Evaluating Distance Learning Delivery Effects on Mission Safety and Performance

Gary Grubb, Dynamics Research Corporation, Enterprise, AL
Kurt Kline, Dynamics Research Corporation, Enterprise, AL
Dr. Larry Katz, Army Research Institute, Fort Rucker, AL

ABSTRACT

Army Research Institute's Aircrew Coordination Training Enhancement (ACTE) effort promotes applied research and development of a distance learning delivered, interactive aircrew coordination training system. The goal of this three-phase program is to provide Army aircrews deployed worldwide with the knowledge and skill-sets needed to increase safety and mission performance in daily operations. Research products from the two completed phases include prototype courseware and training materials. This paper describes Phase III research methods, performance measures and web-based data collection systems that were developed to evaluate the effects of distance learning delivered ACTE materials on safety and mission performance in operational units. The research design included three operational units: one receiving no training, the second receiving traditional classroom instruction, and the third receiving training using the Army's Classroom XXI linked to the unit's local Digital Training Facility. Measures included (1) reported completion, delay or aborted mission segments related to performance of crew coordination objectives and, (2) accident, incident or error reduction reports citing crew coordination as a factor. Data collection methods included a combination of Likert type scales, questionnaires, and a web-based mission performance and incident feedback program. The measures and methods used to quantify the effectiveness of distance learning delivery on operational unit safety and mission performance may be applied to other training systems.

ABOUT THE AUTHORS

Mr. Gary Grubb is the director of the Dynamics Research Corporation's Center for Team Performance and manages the ACTE program. He has published numerous team coordination research papers and designed, developed, implemented and evaluated ACT/CRM programs for the Army and Air Force. A former Army aviator, he has a MS in Management.

Kurt Kline is the Deputy Director, Dynamics Research Corporation's Center for Team Performance and leads the aviation programs. As the lead integrator for aviation training, he has supervised the development and testing of the Army's prototype web based crew coordination products. He holds a Master of Science degree in Human Resource Management. A former Army aviator he is a certified US Army Methods of Instruction (MOI) instructor, Master Army Aviator and Standardization Instructor Pilot.

Dr. Larry Katz is a research psychologist for the Army Research Institute Rotary Wing Aviation Research Unit (ARI-RWARU) and is the Technical Contracting Officer Representative for the Army's Aircrew Coordination Training Enhancement (ACTE) Program. The author of numerous ACT-related articles, he has conducted extensive research in the areas of crew resource management, cockpit leadership and communications, and team training and evaluation. He holds a Ph.D. in Psychology from Loyola University Chicago, an M.S. in Psychology from Indiana State University, and a B.S. in Psychology from the University of Illinois at Urbana-Champaign.

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INTRODUCTION

Aircrew Coordination Training (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 regularity. While aviators generally displayed excellent knowledge and understanding of aircraft systems, operating procedures, rules and regulations and other technical information, they often demonstrated 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).

The U.S. Army implemented its version of Aircrew Coordination Training (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 without losing sight of mission objectives. 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 aviation 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.

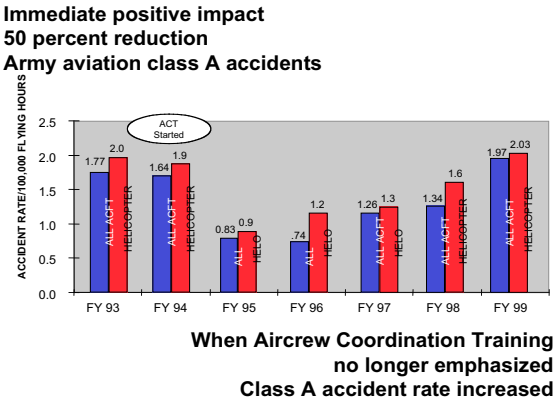

Figure 1. Impact on Accident Rate

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 resulted in a natural erosion of the safety gains initially realized as a result of ACT. Finally, the atrophying of skills and the lowering of experience levels that has occurred during successive years of limited defense funding have now manifested themselves in a sharp increase in accident and incident rates.

Lack of effective aircrew coordination continues to be cited as a 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 (ASIST) was chartered in 1999 to define measurable accident prevention goals and identify the most important Army-wide investments needed to achieve them (see Figure 2). 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 & Puesch, 2000).

