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A Review and Annotated Bibliography of the Literature Pertaining to Team and Small Group Performance (1989 to 1999)

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for the Behavioral and Social Sciences

A Directorate of the U.S. Total Army Personnel Command

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14. ABSTRACT *(Maximum 200 words)*:

The military, along with private industry, is relying more on small teams of specialized individuals who work together to achieve a common goal. Examples of these teams include emergency medical teams, aircrews, decision-making teams, industrial project teams, Special Forces teams, weapon system crews and everyday work teams. Training and military doctrine has been evolving to reflect this emphasis on teamwork. The purpose of this annotated bibliography is to review literature published over the last ten years concerning team and small group performance. Specifically, the articles reviewed in this report represent a sampling of the research published in the social sciences, including psychology, sociology, and business. The team and small group literature reviewed includes examples of the many types of teams mentioned earlier. A summary and integration of this work is provided. In general, the research suggests that there are several components which contribute to the successful performance of teams, and that some of these components can be explicitly trained. Several training models are discussed.

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Personnel Performance and Training Technology

FOREWORD

The Future Battlefield Conditions team of the Armored Forces Research Unit, U.S. Army Research Institute for the Behavioral and Social Sciences (ARI) is conducting research and development (R&D) under the Science and Technology Objective (STO) Force XXI Training Strategies. Research performed for work package (2228) Force XXI Training Methods and Strategies (FASTTRAIN) includes developing prototype training and performance assessment methods for the future force. Some of these R&D efforts concerning future training and assessment focus on tactical decision making (TDM) teams and small groups.

Future military needs will emphasize the rapid formation and deployment of teams and small groups. New insights into teamwork and team training will be needed. Therefore, an understanding of the recent literature concerning teams and small groups is valuable. This Research Product is an annotated review of the recent (1989-1999) literature concerning teams and small groups. It concerns theory and empirical research on teamwork, team and small group processes, performance, training, and assessment. It is intended to provide a foundation for future research efforts to improve team and small group performance, based on a knowledge of the relevant literature.

Several audiences may find this report useful. Researchers will find information on the latest literature concerning teams and small groups, which may be helpful in developing theory-based models to improve group performance or team training. Training developers will be informed of specific training and assessment programs which have been developed for teams and small groups. This research was briefed in an information exchange at Fort Knox on 12 October 1999. Additionally information from this report has been discussed with behavioral researchers within the Department of Defense.

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A REVIEW AND ANNOTATED BIBLIOGRAPHY OF THE LITERATURE PERTAINING TO TEAM AND SMALL GROUP PERFORMANCE (1989 TO 1999)

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A REVIEW AND ANNOTATED BIBLIOGRAPHY OF THE LITERATURE PERTAINING TO TEAM AND SMALL GROUP PERFORMANCE (1989 to 1999)

Introduction

The reliance on teams and workgroups is becoming more ubiquitous in the private and public sectors. While there have always been work teams in the private sector (e.g., construction crews, mining teams), project teams or matrix organizations are becoming increasingly more common. These teams draw members from various parts of the organization. They are formed and exist only for the length of the specific project. Examples of such matrix organizations or project teams might be a corporate team to develop a new product, or medical team performing an emergency procedure. In the public sector, the Federal Emergency Management Agency (FEMA) is an example of a matrix organization. The FEMA might assemble a team of police, firefighters, military engineers, and non-government organizations (NGOs) such as the Red Cross to deal with the aftermath of a natural disaster. Military peacekeeping operations might also necessitate the use of project teams or matrix organizations. For instance, combat arms soldiers may be called upon to stabilize a situation, with military and civilian police forces employed to maintain order on a day-to-day basis. Engineers, medical personnel and NGOs might be needed to meet other needs. Other examples of heterogeneous teams include surgical teams, engineering crews, and software developers.

Since teams and teamwork are becoming more important, the answers to some basic questions concerning teams also become important. Some of these questions include: How do teams work? What factors affect team performance? How does one assess team performance? How can teams be trained? How should teams (versus individuals) be led? Answers (or a least responses) to these questions can come from the recent literature on teams and small groups. The purpose of this report is to examine the team and small group literature published in the last ten years in order to provide information on teams and teamwork and to offer some responses to questions similar to those above. The information provided may aid future R&D efforts to design, assess, train, motivate, and lead teams.

Perhaps the most basic question is: What is a team? Even a cursory review of the literature reveals that no single definition of a team has been universally accepted. For the purposes of this paper, we define a team as two or more people, who, despite having *separate, distinct tasks*, work *concurrently* and *interdependently* to achieve a *common* goal. This definition necessarily limits the classification of a team to one in which a group of people with diverse skills come together for an identified and explicit purpose. The specific nature of the team is not necessarily important. We are primarily concerned with teams that involve the efforts of a few people who must work together to achieve a goal that would otherwise be unobtainable by the summed efforts of the members working individually.

Small groups are considered in this review, too. Small groups are different from teams in that group members often do not have specific roles (McIntyre & Salas, 1995) and are often loosely assembled without a common goal or a shared history. Typically, in experimental research with "teams," ad hoc collections of students are used to approximate teams. However, these "teams" more closely fit into the category of small groups primarily because of the issues

of common goals and shared history. Small groups are important, though, because they can often provide researchers with a model for team development. Monitoring small groups as they evolve into teams can provide unique insights into the temporally-fluctuating nature of teams.

This report is organized into four major sections. In the remainder of the introduction, categories of team and teamwork literature are discussed. Then the method used to conduct the literature search is described. Findings, organized by categories, are described and discussed. An annotated bibliography of the articles reviewed in the literature search is included in Appendix A.

The literature we review in the annotated bibliography generally concerns the relationships between factors external to the team (e.g., organizational climate or the task), the internal team processes (e.g., communication or cohesion), and team performance (e.g., decisions or actions). These factors can be classified as inputs (i.e., the influences placed on the team from external factors), throughputs (i.e., the actions required within the team to accomplish a task), and outputs (i.e., the results from the team's actions). A better knowledge of the team and small group literature may lead to a better understanding of teams and how these input, throughput and output factors interact. A better understanding of these interactions may, in turn, provide knowledge concerning how to control these factors. This review divides the literature into six categories, which are shown in Table 1 and briefly explained below. We recognize that the categories of team mental models, team leadership, and team cohesion could be considered sub-categories of team processes. However, they are discussed separately because of the many articles we found discussing these specific processes.

Table 1.

The main team factors, and their associated processes, reviewed in this annotated bibliography.

Factor	Processes
Theories of teams and team processes	Input, throughput, output
Measurement of team processes and performance	Throughput and output
Team training	Input and throughput
Team mental models	Throughput and output
Team leadership	Throughput and output
Team cohesion	Throughput and output

Theories of Teams and Team Processes

A good deal of team theory and research is based on the classic systems theory of input-throughput-output (Ilgen, 1999). The literature we list under the category, theories of teams and team processes, examines the relationships between the input-throughput-output factors. These articles tend to be theoretical in nature, concerned more specifically with developing hypotheses of teamwork than with experimentally manipulating the various aspects of teamwork. For instance, literature in this category includes the normative-descriptive models developed by Aptima, Inc., and the team performance models developed by Eduardo Salas and his colleagues for the Navy. It also includes a few examinations of the history and trends of team research.

