Technical Report 77-1

HumRRO-TR-77-1

HumRRO

2

B-S.

AD A038505

Team Training and Evaluation Strategies: State-of-the-Art

Harold Wagner, Nancy Hibbits,
Richard D. Rosenblatt, and Russel Schulz

See 1473

DDC
RECEIVED
APR 20 1977
C

HUMAN RESOURCES RESEARCH ORGANIZATION
300 North Washington Street • Alexandria, Virginia 22314

Approved for public release; distribution unlimited.

February 1977

AD No.
DDC FILE COPY

Prepared for

Defense Advanced Research Projects Agency
Cybernetics Technology Office
1400 Wilson Blvd.
Arlington, VA 22209

This research was supported by the Defense Advanced Research Projects Agency
Under ARPA Order No: 3187 Contract No: MDA903 76 C 0210.

The views and conclusions contained in this document are those of the authors and should not be interpreted as necessarily representing the official policies, either expressed or implied, of the Defense Advanced Research Projects Agency or the United States Government.

Technical Report 77-1

HumRRO-TR-77-1

HumRRO

Team Training and Evaluation Strategies: State-of-the-Art

Harold Wagner, Nancy Hibbits,
Richard D. Rosenblatt, and Russel Schulz



HUMAN RESOURCES RESEARCH ORGANIZATION
300 North Washington Street • Alexandria, Virginia 22314

Approved for public release; distribution unlimited.

February 1977

Prepared for

Defense Advanced Research Projects Agency
Cybernetics Technology Office
1400 Wilson Blvd.
Arlington, VA 22209

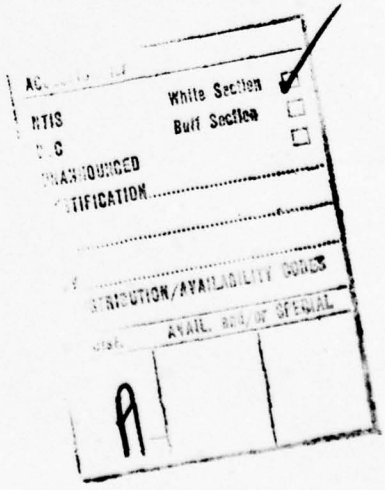
PREFACE

This report contains a review of the literature relevant to team training, surveying and describing current instructional and evaluative techniques within the Services. State-of-the-art gaps were identified and research needs documented as an aid toward planning improved research programs in team training and evaluation.

This study was performed in HumRRO's Eastern Division, Dr. J. Daniel Lyons, Director. The work was performed under the general direction and supervision of Dr. Robert J. Seidel, Program Director, Instructional Technology Group, who assisted the authors of this report in the identification of potential team training research areas.

This research was supported by the Defense Advanced Research Projects Agency under DARPA Order No.: 3187; Contract No.: MDA903 76-C-0210. The Technical Monitor for this project was Dr. Harold F. O'Neil, Jr., who provided both support and substantive assistance in the literature review and analysis. Appreciation is also expressed for the bibliography provided by Dr. John Germas of the Army Research Institute.

William A. McClelland
President
Human Resources Research Organization



SUMMARY

BACKGROUND

This review of team training and evaluation was undertaken by HumRRO in order to provide an information base that the Defense Advanced Research Projects Agency could use as a foundation to facilitate decisions regarding future research program support.

In order to pursue their mission of operational readiness, the Services conduct most of their training in the operational commands. In the past, most training research has been focused on individual training at schools and at other institutional locations. Considering the amount of team training conducted by the Services, either formally recognized as training or combined with operations, the funds committed to R&D support of such training are relatively small. There is a need, therefore, for greater research emphasis to increase the effectiveness of team training and evaluation.

PURPOSE

The purpose of this literature review was to provide information that would be useful for planning research and development programs in the area of team training. Such programs are needed to develop improved team training methods and technologies, as well as to provide new measurement techniques and procedures for evaluation. The specific objectives in preparing this review were to address the following questions:

- What state-of-the-art gaps are there in team training strategies and evaluation techniques?
- What new team training strategies appear to hold promise for application to the DoD environment?
- What new evaluation techniques can be used to assess team training?

METHOD

A thorough search was made of the major documentation sources for publications that would be relevant to team training and evaluation. The initial search included the Educational Resources Information Center (ERIC), National Technical Information Service (NTIS), and Defense Documentation Center (DDC) indices. In addition to DoD-sponsored research reports, the survey included publications from the social psychological areas, such as group dynamics and the industrial training field. Secondary sources and cross-references were then identified and reviewed.

HumRRO personnel with experience in the team training area were consulted for information about current military team training methods. The most recent military doctrine regarding team training procedures was obtained and reviewed. Military personnel were contacted in all the Services to identify team training approaches now in operation. Current team training and evaluation studies under way within the Army Research Institute and the other Services were examined and described.

FINDINGS AND IMPLICATIONS

As an aid toward organizing and analyzing the team training information obtained, a classification scheme was used to categorize the training techniques and situations

discussed in this review along two dimensions. On one dimension, *training focus*, a distinction was made between "team" training and "multi-individual" training. Multi-individual training occurs in a group context but focuses on the development of individual skills. Team training, on the other hand, is focused on developing team skills such as coordination and cooperation. The type of *task situation* was the second dimension used to classify the training techniques reviewed. Task situations were categorized as either "established" or "emergent." Established situations are those in which the tasks and the activities required to perform these tasks can be almost completely specified. Emergent situations are those in which all tasks and activities cannot be specified and the probable consequences of certain actions cannot be predicted. This type of situation allows for unanticipated behaviors to emerge.

Team training studies and practices were categorized according to the classification scheme described. These studies followed two conceptual models of team behavior—Stimulus-Response (S-R) and Organismic. The S-R model adherents tended to study team training in laboratory settings derived from *established* task situations. More realistic environments were used by other researchers who attended to *emergent* factors in the job situation (the organismic approach). It was this latter group of investigators who demonstrated the need for training in team skills, even though individual skill proficiency was found to be a prerequisite for effective team training and performance. Other conclusions which were drawn from the literature are:

- The team context is not the proper location for *initial* individual skill acquisition.
- Performance feedback is critical to the learning of team as well as individual skills.

Current military team training practices were described as varying in cost, in degree of fidelity to the operational site, and in the variety and complexity of the tasks trained. Subjective methods of evaluation were found to be predominant.

Evaluation of team training effectiveness depends upon the development of objective team performance measurement instruments and procedures. This review of the literature and current practice supports the conclusion that this area contains many problems that must be solved before substantial improvement in team training evaluation can occur. The production of standardizable, replicable test conditions and the establishment of accepted performance criteria are two such problems.

A phased research program was suggested as warranting support in order to overcome gaps in the current state of knowledge. *The major factor in this program is the need for methods that differentiate individual, multi-individual, and team skills and training requirements.* Such techniques, which could be integrated with job/task analyses, would discriminate between isolated and interactive behaviors. Possible techniques to study for this purpose are variations of interaction analyses and other unobtrusive measures. Successful development of this methodology will provide an opportunity to establish team performance standards criteria as part of training requirements analyses. Development of these techniques would then permit other research studies to be accomplished effectively.

Issues identified in this review which merit research support include the following:

- **Team Feedback**

  What changes in training methods or content result from feedback? Which method of providing team feedback is most useful (e.g., video recording versus post-exercise debriefing)?

- **Assessment Training**

  Will training of team members to assess their own performance result in greater team proficiency than if no self-assessment training is provided? Will training to assess the performance of other team members affect proficiency.

- **Simulation Fidelity**

  What degree of simulation fidelity is critical for effective team training? Can two-sided engagement simulation techniques be applied to the training of team skills? Although low-fidelity simulations were found to be ineffective in *established* task situations, would they be more useful in *emergent* situations?

- **Team Composition/Structure**

  What are the effects of degree of team member familiarity on the acquisition of team skills? Will the length of time that a team functions together effect proficiency?

- **Skill Training Sequencing**

  Is it more efficient to train individual skills first and then team skills, or team skills first, or both concurrently?

Combined studies dealing with more than one of these research issues are feasible. For example, feedback or skill sequencing issues can be studied in environments that vary in their degree of simulation fidelity, or in task situations that are established or emergent.

The studies that have been suggested point out the considerable research and development effort needed in the team training and evaluation area. With further support, our state of knowledge in the area should expand considerably.

TABLE OF CONTENTS

Page

Preface ... iii

Summary ... v

Background ... v
Purpose of Study ... v
Method ... v
Findings and Implications ... v

Chapter

1 Introduction ... 3

Background ... 3
Purpose of Study ... 3
Approach ... 4
Review of Technical Literature ... 4
Sample of Current Military Team Training Techniques ... 4
Definitions ... 5

2 Review of Team Training Research ... 7

Two Conceptual Approaches to Team Training Research ... 7
Established Vs. Emergent Situations ... 8
Individual Vs. Team Training ... 9
Team Skills ... 11
Simulation Fidelity ... 12
Feedback/Knowledge of Results ... 13
Team Structure and Composition ... 15
Systems Approach to Team Training ... 16
Summation ... 16

3 Review of Evaluation Techniques for Team Training ... 18

Definition of Team Performance Objectives ... 18
Definition of Observable Event Metrics ... 20
Detection, Measurement, and Recording of Observable Events ... 22
Evaluation of Objective Attainment ... 23
Summation ... 24

4 Current Approaches in Military Team Training ... 25

Army Team Training ... 25
SCOPES (Squad Combat Operations Exercise, Simulation) ... 27
REALTRAIN ... 27
MILES (Multiple Integrated Laser Engagement System) ... 27
CATTS (Combined Arms Tactical Training Simulator) ... 28

Chapter		Page
4 *(Cont.)*	Navy Team Training	28
	Device 2F87, Weapons Systems Trainer	29
	Device 14A2, Surface Ship ASW Early Attack Weapons System Trainer	29
	Device 14A6, ASW Coordinated Tactics Trainer	29
	Device 21A37/4, Submarine Fleet Ballistic Missile (FBM) Training Facility	29
	Tactical Advanced Combat Direction and Electronic Warfare System (TACDEW)	30
	Marine Team Training	30
	TESE (Tactical Exercise Simulator and Evaluator)	30
	TWAES (Tactical Warfare Analysis and Evaluation System)	30
	Air Force Team Training	31
	B-52 Weapons System Trainer	31
	C-5 Mission Flight Simulator	31
	C-130 Flight Simulator and C-141 Flight Simulator	31
	Functional Integrated Systems Trainer (FIST)	31
	Summation	31
5	**Research Implications**	33
References		39

Tables

1	Individual vs. Team Training: Classification of Studies Reviewed in Chapter 2, Section 3	9
2	Team Skills: Classification of Studies Reviewed in Chapter 2, Section 4	11
3	Simulation Fidelity: Classification of Studies Reviewed in Chapter 2, Section 5	12
4	Feedback/Knowledge of Results: Classification of Studies Reviewed in Chapter 2, Section 6	13
5	Team Structure and Composition: Classification of Studies Reviewed in Chapter 2, Section 7	15
6	Team Training: Classification of Studies/Procedures Reviewed in Chapter 3	19
7	Classification of Training Contexts	26

Team Training and Evaluation Strategies: State-of-the-Art

Chapter 1

INTRODUCTION

Interdependent, coordinated team performance is a predominant characteristic of most operational activities within the military Services. Training of teams in operational units is the transition between initial individual training and combat. The influence of effective team behavior upon system performance clearly has implications for training. Team training is more difficult, and is assumed to be more costly, than is individual training. It is usually performed in operational environments or in high-fidelity simulations of such environments. For these reasons, sound data are needed for use in determining the relative effectiveness of alternate training concepts as a means for improving team training.

BACKGROUND

In pursuing their mission of operational readiness, the Services conduct most (up to 90%) of their training in the operational commands. However, in the past, most training research has been focused on individual training at Schools and at other institutional locations.

Maj. Gen. Paul F. Gorman, Deputy Chief of Staff for Training, U.S. Army Training and Doctrine Command, recently stated [93] that there is a need for increased research emphasis on what is called "collective training" (team or crew tactical training in a unit context). A recent Defense Science Board task force report [26] stated that in view of the amount of team training that goes on in the Services, either formally recognized as training or combined with operations, the funds committed to R&D support for team training are relatively small. In Fiscal Year 1974, the Army Research Institute (ARI) conducted the largest program of unit research in history, and yet spent less than $2 million—only 11% of the human resources research program in that year. Most of the money in that program went for improved institutional training or exploration of other individual training issues.

PURPOSE OF STUDY

This review of the team training area was undertaken to provide an information base that the Defense Advanced Research Projects Agency (DARPA) and the Services could use to facilitate planning and decisions regarding future research program support. Team training research programs are to develop better team training methods and technologies and to provide new measurement techniques and procedures for team evaluation. The following objectives were established to guide the preparation of this review:

1. *Describe existing instructional strategies and evaluation techniques relevant to team training.*
2. *Identify state-of-the-art gaps in team training and evaluation and suggest new team training strategies and evaluation techniques which warrant further study.*

APPROACH

Review of Technical Literature

An extensive search was made of the major documentation sources in order to amass an initial listing of publications relevant to team training. The emphasis was on a document's applicability to tactical training of teams. However, instructional strategies and evaluation techniques that had been used in other contexts also were examined for possible relevancy.