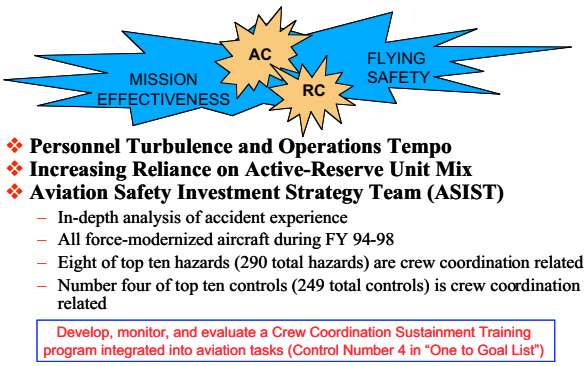

Figure 2. Aviation Safety Investment Strategy Team (ASIST)

This paper describes research methods, performance measures and web-based data collection systems developed to evaluate the effects of distance learning delivered ACTE materials on safety and mission performance in operational units.

AIRCREW COORDINATION TRAINING ENHANCEMENT (ACTE) PROGRAM

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. 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.

The current enhancement program managed by the U.S. Army Research Institute (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. Both Phase I and Phase II of the enhancement effort are complete.

COMPLETED ACTE RESEARCH PRODUCTS

ACTE prototype training and evaluation courseware products have been delivered to ARI. 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 and usability assessment of prototype training, evaluation, and technology products.

The prototype products include interactive multimedia courses of instruction with supporting training materials. The courseware includes a fully integrated Data Management System that tracks student demographics, provides graphic feedback displays during evaluation exercises, and facilitates electronic course critiques. Prototype team training products address all Army aviation skill levels from initial entry flight students through deployed active and reserve component crews. Deployment of the ACTE program would provide mission-oriented sustainment training and web-accessible updates. As shown in Table 1, the comprehensive training program includes training for all skill levels.

Table 1. Prototype Training Products

ACTE Courses of Instruction	Audience
Aircrew Course	Crewmembers
Instructor Course	Unit Instructor Pilots
Train the Trainer Course	Institutional & Unit Trainers
Nonrated Crewmember Qualification Course	Nonrated Crewmembers
Institutional Training Qualification Courses (3)	Initial Entry, Aircraft Qualification, & Instructor Pilot Students
Training Support Package	Mission Aircraft Crewmembers

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 were established from extensive research across DoD and Commercial aviation communities 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 Attachment 1) 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). The BARS numeric rating scale is shown at the bottom of the ACT Performance Evaluation Checklist.

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.

Courseware support materials for all courses of instruction include aircrew and instructor guides, ACT event driven scenario outlines for use in simulator or aircraft evaluations of aircrew ACT performance, courseware user guides and instructor console user guides.

Courseware Delivery

All ACTE courseware is World Wide Web accessible. A number of Internet and distance learning distribution tests were conducted throughout the evaluation of Phase I and Phase II products. In each test, the courseware ran without significant error and the few technical issues presented were easily remedied with minor adjustments to the underlying programming. Importantly, the distribution tests confirmed the utility of the ACTE courseware for simultaneous consumption to geographically dispersed audiences. Additionally, distribution of the courseware in a private LAN, CD ROM and US Army electronic classrooms, i.e., Digital Training Facility and Classroom XXI (CRXXI) format were tested and confirmed (see Figure 3). The outcome of the testing of courseware components across networks and bridges ensured that the Army aviation community can implement ACTE to aircrew members worldwide.

Figure 3. Army Classroom XXI Network Delivery

Effectiveness Results

User testing and validation results indicated high levels of acceptance for both the training and performance evaluation components. Products were evaluated and field tested by 161 active and reserve component crewmembers.

The effectiveness of the ACTE training and evaluation components was measured at increasing levels of fidelity and scope. The first field measurement of the core modules occurred in the demonstration and validation of the completed prototype Aircrew and Instructor courses followed by operational field-testing of the complete set of training and evaluation products associated with both courses. Additional testing was conducted on the Train the Trainer course and Nonrated Crewmember courses. Final testing of the Train the Trainer course with 27 highly experienced active and reserve component ACT instructors resulted in the following participant ratings:

- Information presented in logical structure (4.8 on 5-point scale)
- Amount of information, pace and time good (3.1 on 5-point scale with 1.0 too little, 3.0 about right, 5.0 too much)
- Media mix helped keep my interest (4.4 on 5-point scale)

- Use of actual courseware in the lessons allowed me to practice presentations (4.6 on 5-point scale)
- Instructor knowledge, preparation, and clarity (4.8 on 5-point scale)
- Lessons helped understand how to set up ACTE classes (4.5 on 5-point scale)
- Lessons helped understand how to present ACTE courses (4.6 on 5-point scale)
- Lessons helped understand how to facilitate ACT improvement (4.8 on 5-point scale)
- This ACT Train the Trainer Course will have a positive effect on standardizing ACT (4.8 on 5-point scale)
- Rate the overall value of this ACT Train the Trainer Course (4.6 on 5-point scale)

The prototype courseware and support materials are ready for final approval and subsequent fielding and employment by Army aviation units worldwide. Training effectiveness results suggest applying the ACTE courseware design and delivery model to accelerate the fielding of priority training systems to meet the Army's critical training needs.