These articles offer insights and suggest new ways for understanding teams and small groups. This literature is important in that nothing is as practical as a good theory, i.e., good theory drives all good interventions. This literature could be helpful to those who are planning changes or interventions concerning a wide variety of team-related factors. Examples of input variables that can potentially be influenced by changes or interventions include the organizational reward system (compensation) and team member heterogeneity. Changeable throughput variables include team communications and cohesion, and output variables include the assessment of team performance and feedback.

Measurement of Team Processes or Performance

The articles in this category tend to be more applied, rather than theoretical, and focus on the indirect and direct measurement of throughput and output factors. Some of the researchers reviewed in this report argue that throughput variables, such as coordination and monitoring behavior, can be assessed through observation and subjective rating measures. Others suggest that output variables, such as team decision making, ought to be quantified by using measures such as accuracy and response time. Increasingly, however, many researchers are advocating a mixture of assessment methods that converge upon a performance rating of the particular team process under investigation.

Measurement of team processes and performance is important for providing team members with feedback. It is also important in the development of solid, testable theory. For instance, a hypothesis concerning the effects of an organizational reward structure on team processes such as cohesion cannot be tested without a valid measure of cohesion. Also, before a factor can be measured, it must be defined and operationalized. For instance, an author who purports to measure cohesion might incorporate notions from the shared mental model literature, the communication literature and the literature on trust. A proposed definition of cohesion may exhibit influences from these three areas of research, and others, too. As a result, a measurement of cohesion must also be sensitive to (or discriminative of) the various factors that influence cohesion.

These articles on measurement of team performance are important in that throughput or output factors cannot be improved if they cannot be measured. That is, in order to determine if an intervention is successful, one has to be able to measure its effects. We present several recent articles that reflect the considerable progress which has been made in the measurement of team performance.

Team Training

The category of team training represents the aggregation and overlap of the five other categories we have delineated in this report. Ultimately, these articles report on attempts made at altering team throughput variables (e.g., team processes) through training interventions. We review a few training techniques, such as Targeted Acceptable Responses to Generated Events on Tasks (TARGETS), that have been reported in the literature as being successful at improving team performance. Some measurement issues, such as pre- and post-testing, are also discussed in these articles. Furthermore, this literature represents efforts by applied researchers to improve

teams through the implementation of team theory. In many cases, the training intervention is a direct attempt to test a theory of teamwork. For instance, one may test a theory that cross-training personnel improves team mental models which then results in better team communication. The implications of cross-training can then be measured for improvements in throughput and output processes. Therefore, although the overall classification is team training, the literature in this category tends to represent the application of the current thinking about team processes.

Team Mental Models

These articles are part of a rapidly growing body of literature on a particular team throughput factor known as mental models. A mental model is the representation of the current situation held by an individual or shared by various team members. Numerous types of mental models, including representations of the roles and responsibilities of team members, are discussed and are considered to be important components of team functioning. It is evident from the research reviewed in this document that team mental models are currently considered by many researchers to be vital to team performance. For instance, several authors suggest that good team mental models enable team members to anticipate the information needs of other teammates and "push" information rather than waiting for it to be "pulled" via time-consuming requests. While much of this work is still theoretical in nature, a few articles report on attempts made at actually manipulating or training team mental models. Findings in these articles suggest that team performance can potentially be improved through training designed to foster team mental models.

Team Leadership

These articles focus on the particular team throughput factor, leadership. The literature reviewed here is specifically concerned with leadership of teams as opposed to the traditional social psychological emphasis on leadership of individuals (such as Fiedler's Preferred Leadership Style theory [1967, 1978] or Graen's vertical dyadic linkage theory [Danserau, Graen, & Haga, 1975]). Team leadership research emphasizes concepts such as the team leader's role of representing the team to the organization or setting a cooperative versus competitive tone within the team by use of a collective reward system. Most of the articles are theoretical or observational in nature, examining how team leadership affects or is affected by other throughput factors, and also how leadership affects team output. This literature is important as it relates to ways to improve throughput or output via team leadership.

Team Cohesion

This literature focuses on the throughput (and, according to some authors, output) variable, cohesion. Cohesion, which is defined as commitment or attraction to the team and/or team mission, is posited to be both a cause and effect of team and group performance. Articles in this category are generally theoretical in nature and typically report on efforts to map the relationship between cohesion and other throughput and output factors. As with the literature on team theories and processes, this literature can be useful in determining interventions that might be used to improve team cohesion. It can also be helpful in determining how external conditions

influence cohesion and contribute to the development of effective (or ineffective) group and team performance. This could lead to interventions in input variables that might promote cohesion.

The six categories discussed here were not chosen a-priori. They were derived from the literature we reviewed. In order to review the literature on teams and teamwork, we had to develop a plan, or method, to conduct that review. The method used to review the literature is discussed in detail in the following section.

Method

In order to examine the eclectic area of teams and teamwork, this review involved a guided search through several major databases related to cognitive psychology, sociology, social psychology, business and management, engineering, medicine, sports, and education. It draws primarily from literature located through PsychInfo™ (both journal articles and book chapters) and MINERVA 2000™ (online database at the University of Louisville). The online database, FirstSearch™, was used to locate many of the references found in the business, engineering and educational literature. The Web of Science™ was used to trace the citation history of key references from the time of publication to the present. Similar to the Social Science Citation Index, the Web of Science is an on-line knowledge base that allows researchers to find all references to a specified reference or author. This tool was used primarily to track some of the references found outside of the psychological literature. The Defense Technical Information Center (DTIC) was searched to locate many of the technical reports and government documents reviewed in this paper.

In addition to the traditional sources for literature reviews, this review also utilized the Internet search engine, YAHOO, to locate the homepages of many leading team researchers. For instance, the web site http://www.decisionmaking.com offered a comprehensive list of reports, articles, chapters, and books published by the researchers at Klein and Associates. Other sites that were searched include, but are not limited to: Aptima, Inc. (http://www.aptima.com); Rand Corp. (http://www.rand.org); homepages of faculty members at the University of Central Florida (http://www.ucf.edu); Michigan State University (http://www.msu.edu); and UC-Berkeley (http://www.berkeley.edu). Often times, these web sites provided lists of publications by some of the influential researchers in the study of team processes. The web site at University of Pennsylvania's Wharton School of Business, (http://knowledge.wharton.upenn.edu), offered some current insights on team building and self-managed teams from a business perspective.