The following major sources were searched:

Educational Resources Information Center (ERIC). These indices were searched for relevant titles over the preceding 10-year period. The descriptors used in this search included team training, military training, industrial training, group dynamics, group effectiveness, group instruction, small group instruction, training techniques.

Defense Documentation Center (DDC). The indices of the preceding 10-year period were searched using the following descriptors: team training, group dynamics, group problem solving, training crews.

Psychological Abstracts. The descriptors used to search these indices were group dynamics, training, training/industrial, training/military, and group/small. Here too, a 10-year period was selected for the in-depth search.

National Technical Information Service (NTIS). The general area of "military sciences" was canvassed for appropriate literature. Also, team training, group dynamics, group problem solving, and group training were used as descriptors.

HumRRO Library. This library specializes in publications that are relevant to military training and evaluation. A sizable number of documents were thus obtained "in-house" for this review.

The initial list contained many hundreds of titles. Each document's abstract was reviewed to ensure that only those publications which were relevant to team training and evaluation would be selected for the literature survey. The documents judged to be relevant were then obtained and reviewed.

Once the search in the initial sources was completed, secondary sources (e.g., *Journal of Applied Psychology, Training in Business and Industry)* were canvassed for relevant articles. In addition, "key" documents that were more than 10 years old were identified from the cross-references in documents already reviewed. These "key" documents were also obtained and reviewed. All these items are listed in the References section of this report.

Sample of Current Military Team Training Techniques

The most recent military doctrine regarding team training procedures was obtained and reviewed. Current studies under way within the Army Research Institute and the other Services were examined. Military personnel were contacted in all the Services to identify team training approaches currently in operation. HumRRO personnel with experience in the team training area (e.g., Dr. Joseph Olmstead) were consulted for information about current military team training methods. Examples of current techniques were then chosen for inclusion in this report and are described in Chapter 4.

DEFINITIONS

As can be seen from the variety of sources chosen for the initial literature search, HumRRO reviewers had not yet made a clear conceptual delineation of the team training area. They viewed team training research as part of the more general subject matter of

small group research or group dynamics. This larger field had generated literally thousands of empirical studies and theoretical papers, most of which were only tangentially relevant to the sub-area of team training. An understanding was needed of what makes the team context unique.

Before a state-of-the-art review on team training could be accomplished, one needed to define what constitutes a "team." In various circumstances, teams may be made up of two or more individuals (with no upper limit) and they may be characterized by virtually any degree of formal organizational structure and permanency [49].[1] Rather than attempting to develop one more definition, the authors viewed the description given by Glaser, Klaus, and Egerman [40] as providing the most meaningful distinction between small groups and teams considered in this review:

- "Teams" have the following characteristics:
  1. They are relatively rigid in structure, organization, and communication pattern.
  2. The task of each team member is well defined.
  3. The functioning of the team depends upon the coordinated participation of all or several individuals.
- In contrast, "small groups" differ in that they generally:
  1. Have an indefinite or loose structure, organization, and communication pattern.
  2. Have assignments which are assumed in the course of group interaction rather than designated beforehand.
  3. The group product can be a function of one or more of the group members involved depending upon the quality and quantity of their participation. (Glaser, Klaus, Egerman [40])

These definitions were used to guide the final selection of studies and papers for in-depth review.

Instructional strategies and evaluation techniques for "teams" should take these dimensions into consideration. In addition, teams are goal- or mission-oriented [49] and so the specific context in which the team will operate must be considered before any training or evaluation technique can be applied.

The question of whether "team" or "multi-individual" behaviors are involved in a given context has not been adequately studied. As derived from the above discussion, "team training" can be defined as:

- The training of two or more individuals who are associated together in work or activity. The team is relatively rigid in structure and communication pattern. It is goal- or mission-oriented with the task of each team member well-defined. The functioning of the team depends upon the coordinated participation of all or several individuals. The focus of team training and feedback is on team skills (e.g., coordination), activities, and products.

On the other hand, "multi-individual training" can be defined as:

- The training of two or more individuals who are associated in a group context. The trainees may or may not be part

[1] This document by Hall and Rizzo provides an excellent description of how definitional problems have troubled the team training field and of the various ways in which the research literature has dealt with these difficulties.

of a team. However, the focus of the training and feedback is on individual skills, activities, and products.

Methods are needed by which one can analyze given task situations and derive the requirements for individual or team training.

In the chapters that follow, a distinction will be made on this dimension—that is, whether the study or technique reviewed is pertinent to multi-individual or to team contexts.

Chapter 2

REVIEW OF TEAM TRAINING RESEARCH

Research in the area of team training has been going on for approximately 20 years, albeit at a relatively low level of effort [22, 23, 45, 61, 71, 73, 79, 80]. Despite the importance of the area, Glanzer and Glaser [43] noted in 1955 that relatively little formal knowledge existed concerning methods of describing and analyzing team performance. They cited the complexity of team training problems as contributing to that situation: "In the investigation of the areas of team as opposed to individual training and performance, problems appear of an entirely new order of magnitude."

Twenty years later, the Defense Science Board described some of the difficulties in performing team training research that have prevented significant breakthroughs:

> This kind of R&D must be piggybacked on operations in the field, large numbers of R&D personnel are required, the opportunities for data collection during the exercise are marginal, inferential statistics and psychometrics were not designed for this order of complexity, there are limited opportunities for repeated trials, the ultimate test of team training is combat, which cannot be simulated. [26]

The difficulties cited in doing team training research have prevented a thorough study of the problems and research needs that have been identified during the intervening years. However, some definite progress has been made and certain research trends have been identified and described [44].

Research findings that have been reported on some major team training problems and issues will be described in the eight sections that follow. The topics discussed are:

- Section 1—The "Stimulus-Response" and "Organismic" models which underlie different approaches to the study of team training [1].
- Section 2—The components of "Emergent" versus "Established" situations and their effects on team training research.
- Section 3—The relative importance and interactions of individual training and team training.
- Section 4—Descriptions of and problems involved in studying team skills.
- Section 5—The degree of simulation fidelity and its influence on effective training.
- Section 6—The effects of feedback on team performance, and techniques used to present knowledge of results to team members.
- Section 7—Team structure and composition and their effects on team training.
- Section 8—The benefits of a systems approach to the development of effective team training.

1. TWO CONCEPTUAL APPROACHES TO TEAM TRAINING RESEARCH

Two team training models have been distinguished by Alexander and Cooperband [1] on the basis of the situations in which team behavior takes place. The variables and environment that researchers select for study depend upon the team model they choose.

The "Stimulus-Response" model is applied to teams that operate primarily in established situations, in which the tasks, and the activities required to perform them, can be almost completely specified, and in which the assignment of functions among team members and their equipment is relatively rigid. This viewpoint underlies attempts to apply certain principles and techniques of individual learning (e.g., operant conditioning) to research on team training. Studies performed at the American Institutes for Research Team Training Laboratory are illustrative of the model. For example, in one study [65] reinforcement of team response was manipulated to measure differences in team member proficiency.

In the "Organismic" model [1] the team is considered to be a synthetic organism of which individuals are components. This model is oriented toward teams operating in environments that include a significant proportion of emergent situations. Although there are defined task assignments, the individual has a considerable degree of discretion in how to perform the task under various contingencies. Consequently, proficient team performance can depend upon the development of appropriate team procedures enabling members to cope with the environment. Thus, adaptive innovations are needed and decision-making and problem-solving skills are emphasized [1]. An example of this viewpoint is the work done by Chapman, *et al.* [17], in which teams in a simulated air defense direction center were presented with sudden disruptive changes in their environment and were required to react to the new stimuli quickly in order to solve given problems precisely.

2. ESTABLISHED VS. EMERGENT SITUATIONS

The two conceptual approaches described in Section 1 take as their basis the context in which team behavior occurs. This context is actually a continuum of situations, the end points of which are described as established or emergent. Boguslaw and Porter [10] define these situations as follows:

> An established situation is one in which (1) all action-relevant environmental conditions are specifiable and predictable, (2) all action-relevant states of the system are specifiable and predictable, and (3) available research technology or records are adequate to provide statements about the probable consequences of alternative actions. An emergent situation is one in which (1) all action-relevant environmental conditions have not been specified, (2) the state of the system does not correspond to relied-upon predictions, and (3) analytic solutions are not available, given the current state of analytic technology.

An established situation was the primary focus of a research program of the Team Training Laboratory of the American Institutes for Research [62]. The advantages of such a situation for research are:

- It is relatively easy to abstract key characteristics of real-world team tasks and represent them in the laboratory.
- Experiments can be done relatively inexpensively.
- Studies can be conducted in reasonable time periods.
- Monitoring of team activities is feasible.

On the other hand, simplifying the representation of team functions can mask or omit possible important variables which influence behavior in the real world. By abstracting the situational context in the laboratory, there can be a loss of opportunity for trainees to react to breakdowns and problems that may arise in an operational setting.

Providing skills to deal with emergent, unstructured situations was seen as a major goal of team training in studies by the System Development Corporation [1]. The development of coordinative skills was stressed although it was recognized that these are based upon a certain minimum attainment of individual skill. Team training devices and techniques were seen as requiring orientation toward the training of innovative behaviors and skills necessary to adapt to unforeseen problems [11, 25].

An emergent situation permits a more realistic, less abstract approach to the investigation of team training variables than does an established situation. When a team was formed in the laboratory, its prior motivational characteristics were important determinants of performance. But, when teams were studied while carrying out face-valid activities, prior motivational states appeared to be less important. What was important in this case was training in coordination such that team members became fully aware of their responsibilities to compensate for the inabilities of others, or to overcome temporary problems when the situation called for it [37].

By viewing task situations as established or emergent, one can classify the training techniques and research studies discussed in this review as pertinent to one type of context or the other. Similarly, the distinction between team training and multi-individual training comprises a second classificatory dimension. The resulting 2 x 2 matrix—Task Situation/Training Focus—constitutes a classification scheme which will be used in the remaining sections of this chapter and in later chapters to categorize the research studies and training procedures surveyed.[1]

3. INDIVIDUAL VS. TEAM TRAINING

The studies in this section were classified as shown in Table 1. Although the focus of this literature review was on *team* training, some relevant studies dealt with individual skills training in a multi-individual context.

Table 1

Individual vs. Team Training:
Classification of Studies Reviewed in Chapter 2, Section 3

TASK SITUATION	TRAINING FOCUS: Team	TRAINING FOCUS: Multi-Individual
Established	Briggs & Johnston [11, 13] Hall & Rizzo [49] Klaus & Glaser [62, 63, 64]	Horrocks, *et al.* [52, 53]
Emergent	Alexander & Cooperband [1] Johnston [57] Kanarick, *et al.* [59] McRae [68] Williges, *et al.* [94]	Kanarick, *et al.* [59]

[1] The classification of studies throughout this document represent the judgments of the authors. No formal rating system was used. The discussions include some material from survey-type and other references in addition to the studies classified in the tables.

One common conclusion in the research on team training, regardless of whether it was based on an "Organismic" or a "Stimulus-Response" viewpoint, is that individual proficiency is the basis for an effective team [59]. Thus, in emergent situations, developing team awareness or abilities to deal with unexpected problems requires that each team member has attained the requisite job skills. Team training is likely to proceed most efficiently when the team members have thoroughly mastered their own specific assignments beforehand [62]. Horrocks, *et al.* [52, 53] found that when team coordination was emphasized early in training, it interfered with acquisition of individual task competence.

The question could then be asked whether team training was of any benefit at all and, if so, to what degree and in what manner. Is it possible to predict when individual training will be superior to team training? [13] Briggs and Johnston [11] concluded their review finding no direct evidence for the superiority of team training over individual training. They interpreted this finding as indicating a need for team training devices to include provisions for either refreshing or augmenting individual skills. In other laboratory investigations (derived from established situations) which compared individual with team training, results were equivocal. Horrocks, *et al.* [52] found that if a member of an intact team was replaced by another equally competent person, there was no decrement in team performance. This implied that there was no generalized "team skill" that operated independently of specific task competencies [11]. Evidence supporting this finding came from other AIR laboratory studies [63, 64], in which only the proficiency level of the members at the start of team training determined team performance. In task situations that were routine and well-established, team performance was seen to be the sum total of individual performances [49].

On the other hand, Johnston [57] studied two-person teams working in a simulated radar situation where the objective was to track and intercept incoming aircraft. The amount of coordination and communication in the training task was varied and demonstrated that team training was better than individual training when the criterion task required coordination between individuals. In such emergent situations, training in "team skills" (e.g., coordination) was necessary and effective performance was regarded as something more than the sum of individual skills [68].

Verbal communication training was found not to be useful when the task did not require the skill [57]. In a study by Williges, *et al.* [94] it was concluded that verbal communication played an insignificant role in team work and this role was not enhanced by verbal training. In this study, two-person teams were required to coordinate interception of two planes on a simulated radar screen. In one condition team members received only verbal communication concerning the performance of the other team members; in another condition the team members were given verbal communication and visual access to the radar screen of the other member. It was found that verbal communication facilitated performance of the team only when no other more efficient communication channel was available. In the conditions where verbal and visual communication both were allowed, verbal communication had no effect on team performance.

