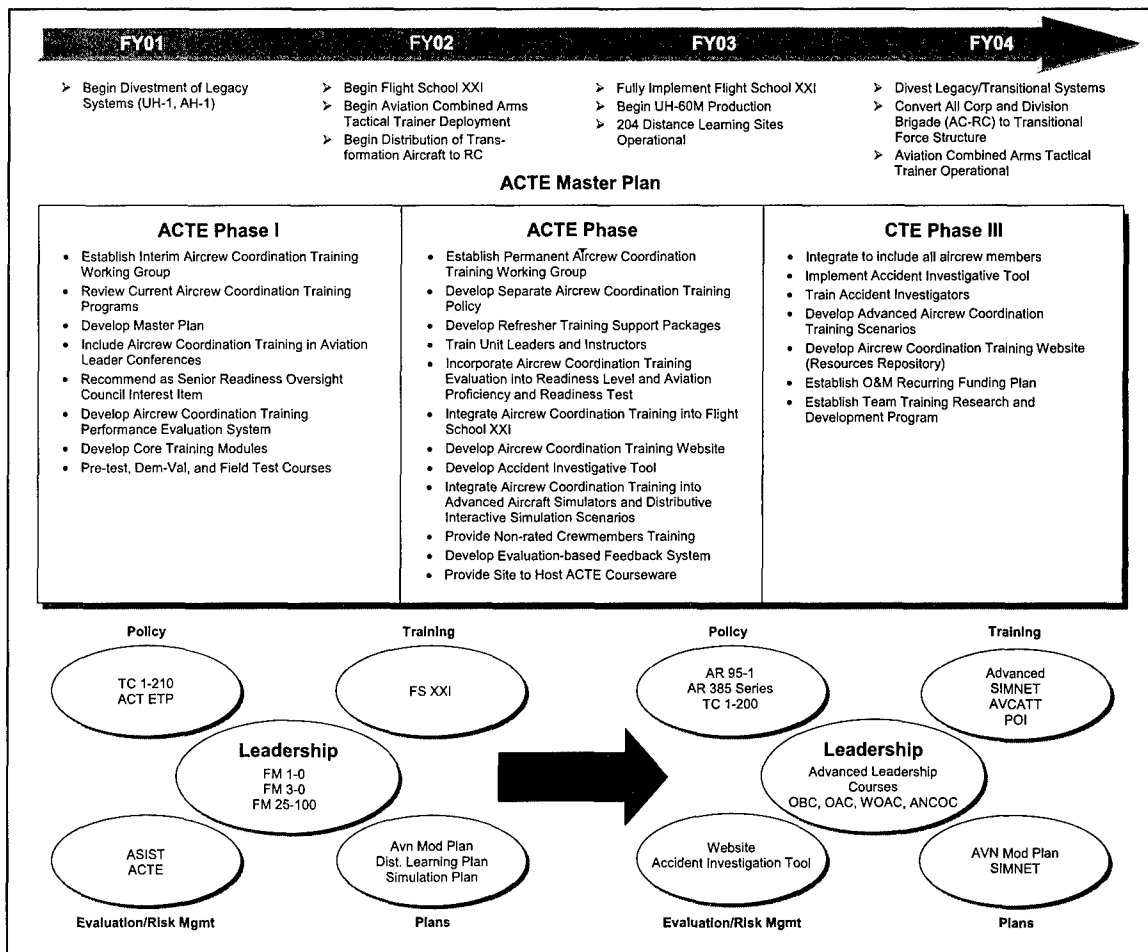
Figure 2. Aviation Safety Investment Strategy Team (ASIST).



Aircrew Coordination Training Master Plan

The ACTE program is being developed under the guidelines established by the ARI-produced Army Aircrew Coordination Training Master Plan. The plan provides a proactive, multi-phased course of continuous improvement to maximize Army aviation modernization investments and complement leadership training initiatives (see Figure 3). The now completed initial research task was to establish a logical master plan that provides a business process for achieving the desired ACTE program end-state. Aircrew training programs currently provided by Army, other Department of Defense (DoD) agencies, and commercial air carriers were reviewed as benchmarks for the training and evaluation of aircrew and team coordination in both the institution and unit environments. Issues relevant to both rated and non-rated aircrew members in rotary wing and fixed wing environments were identified. Insights and operational trend data provided by the aviation safety, standards and evaluation, and training communities were examined.

Figure 3. Aircrew Coordination Training Master Plan.




Aircrew Coordination Training Enhancement (ACTE) Research

The objective of the research effort to enhance Army ACT is to improve the crew and team coordination effectiveness of Army aircrews in their day-to-day mission planning and flight operations. The enhanced ACT program builds on the original exportable training package, revitalizing it from a one-time training event and enhancing it to a dynamic, relevant program that is continuously updated and improved (see Figure 4). Establishing and maintaining a unit-level command climate that promotes the use of team coordination behaviors will realize this objective and places equal emphasis on technical and team coordination skills in daily flight operations. Instructor pilots and ACT facilitators in aviation units are key to the institutionalization of a successful ACT program.