Table 2 lists the keywords used in the literature search, the total number of "hits," and the number of articles which were relevant for this annotated bibliography. These statistics, however, do not reflect the references which were found from sources other than the major literature databases listed above. A review of this sort, on such a broad topic as teams and small groups, produces a number of spurious results. Also, despite the number of different keywords and their various combinations, some of the articles in this review were found only in the reference sections of various articles or the web sites of the reference's authors.

Every effort was made to make this a comprehensive, if narrowly defined, review of the team literature. Despite these efforts, it is likely that a large portion of the available literature remains untapped by us. For instance, Wickens and Seidler (1995) suggest that even with the advances in technology such as online databases, reviews of this sort often produce many "false alarms" and numerous "misses." While we are unable to provide estimates for the number of misses, Table 2 suggests that our literature search techniques produced a considerable number of false alarms. For instance, out of the more than 5000 titles and abstracts we read, only about 400 (7%) were considered potentially useful. After reducing the 400 articles down to those we could easily obtain through local resources or inter-library loans, the number of articles we reviewed was 200. From those 200, we selected approximately 80 articles for inclusion in this annotated bibliography. The criteria we used for selecting articles was that they concern teams or groups in real or simulated organizational settings. For this reason we did not include articles from the clinical psychology literature (e.g., group therapy) or educational research (e.g., groups or teams in classrooms). We also included only articles readily available to us within a reasonable time period.

The success of this annotated bibliography depended on repeatedly searching through the many available databases and using as many keywords as we could generate. Some of the techniques we used, such as the Internet and online databases, resulted in considerable overlap. Other efforts, such as inspection of the publication lists of key researchers, produced finds that were unique. With the caution that this annotated bibliography is far from complete, we feel confident in suggesting that it is representative, within the guidelines we had selected.

In this annotated bibliography, we have attempted to provide informative summaries of the references. In particular, we have tried to indicate aspects of the current literature that are, or might be, directly applicable to training and assessing the performance of military teams. Where possible, we have included detailed information about the methodologies used in the studies. This literature review located a wide variety of articles concerning teams and small groups. In the next section, we present some of the overall conclusions we have drawn from these articles. Conclusions from each of the six categories discussed in the introduction (see Table 1) are presented separately and are then integrated into a final summary and discussion. A list of the articles we review in this annotated bibliography is provided in Table 3, located at the end of the "Findings" section.

Table 2.

List of keywords used during the literature search, number of hits, and relevant articles.

Keywords	Hits	Potentially Useful
Team and :		
Assessment	38	2
Attitude	97	2
Cognitive processes	73	22
Cognitive skills training	14	1
Cohesiveness	124	9
Communication	1124	52
Consensus	49	3
Coordination	160	11
Cross training	23	3
Decision making	47	20
Distributed memory	2	0
Feedback	114	5
Information exchange	28	5
Information sharing	67	23
Leadership qualities	28	2
Leadership styles	28	12
Measurement	45	5
Metacognition	6	1
Opinion	61	3
Organization effectiveness	47	23
Outcome measures	91	4
Performance monitoring	64	10
Process measures	87	13
Processes	202	22
Roles	745	15
Shared mental model	21	6
Size	76	7
Training	938	68
Trust (social behavior)	97	5
Teamwork	326	53
Teamwork training	3	2
Team Adaptation and Coordination Training	7	5
Team Model Trainer	12	1
Group performance	516	71
Miscellaneous finds	72	72

Findings

Theories of Teams and Team Processes

There is very little commonality in the recent literature on factors affecting team effectiveness or performance. Unlike other areas of psychology (e.g., leadership, attitudes), where many articles concern perhaps a half dozen major theories, there seems to be almost no consensus on the theories about factors influencing team performance or effectiveness. Most articles are limited in scope and do not propose general, integrated theories of team performance or effectiveness. They advance one or two (generally throughput) factors and discuss their effects on team performance or effectiveness. Examples of the various throughput variables that have been hypothesized to affect team performance include:

Inter-group conflict	Information flow
Inter-personal trust	Information management
Coordination	Decision-making heuristics and biases
Team monitoring	Challenging behaviors of subordinates and leaders
Shared situational awareness	Pre-mission planning
Anticipative communication	Performance Feedback

Examples of input variables hypothesized to affect team performance include team structure and workload, team member demographics and skill levels, and task complexity.

Only a few of the articles in this category (e.g., Cohen & Bailey, 1997; Cohen, Ledford, & Spreitzer, 1996; Sundstrom, DeMeuse, & Futrell, 1990) propose complex, multi-factor theories which consider input, throughput, and output factors. However, there is very little similarity between even these few theories. Only one of the review articles (McGrath, 1997) discusses "schools" of theories, and these theories concern general group processes, more than theories of teams. A picture of a rather fragmented area of research emerges. This fragmentation suggests that because there are so many types of teams, in so many different organizations, with so many different purposes (i.e., types of output) that a general theory of factors affecting team effectiveness is perhaps too impractical.

We agree with many of the articles reviewed in this paper that one common characteristic of teams in general is the role of shared mental models. When members have similar understandings of the goals and expectations of the team, they are in a better position to put forth a unified effort towards the achievement of the team's goals. A suggestion for possible future research would include an examination of the interaction of input, throughput, and output factors on the formation and maintenance of shared mental models. For instance, one might consider examining whether a hierarchical (or vertically-oriented) team structure requires different training techniques than a flat (or horizontally-oriented) team structure to promote shared awareness by team members.

Measurement of Team Processes or Performance

Many of the articles we reviewed about team measurement are concerned with mental models. One widely used technique for measuring team mental models is to question individual members about their knowledge of their own and the other team members' roles and responsibilities. Teams which have high levels of inter-positional knowledge (IPK) tend to perform better than those with low levels of IPK. Another method of measuring mental models involves assessing the similarities and discrepancies among team members' understanding of the situation. Multidimensional scaling techniques are often used to determine the patterns among situational cues perceived by different team members. Teams who have similar perceptions about the contextual or environmental patterns (i.e., situation awareness) are often able to function more efficiently and effectively because members can predict the needs and actions of other members without verbal prompting.

Measurement of team skills, behaviors or dimensions (e.g., communication, performance monitoring and back-up behavior) is also common. This assessment often uses a method similar to *T*argeted *A*cceptable *R*esponses to *G*enerated *E*vents or *T*asks or TARGET. Use of the TARGET method involves embedding a series of events into a scenario that requires particular behaviors to be executed. These behaviors, which are indicative of particular team skills, are determined in advance by subject matter experts. Observers with checklists or behaviorally-anchored rating scales view the scenario and indicate whether (or to what extent) the team exhibited these behaviors.

Several studies report using multiple assessment techniques to converge on a particular knowledge, skill, or attitude. For instance, team knowledge is often assessed using interviews, multiple choice tests, and natural observations, to elicit team members' knowledge of the tasks, roles, or responsibilities of other team members. Some of the studies reviewed here have considered attitudes about the value of teamwork and the importance of teammates. Such studies include examinations of team cohesion and the degree of trust between team members. Proxy measures, such as the number of sick days taken, are often used as indirect assessments of attitudes toward the team.

