TARGETs for Aircrew Coordination Training

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ABSTRACT

Aircrew coordination training (ACT) has become an important training objective in aviation. Recent ACT training approaches have included behaviorally-based training objectives in the realization that, like other aviation skills, the acquisition of aircrew coordination skills is reinforced through practice and feedback. However, there is little in the way of guidelines for the conduct and debriefing of aircrew team training exercises beyond global ratings of performance. The purpose of this paper is to discuss an aircrew coordination performance measurement methodology which, originally developed for team research, has direct application to the training and debriefing of aircrews as well as other types of teams (e.g., CIC). The methodology is a form of structured observation in which (1) opportunities for crews to demonstrate aircrew coordination skills in training scenarios are provided utilizing carefully structured scenario events, (2) acceptable crew responses to each of the events are determined a priori by utilizing NATOPS, SOPs and subject matter experts (i.e., military aircrews), and (3) appropriate responses to events are scored as either present or absent. The strength of this approach is that it is operationally relevant, minimizes judgements required by observers, and permits observation of crews across a wide variety of specific aircrew coordination behaviors. In research contexts, high inter-observer reliability is achieved and the measures appear to be sensitive to the effects of ACT. In the context of training, these characteristics should (1) enable instructors to provide specific and meaningful feedback with regard to the strengths and weaknesses of aircrew team performance (i.e., it is diagnostic), (2) facilitate standardization of observation and feedback by instructors, and (3) enable the technique to be implemented with minimal instructor training. Applications of the technique to other team training domains are discussed.

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INTRODUCTION

Aircrew coordination training (ACT) is an important training objective for both the military and the airline industry.[1] The reason for this can be traced to aircraft mishap analyses[2-4] and research investigations[5] that implicate crew dysfunctions as contributing factors in accidents or in reduced mission effectiveness. These crew "dysfunctions" include inadequate information transfer and preoccupation with minor malfunctions leading to loss of situational awareness (see Prince et al.[1] for an historical review of the factors pertinent to the introduction of aircrew coordination training, also known as cockpit resource management training). Early ACT programs, instituted in the late seventies and early eighties, focused on classroom-based awareness training.[6] A growing trend, however, is to include behaviorally-based training objectives in ACT.[1] For example, the Federal Aviation Administration will soon issue an advisory circular recommending that ACT programs include a practice and feedback phase[1] and the Navy has developed a methodology for the design of aircrew coordination training that includes, as a major component, a behavioral, skills-based focus.[7]

An implicit assumption in behavioral approaches is that, like other aviation skills, the acquisition of aircrew coordination habits must be supported by reinforced practice such as that provided in a flight simulator. However, crew coordination is not reinforced as a routine aspect of aviation training. Part of the reason for this may be the general schism that exists between training practices and training theory[8]. For example, the team performance literature strongly suggests that feedback is an effective team training intervention. The literature also provides general guidelines regarding the nature of the feedback that should be provided. These are summarized in Table 1. Modrick[9] noted that, in the area of team training, the few training guidelines that exist are usually violated during training exercises.

Table 1.
Summary of Team Training Feedback Guidelines

• The effectiveness of feedback is negatively related to the delay between task completion and the occurrence of the feedback[10-12]
• Feedback should be specific with regard to individual team member performances as well as team performance[13]
• Feedback is especially important on team tasks which do not provide intrinsic feedback[11]
• Feedback should be provided on all important aspects of team performance[11,12]

A more fundamental reason why crew coordination is not routinely reinforced with practice and feedback may be that instructors have little guidance regarding how to design crew coordination training exercises, what to observe, and how those observations can be meaningfully fed back students. Consider that the traditional training emphasis in aviation is on the acquisition of individual technical skills.[1,14,15] This focus has driven the development of simulator performance measurement systems, training exercises, and evaluation approaches. Consider also that the lack of observation and evaluation techniques is a ubiquitous problem in the more general team training domain[9,16]. While team training does occur, there are generally no clear team-related training objectives or evaluation criteria.[9]

The most widely utilized observation and assessment methods for team training in general,[9] and for crew coordination training in particular,[17] are performance rating techniques. With these approaches, the performance of a team/crew is rated across a number of attributes or behavior areas on an interval scale that might range from 1 (meaning "poor" performance) to 5 (meaning "excellent" performance). In the area of crew coordination, crews might be rated on concepts such as "leadership," "decision making," and "mission analysis." Although widely used, there are problems inherent to rating approaches that reduce their effectiveness as training tools and make them difficult for instructors to use:

Feedback Specificity. Feedback based on global performance ratings lacks specificity regarding individual and team actions taken.[9] In short, as a general rule, it does not meet the team feedback specifications outlined in Table 1.