ARI's Rotary-Wing Aviation Research Unit convened an Aircrew Coordination Working Group (ACWG) with recognized knowledge and experience in aircrew coordination training, standards and evaluation, safety, and human factors to review measures, methods, and training materials prior to inclusion in the prototype ACTE courses. The ACWG is composed of designated representatives from the USAAVNC, the USASC, and the Army National Guard. Other agencies that have information or resources that contribute to planning or developing the program or have a role in implementing or evaluating the program are included.

Figure 4. Old versus enhanced ACT.

OLD	Revitalized
<ul style="list-style-type: none">• Initial, one-time qualification training• Facilitated discussion of paper-based courseware with generic video segments• Basic qualities of ACT behaviors• Research-based evaluation methods and measures	<ul style="list-style-type: none">• Sustainment training with annual updates• Advanced adult learning technologies in electronic classroom environment• ACT skills level of instruction• Simplified evaluation tools and techniques• Reduced course length• Reduce instructor requirements for units to implement Tailored to aircraft and unit missions• Hands-on applications based on current operational situations• Enhanced error management tools and techniques• Unit-level training packages with web-based feedback and support• Ongoing program evaluation and management, i.e., training, safety, standards and evaluation
	

The current enhancement program managed by the ARI is a multi-year, multiphase program of applied research structured in three major phases – upgrade and sustain the existing ACT program, refresh and maintain the upgraded ACT program, and deploy advanced ACT applications. Phase I of the research effort to upgrade and sustain the current ACT program is completed. Two ACTE prototype courseware programs have been delivered to the Army, the Aircrew Course and the Instructor Course. Each course of instruction is the integration and end product of:

- Analysis of the current aircrew coordination training program
- Definition of evaluation tools and techniques for assessing along specific behavioral proficiency dimensions overall crewmember team performance
- Development of prototype focused interventions for training and evaluating team coordination behaviors and for managing risk
- Validation of prototype team training and evaluation techniques in selected aviation units
- Field-testing of prototype training, evaluation, and technology products

Enhancement Prototype Products

When the Phase I prototype products are fully developed and deployed, the Aircrew Coordination Training Enhancement (ACTE) program will provide mission-oriented sustainment training and provision for web-accessible updates.

Simplified Performance Evaluation System

The products necessary to provide a simplified performance evaluation system consisted of a practical assessment methodology and a suite of quantitative, field-usable measures to allow across-platform and across-crew configurations evaluation of ACT behaviors and skills. Implementing the evaluation system required a tool for recording ACT performance evaluations to support facilitation of team performance improvement during the after-action review.

The central product is a set of observable measures of individual and collective behavior, the Behaviorally Anchored Rating System (BARS). The BARS is gleaned from extensive research across DoD and commercial aviation communities (e.g., Leedom & Simon, 1993; Simon, 1990) and served as a precursor to courseware content design and development. The BARS evaluation criteria are based on issues relevant to both rated and non-rated aircrew members in rotary wing and fixed wing environments and serve as the benchmarks against which crew team behaviors are evaluated.

The measurement of aircrew coordination behavior is a critical component of the aircrew coordination program and is central to the training content design and delivery. The vehicle for documenting these evaluations is the ACT Performance Evaluation Checklist (see Appendix B) which is based on the 5 Crew Coordination Objectives (CCO) and 13 Basic Qualities (BQ) accepted by the Army as descriptors of aircrew coordination behavior. ACT behaviors and skills are organized by CCO and are rated using a seven-point scale with values ranging from 1, Below Standards to 7, Exceeds Standards (see Figure 5). In an electronic classroom setting, learners observe a training vignette and are given the opportunity to evaluate aircrew behaviors and skills using an on-line electronic ACT Performance Evaluation Checklist. Their individual responses are aggregated as a histogram and displayed to the class to serve as the basis for instructor-facilitated discussion to achieve learning objectives.

Figure 5. BARS numeric rating scale.

Below Standard 1	2	3	Meets Standard 4	5	6	Exceeds Standard 7
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Written descriptions are provided for the ACT behaviors and skills and levels of performance for rating aircrews at the values of 1, 4, and 7. These descriptions serve as behavioral “anchors” and are designed to assist in determining how well an aircrew performs ACT behaviors and skills in relation to a well-defined set of performance criteria. The anchors are used as the standard for evaluating ACT performance. This avoids the trap of norm referencing, i.e., comparing one aircrew’s performance with that of another. An aircrew’s performance is always rated solely in relation to the anchors. This has long-term implications for the objective measurement of aircrew coordination improvement.