Considerable progress has been made in the measurement of team processes and performance. Techniques have been developed that generally have high inter-rater reliability and are good measures of the behaviors for which they were designed. However, researchers do not entirely agree on which team processes are important or on what measures of performance best reflect the team's ability. Because the generic term "teams" applies to a large number of groups with varying purposes, measures of performance will likely remain specific to the particular team being measured. Some progress has been made, however, towards universal indicators of performance (e.g., TARGETS), particularly in the area of measuring mental models (e.g., IPK). Provided researchers continue to fully define the specific behaviors they are intending to measure, the measurement of team processes and team performance will continue to improve.

Team Training

Much of team training is currently conducted with computer-based simulations. Simulations have been used to train various cognitive skills, such as decision making and communication, and soldiering skills, such as battle maneuvers and command and control procedures. Various levels of fidelity and complexity have been used in both research and training. Low-fidelity simulators, such as Michigan State University's Team Interaction Decision Environment/Teams Incorporating Distributed Expertise ($TIDE^2$), that connect users stationed at inexpensive personal computers are useful training and research tools. Other simulators, such as the U.S. Army's Close Combat Tactical Trainer (CCTT), involve vast networks of computers and equipment located throughout the world. These large simulation systems can be useful for combined arms training that would otherwise be prohibitively expensive. For instance, the CCTT could be used to train tank crews and dismounted troops located in Kentucky and Germany with helicopter crews in Florida. Simulations offer many advantages, such as low overhead (compared to field training), the ability to control stimuli and scenarios, the ability to readily provide practice and repetition, and the ability to re-play key parts of the training during feedback.

Training is also beginning to target teamwork processes specifically. Examples of these include training targeted at communication, coordination, behavior monitoring and back-up behavior, and assertiveness. Most of the principles which are trained are derived from (a) interviews with subject matter experts, (b) literature reviews, and (c) early research examining throughput factors that distinguish higher and lower performing teams. Teams are often familiarized with these processes, as well as good and bad examples of these processes in teams, through lecture and demonstration. Then, via event-based training (scenarios containing events designed to cue performance of teamwork processes), teams are given the opportunity to practice these skills and are provided with feedback from observers concerning how well the team performed on these processes.

One particular thrust of team training is adaptability. Teams are trained in various situations and environments and are taught skills that increase the team's ability to confront novel situations. Meta-cognitive behaviors, such as being aware of underlying team processes, are useful across situations and help team members to be adaptive. One particular cognitive ability that has received a lot of attention is implicit communication (e.g., Entin & Serfaty,. 1999). During high workload periods, teams must anticipate the information and action needs of other team members and provide information before it is requested. This "push" versus "pull" of information reduces information management workload and improves performance.

An area related to adaptability is the relatively new attempt to train mental models. One example of this line of research is the Team Model Trainer (Duncan, Rouse, Johnston, Cannon-Bowers, Salas, & Burns, 1996) where team members are trained on team roles, procedures and interactions. Another example is SHAPE (*S*crutinize symptoms, *H*ypothesize solutions, *A*nalyze proposed solutions, *P*erform modifications and corrections, and *E*valuate results; Hartel & Hartel, 1997), where team members are taught a common meta-cognitive decision making model. These techniques have been shown to increase the ability of team members to anticipate other team members' needs and provide information without it being requested.

Team Mental Models

Many of the authors reviewed in this annotated bibliography claim that the formation of a shared mental model is important to team performance. Mental models (also referred to as collective cognitive processes or shared situation representations) are the expectations and beliefs held by team members about the current situation. Most authors agree that there are several mental models that a team can develop; for instance, team members can develop a representation of the team, the situation, and the team's equipment. When team members share similar mental models for these various components, it allows them to predict the needs and actions of their teammates. This may allow members to communicate more effectively and efficiently (e.g., provide information before it is requested).

The results from numerous studies which have measured team mental models suggest that teams with better shared mental models tend to outperform teams with less congruent mental models. These findings are especially robust when the team encounters novel situations in which time and/or resource-demands are high. Other findings suggest that training team members in teamwork skills promotes the development of mental models. Teamwork training includes increasing team members' knowledge and awareness of other team members' roles and responsibilities, and enables implicit coordination. It is therefore important that researchers continue to develop understanding of what constitutes a mental model and how it is formed. This understanding will likely lead to improvements in training and, ideally, better team performance.

Team Leadership

The contribution of the team leader is a critical factor in team performance. This observation derives from findings that suggest the leader's behaviors and actions are reflected in the team members' behaviors and actions. According to one study, it is crucial that the team leader demonstrate emotional intelligence (Goleman, 1998). Emotional intelligence relates to the team leader's ability to recognize the internal and external factors which are affecting him or her. The leader should be able to realize how his or her perceptions may differ from the team members' perceptions and should be able to incorporate that realization into his or her actions. Furthermore, behaviors of the leader promote similar behaviors in team members. For instance, behaviors that indicate commitment to the team and to the larger organization correlate with overall team performance and attitude. Effective leaders also exhibit and promote trust in the team members by allocating important responsibilities to the team members. This type of empowering behavior by the leader often translates into feelings of autonomy in the team.

Several factors relating to a leader's behaviors and actions influence team performance. These factors include psychological, behavioral, and organizational components. When a team's performance is below the leader's expectations, it is often the case that there is inconsistency coming from the leader. For instance, some reward schemes implemented by leaders promote competition among team members. Competition for rewards, however, often breaks down the cohesiveness of the team. It is the leader's responsibility to ensure that organizational and psychological aspects of the team's environment are consistent with the leader's expectations. An additional important responsibility of the leader is to ensure that the team is in good standing

with the larger organization. The leader must possess the skills to negotiate with the higher levels in the organization such that the team's agenda and needs are well-represented. At the same time, however, the leader must recognize how and where the team's objectives fit into the larger organization's mission. If the two are misaligned, the leader must strive to fix the existing dissonance.

Team Cohesion

Cohesion has been variably defined as attraction to the group, commitment to the team, and motivation for goal attainment. It has also been delineated into cohesion amongst peers, cohesion with team leaders, and cohesion within the larger organization. Over the past half century, researchers have developed numerous measures of cohesion in the hopes of relating cohesion to performance. The results have been somewhat mixed. Generally, it appears that teams that perform effectively also demonstrate high levels of cohesion. For instance, one study (Zaccaro, Gualtieri, & Minionis, 1995) manipulated cohesion in teams and found that those with high levels of cohesion outperformed other teams on a time-pressured task. Siebold (1999), however, reports that cohesion manipulations in ad-hoc groups rarely reflect the cohesiveness of existing teams. Studies that use correlation to measure the effects of cohesion on performance tend to reveal a small, but significant relationship. The direction of the relationship, though, is difficult to determine. Most of the studies of cohesion in this annotated bibliography suggest that cohesion is both the cause and effect of good team performance. This bi-directionality has important training implications. It suggests that training programs which stress goal attainment will promote cohesion amongst team members.