Clarity of Procedures. Instructors are likely to disagree about the meaning of performance rating scale values (e.g., what constitutes "excellent" performance) or the way they use the scale (e.g., some may rate all crews as above average and others may give an average rating as the rule). In addition, instructors may disagree on the definitions of the concepts they are evaluating (e.g., what constitutes "leadership"). To the extent that these factors operate, (1) there will be little standardization of crew training across instructors, and (2) extensive training of instructors will be required, not only in the understanding of ACT principles, but also in how to use rating scales. There is ample evidence that these factors do operate not only in operational contexts but also in highly controlled research environments (See Thorndike and Hagen[18] for a summary of these issues).

The purpose of this paper is to describe a method of structured observation that can be used by instructors to observe, and provide feedback on, aircrew team performance. Its characteristics were developed to minimize some of the problems seen with conventional rating techniques. Although it was originally developed for the measurement of aircrew teamwork for research purposes, its properties suggest that it can serve as a valuable training tool.

TARGETS METHODOLOGY

For purposes of illustration, a set of aircrew coordination behaviors is shown in Table 2. These were determined to be critical for mission accomplishment and for flight safety in military cargo helicopter communities based on an aircrew coordination needs analysis.[19] In a training situation, the instructor would be faced with determining how to provide practice on these behaviors and feedback to team members on how well the behaviors were performed in a way that is consistent with the feedback guidelines shown in Table 1. The "TARGETs" approach, described in this paper, provides a method by which this can be accomplished. "TARGETs" stands for Targeted Acceptable Responses to Generated Events or Tasks. The name encompasses two key aspects of the methodology that will be discussed below.

Event-Based

The first key component of the methodology is that it is event-based. That is, in a simulator training hop, events are identified to serve as cues for crew members to exhibit aircrew coordination behaviors such as those shown in Table 2. The second key aspect is that acceptable aircrew coordination responses (i.e., the TARGETs) to each event are identified a priori so that, prior to the exercise, the instructor has a checklist of training events in the hop/scenario and the acceptable responses to each event.

Table 2.
Aircrew Coordination Behaviors for Military Cargo Helicopter Crews Grouped Into Skill Areas (In Bold) (After Prince & Salas[19])

Mission Analysis

Define tasks based on mission requirements
Question data and ideas related to mission accomplishment
Devise long & short term plans
Identify potential impact of unplanned events on mission
Structure tasks, plans, & objectives
Critique existing plans

Adaptability/Flexibility

Alter behavior to meet situational demands
Be receptive to others' ideas
Step in and help others
Alter flight plans to meet situational demands

Leadership

Determine tasks to be assigned
Ask for input, discuss problems
Focus crew attention to task
Tell crew members what to do
Inform crew members of mission progress
Provide a legitimate avenue of dissent
Provide feedback on crew performance

Decision Making

Gather pertinent data before making a decision
Cross check information sources
Identify alternatives and contingencies
Anticipate consequences of decisions
Provide rationale for decisions

Assertiveness

Ask questions when uncertain
Make suggestions
State opinions on decisions/procedures
Confront ambiguities & conflicts
Advocate a specific course of action

Situational Awareness

Note deviations
Provide information in advance
Identify problems/potential problems
Demonstrate awareness of task perf. of self/others
Recognize the need for action
Demonstrate ongoing awareness of mission status

Communication

Provide information as required
Provide information when asked
Repeat information
Use standard terminology
Ask for clarification of comms
Convey information concisely
Verbalize plans for procedures/maneuvers
Use nonverbal communication as approp.
Acknowledge communications

Many of the events that would be typically included in a training hop using this methodology would be routine. For example, in each phase of flight (events), crew members have specific duties that must be accomplished and these can be identified as TARGETs. Events may also be prompts introduced to serve as cues for (1) low frequency of occurrence behaviors (e.g., noting deviations), and (2) "eliciting" behaviors that are not necessarily observable (e.g., awareness of mission status).

Control of Training Exercise

One of the strengths of the TARGETs approach is that the instructor can control what behaviors are evaluated through the selection of events that will be included in a training exercise. To ensure that all intended events are presented, scenario scripts are developed and utilized that detail (1) when events should be introduced, and (2) the communications that should occur

between the crew and the other agencies (e.g., ATC) and personnel (e.g., aircrewman) that are included in the scenario. In research contexts, the script ensures that task conditions are maintained across crews observed. For training, the script would help ensure standardization of training and that the instructor is able to evaluate crews on how they perform the behaviors of interest.