Team training should be effective, according to Alexander and Cooperband [1], when the training stresses the acquisition of coordinative skills, and the tasks being trained are such that formal rules cannot be stated and procedures must be developed by the team in accomplishing the task. Kanarick, *et al.* [59] proposed three phases for team training:

> Initially, there is the need to train individuals in the procedural aspects of their jobs, doctrine, and the process approach to decision making. This training should be followed by a phase in which team members are instructed as a unit, learning the interactive and communicative requirements of team functioning. The final phase is devoted to tactical training where teams are taught to apply their procedural and interactive skills to certain situations requiring innovative and creative behaviors.

4. TEAM SKILLS

Studies discussed in relation to team skill training are classified in Table 2. As can be seen, training in team skills is important for application to emergent situations [89, 88]. What are these skills and how should they be trained?

Table 2

Team Skills:
Classification of Studies Reviewed in Chapter 2, Section 4

TASK SITUATION	TRAINING FOCUS: Team	TRAINING FOCUS: Multi-Individual
Established		
Emergent	Alexander & Cooperband [1] Boguslaw & Porter [10] Federman & Siegel [33] Kanarick, *et al.* [59] Sidorsky & Houseman [88] Sidorsky & Simoneau [89]	Hausser, *et al.* [50]

With respect to one such skill—cooperation—Alexander and Cooperband [1] have described it as follows:

> Learning to cooperate means learning the strengths and weaknesses of one another, learning when the others want help and when they do not want it, learning to pace one's activities to fit the needs of all, and learning to behave so that one's actions are not ambiguous.

Nonetheless, one of the problems in the area of "team skills" is lack of unambiguous, operational definitions of skills such as coordination, interaction, and cooperation [33]. As there are conflicting views regarding these terms, so too are there problems in training and evaluation of these skills [97].

One of the most difficult skills to train, yet one of the most important in dealing with team functions, is skill in the analysis of one's own errors. Boguslaw and Porter [10] reported that it did not appear possible to specify how to train this skill. It was hypothesized that it would help to present trainees with numerous unusual situations which could not be handled by simple adherence to standard operating procedures. Problem-solving discussions (rather than didactic presentations) also could have helped. An effective team performer must learn when he/she is reaching the point of being overloaded and needs assistance. Studies are needed to examine the kinds of "self-evaluative" skills which can enhance team performance and to identify techniques that could be used to train these skills.

Training in team awareness, a skill considered important to performance in emergent situations [59], can benefit from the application of several existing technologies. The

split- or multiple-screen technique of television can be used to show team members how their jobs relate to other team members. With this technique, a trainee could observe how a given action serves as a stimulus for some other team member. Such training gives trainees a better appreciation of their individual roles in the team and of the need for effective communication and interaction.

In another study, the PLATO IV Computer Assisted Instruction (CAI) system was applied to training interpersonal skills [50]. The content areas chosen included feedback, communication, goal setting, problem solving, decision making, and reinforcement. Training had a positive effect on some of the skill performances of company commanders in leading recruit companies through a nine-week training period. However, in most of the behavioral measures of company commander performance, CAI training did not have a discernible effect. Further investigation of the usefulness of CAI as an approach to training team skills appears needed.

5. SIMULATION FIDELITY

Studies discussed in terms of simulation fidelity are classified as shown in Table 3.

Table 3

Simulation Fidelity:
Classification of Studies Reviewed in Chapter 2, Section 5

TASK SITUATION	TRAINING FOCUS: Team	TRAINING FOCUS: Multi-Individual
Established	Briggs & Johnston [11, 12, 13] Briggs & Naylor [14]	
Emergent	Alexander & Cooperband [1] Bachrach [3]	Madden [69] Prophet & Caro [82]

In training teams or studying their behavior in emergent situations, high-fidelity simulations may be contemplated [69, 82]. High-fidelity simulation can be both costly and time consuming; space, equipment, and staffing require substantial investments in money and time. The problems of measurement are great because of the interactions of the many variables involved. Once a large-scale simulation exercise has begun, the experimenters have little control over the events that follow [3].

High-fidelity simulation of complex team tasks is exemplified by those simulating air traffic control tasks and air defense operations which utilized teams ranging from 30 to 40 people. These tasks very closely approached the complexities of the operational task and task fidelity was very high, since in some cases an operational system itself was used in training [1].

Can low-fidelity simulations be used adequately for team training? A series of experiments by Briggs, *et al.* [11, 12, 13, 14] led to the conclusion that team training did not transfer well to the operational environment when the training simulation was of low fidelity. However, all these studies were performed in contexts derived from established situations. No studies were found using low-fidelity simulations in emergent situations. Recent techniques used in the Army to simulate two-sided combat engagements have employed low-cost, high-fidelity procedures in emergent contexts. These techniques will be discussed further in later chapters of this report.

6. FEEDBACK/KNOWLEDGE OF RESULTS

Studies on performance feedback discussed in this section were classified as shown in Table 4. Most of this research was performed in laboratory settings.

Table 4

Feedback/Knowledge of Results:
Classification of Studies Reviewed in Chapter 2, Section 6

TASK SITUATION	TRAINING FOCUS: Team	TRAINING FOCUS: Multi-Individual
Established	Burnstein & Wolff [15] Cockrell [19] Cockrell & Sadacca [20] Egerman, *et al.* [31, 32] Glanzer [42] Glaser, *et al.* [40] Klaus & Glaser [62, 63, 64] Klaus, *et al.* [65] Marra [70] Short, *et al.* [86] Wolff, *et al.* [95, 96]	Nebeker, *et al.* [74] Burnstein & Wolff [15] Wolff, *et al.* [95, 96]
Emergent	Alexander & Cooperband [1] Kanarick, *et al.* [59]	

"Performance feedback is unquestionably the single most critical parameter in team or individual training," concluded Kanarick, *et al.* [59] in a review of the research literature on feedback. The series of studies by AIR [31, 32, 40, 62, 63, 64, 86] considered an important characteristic of teams to be the fact that, regardless of how a correct team response was made, every member of the team was exposed to the same reinforcing

event—even when some team members made errors or were idle. These studies demonstrated that, on occasion, team reinforcement might foster unwanted, inappropriate responses that could create a significant decrement in team performance. The results of this program of research suggested several guidelines which should be employed for team training:

> . . . it appears essential that team practice result in clear and immediate reinforcement following each correct team response; practice in the absence of team reinforcement for criterion-level performance is more than likely to lead to a decrement in team proficiency [62].

An approach used to provide team members with feedback or "knowledge of results" is the post-exercise debriefing. Debriefing sessions following team training sessions are an opportunity for the team to examine individual proficiencies and to explore alternative ways of organizing the task so as to develop more efficient and proficient team performance. However, the post-exercise discussion as feedback may have an undesirable characteristic—a large time gap between the response and the feedback [42]. The amount of elapsed time before feedback is given should be studied systematically to determine the effects of delayed feedback.

The results in a study by Nebeker, *et al.* [74], showed that although individuals performed better with feedback than without, it did not matter whether the feedback was raw or percentile scores or whether it concerned the individual, his/her group, or both. The results underscored the importance of feedback as a general factor which augmented and sustained performance. Other studies of feedback have demonstrated that reinforcement contingencies affect team performance, and have illustrated the effectiveness of feedback or knowledge of results to sustain performance [15, 65, 70, 95, 96].

Team members receive feedback information from intrinsic and/or extrinsic sources. Extrinsic feedback is provided by a source external to the system, such as an instructor. Intrinsic feedback is received while the team is performing its tasks and is inherent in the task itself. The effectiveness of intrinsic feedback has been shown in a variety of studies [19, 20].

Providing feedback in team training presents problems beyond those encountered in training individuals:

> These problems arise from three considerations. (1) There may be several criteria of effective team performance with no clear-cut trade-offs among them; these criteria may be vague and difficult to state objectively and may change during system operations. (2) In order for a team to operate effectively, it is necessary for its members to develop and maintain individual skills as well as skill in working together; there is a possibility that these skills may require different feedback procedures which may mutually interfere. (3) When a complex system operates, there is usually a large volume of information available about the state of the environment, the state of the system, and the performance of system personnel; some of this information may be conducive and some inimical to effective learning [1].

A major source of difficulty in team training is the identification and correction of individual errors. In many complex team tasks, there are often many possible correct procedures, making error identification difficult. These conditions give rise to the problem of monitoring or supervising team responses to evaluate their adequacy.

Although the studies cited discuss the general effectiveness of feedback, more work needs to be done to systematically investigate the methods that might be used to deliver feedback information. Various techniques such as videorecording and post-training briefings are now used to inform team members about their responses. These and other methods need to be studied regarding their effects on team performance.

7. TEAM STRUCTURE AND COMPOSITION

Studies discussed with reference to team structure and composition were classified as shown in Table 5. Although not directly related to team training techniques, questions regarding the effects of group structure and composition upon training are important for understanding the effects of training upon team performance [6].

Table 5

Team Structure and Composition:
Classification of Studies Reviewed in Chapter 2, Section 7

TASK SITUATION	TRAINING FOCUS: Team	TRAINING FOCUS: Multi-Individual
Established	Bolin, *et al.* [9] Briggs & Johnston [11] Briggs & Naylor [14] Egerman, *et al.* [31, 32] Johnston & Briggs [58] Klaus and Glaser [62]	Bolin, *et al.* [9] Nebeker, *et al.* [74]
Emergent	George [38] Moore [72]	Baldwin, *et al.* [6]

Two types of team structure were identified and studied in a series of laboratory experiments [11]. In a serial or vertical structure, activities are sequential with input from one team member based on output of another. Parallel team structures (e.g., rowing team) do not have the same member interactions. Briggs and Naylor [14] suggested that parallel team structures are preferable to serial structures, because team performance in the parallel structure is not dependent on the least skilled member. However, Klaus and Glaser [62] reported that the parallel structure led to only a short-term gain and eventually to a decrement in team performance.

A variety of studies on team structure, workload allocation, physical arrangement, and member replacement yielded conflicting results [47, 48]. For example, Bolin, *et al.* [9] found in studying task size and team performance that fully cooperative three-man teams performed better than individuals working alone on image interpretation. Moore [72] and George [38] studied the effects of task characteristics on team performance in emergent settings. Moore found that increasing the task load on teams did not affect team performance when all the information necessary for task completion was furnished to the team. George showed teams performed better when they were required to use a communication network that included all of the team members. In a study conducted in an established task context to test the effects of team arrangement on performance of radar controller teams [58], investigators found that team communication inhibited team performance in some cases.

In several studies occurring in established task situations, the effect of team member replacement was found to be relatively unimportant and dependent on the skill levels of the persons involved [30, 31, 32, 48]. However, personnel turnover was considered to be a major factor degrading team performance in an operational setting. For example, a tank commander reported that with 40% turnover in crews every 90 days, one cannot expect acceptable levels of team proficiency [26]. There is a need for a systematic study of the effects on team proficiency of the length of time a team performs together under established or emergent conditions.

With such conflicting findings, the search for superior team training methods has not made much progress. Task- or situation-specific characteristics may account for many of the divergent findings obtained in team training research. A more systematic approach to the research area appears necessary. This suggestion is amplified in the following section.

8. SYSTEMS APPROACH TO TEAM TRAINING

The most common framework for research in the team training field has been to study team behavior in the same manner in which individual behavior is investigated. The "Stimulus-Response" adherents viewed the team as a "single response unit" [62]. The team product as a whole, rather than its component parts, was the focus of research. This made it feasible to investigate the effects of various conditions of feedback upon team proficiency. The fact that the team response might have been quite complex and might have resulted from the integration of separate responses of several team members was of interest only to investigators who followed the "Organismic" viewpoint.

Both sets of researchers favor the application of a "systems approach" or Instructional System Development (ISD) model to the design and development of team training exercises, materials, methods, and devices. Implementing such an approach could yield information needed to identify critical variables to be studied as part of an extensive program of team training research.

Teams are created or defined to accomplish certain goals or missions [36]. The relationships among team members are meaningful only to the extent that they are involved in attainment of the goals. Thus, before any team training is undertaken, an in-depth analysis of the system should be performed [81]. The task characteristics need to be identified and training objectives derived [46, 58]. The members of the team should be made aware of the team's goals and objectives. Exercises and instructional materials should be structured with respect to the objectives, and the training situation should be made as similar as possible to the operational criterion situation [8, 42]. Finally, the quality control components of the system should provide feedback data to trainees and trainers for the purpose of improving the training system and team proficiency.

The major difficulties to overcome in order to implement an ISD approach to team training are its expense, the need for qualified personnel, and the problem of obtaining the resources and authority to carry out the training research and development deemed necessary.

SUMMATION

Two approaches to the study of team training have been described. These research trends were based upon what was termed the "Stimulus-Response (S-R)" and "Organismic" models. The Stimulus-Response model led to laboratory investigations which addressed team training problems occurring in established task situations. Adherents of

the Organismic model tended to study team training in more realistic surroundings, as they were more interested in the emergent phenomena present in the task situation.

Despite their conceptual and methodological differences, the studies performed by both groups of investigators suggested the following general conclusions.