Early seminal work by Leonard Berkowitz (e.g., Berkowitz, 1956, 1954) suggested that cohesion tends to have a positive impact on group or team performance when the group or team norms support the organizational norms. Later evidence by Siebold (1987), suggested that when group or team norms are not aligned with organizational norms, cohesion can have deleterious effects on performance. Siebold suggested cohesion is most likely to occur under conditions in which soldiers support the purposes, goals, and values of their units and the Army implements policies that enhance the soldiers' quality of life and facilitate individual goal attainment (see Yagil, 1995, for a review of Seibold, 1987, and other articles related to cohesion). Overall, it appears that for teams to function as cohesive units, efforts should be made by both the team leaders and the soldiers to support the objectives of the team and of the larger organization.

In summary, based on the conclusions we have drawn from the six categories of team performance, several overall themes seem to emerge. In particular, we introduce and discuss the concept of implicit coordination. We indicate that implicit coordination between team members results from the execution or adaptation of many of the ideas which are presented in this review.

Discussion and Conclusions

A consistent theme in the articles we reviewed for this annotated bibliography is that high performing teams typically demonstrate implicit coordination. Implicit coordination occurs when team members are able to predict and respond to the needs and actions of other team members. This includes communication that is proactive, efficient, and direct. For instance,

within teams that have developed implicit coordination, communication patterns suggest that information is "pushed" rather than "pulled." When a team member obtains information that might be useful to another member, the information is passed along – as opposed to the time-wasting practice of waiting until (and if) the information is specifically requested. This communication pattern reflects an increased shared awareness of the situation and suggests that team members can predict the needs and actions of other members. As a result of implicit coordination, other team processes (e.g., performance monitoring and back-up) become more effective, which in turn results in better decisions and actions.

A necessary component of implicit coordination is the shared mental model. Several methods for promoting mental models have been developed and tested. These include the Team Adaptation and Coordination Training model (TACT; Entin & Serfaty, 1999), the Team Model Trainer method (TMT; Duncan, et al., 1996), and the suggestion that there should be increased emphasis on cross-training (Cannon-Bowers, Salas, Blickensderfer, & Bowers, 1998). Effective planning is also mentioned as being important in forming team mental models (Stout, Cannon-Bowers, Salas, & Milanovich, 1999).

While implicit coordination may be an important component of team performance, it is also a very difficult one to measure. The recent training literature suggests that trainers and evaluators are employing many different techniques and methods to measure and improve team performance. Some of the common training methods include lecture, demonstration, role playing and simulation training. These techniques form a continuum of involvement and realism, from low to high. Assessment techniques examine knowledge, attitudes and skills. Teamwork knowledge, such as knowledge of others' roles and responsibilities, are often assessed via multiple choice tests or interviews. Attitudes toward teamwork, or attitudes toward the team, such as cohesion, are assessed using surveys. Team skills are often assessed (and trained) using observational techniques, such as team self-correction (Blickensderfer, Cannon-Bowers, & Salas, 1997) or event-based training (Dwyer, Oser, & Salas, 1999).

One area of future research that seems particularly promising involves training to develop team mental models. Research suggests that teams that pre-plan effectively develop good team mental models. Planning involves assessing the current situation, developing a course of action, and evaluating that course of action by mental simulation. Mental simulation involves actions such as projecting what will happen in the near future, rehearsing team actions, determining information needs, uncovering potential problems and determining how to handle the problems. It is likely that teams which go through these processes will develop a common understanding of the external and internal team situation. Thus research on decision making training which requires teams to perform these various actions may improve team mental models, teamwork and team performance.

Based on the above discussion, we offer the following model of team performance. Team interaction training, which focuses on member roles and functions in specific situations, may be implemented through techniques such as the TMT, TACT, or an emphasis on pre-planning. This team interaction training leads to both shared team mental models and enhanced cohesion. Shared mental models and enhanced cohesion result in implicit coordination and improved teamwork behaviors (such as communication, performance monitoring and back-up).

Implicit coordination and teamwork behaviors generate effective performance (e.g., decision making). Effective team performance may or may not lead to positive outcomes, depending on situational factors beyond the control of the team. Effective team performance may result in increased team cohesion. The model is presented in Figure 1 and represents a testable extension of our theory.

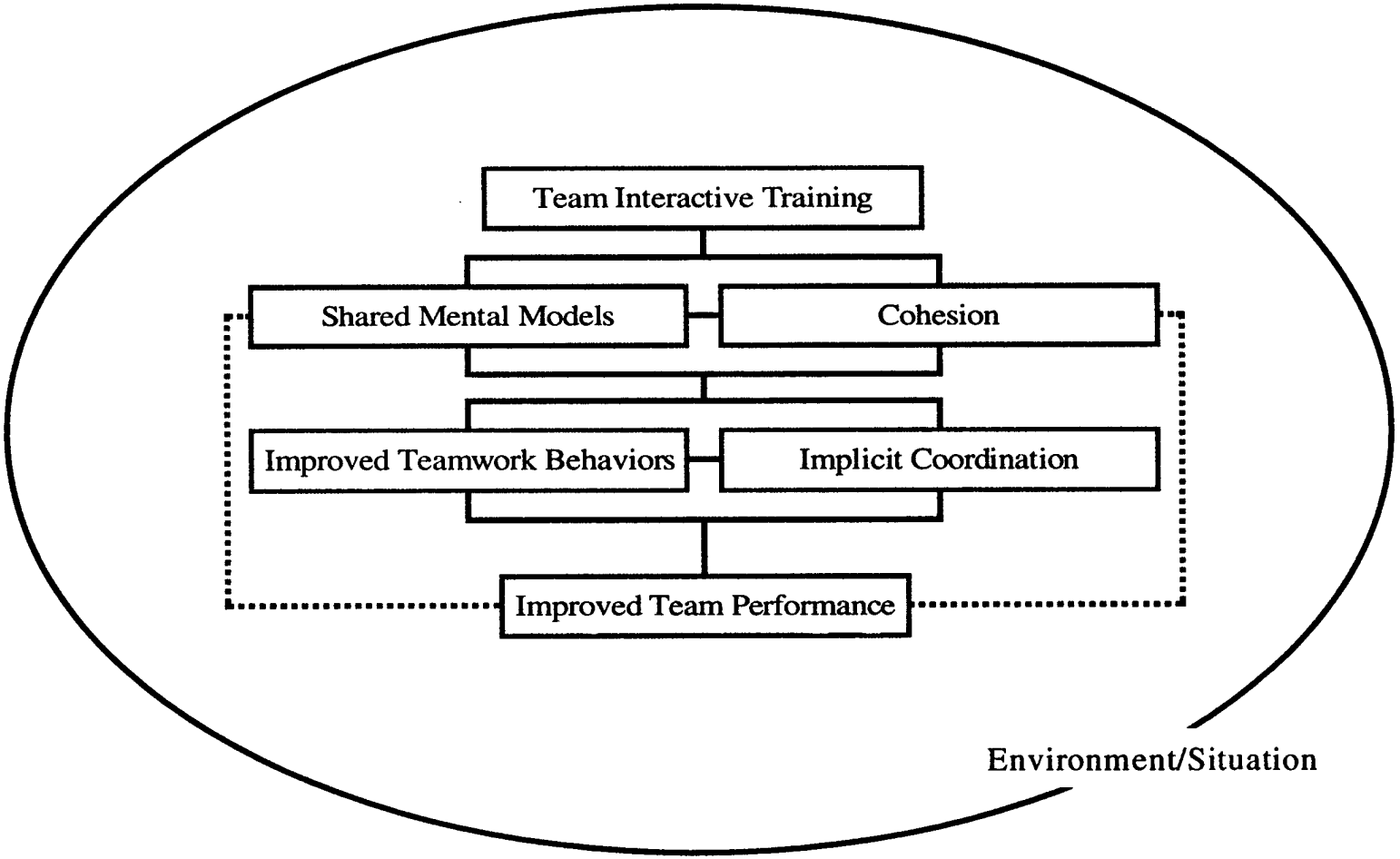
In summary, several ideas can be extracted from the articles we review in this annotated bibliography. First and foremost, teams are complex entities. As was mentioned earlier, there are very few unified theories of teamwork and performance. This is acceptable, though, because each team is uniquely tied to its task and structure. An understanding of the processes at work in a team may not necessarily permit one to make predictions about future behaviors, nor may it permit one to make generalizations to other teams. With a variety of external and individual pressures and forces working on a team, it is a safe bet to say that no two teams are alike and, therefore, no single training paradigm might be applicable to all teams.