RESEARCH METHODS

The Phase III research effort capitalizes on products, evaluation approaches, and insights from previous ACTE research tasks.

Research Design

Our approach centers on aligning three participating units with the complimentary tasks to address the persistent issues of training delivery and effectiveness (see Table 2).

Table 2. Research Approach

Participating Units	Distance Learning Delivery	Mission and Risk Management
Unit 1 (Control)	No ACTE Training	- Evaluation mission - Mission & Risk Management Reports
Unit 2 (LAN Training)	ACTE Training Instructor in Classroom	- Pre & post training mission - Mission & Risk Management Reports
Unit 3 (DL Training)	ACTE Training Instructor not in Classroom	- Pre & post training mission - Mission & Risk Management Reports

We use the prototype ACTE courseware previously tested on Army distance learning facilities and deliver the standardized training with and without the instructor in the classroom with the learners. We administer aircrew coordination event-driven scenarios to measure pre versus post training effectiveness and benchmark daily flight operations mission and risk management reporting topics. We use mission and risk management trends information to develop the multiple aircraft and battle staff scenarios.

Selected Units

The research design includes three operational units: one receiving no training, the second receiving instructor in an electronic classroom instruction, and the third receiving video teletraining using Fort Rucker's Classroom XXI linked to the unit's local Digital Training Facility.

Phase III research compares the effectiveness of three different levels of team training. The control group receives no aircrew coordination training beyond current Army directed training levels. This control group, Unit 1 will receive access to the web-based data collection system to provide aircrew coordination training related data. Unit participants will be briefed only on the access and use of the system. The second group, Unit 2 receives the ACTE prototype Aircrew and Instructor courses using an electronic classroom with the traditional instructor/facilitator on site to present all training. The third group, Unit 3 receives ACTE prototype Aircrew and Instructor courses by means of distance learning. The primary instructor is located off site and only a unit based facilitator is present to assist in user interface with the courseware and to view and provide feedback to the instructor and participants while conducting team building exercises off line. The participating units have similar aviation missions, e.g., Attack helicopter units flying AH-64D Apache Longbow helicopters in the same environmental conditions.

Performance Evaluation

Evaluation of the unit effectiveness in employing aircrew coordination is based on official mishap reports, imbedded courseware critiques (see Attachment 2), pre and post ACTE training evaluations conducted in the Army's Longbow Collective Training System (LCTS), and web-based survey and incident reports submitted by participating units. While using the LCTS, trained observer evaluators audit crew coordination events using an event-based data collection instrument (see Attachment 3).

PERFORMANCE MEASURES

The evaluation framework and supporting measures (see Table 3) to link DL effectiveness with mission and safety effectiveness is the generic, four-level Kirkpatrick model (Hiller & Wampler, 2000). Course critiques and learner questionnaires to include items on lesson realism and relevance provide Reaction Measures, Level I data. Level II, Learning Measures data is collected from end of lesson tests and Aircrew Training Manual (ATM) task performance measures. Behavioral Measures, Level III evaluation data is collected from the Performance Evaluation Checklist and criteria-based Behaviorally Anchored Evaluation System. Results Measures, evaluation Level IV use scenario worksheets to collect learner performance during event-based simulation scenarios to link the behaviorally based training and evaluation learning objectives to organizational outcomes.

Table 3. Performance and Effectiveness Measures

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

Note: ATM equals Aircrew Training Manual

DATA COLLECTION SYSTEMS

Data collection capitalizes on functions embedded in the ACTE courseware and participants' access to online networks. Course critique items, both fixed and open-ended, and end of lesson tests are embedded in the courseware. Learner feedback functions in the interactive multimedia courseware collect data on learner responses to practical exercises and provide data on learner knowledge of the performance evaluation system, i.e., the Performance Evaluation Checklist and Behaviorally Anchored Rating System. Paper-based scenario worksheets are the means to collect ATM Task Performance and Mission and Safety Effectiveness data for all phases of simulator-based scenarios, i.e., planning, execution, and after action review. Knowledge probes are included in Scenario Worksheets for selected critical events and mission segments.

Online data collection includes a private web site for participants to submit reports on completion, delay or aborted mission segments related to performance of crew coordination objectives. The private site allows for collection of accident, incident or error reduction reports citing crew coordination as a factor. An online discussion group is available on a voluntary basis to clarify the information in the reports without compromising privacy.