- Team training is a necessary addition to individual training for tasks which require interaction and other "team skills."
- Effective team training can occur only if the team members enter the training situation with the individual skill competencies that are needed.
- The team context is not the appropriate location for initial acquisition of skills by individuals.
- Performance feedback is critical to team as well as individual acquisition of skills.

The research findings discussed in this chapter, indicating that a particular team structure is "better" than others or that one type of reinforcement schedule is more effective than another, are quite fragile results. They can be largely obviated by such things as lack of fidelity in the training situation [16]. The nature of the training situation is a critical element for future team training research. Up to now, the tasks used to study team training have, with some notable exceptions, been quite limited.

Recent programs in the Army have demonstrated the possibility of developing simulations that are high in fidelity, yet low in cost. Such simulations may provide team training researchers with the controls they need to study "team skills" in realistic environments rather than in the laboratory [26]. Other implications for research generated by the literature review will be discussed further in Chapter 5.

The review of the research literature has shown that weaknesses exist in conceptual definitions of such terms as "team," "coordination," "fidelity," and "interaction." Efforts are needed to provide a more precise taxonomic underpinning in this field, to serve as a framework for more generalizable and comparable research.

Chapter 3

REVIEW OF EVALUATION TECHNIQUES FOR TEAM TRAINING

The importance of methods for systematically evaluating team training effectiveness and the difficulty in developing such methods have been widely acknowledged for a number of years [26, 41, 42, 65, 76]. In 1955, Glanzer and Glaser [43] noted the lack of satisfactory proficiency measures for team performance. In 1962, Glaser [39] remarked:

> With respect to proficiency measurement, less work has been done in this area than has been carried out with individual performance, yet the importance of developing proficiency measures for multiman systems is being more frequently considered.

By 1974, Obermayer, *et al.* [76] commented that an economically acceptable means of objectively measuring behavioral skills in the team training setting was an elusive goal. This conclusion was echoed by the Defense Science Board's 1975 review [26] of research and development programs in military training. Their report stated that the team performance measurement problem is a "fundamental stumbling block to progress" in improving team training.

While a systematic, widely applicable methodology for team training evaluation is not yet at hand, there appears to be a reasonable consensus as to what the methodology ought to accomplish [8, 18, 60, 76]. The literature reviewed suggested that any team performance measurement system must address the following areas:

- The definition of team performance objectives in terms of specified, observable outcomes, to include criteria for acceptance and conditions of performance.
- The definition of a metric or range of values applicable to each specified observable event.
- The detection, measurement, and recording of the value of an observed event at each occurrence.
- An evaluation of the team as having attained or not attained the objective—based on discrepancies between outcome criteria and observed event values.
- The feedback of team performance data to the training environment.

The remainder of this chapter will deal with current developments in team training evaluation in the first four areas listed.[1] In terms of the two-dimensional categorization of *training focus* and *task situation*, most of the studies reviewed in this chapter are related to the evaluation of team training in emergent task situations (Table 6).

DEFINITION OF TEAM PERFORMANCE OBJECTIVES

Much has been written on procedures for deriving training and performance objectives [2, 91]. The actual statements of objectives are the end products of a series of steps

[1] The feedback of team performance data was discussed in Chapter 2.

Table 6

Team Training
Classification of Studies/Procedures Reviewed in Chapter 3.

TEAM TRAINING

TASK SITUATION	Team	Multi-Individual
Established	Project IDOC (tank gunnery)	
Emergent	ARTEP Validation Studies [51] CARMONETTE (computer simulator models) [21] Combat-Ready Crew Performance [Obermayer's study, 76] MASSTER METTEST (investigation of types of aggregate models) NORM Project [84] REALTRAIN (crew-served weapons) [29, 87] SAGE studies described by Biel [8] TACDEW System [18, 34, 35] UPAM (casualty assessment method)	MILES [29] REALTRAIN (rifle studies) [29]

in a systems approach to training development. Under this approach, the resulting objectives have three characteristics:

- They must describe behaviors that are to be demonstrated in the test situation.
- They should indicate the conditions under which these behaviors are to be demonstrated.
- They should include criteria or standards of performance.

The absence of performance criteria, usually stated in terms of accuracy, time, casualties taken, tolerance limits, and so forth, appears to be a seriously deficient aspect of the evaluation of team training and performance.

The Army Training and Evaluation Program (ARTEP)[1], a body of training reference literature stressing a mission-oriented, performance-based approach, has been under development since 1974. In 1974-75, the 9th Infantry Division and the 1st Cavalry Division trained and tested under prototype ARTEPs as part of an extensive examination of the feasibility of ARTEP implementation. One of the primary objectives of the effort was to "assess the effectiveness of the ARTEP as an instrument for evaluating unit proficiency" [51].

[1] See Chapter 4 for a more detailed description of ARTEP.

It was concluded that the standards of performance stated for ARTEP missions needed revision. The standards were inaccurate in some instances and too general and vague in many others, requiring individual rater judgment to a greater extent than necessary. Army Training and Evaluation Program standards, while ostensibly stated in specific performance terms, contained many indefinite terms such as "on time," "excessive," "sufficient," "promptly," and "proper." Without some guidance, interpretation of such terms is certain to vary widely. One major difficulty relates to the use of multiple standards and the lack of guidance as to the relative value of each component. Such heavy reliance upon judgments of individual evaluators can lead to diminished Army Training and Evaluation Program validity and reliability.

Obermayer *et al.* [76], describing a highly sophisticated, semi-automated system for evaluating air crew performance, stated that in some areas, such as air combat maneuvering, combat readiness determination is purely subjective. Chesler [18] asserted that standards for many combat situations—simulated or real—are often matters of widely differing opinion. Larson [67] described a possible way to overcome these differences. In his survey of team performance effectiveness measures, he suggested the use of the Delphi technique—a method for systematically extracting expert opinion—to elicit subjective indicators of team performance from senior Marine Corps personnel. These performance indicators could then be used in field exercises by less experienced evaluators.

DEFINITION OF OBSERVABLE EVENT METRICS

The critical concern in proficiency evaluation is whether a team has or has not gotten the job done. It is the objective of evaluation indices to measure data that indicate whether the defined mission has been successfully performed. Precise specifications of events to be assessed could be advanced by implementing the Instructional System Development (ISD) approach, which subsumes the use of job/task analysis procedures. However, much performance evaluation in training situations today is still highly subjective [18].

Upon examination, this problem inevitably boils down to a lack of criterion performance variables that are objective, recordable, discriminatory, and—most important—acceptable to a consensus of persons familiar with the tasks and skills of concern. This is the criterion dilemma, which is especially severe for team training. Acceptable indices of good and poor performance for military operations are difficult to define [18]. Nonetheless, some techniques for the systematic identification of measurable, related events have been developed [8, 18, 76].

Adoption of such methods may well provide the kind of comprehensive, detailed information which is necessary to the development of valid performance criteria, but which at present is generally not available to training and evaluation personnel. The Navy's Tactical Advanced Combat Direction and Electronic Warfare (TACDEW) System appears well thought out and could readily serve as a model approach for other team performance evaluation efforts.

The basic events in the TACDEW evaluation approach [18] are the "performance variable" and the "situational variable":

> A performance variable is a measure of the accuracy of timeliness of a trainee response. A situational variable is a measure of some aspect of the embedding environment for the trainee's response. Performance variables derive from two types of data elements: actual trainee response, and the response considered correct. The performance variable is the quantitative difference between or qualitative comparison of the two. For example, reported bearing (trainee response data element) for a target is 320 degrees; the true target bearing (correct respone data

element) is 300 degrees; the performance variable, error in reported bearing, is 20 degrees. This performance variable is a measure of accuracy of response.

Performance variables relating to timeliness of trainee response are derived from the actual latency of the trainee's response and a reference or ideal response latency. A set of performance (and situational) variables is then related to an event. Once the event occurs, preliminary lists of performance variables are generated to identify any and all variables that show promise of serving as measures of the attainment of training objective. The developers of the TACDEW system anticipate that their approach will help clarify the relationship among the various measurements and their relevance as criteria for making adequate judgments regarding team training outcomes.

Using similar, but perhaps less clearly articulated methods, training evaluators in other Services are attempting to define objective-related events. For example, in Project REALTRAIN,[1] an Army-supported approach which uses realistic, two-sided, free-play exercises, a casualty assessment technique was developed for the basic infantry weapon, the M16A1 rifle. The development of the casualty assessment technique for the M16A1 and of similar techniques for other infantry and armor weapons was considered a breakthrough necessary in simulating the tactical environment [29, 87]. As part of the REALTRAIN procedures, a sequential record of events is kept at the controller's station during each engagement. This record includes each casualty, the time at which it occurred, and the weapon used.

Statistical analysis can help to reduce the number of possible variables. Some variables may correlate highly with others, and can be eliminated. Other variables may show very little spread in range of scores, so they do not differentiate among trainees. Project NORM (Normative Operations Reporting Method) was an effort by the System Development Corporation [84] to identify valid performance variables for SAGE (Simulated Air-Ground Environment, 18) team evaluation, and to determine how situational variables affected team performance. A basic concept of Project NORM was that situational variables were measures of exercise difficulty. An exploratory pilot study provided data for 41 variables—24 performance and 17 situational variables. Correlational, linear multivariate regression, and factor analysis techniques were used to reduce the original number of 41 variables to 13 [24]. Six situational variables (related to the task at hand) were potential contributors to performance, and seven performance variables (e.g., detection latency) were considered relevant for evaluating system performance. While the specific variables selected appear to be useful primarily to the study content, the analytic methodology employed to derive these variables is applicable to emergent task situations in general.

Biel [8] described another SAGE study in which all measures used to evaluate team performance in a simulated environment were collected during a series of specially prepared simulated exercises. Correlations among team performance variables with measures of overall system performance in detection, identification, tracking, interceptor commitment, and interceptor guidance were computed and the resulting matrix factored. The deletion of those measures which did not have a significant relationship to overall system performance was recommended. It was recommended that a small number of systematically obtained observations be used to make judgments about team performance.

In Army tank crew training, a large number of performance objectives have been developed for tank gunnery training and proficiency assessment. Project IDOC (Identification of Test Doctrine for Cost-Effective Qualification of Tank Crews) is concerned

[1] See Chapter 4 for a further discussion of REALTRAIN.

with identifying a reduced set of tasks on which to base the development of cost-effective performance measures that are applicable to the entire set of objectives. A joint HumRRO/ American Institutes for Research effort was undertaken to determine the component team behaviors for each objective, and the commonality of behaviors across objectives.[1] Plans are currently being formulated to analyze data obtained so far on generalities across tank gunnery tasks, psychometric problems, and practical constraints on performance assessment.

DETECTION, MEASUREMENT, AND RECORDING OF OBSERVABLE EVENTS

A problem of some concern is the unreliability and inaccuracy of trainers and observers in evaluating team performance in the field. Since there is no fixed doctrine of what to observe and how to evaluate it for various team activities, the tendency is for inter-rater reliability to be quite low.

Larson's 1971 review [67] of the team performance measurement literature concurs with this assessment. He stated that there was a shortage of objective, quantitative methods available for application in field exercises, caused by an inherent difficulty in measuring complex human performance in a field environment. In REALTRAIN field exercises, detection and measurement of observable events (casualty assessment) are performed entirely by human controllers [87]. The light anti-tank weapon (LAW) and 90mm recoiless rifle (RCLR) are equipped with range-calibrated sighting plates which a controller looks through during a simulated engagement to determine hits. Casualties with the anti-tank weapon (TOW) are determined by a controller sighting through an accessory telescope mounted on the outside of the weapon. In a recent field tryout of the REALTRAIN method for combined arms tactical training, it was reported that the data collected were limited because of the methodological problems of quantitatively measuring team performance [87].

Some team training evaluation efforts attempted to circumvent the "unreliable" observer problem by automating detection and measurement as much as possible. This is particularly evident in areas where sophisticated electronic and computing technology are employed in mission fulfillment [4, 8, 18, 76]. The Army is presently investigating the use of laser technology for this purpose. Project MILES (Multiple Integrated Laser Engagement System) involves the integration of lasers with a variety of weapons types [29]. "Firing" of a weapon emits a weak laser beam which, if aim is accurate, activates a recording device on the target. The MILES system is still experimental and has not been subjected to field trials, but it has good potential for solving the problem of unreliable human measurement. Even though MILES was developed for use in multi-individual training settings, the concept could be applicable to the evaluation of crew-served weapons systems training.

Where such technological solutions are not to be used, other techniques for minimizing rater effect are being explored. To support the development of systematic methods of criterion-referenced performance assessment, the Army Research Institute through Project METTEST (Methodological Issues in Criterion Referenced Testing) is funding several investigations into the applicability of psychometric methods to the requirements of measuring combat team performance. One such effort addresses the question of which tasks, given limited time and resources, should be assessed via high-fidelity operational simulations, which may be measured "synthetically" (via paper-and-pencil instruments), and which may be assessed by inference from performance on related, more inclusive tasks.

[1] Interview with Army Research Institute staff.

EVALUATION OF OBJECTIVE ATTAINMENT

Attempts to evaluate team performance during field performance tests have varied considerably. In some cases it is assumed that if a given team completes an exercise successfully, the team had received training in relevant behaviors.