Despite the heterogeneity of tasks, member composition, environment, and other factors facing "teams," it is still possible to delineate a few potential candidates for a generalized theory of teamwork. One candidate is communication between team members. Research shows that periods of time pressure force members to limit the amount of information they can share. Splitting one's limited cognitive resources between what is being communicated and what is occurring in the scenario can be fatiguing. Better communication requires that team members draw on their inter-positional knowledge to know what should be or should not be communicated. Information that is succinct, timely, and necessary is pushed up the chain of command rather than pulled from subordinates. Good communication skills depend on team members having similar representations of the situations. Team leaders can help promote shared mental models by providing periodic situation updates and by holding preplanning decision making sessions which involve all team members. After action reviews or informative debriefing sessions help team members understand where conflicts in awareness and expectations have arisen.

Recently, researchers have begun to emphasize that teams (and their trainers) need to be adaptive. Important strides have been made in the recognition that team leaders can promote creative problem solving and decision making in team members by developing supportive environments. Furthermore, by embedding teamwork tasks into realistic training scenarios, teams can improve performance by developing the skills that allow them to react to novel situations. And finally, teams which are committed to the task, the team, the larger organization, and the objective will develop strong bonds of cohesion with one another. Team performance will likely improve, which in turn will further strengthen the team bonds.

Given the changing demands currently facing the American military and its allies, we feel that success in future military endeavors will likely depend on how well the Army can train its soldiers to work in teams. This annotated bibliography reviews several articles that contain good ideas and thoughts about team performance. Already, suggestions for improvements in training have been put forth. However, future research efforts are still needed to solidify and strengthen the approaches to training.

Figure 1. A proposed model of the factors affecting team performance.



Note. Solid lines indicate direct connections, and dashed lines represent feedback loops.

Table 3. List of the articles reviewed by category

AUTHORS	TEAM THEORY AND TEAM PROCESSES	TEAM MEASURE-MENT	TEAM TRAINING	TEAM MENTAL MODELS	TEAM LEADER-SHIP	TEAM COHESION
Achille, Schulze, & Schmidt-Neilsen (1995)			X			
Amason, Thompson, Hochwarter, & Harrison (1995)	X					
Baker & Salas (1997)		X				
Baker & Salas (1992)		X				
Blickensderfer, Cannon-Bowers, & Salas (1997)			X			
Bolman & Deal (1992)	X					
Bowers, Baker, & Salas (1994)		X				
Bowers, Salas, Prince, & Brannick (1992)		X				
Brannick, Prince, Prince, & Salas (1995)		X				
Caldwell & Everhart (1998)	X					
Cannon-Bowers, Salas, Blickensderfer, & Bowers (1998)			X			
Cannon-Bowers, Salas, & Converse (1993)				X		
Cannon-Bowers, Tannenbaum, Salas, & Volpe (1995)			X			
Cohen & Bailey (1997)	X					
Cohen, Ledford, & Spreitzer (1996)	X					
Cooke, Stout, Rivera, & Salas (1998)		X				
Cooke, Stout, & Salas (N.D.)		X		X		
Dirks (1999)	X					
Duncan, Rouse, Johnston, Cannon-Bowers, Salas, & Burns (1996)			X	X		
Dwyer, Oser, & Salas (1999)		X				
Ehrlich, Knerr, Lampton, & McDonald (1997)	X		X			
Entin & Serfarty (1999)			X			
Entin, Serfaty, & Deckert (1994)			X			

Table 3. Continued

AUTHORS	TEAM THEORY AND TEAM PROCESSES	TEAM MEASURE-MENT	TEAM TRAINING	TEAM MENTAL MODELS	TEAM LEADER-SHIP	TEAM COHESION
Fleisman & Zaccaro (1992)	X					
Fowlkes, Lane, Salas, Franz, & Oser (1994)		X				
Gigone & Hastie (1997)	X					
Goleman (1998)					X	
Guastello (1998)	X					
Guzzo & Dickson (1996)	X					
Hartel & Hartel (1997)			X			
Hinsz (1995)				X		
Hogan, Petersons, Salas, & Willis (1991)			X			
Hollenbeck, Ilgen, Sego, Hedlund, Major, & Phillips (1995)	X					X
Hollenbeck, Ilgen, Tuttle, & Sego (1995)		X				
Ilgen (1999)	X					
Johnston, Smith-Jentsch, & Cannon-Bowers (1997)		X				
Jones & George (1998)	X					
Kalisetty, Kleinman, Serfaty, & Entin (1993)			X			
Klein, Zsambok, & Thordsen (1993)	X		X			
Kleinman & Serfaty (1998)	X					
Klinger & Thordsen (1998)				X		
Kolb (1992)					X	
Kruger, Cohen, Marca, & Matthews (1996)			X			
Larson, Christensen, Abbott, & Franz (1996)		X				
Leedom & Simon (1995)			X			
Levine & Moreland (1990)	X					
Mael & Alderks (1993)					X	X