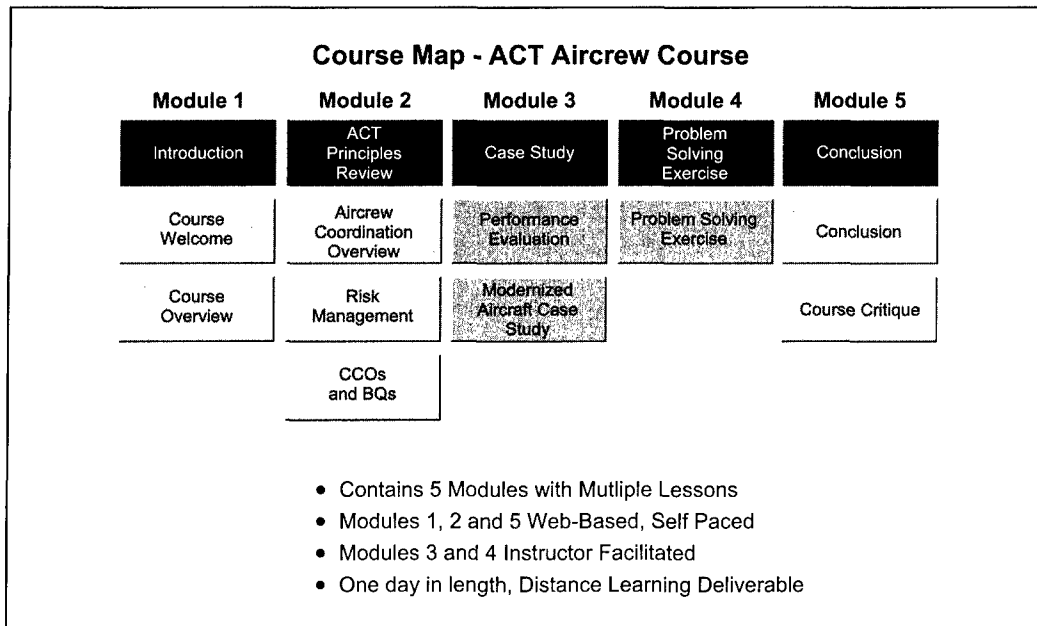
Web-based Courseware Development

ACTE courses are designed for access via an Internet browser. Courseware web application components are compliant with Army Distance Learning software requirements and graphics are produced with a suite of Macromedia Flash and Dreamweaver UltraDev authoring tools. A Microsoft Access hosted Data Management System (DMS) that is fully compatible with emerging learning management system (LMS) standards is used to manage course administration tasks, track student demographics, and collect student critique data. A key feature of the DMS is its ability to capture student responses from their use of the ACT Performance Evaluation Checklist and provide graphic feedback displays of practical exercise results. Student reports can be printed directly from a web browser. Critique items were developed to collect participant data on the following information areas: Course structure and delivery, length of lesson, instructor, equipment, and course effectiveness. A five-point response scale with values ranging from 1 (Strongly Disagree), 3 (Neither Agree nor Disagree), and 5 (Strongly Agree) were presented for each item in the electronic course critique.

Aircrew Course

The Aircrew Course consists of five modules of instruction: Introduction, an ACT Principles and Risk Management Review module, a Case Study, a Problem Solving Exercise, and a Conclusion (see Figure 6).

Figure 6. Aircrew Course design.



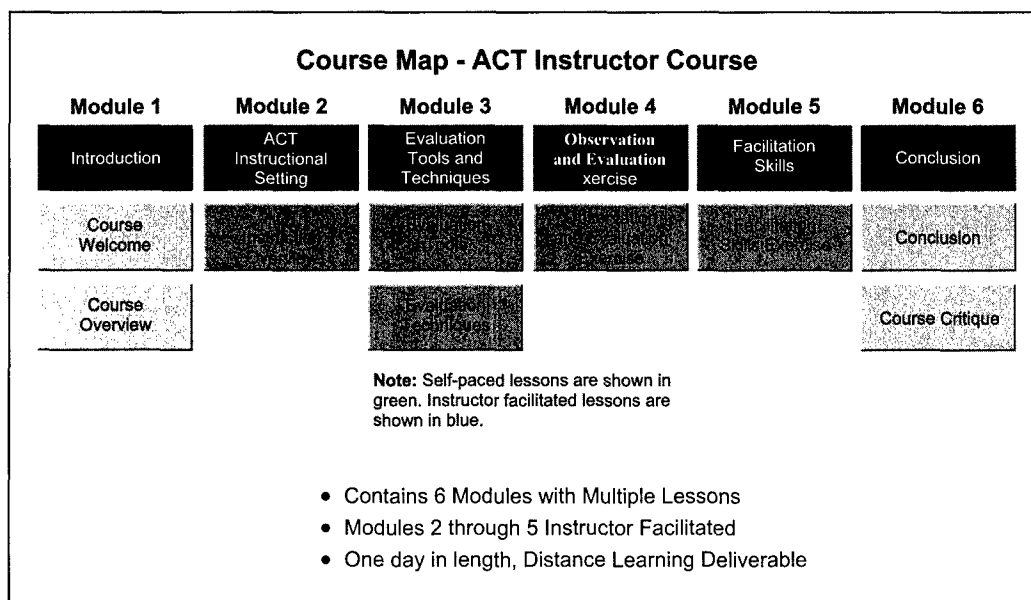
Both the Principles Review and Risk Management modules employ extensive use of narrated audio video files. The narration guides the user through the course material while the audio video files provide support at the exact time of cognitive need. Comprehension checks provide learners the opportunity to check their retention and feedback relating to their understanding of important information. A linked list of related topics is provided on each topic header page for those aircrew members who desire a more in-depth review.