The most common means of evaluating performance is overall subjective evaluation. Where detailed checklists are used, each individual team member receives a numerically weighted score. The team score then is calculated through some weighted combination of individual scores—generally a simple sum.

The ability of human evaluators to effectively judge the success of teams in complex field exercises is generally considered unsatisfactory. In the Army Training and Evaluation Program (ARTEP) validation report [51] cited earlier, it was concluded that the ARTEP in its present form is not a standardized test instrument. There is no reason to expect that different teams would be evaluated under the same conditions when using Army Training and Evaluation Program guidance and standards. The standards are too subjective and evaluator performance is too erratic. There is no explanation of how to relate task performance to overall mission performance or how to adjust standards to account for varying test conditions [51].

The Modern Army Selected System Test Evaluation and Review (MASSTER) attempts to evaluate weapons systems training by employing a combination of checklists, associated logic trees, and expert judges in the field environment. The checklist logic tree evaluation uses field observers to check off the team's performance in specified situations. The team passes or fails progressively larger tests as a result of their performance on previous examinations. MASSTER also assigns officers to subjectively evaluate large teams during an exercise [67].

The difficulties currently experienced in making reliable and accurate judgments about team performance are in large measure due to the multiplicity of potentially influential factors. Chesler [18] stated:

> . . . single performance measures are inadequate for making overall evaluations of system effectiveness, presumably because multiple factors are involved in the determination of mission success or failure. Combining measures into overall indices has, so far, not seemed to help much, probably because the relationship between them is not clearly understood. Thus, lumping them together does not necessarily improve the quality of system evaluation.

Recognition of this complexity has led to a number of investigations of analytic or modeling approaches to the evaluation problem. A study within the Army Research Institute's METTEST (Methodological Issues in Criterion Referenced Testing) project is concerned with the applicability of traditional measurement models to the need for team performance indices. Measures are needed that give valid representation to the many team-related and environmental factors that influence mission attainment. Preliminary work has suggested that the predominantly linear additive models of psychometrics are not applicable in this context—that non-linear (e.g., exponential) and "multiple-cutoff' models may be more appropriate. In "multiple-cutoff models," team activities are structured in a manner related to the sequence in which they would occur in the field, and each is evaluated on a GO/NO-GO basis. Within this approach "compensatory" and "non-compensatory" activities can be identified. An activity is non-compensatory if one particular component will abort the attainment of the mission if it is not performed properly. If some other component can successfully pick up the slack left by the failed component, then it is compensatory.

The UPAM model (Unit Performance Assessment Model) developed at the Army Research Institute employs casualty data as a measure of both the achievements of a

team (casualties inflicted on an opposing force) and the cost to the team (casualties sustained) during its efforts to fulfill a mission. A team's accomplishments are measured by inputting to the model data from REALTRAIN field exercises and deriving a single value reflecting both cost and achievement. A criterion value for assessing the empirical result is obtained by having the unit commander provide estimates of these values that, in his judgment, are indicative of a successfully accomplished mission. The difference between empirical output and the commander's "expected" output (on a scale from -1 to +1) is viewed as an index of the team's success in attaining its goal. The UPAM model has been applied to both infantry and armor units. However, in its present state of development, the model does not provide evaluative information concerning team activities that contribute to or detract from mission accomplishment.

The most detailed and sophisticated analytic model found in this survey is the CARMONETTE ground close combat computer simulation [21]. Its parameters include detailed descriptions of team size, team type, firepower, vulnerability, mobility, and sensing capabilities. Data on terrain range from elevation and height of vegetation to trafficability. A set of "orders" (i.e., a mission) can be transmitted to each team of opposing forces. Each team can acquire information and relay it to equivalent teams or to its command headquarters. While the output from CARMONETTE provides only descriptive data, it could, if provided with field data, provide valuable clues concerning the effect of performance and situational variables on mission outcomes.

SUMMATION

There is still a major unsolved problem in the development of evaluation methods and tools for team training—namely, there is a need for reliable, objective-based, team performance measures. The literature reviewed indicated the difficulties of doing research in this area in spite of its acknowledged importance to the improvement of team training. The current support within the Army Research Institute for R&D in this area demonstrates their realization of its criticality. Most of this research is still in progress. Findings gleaned from the studies surveyed suggested the following:

- A systems approach to team training development should alleviate some of the problems associated with the establishment of criteria/standards.
- Much performance evaluation in team training today is highly subjective and unreliable.
- Lacking an adequate team performance measurement system, alternative team training programs and team proficiency cannot be properly evaluated.
- Automation of the monitoring and/or data recording process is needed in order to solve the problem of unreliable human observers.

Recent innovations in team training methodology discussed in Chapter 2 promise significant improvements in operational performance. A strong emphasis on R&D in team performance measurement is necessary if this improvement is to be detected and operationally realized.

Chapter 4

CURRENT APPROACHES IN MILITARY TEAM TRAINING

Examples of team training techniques currently in use in the Services are presented in this chapter. It is not intended to be an exhaustive presentation of such training methods. Rather, the examples were chosen to represent the variety of methods now employed to conduct team training. The training devices and systems discussed are categorized in Table 7. All were classified as pertaining to emergent task situations because they stress the realistic requirements of operational environments.

ARMY TEAM TRAINING

Army team training is predominantly a unit training function with no formal institutional training requirements. The great majority of personnel who complete Military Occupational Specialty (MOS) training at Army schools and training centers are assigned to units as replacements. They receive team training in the units in the form of individual on-the-job training, augmentation, cross-training, and collective (team) training. Most training is performed on operational equipment with the objectives of maximizing proficiency of readiness [27, 49].

In the Army, Advanced Flight Training is considered team training. Graduates of Undergraduate Pilot Training receive supplementary training in the specific aircraft they will fly on operational missions. The supplementary training is provided by the operational unit. The new pilot is integrated into the operational unit where he undergoes transitional training as part of normal unit training [26].

Much of the team training conducted in the Army is based on information contained in Army Training and Evaluation Program (ARTEP) publications. That is, ARTEPs "drive" the Army's team training system. ARTEPs are developed to assist training managers and trainers in the preparation, conduct, and evaluation of team training.[1] They consist of a series of training and evaluation outlines which specify for a particular element of a battalion/task force, or separate company, the following information:

- The unit (i.e., crew, squad, platoon, company/team or battalion/task force) for which the outline is applicable.
- The mission to be performed.
- The general conditions (situation) under which the mission will be performed.
- The primary training and evaluation standards upon which the unit will be evaluated as either satisfactory or unsatisfactory (Go/No Go).
- The collective training objectives applicable in the performance of the mission; guidance for estimating support requirements necessary to conduct formal evaluations, and tips to trainers and evaluators. [28]

[1] See Chapter 3 for a discussion of ARTEP as an evaluation mechanism.

Table 7

Classification of Training Contexts

TASK SITUATION	TRAINING SITUATION: Team	TRAINING SITUATION: Multi-Individual
Established		
Emergent	CATTS (Combined Arms Tactical Training Simulator) [26] C-5 Mission Flight Simulator C-130 Flight Simulator C-141 Flight Simulator FIST (Functional Integrated Systems Trainer) [26] Device 14A2, Surface Ship Anti-submarine Warfare (ASW) Early Attack Weapons Systems Team Trainer [49] Device 14A6, ASW Coordinated Tactics Trainer [49] Device 21A37/4, Submarine Fleet Ballistic Missile (FBM) Training Facility [49] TACDEW (Tactical Advanced Combat Direction and Electronic Warfare System) [34, 49] TESE (Tactical Exercise Simulator and Evaluator) [83] WST (B-52 Weapons Systems Trainer) WST (Device 2F87, Weapons System Trainer) [49]	MILES (Multiple Integrated Laser Engagement System) [29] REALTRAIN [29] SCOPES (Squad Combat Operations Exercise, Simulation) [28, 92] TWAES (Tactical Warfare Analysis and Evaluation System) [26]

Inasmuch as the Army Training and Evaluation Programs (ARTEPs) outline the basic missions that teams should be able to perform to be combat ready, they are a valuable source of information in preparing the scenarios for training strategies/exercises such as SCOPES (Squad Combat Operations Exercise, Simulation), REALTRAIN, MILES (Multiple Integrated Laser Engagement System), and CATTS (Combined Arms Tactical Training Simulator), which are discussed in this section.

1. SCOPES (Squad Combat Operations Exercise, Simulation)

SCOPES was originally designed to teach movement techniques to rifle teams and squads. It has been successfully used to train and/or evaluate soldiers or small teams on a wide range of battlefield skills, tasks, or missions.

Briefly, SCOPES [28, 92] works in the following way. Trainers first develop a tactical scenario based on specified training objectives. Six-power telescopes mounted on each rifleman's M16A1 rifle are used to identify numbers worn on the helmets of all participants in opposing forces. When a number of an "enemy" soldier is identified, the soldier making the identification fires a blank round and calls out the number he sees. Controllers in the vicinity in turn pass the number over a radio net to controllers operating with the opposing force. If the number is correct, the controller immediately "kills" the man wearing the number seen.

With this technique, "battles" may be conducted with real outcomes that depend on the tactics selected and the individual techniques used. It is possible to objectively determine "winners" and "losers."

After each engagement, troops on both sides are brought together for an after-action review to discuss errors made and lessons learned. In this manner, the correct techniques to avoid being "killed" can be brought out, learned, and practiced in subsequent engagements.

2. REALTRAIN

The REALTRAIN program permits the conduct of exercises using opposing forces on a larger scale than does SCOPES. To simulate the effects of other weapons systems, optical devices including telescopes and plastic sighting plates are mounted or used with light anti-tank weapons (LAWs), 106mm recoiless rifles (RCLRs), anti-tank weapons (TOWs), tank man guns, DRAGON medium anti-tank weapons, and 90mm RCLRs. These devices are aligned with the weapon's sight picture, thereby allowing controllers to see the same sight picture as the gunners. This permits them to verify a gunner's aim during a target engagement. Gunners "shoot" at targets by announcing the identification numbers worn by the soldiers aligned in their sights. Each optical device is correlated with the maximum effective range of the particular weapons system with which it is used [29].[1]

Field tests conducted using SCOPES and REALTRAIN exercises have proven that engagement simulation techniques work for training multi-individual groups. Both individual soldiers and units reach higher levels of tactical proficiency more rapidly, and soldiers are motivated to train because the tactical exercises present a real challenge.

3. MILES (Multiple Integrated Laser Engagement System)

MILES is a group of experimental training devices that use an eye-safe laser beam to simulate the effects of weapons expected on the modern battlefield. The MILES system will permit conduct of day and night tactical exercises involving battalion and task force size teams [29]. It is scheduled for testing in 1978.

The system will improve the integration of gunnery techniques into tactical training. Some of the subsystems are:

- Vehicle Engagement System (VES). The VES will be used by armor units and anti-armor weapons such as TOW (tube-launched optically tracked wire

[1] A more complete description of REALTRAIN can be found in Army Training Circular 71-5. [29]

guided missile), DRAGON (medium anti-tank weapon), and the 106mm recoiless rifle.

- Target Engagement Simulator (TES). The TES will be used by infantry troops to provide engagement realism. It consists of a laser transmitter and a hit indication device which signals "kills" and "near misses."
- Machine Gun Laser (MGL). The MGL simulates machine guns both unmounted and mounted on tanks.

The MILES procedure (as well as SCOPES and REALTRAIN) focuses on individual skills training in emergent task situations. The feasibility of using these techniques for training team skills needs to be determined.

4. CATTS (Combined Arms Tactical Training Simulator)

The purpose of the CATTS system, which is still under development, is to provide battalion commanders and their staffs with simulated combat situations operating from a ground command post.

The CATTS system has several features desired for training [26]. It allows realistic, real-time ground combat simulation; realistic mockups of command post vehicles; actual field radios for communication; on-the-spot command decisions and critiques; extensive automation to assist controllers; and cost-effective software and hardware.

The simulator utilizes a Xerox Sigma 9 computer to meet the following training objectives:

- Identify the relationships that exist among various elements and with the enemy.
- Identify alternative courses of action, appropriate formation maneuvers, and fire support applications.
- Communicate decisions to subordinates using tactical orders so that decisions can be effectively interpreted.
- Manipulate and monitor the variety of tactical radio networks available at the battalion level.

NAVY TEAM TRAINING

As in the other Services, team training in the Navy consists of training provided to organized teams for the performance of a specific mission. The Navy discusses team training in terms of five categories: Pre-Team Indoctrination Training, Subsystem Team Training, System Sub-Team Training, System-Level Operational Training, and Multi-Unit System Operational Training [26].

Pre-Team Indoctrination Training is conducted in a team context with emphasis on increasing the skill levels of the individuals who will later be assigned to operational teams.

In Subsystem Team Training teams vary in composition under different conditions of shipboard readiness. The teams are divided into three departments: Combat System Teams (e.g., Search Radar Detection and Tracking), Unit Operations Teams (e.g., Navigation), and Engineering Systems (e.g., Firefighting/Damage Control).

System Sub-Team Training involves the training of two or more subsystem teams—generally, an entire ship.