Table 3. Continued

AUTHORS	TEAM THEORY AND TEAM PROCESSES	TEAM MEASURE-MENT	TEAM TRAINING	TEAM MENTAL MODELS	TEAM LEADER-SHIP	TEAM COHESION
Mallubhatla, Pattipati, Kleinman, & Tang (1991)	X					
Mastaglio & Callahan (1995)			X			
McGrath (1997)	X					
Minionis, Zaccaro, & Perez (1995)			X	X		
Mullen & Copper (1994)						X
Orasanu et al. (1998)	X			X		
Orasanu & Salas (1993)	X			X		
Pacanowsky (1995)			X			
Proctor & Lipinski (N.D.)		X				
Rentsch, Heffner, & Duffy (1994)				X		
Saavedra, Earley, & Van Dyne (1993)	X					
Salas, Bowers, & Cannon-Bowers (1995)	X					
Salas, Cannon-Bowers, & Blickensderfer (1993)			X			
Salas, Cannon-Bowers, & Johnston (1997)			X			
Salas, Fowlkes, Stout, & Milanovich (1999)			X			
Salas, Prince, Baker, & Shrestha (1995)		X	X			
Schlechter, Zaccaro, & Burke (1998)				X		
Siebold (1999)						X
Solomon (1993)			X			
Spiker, Nullmeyer, Tourville, & Silverman (1998)			X			
Spiker, Silverman, Tourville, & Nullmeyer (1998)			X			
Steckler & Fondas (1995)					X	

Table 3. Continued

Table 3. Continued

AUTHORS	TEAM THEORY AND TEAM PROCESSES	TEAM MEASURE-MENT	TEAM TRAINING	TEAM MENTAL MODELS	TEAM LEADER-SHIP	TEAM COHESION
Stewart & Manz (1995)					X	
Stout, Cannon-Bowers, Salas, & Milanovich (1999)				X		
Stout, Salas, & Carson (1994)	X					
Stout, Salas, & Fowlkes (1997)			X			
Sundstrom, De Meuse, & Futrell (1990)	X		X			
Teslul & Mathieu (1999)	X	X				
Urban, Bowers, Monday, & Morgan (1995)	X					
Urban, Weaver, Bowers, & Rhodenizer (1996)	X					
Watson, Michaelsen, & Sharp (1991)	X					
Xiao, Hunter, Mackenzie, Jefferies, & Horst (1996)	X					
Zaccaro, Gualtieri, & Minionis (1995)						X

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1. **Achille, L.B., Schulze, K.G., & Schmidt-Neilsen, A. (1995). An analysis of communication and the use of military terms in Navy team training. Military Psychology, 7(2), 95-107.**

This article reports the results of research conducted at the Naval Research Laboratory on team communication. The authors conclude that communication, particularly in a hierarchical organization such as a military team, is an essential process of team performance. However, when communication is based over a distributed radio net, it can become confusing and burdensome to those attempting to monitor more than one site. Achille and her colleagues identified four components essential for effective team communication: 1. accurate and unambiguous wording (e.g., properly used military terms, like North Atlantic Treaty Organization (NATO) brevity codes); 2. terseness and brevity (e.g., elimination of excess verbiage, like "sir," "um," "thank you"); 3. selective content that is useful to the receiver, such as interpreted data rather than raw data; and 4. identification of speaker and intended receiver.

This research involved team training exercises for a commissioning crew at the Combat Systems Engineering Development Site in Moorestown, NJ. Communication training was not explicit, based on participant comments, it was considered to be important. Two training scenarios, repeated early and late in the two-week training period, were monitored for communication. Each individual message made over the command net was recorded and transcribed. Transcriptions were analyzed for word counts, errors, format violations, status-related comments, identifications, and acknowledgments. Results indicated that the changes in communication over the training session were minimal, with a few notable exceptions. Regarding total word count, there was an increase in the use of military terms from early to late training sessions. Speech turns involving military terms were wordier than those without military terms. Acknowledgements and speaker identification increased in late training. Despite these changes, on-the-job training did not appear to alter many of the communication patterns significantly. Achille et al. recommend that explicit training in communication, particularly in the use of military terms, is needed. Communication skills, the authors say, are important in effective team performance and contribute to the development of the team's shared mental model.

2. **Amason, A.C., Thompson, K.R., Hochwarter, W.A., & Harrison, A.W. (1995). An important dimension in successful management teams. Organizational Dynamics, 24(2), 20-35.**

The manner in which teams handle conflict is seen as an important dimension of successful team interaction. After conducting on-site interviews of teams from ten diverse organizations, Amason and his colleagues recognized that there are mainly two types of conflict: Cognitive conflict (C-type) and Affective conflict (A-type). The C-type conflict is considered to be essential for building and maintaining effective teams. It occurs when discussions and disagreements focus on substantive, issue-related differences of opinion. The C-type conflicts promote involvement from all team members by empowering members to "speak their minds." It helps focus attention on the underlying assumptions of the issue at hand and encourages

innovative thinking. Furthermore, the open discussions involved in C-type conflicts result in better decisions that are widely accepted by team members. The A-type conflicts, on the other hand, occur when disagreements are based on personalized, individually-oriented matters. This type of conflict results in hostility, distrust, cynicism, and apathy among team members. Team members become reluctant to engage in open communication, are less likely to participate in decision making, and are less accepting of, or dedicated to, the final decisions. The authors found that the most effective teams were intuitively aware of these two types of conflict and took strides to avoid A-type conflicts.

Four attributes of effective team meetings are described: focused activity, creativity, open communication, and integration. Focused activity refers to sticking close to the core issues of the problem under discussion and not veering far off course. One suggestion for promoting focused activity is to distribute agendas ahead of time which include descriptions of the proposals to be discussed. Creativity refers to involving all members of the team during idea generation, listening to the minority opinions, and encourage team members to think beyond the normal options. This type of encouragement promotes C-type conflict. Open communication dictates that members feel free to speak their opinions and challenge the opinions of others, without threat of retribution. By maintaining open communication, team members distribute their diverse skills and experiences and develop more unique and creative options. Integration involves including and getting the best from all team members. This includes seeking out the opinions of those who appear to be less involved and moderating those who wish to monopolize the conversation.

Amason et al. concluded by saying that the team leader is responsible for promoting C-type conflicts and limiting A-type conflicts. They suggest that taking the following steps will go a long way towards developing effective teams: (a) distribute an agenda early; (b) openly discuss how the leader will deal with conflicts ahead of time; (c) provide an open environment; (d) develop strategies for promoting and keeping openness and cooperation in the meetings; (e) monitor and facilitate where the discussions are going; (f) channel discussions away from A-type conflict and towards C-type conflict; (g) demonstrate support for the team; and (h) be proactive.

3. Baker, D.P., & Salas, E. (1997). Principles for measuring teamwork: A summary and look toward the future. In M.T. Brannick, E. Salas, & C. Prince, (Eds.), Team performance assessment and measurement (pp. 331-355). Mahwah, NJ: Earlbaum.