The case study module provides an opportunity for aircrew members to become familiar with the performance evaluation system and the BARS for their use in promoting and evaluating team coordination behaviors. Once they have reviewed the CCOs and BQs, students are presented a current case study. A central feature of the case study is an audio video vignette, based on a mishap taken from actual USASC files, that focuses on automation or crew configuration related accident or incident trends. Once students observe the vignette, they are given the opportunity to evaluate aircrew behaviors using the on-line electronic ACT Performance Evaluation Checklist. Their individual responses are aggregated as a histogram and displayed to the class to serve as the basis for instructor-facilitated discussion to achieve learning objectives. Finally, the learners are presented a problem solving exercise in which they are given the opportunity to apply their ACT knowledge and evaluation skills to a simulation derived from actual events and experiences in the field.

Instructor Course

The Instructor Course consists of six modules of instruction: Introduction, ACT Instructional Setting module, Evaluation Tools and Techniques, Observation and Evaluation Exercise, a module on Facilitation Skills, and a Conclusion (see Figure 7).

Figure 7. Instructor Course Design.



Completion of the ACTE Aircrew Course by unit instructor pilots is a prerequisite to attending the Instructor Course. Instructor pilots must be highly proficient in all ACT behaviors and skills learned during the Aircrew Course and they must be able to apply and evaluate them in their organization's mission environment. As the role model of ACT behaviors and skills for other aircrew members, they must "walk the walk" every flight and every simulation period. The ACT Instructional Setting module emphasizes the ACT Instructor's role in an operational unit, relates the ACT Crew Coordination Objectives (CCOs) and Basic Qualities (BQs) to the Army Risk Management Process, and demonstrates their use as control measures to mitigate risk.

Presentation approaches and features similar to those used in the Aircrew Course provide in-depth instruction and practice exercises on applying the ACT Performance Evaluation System tools and techniques to achieve reliable ratings of observed aircrew situations. The Instructor Course provides a module consisting of two separate lessons on detailed evaluation tools and evaluation techniques to equip unit instructor pilots as experts in identifying, evaluating, and facilitating ACT performance improvement. A second module devoted to practice exercises provides three mission related situations for instructors to improve their use of the performance evaluation system and establish a pattern of rating reliability.

Inherent to the ACT performance evaluation process is the ability to identify and apply the CCOs and BQs to operational and simulated mission settings. Courseware support materials for the Instructor Course include an Instructor Guide and ACT event driven scenario outlines for use in simulator or aircraft evaluations of aircrew ACT performance.

Additionally, to ensure that the ACT lessons learned during unit operational or training missions do not go unheeded, students will be taught the facilitation skills necessary to ensure that unit aircrews do, in fact, identify, apply and assimilate such lessons learned into future missions on a daily basis. This training requires well-developed observational and evaluative skills. The use of vignettes and the electronic Performance Evaluation Checklist supports practice exercises in the Facilitation Skills module.

Distance Learning Delivery

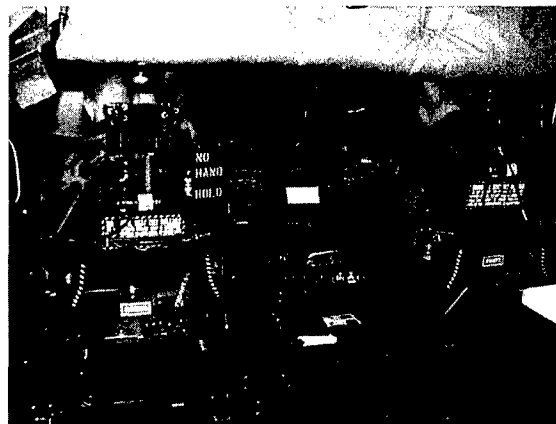
Both the Aircrew Course and Instructor course are accessible on the World Wide Web. A number of distribution tests, or evaluations of the courseware deliverability, were conducted throughout the testing and pre-fielding periods of Phase I. In each test, the courseware ran without significant error and the few technical issues presented were easily remedied with minor technical adjustments to the underlying programming. Importantly, the distribution tests confirmed the utility of the ACTE courseware for simultaneous consumption by geographically dispersed audiences. Additionally, distribution of the courseware in both a private local area network (LAN) and CD ROM format were tested and confirmed (see Figure 8). The outcome of the testing of courseware components ensures that the Army aviation community can make ACTE available to aviators worldwide.

Figure 8. Local Area Network and Classroom XXI Delivery



Performance and Effectiveness Results

After the board findings were released, the unit sat down and conducted a sincere self-assessment of their crew coordination performance. They were all qualified in aircrew coordination training, either from the original team training in 1994-95, Initial Entry Rotary Wing training, or the Exportable Training Package. What had happened to their skills? What could they do to regain or enhance these skills? By chance, ARI was bringing a new ACT enhancement prototype program to their installation for usability assessment. Could this enhanced program help to revive their behaviors and skills that they once had? They had little to lose



by participating in the program. In just under two months they were due to deploy to the National Training Center (NTC), and there they would encounter the same type of environmental conditions that created the situation for the accident. The unit decided to sign on for the evaluation of the research program, and was able to refresh 24 of their crewmembers in ACT. At the conclusion of this training, all participants felt that their skills were enhanced, and were ready to apply these skills on the NTC rotation.