System-Level Operational Training is accomplished by at-sea training because existing pierside facilities are not capable of handling an entire crew of a ship in all facets of an operation. This type of training is best described as a battle problem which is conducted by underway training units and fleet training groups.

Multi-Unit System Operational Training is in-port exercises utilizing shore-based trainers for the purpose of training crews prior to getting under way for the exercise operations area. Major in-port exercises utilize the Tactical Advanced Combat Direction and Electronic Warfare (TACDEW) Trainer [26].

The following major team training devices used in the Navy are described below: Device 2F87 (Weapons Systems Trainer), Device 14A2 (Surface Ship Anti-Submarine Warfare Early Attack Weapons Systems Trainer), Device 14A6 (Anti-Submarine Warfare Coordinated Tactics Trainer), Device 21A37/4 (Submarine Fleet Ballistic Missile Training Facility), and TACDEW [49].

1. Device 2F87, Weapons Systems Trainer

The weapons systems trainer (WST) duplicates the interior arrangement and appearance of the P-3C aircraft. Five trainee stations simulate corresponding stations in the aircraft. The purpose of WST training is to teach team coordination. Students are organized into teams according to positions for which they are being trained, and they "fly" simulated anti-submarine warfare (ASW) missions. These missions are graduated in difficulty from very simple scenarios early in training to more complex exercises toward course completion.

2. Device 14A2, Surface Ship ASW Early Attack Weapons System Trainer

Device 14A2 is used to train surface ship teams in the proper utilization of operational ASW systems. Training emphasizes the procedural, tactical decision making, and team coordination activities in operating and employing ASW weapons systems. The device provides for indoctrination of personnel in ASW procedures and evaluation of tactical situations. The trainer is also used in developing and planning advanced naval undersea defense tactics.

The trainer occupies over 3000 square feet of floor space and duplicates the physical configuration of major operational compartments and equipments of surface ship ASW attack weapons. It simulates their functional operation and responses, such as target detection, fire control solution, and weapon launching and tracking.

3. Device 14A6, ASW Coordinated Tactics Trainer

Device 14A6 is designed to train decision-making personnel in the tasks they must perform when engaged in coordinated ASW tactics. Simultaneous operation of 48 vehicles of various types and a multiplicity of sensors can be simulated. Communications facilities simulate the various radio channels employed operationally to coordinate all phases of an ASW mission from search through attack. Device 14A6 provides a synthetic environment within which ASW personnel can practice collecting and evaluating ASW information, making decisions, and implementing the decisions based on this information. The device is not intended to train equipment operators; therefore, simulated equipment does not resemble fleet equipment. Functional characteristics of the simulated equipment are similar to fleet equipment.

Virtually any exercise at sea which requires communication, coordination, maneuvering, and decision making may be practiced in the 14A6 trainer prior to going to sea.

4. Device 21A37/4, Submarine Fleet Ballistic Missile (FBM) Training Facility

Device 21A37/4 provides training in offensive and defensive tactics for nuclear attack center teams. Surface or subsurface maneuvers may be accomplished, and training may be given independently or in coordination with other units. Instruction of senior command and staff officers in direction and coordination of submarine task groups with surface support units may also be given.

A central digital computer provides problem generation, position, and motion data generation. Up to 41 different vehicles can be included in training problems. A projection system in the attack centers permits both in-progress monitoring and post-fire analysis of training problems. Attack centers can be operated independently or operation can be coordinated to provide submarine versus submarine training. Fifteen different classifications of targets are currently available, 12 at any one time.

5. Tactical Advanced Combat Direction and Electronic Warfare System (TACDEW)[1]

TACDEW is a highly sophisticated, computer-based simulation facility having three primary missions: individual and team training, tactics evaluation, and testing of operational computer programs for Navy Tactical Data System (NTDS) ships. Training is conducted in 23 Combat Information Center (CIC) mockups typical of the ships on which trainees serve [49]. Team and multi-team training is accomplished. The purpose of TACDEW training is not so much to establish team interactive skills as it is to maintain or enhance these skills in simulated mission contexts. Training typically consists of exercising a given team, or some combination of teams, in a series of scenarios of graded difficulty. The scenarios are designed to model tactical situations which might be encountered in an operational environment.

MARINE TEAM TRAINING

The Marine Corps has recently initiated two tactical exercise projects whose objectives are to develop and integrate computer-driven systems into ongoing field and school training programs. The computer-driven simulation, which is the heart of these training systems, can handle a greater number of factors with greater precision and finer resolution than was previously possible in any manually conducted model [83].

The two team training systems associated with these projects are briefly discussed below: TESE (Tactical Exercise Simulator and Evaluator); TWAES (Tactical Warfare Analysis and Evaluation System).

1. TESE (Tactical Exercise Simulator and Evaluator)

TESE is used to train Marine Corps officers in combat decision making. The project seeks to define procedures for war gaming. The goals are to get computer-based measures of both individuals and teams during amphibious warfare exercises, and to increase the number of trainees who can be processed.

2. TWAES (Tactical Warfare Analysis and Evaluation System)

TWAES is a computer-assisted system to control tactical field training exercises. The system offers potential improvements in maneuver control and simulation of indirect fire [26]. The current TWAES research effort is studying the exact role that the post-exercise session will play in the total tactical exercise. The question being addressed is whether this feedback session will be a training vehicle to further extend the game's learning effectiveness or whether it will be merely a post-exercise debriefing during which administrative information about game procedures is passed on [83].

[1] A more detailed description of the TACDEW system is presented in the TACDEW Information Pamphlet [34].

AIR FORCE TEAM TRAINING

In the Air Force, very little formal team training is being conducted. All such formal courses surveyed were used in training strategic missile teams. Students are provided training in the responsibilities and necessary technical procedures of the appropriate weapons system, but their proficiency upon graduation from team training courses is less than that required for combat readiness. Thus, additional upgrade training is required at the unit/base prior to actual job performance [26].

Similarly, there are few team training devices. One device identified in this survey is the Functional Integrated Systems Trainer (FIST), used to provide a better training for the fire control team on the AC-130E Gunship.

Like the team training courses, most team training devices deal with the training of aircraft flight crew members. Representative training devices are available for the B-52, C-5, C-130, and C-141 aircraft as described below.

1. B-52 Weapons System Trainer

The WST (G&H models) is presently under development. It will permit the integration into a single team training device of four individual devices presently being used: (a) Mission Trainer used for training pilots and co-pilots, (b) Navigator Trainer used for training radar navigators and navigators, (c) Electronic Warfare Officer (EWO) Trainer, and (d) Gunnery Trainer. The WST when developed will permit simultaneous team training of the entire six-man B-52 crew.[1]

2. C-5 Mission Flight Simulator

This team training device consists of three training stations which permit integrated team training of pilots/co-pilots, navigator, and flight engineer.[2]

3. C-130 Flight Simulator and C-141 Flight Simulator

Both of these training devices are similar to the C-5 Mission Flight Simulator except that training is not provided for the navigator station. However, the C-130 Flight Simulator is scheduled to add the navigator station as part of the device in 1981.[3]

4. Functional Integrated Systems Trainer (FIST)

The purpose of FIST is to provide a better means for training four members of the fire control team on the AC-130E Gunship. The second objective of FIST is to refine and promote the use of the technology for developing low-cost, interlinked, functional, part task trainers [26].

SUMMATION

The emphasis in this survey has been on formal team training. In addition, much informal team on-the-job training occurs in the daily operations of the Services. In such activities, it is extremely difficult to delineate the training mode from the operational, especially in areas such as flight training and air defense.

[1] Personal communication with COL Roy L. Ripley and LTC Walter D. Black III, Instructional Systems Branch, Audiovisual and Instructional Systems Division, US Air Force, Washington, D.C.

[2] Personal communication with LTC C.R. Philbrick, MAC/DOTF, Scott Air Force Base, IL.

[3] *Ibid.*

Various methods of team training that are currently under way in the Services include the following:

- Large-scale opposing forces tactical exercises
- Devices which simulate effects of weapons
- Computer simulations of tactical decision-making problems
- Simulations of mission-specific hardware and software (e.g., anti-submarine warfare vehicles)

These methods are tailored for both initial team training and maintenance of already acquired team skills. They vary in cost, simulation fidelity, and generalizability. Although these devices are now being used, the amount of programmatic R&D performed upon them has been relatively small considering the cost of such systems.

Chapter 5

RESEARCH IMPLICATIONS

A number of implications for research in team training and evaluation are presented in this chapter. These implications were drawn from a comparison of current military practice with the findings of the literature review. The experience of the HumRRO staff in training research provided additional basis for identifying the areas in which the need for support is most critical. The suggested programs are in response to the primary questions addressed in this report:

(1) *What state-of-the-art gaps are there in team training strategies and evaluation techniques?*

(2) *What new team training and evaluation strategies appear to hold promise for applications to the DoD environment and warrant further study?*

The literature reviewed for this report supports the contention of the Defense Science Board [26] that there is a great need for R&D in team training, considering the magnitude of such training in the Services.

One major problem to overcome in planning research in this area is the tremendous diversity of terms, concepts, and operations in the "team training." A "team" is not a simple fixed unit; usage of the term is arbitrary, has unclear boundaries, and does not denote stable structure and composition. A team should be defined on the basis of its criterion situation, not on the basis of administrative convenience [42]. Describing team training in the Services, the Defense Science Board [26] resorted to an awkward abbreviation, CGTU, for Crew, Group, Team, and Unit to accommodate users of each of these terms. More standardization and sharing of terms would contribute to more effective planning of research and utilization of its results. Efforts should be supported to develop a reasonable taxonomy upon which to build research programs in team training.

A classification scheme proved useful for categorizing the studies and techniques discussed in this review along two dimensions—*training focus* and *task situation*. The training focus can be either team or multi-individual, depending upon the skills to be trained; the task situation can be characterized as either established or emergent.

Methods are needed for differentiating individual, multi-individual, and team skills. Techniques need to be developed which can be used to identify individual and team skill training requirements as part of job/task analyses. Such techniques would discriminate between isolated and interactive behaviors and would provide the opportunity for establishing criteria/standards of team performance as part of training requirement analyses. Variations and/or combinations of observational interaction analyses and other unobtrusive measures which have been used in non-classroom settings should be studied for their possible application. A recent compendium [90] of such methods provides detailed information about techniques which are of potential value, such as:

- Interaction Process Analysis—Robert F. Bales
- Sequential Analysis of Verbal Interaction (SAVI)—Anita Simon, Yvonne Agazarian
- CERLI Verbal Behavior Classification (CVC)—Cooperative Educational Research Laboratory, Inc.

The development of such analytic techniques is a critical early step in any research program that seeks to use realistic team performance standards as effectiveness criteria.

There is a considerable need for measures of team performance to apply both during and following training. As described in Chapter 3, this problem has resisted solution for the past 20 years. The difficulties of observing team member interactions, the great costs in money and time to conduct studies in this area, and the unclear relationships between task or training variables and team performance have all contributed to the lack of success in the search for measures of team proficiency. The production of standardizable, relatively invariant test conditions for evaluating dynamic and interactive team behavior remains one of the major problems in team evaluation.

Only in recent years has considerable research support been provided to seek measures of team performance. Critical problems to overcome are:

- The criterion problem—Without agreed-upon criteria or standards of team performance, training or team proficiency cannot be evaluated.
- The measurement problem—What to measure, where, when, and how, are still all unanswered questions in the evaluation of team performance.

Considering the current lack of information in this area, the potential heuristic value of the analytic or modeling approach is worthy of continued support. Of course, the usefulness of any model depends on its ability to generate information and ideas that lead to the development of practical and worthwhile evaluation tools and techniques.

For example, the CARMONETTE simulation outputs predictions of team performance based on hypothetical values for a number of performance and situational variables pertinent to the team and to an opposing force (e.g., size/vulnerability, firepower, mobility, and terrain features). Empirical values gathered from field exercise data for the variables could then be input to the simulation and outcomes compared. Continued systematic iterations of the model would suggest the specific variables that made a difference. If validated in further field exercises, these variables could guide the refinement of test situations and the development of better measurement techniques.

It is probably true that teams operate in situations that have a combination of both emergent and established characteristics. This underlies the importance of performing a thorough analysis of the criterion task situation prior to developing team training programs. Applying the systems approach to the development of team training should permit identification of the interactions, communication, coordination, decision making, and other activities required in the task performance of each team member. The information gathered with the appropriate analytical tools should include standards and relevant conditions of performance. This would be a major step toward obtaining clearly stated, objective criteria and procedures for evaluating team performance.

One consistent finding of this literature review was that individual proficiency has been shown to be a major determiner of team performance. This had led investigators such as Hall and Rizzo[49] to conclude that more emphasis should be placed upon individual rather than team training. The authors of this review do not agree. Although certain laboratory studies showed that team training was superfluous when the tasks required only individual skills, other investigations, primarily in more realistic, "emergent" situations, showed the importance of team training. When "team skills" (e.g., interaction), even though poorly defined, were important in the task situation, team training was more effective than individual training.

Further research into this area should provide information which can impact on the issue of where and when to conduct team training. For example, individuals in air squadrons are trained within a team context and are then individually assigned to operational units. If team skills are relevant to a given task situation and can be learned during a limited training period, it may be more efficient to assign the team intact rather than disband it following training [49].