Observable Behaviors

Implicit in the foregoing discussion is that TARGETs are behaviors that the instructor can plainly observe and determine as being present (i.e., TARGET was "hit") or absent (i.e., TARGET was "missed"). This functions to simplify the task for instructors compared to what is required using conventional rating techniques. For example, during training exercises, instructors would not be required to:

(1) judge the quality of responses.
(2) interpret scale values.
(3) infer team member states such as "uncertainty."
(4) interpret concept definitions.

Specific Feedback

Figure 1 provides examples of events and associated TARGETs that might be included in a training exercise. Figure 2 provides events and associated TARGETs for a short segment of a training exercise in a checklist format. (TARGETs in both figures pertain to two-piloted cargo helicopters.) To provide feedback, an instructor might use a checklist that looks much the one shown in Figure 2. TARGET checklists could be developed for complete aircrew coordination training scenarios. Alternatively, TARGET checklists could be developed for simulator hops that exist as part of a training curriculum.

Figures 1 and 2 demonstrate that feedback provided utilizing the TARGETs methodology could be highly specific with regard to both individual (e.g., the pilot flying reporting to the crew that takeoff is imminent) and team member actions (e.g., either pilot noting that the lead aircraft is off course in a formation flight). In addition, feedback could be provided in any number of ways. For example, overall performance scores could be obtained (percentage of TARGETs hit) or scores could be obtained for specific flight segments.

In summary, the TARGETs methodology provides an observational protocol that potentially can be used by instructors to evaluate, and provide feedback on, aircrew coordination performance. Moreover, the feedback provided would be highly specific and diagnostic of aircrew coordination breakdowns. The next section presents empirical data that bear on the usefulness of TARGETs in a training context.

IS TARGETS ON TARGET?

The properties of TARGETs were investigated in research in which the percentage of TARGETs hit was compared for three ACT-trained and three ACT-untrained military cargo helicopter crews. All crews flew a scenario that was implemented on a full mission simulator. Videotapes were made of crew performances and later were scored independently by two observers. One observer was aware of which crews were trained versus untrained. Finally, ACT was primarily classroom-based although some behavioral practice was provided through role play exercises.

The results are reported below. In addition, Table 3 summarizes the findings and also identifies the implication of each finding for the use of TARGETs in a training application.

Inter-Observer Reliability

Inter-observer reliability was found to be $\underline{r} = .94$, *indicating a high level of agreement* between observers. The implication of this for training is that (1) training can be standardized across instructors, and (2) minimal instructor training would be required to use TARGETs checklists.

Performance Scores

Percentage of TARGETs hit scores (averaged across observers) ranged from 61% to 89%, indicating that the methodology differentiates crew performances. Moreover, the data indicate that the individual crew performance scores were stable, at least across segments of

EVENT	TARGET	AIRCREW COORDINATION BEHAVIOR
Section leader asks crew to perform unsafe navigation procedure during preflight brief	Pilots question unsafe navigation procedure	State opinion on decisions/procedures (under Assertiveness)
Ship's helicopter direction center provides erroneous vector to first waypoint	Pilots question heading information	Ask questions when uncertain (under Assertiveness)
Communications from ship's tower, aircrewman, lead aircraft	Pilot flying acknowledges communications	Acknowledge communications (under Communication)
En route navigation	Pilot not flying provides heading and distance for next leg of flight	Provide information in advance (under Situational Awareness)
Section leader calls for lead change	Pilot flying uses standard terminology during lead change	Use standard terminology (under Communication)

Figure 1. **Examples of events, TARGETs, and associated aircrew coordination skills (from Table 2) for a helicopter flight.**

FLIGHT SEGMENT	EVENT	TARGET	HIT
Prior to liftoff	Ship's tower provides erroneous weather during takeoff clearance	Pilot flying questions weather information	
	Takeoff clearance given	Pilot flying acknowledges takeoff clearance	
		Takeoff checklist completed using challenge and reply method	
		Completion of takeoff checklist acknowledged by both pilots	
		Pilot flying asks aircrewman if cabin ready for lift	
		Pilot flying alerts crew that he/she is taking off	

Figure 2. **Events and associated TARGETs for a short segment of a training hop in which a helicopter crew is about to takeoff from a ship (NOTE: the instructor/operator would act as the aircrewman and the ship's tower).**

Table 3.
Psychometric Properties of TARGETS and their Implications for Use of TARGETs as a Training Tool

PROPERTY	TRAINING IMPLICATION
High Inter-observer Reliability	Standardization of Training
	Minimal Instructor Training Required for Use
Yields Stable Range of Crew Performance Scores	Identification of Weak and Strong Crew Performances
Sensitive to ACT	Valid, Meaningful Feedback

a single simulated flight (r = .81). The implication of these results for training is that the methodology permits strong and weak crews to be identified.