The effectiveness of the ACTE training and evaluation components was measured at increasing levels of fidelity and scope. The ACWG actively participated in the courseware design and development process, approved release of prototype products for unit testing, and reviewed test results and approved subsequent products as they progressed through the prototype courseware development and testing process. The sequence of prototype product design, development, review, approval, testing, improvement began with user pretest of core modules, continued through usability assessment and field study, and concluded with operational field testing of the final prototype products. The demonstration and validation of the effectiveness of the Aircrew and Instructor Courses occurred as a two-part process consisting of a usability assessment and a field study followed by a final operational field test.

Usability Assessment

For the usability assessment, use of the courseware was observed and assessed in selected Army National Guard (ARNG) aviation units that represented cargo and observation aircraft, missions, and operating conditions. A type of formative evaluation, the usability assessment employed the prototype courseware in a field setting using representative groups of the target training audience. Data were gathered on Aircrew and Instructor course usability, effectiveness, and areas of needed interface and content improvement.

Using unit classrooms and facilities, contractor instructors presented the Aircrew and Instructor Courses in two four-hour periods each using the contractor provided LAN of notebook computers. ARI reviewed and approved the automated data collection items. Units identified and scheduled 20 participants to provide a cross section of highly experienced aircrew members and instructors. Participant ratings for the Aircrew Course averaged 4.0 or higher on a 5-point scale (see Table 2).

Table 2. Usability Assessment Participant Ratings.

Rating Items	Aircrew Course	Instructor Course
Courseware structure and navigation logical and understandable	4.0	3.8
Comprehension checks understandable	4.1	
Amount of information, pace and time good (On 5-point scale, 1= "too little", 5="too much"; 3 is optimal)	3.0	3.1
Vignettes allowed observation & related ACT to risk management	4.0	3.8
Instructor knowledge, preparation, and clarity	4.6	4.4
Student workstation equipment	4.6	
Performance Evaluation System and Aircrew Guide helpful	4.2	
Content relevant	4.3	
Positive effect on flying safety	4.4	4.1
Effect as refresher to previous Aircrew Coordination Training	4.2	
Positive effect on mission effectiveness	4.0	
Lessons helped understand how to identify ACT behaviors		4.1
Lessons helped understand how to evaluate ACT performance		4.0
Lessons helped understand how to facilitate ACT performance improvement		4.1
Instructor Evaluator Guide helpful for implementing ACT in daily ops		4.3

The subsequent analysis of usability assessment ratings and comments indicated wide and enthusiastic acceptance of the courseware as necessary and beneficial to Army aviation flight safety. Example participant comments include:

- “It was quick and to the point and covered applicable material without dragging on for a week or two.” (Aircrew Course)
- “I enjoyed the interaction of the problem solving exercises. I think this is where the real learning takes place.” (Aircrew Course)
- “New information and examples should be added at least annually for continuation training to be effective.” (Aircrew Course)
- “The interaction of other Instructor Pilots on an important topic that can model the attitude of a unit by helping mold the attitudes of individuals in the unit and make them function as a team.” (Instructor Course)

Field Study

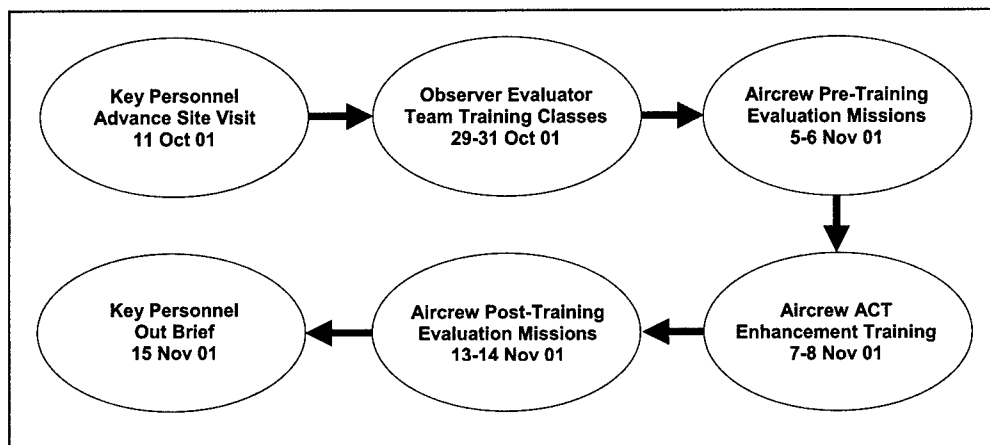
The field study was designed to compare units immediately before and after receiving the prototype ACTE training and evaluation instruction. Field study participants were aviation units that represented utility aircraft, missions, and operating conditions. The study provided evidence of relative improvement due to training. It also supported descriptive, graphical, and user comments analysis (see Table 3).

Table 3. Field Study Measures.