ROADMAP FOR FURTHER ENHANCEMENT OF ACT

The persistent challenge is how to sustain and advance the cultural and team performance improvements achieved by initial aircrew coordination 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.
- 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 aircrew coordination 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 III research, to be completed in the summer of 2004, will further advance the enhanced program by using the above described measures and methods to evaluate the effectiveness of distance learning delivered courseware verses traditional classroom delivery. Leveraging the US Army's DL capabilities to deliver team skills training using a combination of computer based training and video teletraining will support other team skills training and evaluation initiatives, e.g., battle command.

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ACT Performance Evaluation Checklist

For use of this form, see the ACT Aircrew Guide

CCO	BQ	Crew Coordination Objectives (CCO)/Basic Qualities (BQ)	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 Standards			Meets Standards			Exceeds Standards
1	2	3	4	5	6	7

Attachment 1. ACT Performance Evaluation Checklist

Critique Areas and Items

Course Structure and Delivery

1) The ACT Help Tutorial provided me with the knowledge necessary to navigate the courseware.

2) The on-screen directions for navigating within the Aircrew Coordination training lessons were understandable.

3) The information was presented in a logical structure.

4) The amount of information presented was _____.

5) The lesson pace was _____.

6) The media mix helped keep my interest.

7) The comprehension checks were understandable

8) The mission vignettes in the lessons allowed observation of CCO and BQ relationships.

9) The mission vignettes in the lessons helped relate ACT to Risk Management.

Length of Lesson

10) The time required to complete the course was _____.

11) The time available for the Instructor-led and facilitated lessons was _____.

Instructor

12) The instructor was knowledgeable of course content.

13) The instructor was well prepared for the course.

14) The instructor was clear about basic concepts.

Equipment

15) My workstation worked properly.

Course Effectiveness

16) The lessons helped me to understand how to evaluate Aircrew Coordination.

17) The Aircrew Guide is helpful for reinforcing Aircrew Coordination.

18) The information presented was relevant to my daily flying operations.

19) The Aircrew Coordination training will have a positive effect on my contribution to flying safety.

20) The Aircrew Coordination training will have a positive effect on my to flying safety.

21) The lessons helped me to understand how to apply Aircrew Coordination.

22) The lessons were effective in providing refresher training to my previous Aircrew Coordination training.

23) The Aircrew Coordination training will have a positive effect on my unit's mission effectiveness.

24) The Aircrew Coordination training will have a positive effect on my mission effectiveness.

25) The overall effectiveness of this Aircrew Coordination training is positive.

26) The overall value of this Aircrew Coordination training is positive.

Attachment 2. Sample Courseware Imbedded Critique Instrument

SEGMENT 1: Pre-Mission Planning H -2+00

DESCRIPTION: The pre-mission planning segment begins when the crew receives the mission briefing and includes all preparatory tasks associated with planning the tactical mission. These tasks include terrain flight mission planning, performance planning, assigning crewmember responsibilities, and all required briefings and brief-backs. The segment ends when the crew completes all required briefings and prepares to enter the simulator.

TASK 1004	**Task Title: Prepare a Performance Planning Card**
Event Trigger:	Crew Action: Crewmember confirms ETF and ATF with the aircraft logbook.
Rating: S+ S S- U	Related CCO: 1 2 3 4 5
NOTES:	

TASK 1003	**Task Title: Verify Aircraft Weight And Balance**
Event Trigger: During PPC preparation	Crew Action: Crewmember confirms standard loads are available for the mission or prepares a weight and balance form
Rating: S+ S S- U	Related CCO: 1 2 3 4 5
NOTES:	

TASK 2078	**Task Title: Perform Terrain Flight Mission Planning**
Event Trigger: Crew starts to plan mission	Crew Action: All crewmembers are assigned tasks by the PC to assist in planning the mission.
Rating: S+ S S- U	Related CCO: 1 2 3 4 5
NOTES:	

Are METT-T factors used in the mission planning sequence? Yes / No (Circle one)
Is the risk management process used? Yes / No (Circle one)

Attachment 3. Sample Event-based Data Collection Instrument

TASK 1000	**Task Title: Participate In A Crew Mission Briefing**
Event Trigger: PC starts to brief the crew.	Crew Action: All members of the crew are present and the PC starts the briefing.
Rating: S+ S S- U	Related CCO: 1 2 3 4 5

NOTES:

Does the PC use a checklist or the ATM to ensure all items are briefed? Yes / No (Circle one)

SEGMENT 1 OVERALL: Crew's thoroughness in accomplishing the planning and briefing requirements in the time allowed. Each crewmember's knowledge and understanding of the various mission requirements and the crew's plan to accomplish them. Did all crewmembers participate in the planning, if not, were the absent members briefed as to the conduct of the mission and specific duties.

GRADE: S+ S S- U CCOs: 1 2 3 4 5 (OPTIONAL)

NOTES:

Attachment 3. Sample Event-based Data Collection Instrument (Concluded)