A need exists for studies which explore the issue of skill training sequencing. After individual and team skill requirements for a given task situation have been identified, the

sequence in which component skills are trained can be systematically varied and the resulting effects compared. For example, individual skills can be trained prior to team skills training; training of team skills can occur first; or both individual and team skills can be integrated within the training program and taught concurrently. The results of such studies, which can be performed in either established or emergent task situations, will help determine when and under what conditions team training can be administered most effectively.

Some types of team training are so expensive that one cannot conduct them in an operational environment. Other types of training have logistic or safety factors that preclude operational, full-fidelity training or testing. High-fidelity simulations which have been common in individual training for many years have been shown to be effective for team training. However, such simulation techniques, though costly, provide little generality beyond a specific training mission. A substantial research and development effort is needed to determine the degree of simulation fidelity required for effective training in different situations. While relatively low-fidelity simulation techniques have been effective and economical in individual training, the review of the literature indicated that high-fidelity simulations were needed for effective team training. However, the studies surveyed were performed in established laboratory settings. The search should continue for effective low-fidelity devices or methods to apply to team training in emergent task situations because of their potential cost savings.

The second question addressed in this review involved the identification of team training/evaluation techniques which warranted further study and support. One of the most promising new approaches is two-sided engagement training. Current implementations of this technique were described in Chapter 4 in discussions of SCOPES, REALTRAIN, and MILES. The two-sided engagement simulation provides a low-cost, high-fidelity framework for developing individual skills. It provides a situation in which there is high motivation fostered by competition in a natural, realistic environment. This approach, which can be classified as situational or contextual training, is an outgrowth of the effective "functional context" approach to individual training [85].

Up to now, two-sided engagement training has been used to teach individual skills within a group context. Support is needed to study the feasibility of applying these methods to train team skills. There is a need to study how effective the techniques are, analyze the factors which produce favorable training outcomes, and explore how these methods can be transferred to other training situations. Thus far, post-exercise debriefings have been used to discuss individual performances. Team performance information needs to be fed back to trainees in a more timely and effective manner both during and after training.

A systematic investigation of feedback effects upon team training is needed. Support for research on the following issues would be particularly useful:

- Need for feedback—What changes in training methods or content result from feedback? Will there be differences if remediation is contingent or non-contingent upon feedback?
- Feedback mode—Methods should be available for giving both trainees and trainer feedback of how well the team is performing. Identifying appropriate methods for giving performance feedback to team members is an area requiring further R&D (e.g., compare video recording with post-exercise debriefing procedures—to test the hypothesis that clarity and objectivity of observation will provide more useful feedback). The use of television and video recording to provide relatively responsive performance feedback has been used successfully in a variety of contexts (e.g., sports, teacher training). Its potential value to military team training appears great, but considerable R&D support is needed to identify its most appropriate applications.

- Delay of feedback—A systematic study is needed to determine the conditions under which provision of feedback immediately after a training exercise is superior, equal to, or inferior compared to delayed presentations (1, 2, or more days following the event).

Another issue which merits study concerns the effects of team member familiarity on the acquisition of team skills. Does the length of time that a team functions together affect team performance? One could systematically vary this time parameter, re-allocate team members, set up new teams, and then study transfer effects.

The ability to evaluate oneself accurately is a skill that should help to produce effective team performance. Analysis of one's own errors, and awareness that one is overburdened and needs other team members' help are two specific components of this ability which should be trained. There is a need for a program supporting the development and evaluation of training packages which would provide generalizable instruction in these self-assessment skills. One could compare subsequent team performance with or without prior self-assessment training. Greater proficiency would be expected from those teams who have had such self-assessment skill training.

Another possibility is that prior training of team members to assess the capabilities of others will result in better subsequent team performance. Having the ability to assess other team members' strengths and weaknesses might provide the basis for selection of the individual team member best suited to take over or help out on a given activity—and thereby enhance overall team performance.

It may be more efficient to do research on a combination of some of the issues discussed above within the same study. For example, group feedback or skill sequencing issues can be studied in environments that contain established or emergent task situations and that vary in their degree of simulation fidelity.

The research and development implications mentioned in the preceding paragraphs are merely major examples of what should be considered programmatic efforts in the team training/evaluation area. Considering the importance and extent of this area, the current state of knowledge is quite meager. Studies and techniques such as those mentioned, if supported, should help to remedy this condition.

REFERENCES

REFERENCES

1. Alexander, Lawrence T. and Cooperband, Alvin S. *System Training and Research in Team Behavior*, Technical Memorandum 2581, System Development Corporation, August 1965.

2. Ammerman, Harry L. *Manual of Procedures for Deriving Training Objectives for Junior Officers*, Fort Bliss, TX: U.S. Army Air Defense Human Research Unit, Human Resources Research Office, November 1964.

3. Backrach, Arthur J. *Systems Analysis and Modeling of Small Groups: Isolation and SEALAB*, Final Technical Report 1 October 1962 - 31 March 1968, Report No. 0201071, Arizona State University, Tempe, March 1968.

4. Baker, James D. *Quantitative Modeling of Human Performance in Information Systems*, Technical Research Note 232, Washington, DC: U.S. Army Behavioral Science Research Laboratory, June 1972.

5. Baker, Robert A. "The Determination of Goals and Objectives," in *An Experimental Program of Instruction on the Management of Training* by Donald F. Haggard, *et al.*, Technical Report 70-9, Alexandria, VA: Human Resources Research Organization, June 1970.

6. Baldwin, Robert D., Frederickson, Edward W., and Hackerson, Edward C. *Aircraft Recognition Performance of Crew Chiefs With and Without Forward Observers*, Technical Report 70-12, Alexandria, VA: Human Resources Research Organization, August 1970.

7. Bass, Bernard M. *Administrative Training and Research Using Small Group Exercises. I. Combining Management Training and Research*, Report No. MRC-Reprint 67-1, MRC-Reprint 67-2, Pittsburgh University: Management Research Center, 1966.

8. Biel, W.C., Harman, H.H., and Sheldon, M.S. *Exercising Teams in Military Systems Through the Use of Simulation*, Professional Paper SP-1739, System Development Corporation, October 1964.

9. Bolin, Stanley F., Sadacca, Robert, and Martinek, Harold. "Team Procedures in Image Interpretation," *U.S. Army Personnel Research Office Technical Research Note* No. 164, 1965.

10. Boguslaw, Robert and Porter, Elias H. "Team Functions and Training," in *Psychological Principles in System Development*, Robert M. Gagne, (Ed.), New York: Holt, Rinehart and Winston, 1962.

11. Briggs, George E. and Johnston, William A. *Team Training*, Final Report, February 1966 - February 1967, NAVTRADEVCEN-1327-4, Orlando, FL: Naval Training Device Center, 1967.

12. Briggs, George E. and Johnston, William A. "Stimulus and Response Fidelity in Team Training," *Journal of Applied Psychology*, Vol. 50, No. 2, 1966, pp. 114-117.

13. Briggs, George W. and Johnston, Wiiliam A. *Team Training Research*, NAVTRADEVCEN Technical Report No. 1327-2, Orlando, FL: Naval Training Device Center, 1965.

14. Briggs, George E. and Naylor, James C. "Team Versus Individual Training, Training Task Fidelity, and Task Organization Effects on Transfer Performance by Three-Man Teams," *Journal of Applied Psychology*, Vol. 49, No. 6, 1965, pp. 387-392.

15. Burnstein, David D. and Wolff, Peter C. "Shaping of Three-Man Teams on a Multiple-DRL-DRH Schedule Using Collective Reinforcement," *Journal of the Experimental Analysis of Behavior*, Vol. 7, No. 2, March 1964.

16. Campbell, John P. "Personnel Training and Development," *Annual Review of Psychology*, 1971, pp. 565-602.

17. Chapman, R.L., Kennedy, J.L., Newell, A., and Biel, W.C. "The System Research Laboratory's Air Defense Experiments," *Management Science*, Vol. 5, 1959, pp. 250-269.

18. Chesler, David J. *Computer-Assisted Performance Evaluation for Navy Anti-Air Warfare Training: Concepts, Methods, and Constraints*, Research Report SRR 71-25, San Diego, CA: Naval Personnel and Training Research Laboratory, May 1971.

19. Cockrell, John T. *Maintaining Target Detection Proficiency Through Team Consensus Feedback*, Technical Research Note 219, Washington, DC: U.S. Army Behavioral Science Research Laboratory, December 1969.

20. Cockrell, John T. and Sadacca, Robert. *Training Individual Image Interpreters Using Team Consensus Feedback*, Technical Report 1171, Washington, DC: U.S. Army Behavioral Science Research Laboratory, June 1971.

21. Colonna, Gary S., *et al. CARMONETTE Volume I*, Report No. OAD-CR-73, General Research Corporation, November 1974.

22. Cook, John G. and Baker, Robert A. (Part I); Baker, Robert A. and Cook, John C. (Part II). *Armored Cavalry Platoon Training and Evaluation*, Professional Paper 28-68, Alexandria, VA: Human Resources Research Organization, September 1968.

23. Crawford, Meredith P. *A Review of Recent Research and Development on Military Leadership, Command, and Team Function*, Research Memorandum, Alexandria, VA: Human Resources Research Office, September 1964.

24. Cunningham, R.P., Sheldon, M.S., and Zagorski, H.J. *Project NORM Pilot Study Report*, Technical Memorandum TM-2232/000/00, Santa Monica, CA: System Development Corporation, February 1965.

25. Daniels, R.W., *et al. Automated Operator Instruction in Team Tactics*, Final Technical Report, 26 June 1970 - 26 March 1971, Report No. 12244-FR1 NAVTRADEVCEN-70-C-0310-1, Orlando, FL: Naval Training Device Center, January 1972.

26. Defense Science Board. *Report of the Task Force on Training Technology, Chapter 8. Crew/Group/Unit Training*, Washington, DC: Office of the Director of Defense Research and Engineering, Department of Defense, May 1975.

27. Department of the Army. "What's Happening in Training: One Station Training/ One Station Unit Training," 1976.

28. Department of the Army. *How to Prepare and Conduct Military Training*, Field Manual 21-6, November 1975.

29. Department of the Army. *Tactical Training for Combined Arms Elements (REALTRAIN)*, Training Circular TC 71-5, January 1975.

30. Egerman, Karl. "Effects of Team Arrangement on Team Performance: A Learning-Theoretic Analysis," *Journal of Personality & Social Psychology*, Vol. 3, No. 5, 1966, pp. 541-550.

31. Egerman, Karl, Glaser, Robert, and Klaus, David J. *Increasing Team Proficiency Through Training: 4. A Learning Theoretic Analysis of the Effects of Team Arrangement on Team Performance*, Technical Report AIR B64-9/63, American Institutes for Research, September 1963.

32. Egerman, Karl, Klaus, David J., and Glaser, Robert. *Increasing Team Proficiency Through Training: 3. Decremental Effects of Reinforcement in Teams With Redundant Members*, Technical Report AIR B64-6/62, American Institutes for Research, June 1962.

33. Federman, Philip and Siegel, Arthur I. *Communications as a Measurable Index of Team Behavior*, Technical Report NAVTRADEVCEN 1537-1, Orlando, FL: Naval Training Device Center, October 1965.

34. Fleet Anti-Air Warfare Training Center. *TACDEW Information Pamphlet*, San Diego, 1970.

35. Fleet Anti-Air Warfare Training Center and Navy Training Research Laboratory. *Design and Conduct of Team Training Exercises for the Tactical Advanced Combat Direction and Electronic Warfare (TACDEW) System*, November 1968.

36. Gagne, Robert M. (Ed.). *Psychological Principles in System Development*, New York: Holt, Rinehart and Winston, 1962.

37. George, Clay E. *The View From the Underside: Task Demands and Group Structures*, Professional Paper 11-67, Alexandria, VA: Human Resources Research Office, 1967.

38. George, Clay E. "Structure, Training Procedures, and Operations of Small Work Groups," Human Resources Research Office, paper presented at Georgia Psychological Association Meeting, February 1965.

39. Glaser, Robert and Klaus, David J. "Proficiency Measurement: Assessing Human Performance," in *Psychological Principles in System Development*, Robert M. Gagne (Ed.), New York: Holt, Rinehart and Winston, 1962.

40. Glaser, Robert, Klaus, David J., and Egerman, Karl. *Increasing Team Proficiency Through Training: 2. The Acquisition and Extinction of a Team Response*, Technical Report AIR B64-5/62, American Institutes for Research, May 1962.

41. Glaser, Robert, *et al. A Study of Some Dimensions of Team Performance*, Technical Report, American Institutes for Research, September 1955.

42. Glanzer, Murray. "Experimental Study of Team Training and Team Functioning," in *Training Research and Education*, Robert Glaser (Ed.), University of Pittsburgh, September 1961.

43. Glanzer, Murray and Glaser, Robert. *A Review of Team Training Problems*, Technical Report, Pittsburgh, PA: American Institutes for Research, September 1955.

44. Glatthorn, Allan A. *Learning in the Small Groups*, Dayton, OH: Institute for Development of Educational Activities, 1968.

45. Greer, F. Loyal. *Small Group Effectiveness*, Institute Report No. 6, Series 1955, Institute for Research in Human Relations, Philadelphia, PA: 1955.