Measurement Area	Measurement Instruments
ACT Behaviors	Performance Evaluation Checklist Behaviorally Anchored Rating System (BARS)
ATM Task Performance	Scenario Worksheets
Mission Effectiveness	Scenario Worksheets
Crew Related Errors	Scenario Worksheets
Course Critique	Data Management System Scalar Critique Items Data Management System Open-ended Items

Prototype courseware for the Aircrew and Instructor Courses was used to train observer-evaluators, establish inter-rater reliability, and standardize the field study scenarios. Once observer-evaluators were trained, a total of 35 unit leaders, instructor pilots, and aircrews participated in structured training and evaluation events (see Figure 9).

Figure 9. Field study events.



As in the usability assessment, field study data were analyzed and the findings reported to the Aircrew Coordination Working Group. Participant ratings for the Aircrew Course averaged 4.0 or higher on a 5-point scale (see Table 4). Results of the simulator-based evaluation scenarios indicated measurable improvement between pre and post training mission effectiveness and flying safety, despite the fact that all participants have been previously ACT qualified (see Table 5).

Table 4. Field Study Participant Ratings.

Rating Items	Aircrew Course	Instructor Course
Tutorial provided knowledge to navigate courseware	4.3	
Courseware structure and navigation logical and understandable	4.6	4.0
Comprehension checks understandable	4.2	
Amount of information, pace and time good (On 5-point scale, 1= "too little", 5="too much"; 3 is optimal)	3.0	3.0
Vignettes allowed observation & related ACT to risk management	4.1	4.0
Instructor knowledge, preparation, and clarity	4.8	4.3
Student workstation equipment	4.9	
Performance Evaluation System and Aircrew Guide helpful	4.3	
Content relevant	4.4	
Positive effect on flying safety	4.4	4.0
Effect as refresher to previous Aircrew Coordination Training	4.6	
Positive effect on mission effectiveness	4.3	
Lessons helped understand how to identify ACT behaviors		4.2
Lessons helped understand how to evaluate ACT performance		4.2
Lessons helped understand how to facilitate ACT performance improvement		3.8
Instructor Evaluator Guide helpful for implementing ACT in daily ops		4.3

Example field study participant comments include:

- “The actual interaction between instructor and student; being evaluated and seeing the relevance.” (Aircrew Course)
- “The multi-media usage was a very good combination of resources and kept me interested throughout the entire lesson. It was very easy to navigate. The scenarios and role-play were very helpful.” (Aircrew Course)
- “It provides a solid foundation for all ACT Instructors to work from. It should standardize how ACT is trained and evaluated throughout the Army.” (Instructor Course)

Table 5. ACT Versus ACTE Pre-Post Training Effectiveness.

Comparison Points	ACT (1992)	ACTE (2001)
Validation Test	16 UH-60 aircrews 18 hours classroom academics 2 simulator training missions	8 UH-60 aircrews 8 hours web-based CBT Courseware
Measures and Metrics	1993 final report Descriptive statistics and significance test data	2002 final report Descriptive statistics
ACT Behaviors	+34% (13 Basic Qualities)	+14% (5 Crew Objectives)
ATM Tasks	+33%	+11%
Mission Effectiveness	+20%	+20%
Crew Related Errors		
- Manage Threatening Errors	+27%	+37%
- Number of aircraft crashes	-43%	-67%

Operational Field Test

For the final operational field test, use of the courseware was observed and assessed in both Army National Guard (ARNG) and Army Active Component (AC) aviation units that represented cargo, attack, and utility aircraft, missions, and operating conditions. The field test employed the prototype courseware in a field setting using representative groups of the target training audience. Contractor instructors used unit classrooms and facilities to present the Aircrew and Instructor Courses to a cross section of 31 highly experienced aircrew members and instructors. Data were gathered on Aircrew and Instructor Course usability, effectiveness, and areas that needed interface and content improvement. Participant rating results are shown in Table 6.

Table 6. Operational Field Test Participant Ratings Results

Rating Items	Aircrew Course	Instructor Course
Tutorial provided knowledge to navigate courseware	4.0	
Courseware structure and navigation logical and understandable	4.0	3.9
Comprehension checks understandable	3.5	
Amount of information, pace and time good (3.0 optimal)	3.1	3.3
Mission vignettes allowed observation and related ACT to RM	3.8	4.1
Instructor knowledge, preparation, and clarity	4.4	4.5
Student workstation equipment	4.2	
Performance Evaluation System and Aircrew Guide helpful	3.9	
Content relevant	3.8	
Positive effect on flying safety	4.0	4.0
Effect as refresher to previous Aircrew Coordination Training	4.1	
Positive effect on mission effectiveness	3.9	
Lessons helped understand how to identify ACT behaviors		3.9
Lessons helped understand how to evaluate ACT performance		4.2
Lessons helped understand how to facilitate ACT performance improvement		4.0
Instructor Evaluator Guide helpful for implementing ACT in daily ops		4.0

Example operational field test participant comments include:

- “The combination of self-paced computer and classroom instruction, as well as the facilitated discussion helped to enhance absorption of material.” (Aircrew Course)
- “Working through scenarios and evaluating the crews in those scenarios [was most helpful].” (Instructor Course)
- “It got you thinking about ACT. Also, the case studies were good but could have been much better by having more in-depth detailed study.” (Instructor Course)

Meeting the Challenge

The NTC rotation was just what the unit had expected. Very dusty conditions flown at high gross weights and under day and night vision goggle scenarios. Under these conditions, the unit aircrews applied the behaviors and skills they had re-learned during their participation in the previous ARI ACTE usability assessment program. They rigorously applied the crew coordination objectives (CCOs) and basic qualities (BQs), and conducted thorough, well-documented after-action reviews (AAR). After each mission they ensured that the lessons learned from AARs were disseminated to all aircrew members in the unit.