Sensitivity to ACT

The percentage of TARGETs hit was 8% higher for ACT-trained crews over ACT-untrained crews (this difference could be expected to be higher if behavioral practice and feedback were provided). Sensitivity of the performance scores to ACT is evidence of their validity. For training, this suggests that feedback will be meaningful.

IS TARGETS A NOVEL TRAINING APPROACH?

The idea of event-based student assessment may not appear novel to some flight instructors. Indeed, flight simulator "emergency drill" training incorporates this idea; that is, an emergency is introduced and the pilot is observed to see if the appropriate procedures are executed. Some training communities incorporate event-based training for evaluating multiple aspects of crew member performances, even down to the use of scripts. However, this is not a standard practice and it is not practiced for the evaluation of aircrew team performance. Moreover, the TARGETs methodology incorporates some basic principles that, as far as we know, have not been infused into aviation training, and certainly not into aviation aircrew coordination training: Event-based training offers control over the training exercise so that the instructor may observe the presence or absence of the specific behaviors that must be evaluated.

TRAINING APPLICATIONS

Teamwork is becoming an increasingly important variable in the success of organizations and of work groups within organizations.[16] Indeed, many training domains are facing the same problems faced in aviation. That is, individual training methodologies must be augmented by team training methodologies. The training context in which the TARGETs methodology is proposed has several characteristics: (1) the sequencing of events and contingencies can be fairly well predicted/worked out, (2) team members have explicit roles, and (3) team members are assembled to achieve a specific goal (e.g, to complete a flight or mission). We believe that, at a minimum, the TARGETs methodology is applicable to team training environments in which these characteristics exist. For example, in the military, we believe it could be applied across a variety of tasks in most aircraft and expect that it could be applied to teams (e.g., tactical, maintenance) in surface and subsurface platforms as well. Below, some specific applications are discussed.

Increase Training Value of Flight Simulators

Flight simulators have proved a cost-effective and generally safe means for training military aircrews. However, as has been discussed in this paper, traditional training emphases focus largely on individual technical skills. A neglected area, and one in which there is potentially high payoff, is crew team training. It is worthwhile to note that TARGETs offers a tool that can be used to increase the scope of training that is conducted in flight simulators at no cost and with no system modifications.

Distributed Interactive Simulation

Current Distributed Interactive Simulation (DIS) technology (e.g., SIMNET) permits multiple aircraft, weapons platforms, units, etc. to perform training exercises. Although the potential training value of this capability is enormous, unless clear performance evaluation protocols are utilized, such as can be provided by TARGETs, these exercises may be characterized by the same weaknesses described by Modrick[9] for team training:

> Team exercises are in fact merely multiorganizational exercises rather than team training...There are exercises that bring together several individuals, two or more teams, and two or more organizations to function as a team or network of teams. However, the emphasis is on operational tasks rather than team functioning and team skills. Each operator is provided with an opportunity to practice his or her own operational tasks in parallel with other people. (p. 150).

Advanced Technology Cockpits

Advanced technology aircraft pose a host of aircrew coordination challenges. These include automation complacency, or the tendency to excessively rely on automated functions;[20-22] the difficulty of transitioning between automated and manual flight control;[21,22] and the difficulty of maintaining situational awareness when utilizing automated systems.[22] It has been noted that the training of crews to meet these and other challenges has lagged behind the introduction of such systems.[20] Awareness of the requirement for alternative training approaches has been heightened by the recent A320 crash which may have resulted from confusion between the pilots regarding which automatic flight mode was selected.[23] "The Air Inter A320 crash is expected to focus new attention on the need for maximum pilot interface and coordination with the new generation of highly automated transports piloted by a two-member flight crew" (p. 29).[23]

TARGETs may provide a method for evaluating crew member interactions in advanced technology aircraft. Such TARGETs might include: communicating that system configuration changes have been made; reporting that automated systems status are being monitored; ensuring that other crew members are informed, and offer input, when automated modes are chosen. In addition, TARGETs may provide an innovative method of evaluating crew member interactions with automated systems. For example, such training/evaluation might focus on events that provide opportunities for observable indications of crew members: tasking of automated systems, monitoring of system performance against expected system performance, verifying data input, and maintaining situational awareness.

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