46. Hackman, Richard J. *Effects of Task Characteristics on Performance*, Final Scientific Report AFOSR-TR-71-0501, New Haven, CT: Yale University, Department of Administrative Sciences, March 1971.

47. Hackman, Richard J. *Studies in the Social Psychology of Conflict: Effects of Task Characteristics on Group Products*, Technical Report No. 5, University of Illinois: Department of Psychology, June 1966.

48. Hackman, Richard J. and Morris, Charles G. *Group Tasks, Group Interaction Process, and Group Performance Effectiveness: A Review and Proposed Integration*, Technical Report No. 7, New Haven, CT: Yale University, Department of Administrative Sciences, August 1974.

49. Hall, Eugene R. and Rizzo, William A. *An Assessment of US Navy Tactical Team Training: Focus on the Trained Man*, TAEG Report No. 18, Training Analysis and Evaluation Group, March 1975.

50. Hausser, Doris, *et al. Application of Computer-Assisted Instruction to Inter-Personal Skill Training*, Final Report, NAVTRAEQUIPCEN 74-C-0100-1, Naval Training Equipment Center, January 1976.

51. Hayes, John F. and Wallis, Matthew R. *ARTEP Validation Report*, U.S. Army Research Institute for Behavioral and Social Sciences, 1974.

52. Horrocks, John, Heermann, Emil, and Krug, Robert E. *Team Training III: An Approach to Optimum Methods and Procedures*, Technical Report NAVTRADEVCEN 198-3, Port Washington, NY: U.S. Naval Training Device Center, August 1961.

53. Horrocks, John E., Krug, Robert E., and Heermann, Emil. *Team Training II: Individual Learning and Team Performance*, Technical Report NAVTRADEVCEN 198-2, Port Washington, NY: U.S. Naval Training Device Center, August 1960.

54. Hulten, Burma H. *Games and Teams: An Effective Combination in the Classroom*, Baltimore, MD: Johns Hopkins University, Center for the Study of Social Organization of Schools, April 1974.

55. Institute for Development of Educational Activities. *Learning in the Small Group*, IDEA Technical Manual, Dayton, OH, 1971.

56. Jeantheau, G.G. "The Use of Multi-Man System Trainers," *Ergonomics*, Vol. 12, No. 4, 1969.

57. Johnston, William A. "Transfer of Team Skills as a Function of Type of Training," *Journal of Applied Psychology*, Vol. 50, No. 2, 1966, pp. 102-108.

58. Johnston, William A. and Briggs, George E. "Team Performance as a Function of Team Arrangement and Work Load," *Journal of Applied Psychology*, Vol. 2, No. 2, 1968, pp. 89-94.

59. Kanarick, A.F., Alden, D.G., and Daniels, R.W. "Decision Making and Team Training in Complex Tactical Training Systems of the Future," in *25th Anniversary Commemorative Technical Journal*, Naval Training Device Center, 1971.

60. Karcher, E.K., *et al. PRS Report 923 Unit Effectiveness Tests*, Department of the Army, Personnel Research Section, January 1952.

61. Klaus, David J. and Glaser, Robert. "Reinforcement Determinants of Team Proficiency," *Organizational Behavior and Human Performance*, Vol. 5, 1970, pp. 33-67.

62. Klaus, David J. and Glaser, Robert. *Increasing Team Proficiency Through Training: 8. Final Summary Report*, AIR E 1-6/68-FR, American Institutes for Research, May 1968.

63. Klaus, David J. and Glaser, Robert. *Increasing Team Proficiency Through Training: 5. Team Learning as a Function of Member Learning Characteristics and Practice Conditions*, Technical Report AIR E 1-4/65-TR, American Institutes for Research, May 1965.

64. Klaus, David J. and Glaser, Robert. *Increasing Team Proficiency Through Training: 1. A Program of Research*, Technical Report AIR 264-60-TR-137, American Institutes for Research, December 1960.

65. Klaus, David J., *et al. Increasing Team Proficiency Through Training: 6. Supervisory Furnished Reinforcement in Team Training*, Technical Report AIR E 1-5/65-TR, American Institutes for Research, May 1965.

66. Lange, Carl J. *Leadership in Small Military Units: Some Research Findings*, Professional Paper 24-67, Alexandria, VA: Human Resources Research Office, June 1967.

67. Larson, Orvin A., *et al. Survey of Unit Performance Effectiveness Measures*, NPRDC Report No. TR-74-11, San Diego, CA: Navy Personnel Research and Development Center, January 1974.

68. McRae, Adie V. *Interaction Content and Team Effectiveness*, Technical Report 66-10, Alexandria, VA: Human Resources Research Office, June 1966.

69. Madden, LTC Jom L. "Engagement Simulation: A Dynamic New Approach to Tactical Training," Fort Benning, GA., September 1975.

70. Marra, Herbert A. *A Comparative Analysis of Group Reinforcement Contingencies*, Final Report LAIR-9, San Francisco, CA: Letterman Army Institute of Research, September 1971.

71. Marschak, J. "Elements for a Theory of Teams," Cowles Commission Discussion Papers (ASTIA, February 26, 1960), October 1954.

72. Moore, H.G. *The Effects of Load and Accessibility of Information Upon Performance of Small Teams*, Technical Report, University of Michigan, October 1961.

73. Myers, Thomas I. and Palmer, Francis H. "Crew Description Dimensions and Radar Crew Effectiveness," paper presented at American Psychological Association convention, September 1955.

74. Nebeker, Delbert M., *et al. A Comparison of the Effects of Individual and Team Performance Feedback Upon Subsequent Performance*, NPRDC Technical Report 75-35, Navy Personnel Research and Development Center, May 1975.

75. Nerome, F.A. and Connor, J.J. *Informal Military Reference*, Nov-Dec 1974.

76. Obermayer, Richard W., *et al. Combat-Ready Crew Performance Measurement System*, AFHRL Final Report TR-74-108(I), Air Force Human Resources Laboratory, December 1974.

77. Olmstead, Joseph A. *Small-Group Instruction: Theory and Practice*, Alexandria VA: Human Resources Research Organization, 1974.

78. Olmstead, Joseph A., *et al. Selection and Training for Small Independent Action Forces: Final Report*, Technical Report 72-2, Alexandria, VA: Human Resources Research Organization, February 1972.

79. Osborn, William C., *et al. Instruction for Unit Trainers in How to Conduct Performance Training, Vol. I, Course Development*, Final Report FR-CD(L)-75-3, Alexandria, VA: Human Resources Research Organization, June 1975.

80. Osborn, William C., *et al. Instruction for Unit Trainers in How to Conduct Performance Training, Vol. II, Course Outline*, Final Report FR-CD(L)-75-3, Alexandria, VA: Human Resources Research Organization, June 1975.

81. Pesch, A.J., Hammell, T.J., and Ewalt, F.M. *Tactical Decision-Making Training System Design*, NAVTRAEQUIPCEN-73-C-0158-1, Naval Training Equipment Center, November 1974.

82. Prophet, Wallace W. and Caro, Paul W. *Simulation and Aircrew Training and Performance*, Professional Paper 4-74, Alexandria, VA: Human Resources Research Organization, April 1974.

83. Rocklyn, Eugene H., *et al. A Method for Increasing the Training Effectiveness of Marine Corps Tactical Exercises: A Pilot Study*, NPRDC Technical Report 75-34, Navy Personnel Research and Development Center, May 1975.

84. Sheldon, M.S., and Zagorski, H.J. *Project NORM Field Evaluation Test Report*, Technical Memorandum TM-2232/003/00, Santa Monica, CA: System Development Corporation, July 1966.

85. Shoemaker, Harry A. "The Functional Context Method of Instruction," in IRE *Transactions on Education*, Vol. E-3, No. 2, June 1960 (issued as Professional Paper 35-67, Alexandria, VA: Human Resources Research Organization).

86. Short, Jerry G., Cotton, Timothy S., and Klaus, David J. *Increasing Team Proficiency Through Training: 7. The Simulation of Team Environments*, AIR Technical Report E 1-5/68, American Institutes for Research, May 1968.

87. Shriver, Edgar, *et al. REALTRAIN: A New Method for Tactical Training of Small Units*, Technical Report S-4, Army Research Institute, December 1975.

88. Sidorsky, Raymond C. and Houseman, Joan F. *Research on Generalized Skills Related to Tactical Decision Making*, NAVTRADEVCEN Report 1329-2, Naval Training Device Center, December 1966.

89. Sidorsky, Raymond C. and Simoneau, George. *Decision-Making Study: Final Report 1. An Experimental Evaluation . . .*" NAVTRADEVCEN Report 1329-4, Naval Training Device Center, June 1970.

90. Simon, Anita and Boyer, E. Gil (Eds.). *Mirrors for Behavior II: An Anthology of Observation Instruments*, Volumes A and B, Philadelphia, PA: Classroom Interaction Newsletter, c/p Research for Better Schools, Inc., 1970.

91. Smith, Jr., Robert G. *The Development of Training Objectives*, Research Bulletin 11, Alexandria, VA: Human Resources Research Organization, June 1964.

92. U.S. Army Infantry School. *Squad Combat Operations Exercise Simulation (SCOPES)*, Training Circular ST 7-2-172, 1975.

93. U.S. Army Training and Doctrine Command. *Analyzing Training Effectiveness* (Draft), 1975.

94. Williges, Robert C., Johnston, William A., and Briggs, George E. "Role of Verbal Communication in Teamwork," *Journal of Applied Psychology*, Vol. 50, No. 6, 1966, pp. 473-478.

95. Wolff, Peter C., Burnstein, David D., and Cannon, L. Dennis "The Effects of DRL and DRH Schedules of Reinforcement in Shaping the Collective Response Rate of Two and Three-Man Teams," paper for the American Psychological Association convention, September 1962.

96. Wolff, Peter C., Burnstein, David D., and Cannon, L. Dennis "The Use of Schedules of Reinforcement to Regulate a Collective Team Response Rate," *Psychological Record*, Vol. 14, No. 1, January 1964.

97. Wolff, Peter C., *et al.* "Group Training With Active Participation: Some Methodological Limitations," *Perceptual and Motor Skills*, 1963.

Unclassified

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS BEFORE COMPLETING FORM

1. REPORT NUMBER: HumRRO-TR-77-1	2. GOVT ACCESSION NO.
3. RECIPIENT'S CATALOG NUMBER	
4. TITLE (and Subtitle): TEAM TRAINING AND EVALUATION STRATEGIES: STATE-OF-THE-ART	5. TYPE OF REPORT & PERIOD COVERED: Technical Report
6. PERFORMING ORG. REPORT NUMBER	
7. AUTHOR(S): H. Wagner, N. Hibbits, R. Rosenblatt and R. Schulz	8. CONTRACT OR GRANT NUMBER(S): Contract No. MDA903-76-C-0210, ARPA Order No. 3187
9. PERFORMING ORGANIZATION NAME AND ADDRESS: Human Resources Research Organization (HumRRO), 300 North Washington Street, Alexandria, VA 22314	10. PROGRAM ELEMENT PROJECT TASK AREA & WORK UNIT NUMBERS
11. CONTROLLING OFFICE NAME AND ADDRESS: Defense Advanced Research Projects Agency, Cybernetics Technology Office, 1400 Wilson Blvd., Arlington, VA 22209	12. REPORT DATE: February 1977
	13. NUMBER OF PAGES: 50
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office): Commander, DCASD, Baltimore, 300 East Joppa Road, Room 200, Towson, MD 21204	15. SECURITY CLASS. (of this report): Unclassified
	15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release; distribution unlimited.

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

Harold Wagner, Nancy Hibbits, Richard D. Rosenblatt, Russell Schulz

18. SUPPLEMENTARY NOTES

Research performed by HumRRO Eastern Division, Alexandria, VA, under Project ESCORT. Report originally delivered to the Sponsor as Special Report SR-ED-76-11, June 1976.

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Evaluation methods	Team performance
Instructional techniques	Team training
Literature review	Team training evaluation
Multi-individual training	Testing
Simulation fidelity	

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

A critical review and evaluation of the literature was performed to describe existing instructional and evaluative techniques relevant to team training. Comprehensive documentation sources such as Educational Resources Information Center (ERIC), Defense Documentation Center (DDC), and National Technical Information Service (NTIS) were searched. In

(Continued)

DD FORM 1 JAN 73 1473 EDITION OF 1 NOV 65 IS OBSOLETE

Unclassified

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

405 260

20. ABSTRACT (Cont.)

addition, the social psychological areas and the industrial training field were surveyed for relevant publications. Current studies and team training practices underway within the Services were examined and described. A classification scheme was introduced in which the training situations discussed in this review were categorized as either "emergent" or "established." Established situations are those in which the tasks and required behaviors can be almost completely specified. Emergent situations permit some discretionary behaviors because all activities cannot be predicted. Additionally, "team" training was distinguished from "multi-individual" training. Although both occur in a group setting, the focus in the latter is on individual skills whereas team training focuses on team skills (e.g., coordination). Using this classification scheme, state-of-the-art gaps in team training and evaluation were identified for needed research and development. In addition, new techniques, such as simulated two-sided engagement training, were suggested as warranting further study of their applicability to team training.