As a result of this meticulous application of ACT, the unit had a productive and incident-free NTC rotation. The crews were especially proud of being able to apply their enhanced skills to trap developing errors in the execution phase of each mission, and mitigate the risk of these errors to manageable levels. However, the challenge of maintaining these skills was still a significant concern. The unit Commander stated that ACT, as a perishable skill, deteriorates without command emphasis and sustainment training. The solution he suggested was for the command to emphasize, and the Army to provide sustainment-training products to ensure that crew coordination errors are minimized.

Fielding Effective Training Products

Can interactive multimedia courseware using web-based distribution provide the realism and relevance necessary for effective behavior-based team training and evaluation? The results of this applied research effort lead to the conclusion that the prototype Aircrew Course and Instructor Course provide operational situations that effectively convey ACT information to multiple mission aircraft audiences. User testing and validation results indicate high levels of acceptance for both the training and performance evaluation components. Initial testing of the prototype courseware on the Army's distance learning suite supports both the web-based and instructor facilitated delivery strategies for Army-wide implementation.

The prototype products from the first phase of research include two interactive multimedia courses of instruction with supporting training materials. The Aircrew Course and Instructor Course include a fully integrated Data Management System that tracks student demographics, provides graphic feedback displays during evaluation exercises, and facilitates electronic course critiques. The prototype courseware designed and developed to support ACTE research used the collective experience of the Aircrew Coordination Working Group and the contractor, innovative application of proven processes and procedures, and Army and training industry preferred technology and products. ACTE training effectiveness results from systematic evaluation and testing by aviation units in the field serve to validate the application of experience, innovation, and advanced

instructional technology in the development of this prototype courseware. Furthermore, prototype courseware products are—

- Authored using Army and industry accepted authoring software
- Tested and demonstrated on the Army's distance learning system
- Manageable using approved Army course management systems
- Upgradeable to comply with Shareable Content Object Reference Model (SCORM) guidelines
- Documented in sufficient detail to readily meet certification requirements

Sustaining Performance Improvements

The persistent challenge is how to sustain and advance the cultural and team performance improvements achieved by initial ACT training and enhancements. Key elements for an effective long-range strategy include actions to:

- Fully integrate ACT into the organizational structure, command climate, rules, and regulations that set the stage for daily flying operations
- Institute ongoing ACT program evaluation and sustainment activities to keep training realistic and relevant to operational missions and conditions (Abell, 2000)
- Correlate accident investigation and accident data analysis to the ACT program structure (behaviors) so that accident investigation data can be used to target specific areas of the ACT training program for increased emphasis
- Include instruction on strategies, tools, and techniques that apply ACT behaviors and skills to manage risk and avoid, trap, or mitigate aircrew error

ACTE Phase II research is currently underway and will further advance the upgraded program by designing and delivering a comprehensive train-the-trainer course; developing training support packages for specific aircraft and missions; integrating ACT into Non-rated Crewmember and Flight School XXI institutional courses; developing a prototype evaluation-based feedback system; and including ACT in distance learning developments.

Phase III research will focus on incorporating the products of Phase I and II as part of normal operations and deploying advanced ACT applications. It will include the development of ACT event-driven scenarios for multiple aircraft missions and extending ACT scenarios to advanced simulators and distributed interactive simulation training exercises.

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Appendix A

Relationship of Aircrew Coordination Objectives, Basic Qualities, and Risk Management Process

Aircrew Coordination Basic Qualities					Risk Management Process
Crew Coordination Objectives	Mission Planning and Rehearsal	Establish and Maintain Workload Levels	Exchange Mission Information	Cross-Monitor Performance	 <p>As controls for threats are identified and selected, the Assess Threats Process is repeated.</p> <p>Continuous Application of Risk Management</p>
Establish and Maintain Team Relationships	P				
Establish and Maintain Team Relationships	P				
Establish and Maintain Team Relationships	P				
Establish and Maintain Team Relationships	P				
Establish and Maintain Team Relationships	P				
Establish and Maintain Team Relationships	P				
Establish and Maintain Team Relationships	P				
Establish and Maintain Team Relationships	P				
Establish and Maintain Team Relationships	P				
Establish and Maintain Team Relationships	P				
Establish and Maintain Team Relationships	P				
Establish and Maintain Team Relationships	P				

- Notes: P - Primary Relationship, S - Secondary Relationship
1. Establish and maintain flight team leadership and crew climate
 2. Pre-mission planning and rehearsal accomplished
 3. Application of appropriate decision making techniques
 4. Prioritize actions and distribute workload
 5. Management of unexpected events
 6. Statements and directives clear, timely, relevant, complete, and verified
 7. Maintenance of mission situational awareness
 8. Decisions and actions communicated and acknowledged
 9. Supporting information and actions sought from crew
 10. Crewmember actions mutually cross-monitored
 11. Supporting information and actions offered by crew
 12. Advocacy and assertion practiced
 13. Crew-level after-action reviews accomplished

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Appendix B

ACT Performance Evaluation Checklist For use of this form, see the ACT Aircrew Guide						
CCO	BQ	Crew Coordination Objectives/Basic Qualities	Rating			
1		Establish and Maintain Team Relationships				
	1	Establish and Maintain Team Leadership and Crew Climate				
2		Mission Planning and Rehearsal				
	2	Pre-mission Planning and Rehearsal Accomplished				
	3	Application of Appropriate Decision Making Techniques				
3		Establish and Maintain Workload Levels				
	4	Prioritize Actions and Distribute Workload				
	5	Management of Unexpected Events				
4		Exchange Mission Information				
	6	Statements and Directives Clear, Timely, Relevant, Complete and Verified				
	7	Maintenance of Situational Awareness				
	8	Decisions and Actions Communicated and Acknowledged				
	9	Supporting Information and Actions Sought from Crew				
5		Cross-Monitor Performance				
	10	Crewmembers Actions Mutually Cross-Monitored				
	11	Supporting Information and Actions Offered by Crew				
	12	Advocacy and Assertion Practiced				
	13	Crew/Flight After-Action Reviews Accomplished				
Remarks: (Use continuation sheet[s] if necessary)						
Notes: Consult the ACT Aircrew Guide evaluation procedures and guidelines. Enter a summary rating (1 - 7) in the rating block for each ACT Crew Coordination Objective (CCO). Refer to the rating scale below.						
Below Standard 1	2	3	Meets Standards 4	5	6	Exceeds Standards 7

REPORT DOCUMENTATION PAGE

1. REPORT DATE (dd-mm-yy) May 2003		2. REPORT TYPE Final		3. DATES COVERED (from. . . to) September 2000 – March 2002	
4. TITLE AND SUBTITLE Enhancing U.S. Army Aircrew Coordination Training				5a. CONTRACT OR GRANT NUMBER N61339-01-C-0120	
				5b. PROGRAM ELEMENT NUMBER	
6. AUTHOR(S) Lawrence C. Katz (U.S. Army Research Institute), and Gary N. Grubb (Dynamics Research Corporation)				5c. PROJECT NUMBER 63007A792	
				5d. TASK NUMBER 252	
				5e. WORK UNIT NUMBER C01	
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) Dynamics Research Corporation 60 Frontage Road Andover, MA 01810				8. PERFORMING ORGANIZATION REPORT NUMBER E-5502U	
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES) U. S. Army Research Institute for the Behavioral & Social Sciences ATTN: Rotary-Wing Aviation Research Unit 5001 Eisenhower Avenue Alexandria, VA 22333				10. MONITOR ACRONYM ARI	
				11. MONITOR REPORT NUMBER Special Report 56	
12. DISTRIBUTION/AVAILABILITY STATEMENT Approved for public release; distribution unlimited.					
13. SUPPLEMENTARY NOTES Contracting Officer's Representative: Dennis C. Wightman					
14. ABSTRACT (<i>Maximum 200 words</i>): This report summarizes the objectives and outcomes of ongoing team training research and development under the guidance of the U.S. Army Research Institute for the Behavioral and Social Sciences (ARI). The Aircrew Coordination Training Enhancement (ACTE) program is an applied research project that applies experience, innovation, and technology to research the operational issue, "Can interactive multimedia courseware using web-based distribution provide the realism and relevance necessary for effective behavior-based team training and evaluation?" The report briefly describes prototype products from the first phase of research as two interactive multimedia courses of instruction with supporting training materials for usability assessment, evaluation, and validation testing by aviation units in the field. User testing and validation results indicate high levels of acceptance for both the training and performance evaluation components. Initial testing of the prototype courseware on the Army's distance learning suite supports both the web-based and instructor facilitated delivery strategies. The final prototype courseware and support materials are ready for refinements to meet certification requirements and subsequent fielding. Training effectiveness results suggest research into applying the ACTE courseware design and delivery model to accelerate the fielding of priority training systems to meet the Army's critical training needs.					
15. SUBJECT TERMS Aircrew coordination, training, web-distributed, distance learning, flight safety, crew coordination objectives, Army aviation, computer-based training (CBT), interactive media instruction (IMI)					
SECURITY CLASSIFICATION OF			19. LIMITATION OF ABSTRACT Unlimited	20. NUMBER OF PAGES	21. RESPONSIBLE PERSON (Name and Telephone Number) Dennis C. Wightman (334) 255-2834
16. REPORT Unclassified	17. ABSTRACT Unclassified	18. THIS PAGE Unclassified			