Baker and Salas expand upon an earlier publication which described the principles for measuring teamwork. The original six principles included: (a) the need for good theory; (b) understanding the dynamic nature of teams requires multiple observations; (c) observational studies are a must; (d) there is a need for more application and development of team performance measures; (e) the reliability and validity of team measures and observers must be established; and (f) measures of team performance must have content, construct, and face validity. Adding to these six principles, Baker and Salas describe 20 sub-principles that define the state and needs of teamwork research. Under each of the six main principles and 20 sub-principles, the authors list the progress that has been made in the field. They conclude by stating that while much work has already been done, there is a need for a unified theory of teamwork. A unified theory of teamwork, they say, will include an integration of the knowledge, skills, and attitudes necessary

for good team performance. Furthermore, there is a great need for the development of team performance measures and for the validation and verification of the psychometric properties of existing measures.

4. Baker, D.P., & Salas, E. (1992). Principles for measuring teamwork skills. Human Factors, 34(4), 469-475.

Baker and Salas examine the measurement of teamwork skills and outline six principles that future researchers need to address. These six principles are outlined in the summary by Baker and Salas (1997) in a previous entry in this annotated bibliography. The authors briefly discuss the historical definitions of a team and the properties of teamwork. Noting the variety of definitions and ideas about what constitutes a team, the authors suggest that the development of a shared definition is important because it provides the boundaries that guide team researchers. Furthermore, identification of the critical behaviors and dimensions of team processes can be used in the development of measurement devices and provide the foundations for a theory of teamwork.

Baker and Salas suggest that for teamwork to be understood, researchers must employ various techniques of observation and measurement, including the use of self-reports, on-site observers, and off-site observers. By first producing a shared teamwork definition which provides the boundaries of research, and then by approaching the study of teamwork with multiple techniques, researchers can come to an understanding of teamwork as a dynamic entity which possesses its own set of processes and behaviors.

5. Blickensderfer, E., Cannon-Bowers, J. A., & Salas, E. (1997). Training teams to self-correct: An empirical investigation. Paper presented at the 12th Annual Meeting of the Society for Industrial and Organizational Psychology, St. Louis, MO.

Implicit coordination, as evidenced by team members providing information prior to a request, is based on shared expectations concerning team members' roles and responsibilities. Blickensderfer and her colleagues hypothesized that intra-team feedback would help build such shared expectations. In this study, post-performance discussions, called team self-correction sessions, were used to provide such feedback. This feedback consisted of an objective review of what happened, identification and solution of errors or problems, provision of corrective feedback, plan development for the future, and a review of the discussion. To examine the influence of self-correction sessions on improvements in team performance, two groups of 3-person teams were provided with training. One of the groups received self-correction training that included an audio-taped lecture, demonstration, and practice, whereas the other group of teams received unrelated training for the same length of time.

Teams then executed a naval air-defense scenario. Discussions between team members were video-taped and scored for 13 behaviors (e.g., began discussion with review). Process and outcome measures during subsequent scenarios were collected. The two main communication process behaviors of interest were: giving information in advance and using shortened phraseology. Team outcome measures were based on decision accuracy (e.g., shoot-don't shoot). Also, team expectations were measured by questions concerning when and how

information was passed among team members. Team cohesion was also assessed via survey. Results showed that the more agreement on team expectations (concerning information sharing), the better team communication (process) and performance (outcome). Compared to untrained teams, trained teams exhibited more self-corrective behaviors, had more agreement on team expectations concerning information sharing and had better communication and higher team cohesion.

6. Bolman, L.G., & Deal, T.E. (1992). What makes a team work? Organizational Dynamics, 21(2), 34-44.

Bolman and Deal discuss an aspect of effective teamwork that gets little attention in the mainstream academic research. Team leaders view their responsibilities and situations through four "frames". These include a structural frame (e.g., data-driven, bottom-line thinking), a human resource frame (e.g., individual and organizational needs), a political frame (e.g., conflict between groups and resource allocation), and a symbolic frame (e.g., myth, ritual, and ceremony). Most research emphasizes the first three frames. Bolman and Deal, however, claim that the symbolic frame is vital for team cohesiveness.

A software and computer development team is presented as an example of an effective team. The article highlights the important role of symbolism in the team's success. Ten key components of symbolism are presented, as follows: rituals of member induction, member diversity, leading by example rather than by command, shared and exclusive language, stories and myths, humor, spirit-renewing rituals, and the importance of informal member roles, such as the team "priest" who listens to everyone's problems. The authors conclude that the essence of high performance is spirit, and the spirit is embodied in the symbolic frame.

7. Bowers, C.A., Baker, D.P., & Salas, E. (1994). Measuring the importance of teamwork: The reliability and validity of job/task analysis indices for team-training design. Military Psychology, 6(4), 205-214.

Performance in military settings is often determined by teamwork; however, there is currently no good method to determine empirically the relative importance of different teamwork tasks. The authors attempt to apply task analysis rating procedures used in individual task analysis to team task analysis. Teamwork tasks were generated for three types of aircraft. The tasks for one type of aircraft (helicopter) were used to develop the new composite measure. Pilots rated each task in terms of criticality, frequency, importance to training, and overall importance. The first three variables, plus some other computed measures, were used in regression to predict overall task importance. Results showed that criticality and importance to training accounted for 79 percent of the variance in overall task importance. Using this equation for all three aircraft, relatively low inter-rater reliability and validity ratings resulted.

8. Bowers, C., Salas, E., Prince, C., & Brannick, M. (1992). Games teams play: A method for investigating team coordination and performance. Behavior Research Methods, Instruments, & Computers, 24(4), 503-506.

The authors recommend low-fidelity simulation as a means to study and train team processes. While high-fidelity simulators offer potentially greater realism than low fidelity simulators, the costs and needed resources are prohibitive. Low-fidelity simulators are posited to be effective at training teams in teamwork skills. Teamwork skills, as opposed to individual task work skills, are those that the team must perform interactively to be successful. They include situation assessment, mission analysis and decision making. The generic nature of teamwork skills is well suited for development in some of the currently available commercial simulators. For instance, one low-fidelity simulator, Gunship, involves individual tasks for each of two crew members plus shared (overlapping) tasks. The authors state that users can structure the scenario and measure task performance (e.g., time to complete mission) and team processes. Specifically, the authors suggest that performance and team processes can be measured with the aircrew observation and evaluation scale (ACOE). The ACOE targets specific behaviors to measure communication, situational awareness, leadership, assertiveness, decision making, mission analysis and adaptability. Results obtained from the ACOE can be useful in determining the teamwork dimensions related to team performance. These results can then be used to develop effective team training.

9. Brannick, M. T., Prince, A., Prince, C., & Salas, E. (1995). The measurement of team process. Human Factors, 37(3), 641-651.

A multi-trait multi-method rating of team processes (assertiveness, decision making/mission analysis, adaptability/flexibility, situational awareness, leadership, communication) was performed using experienced pilots in a low fidelity flight simulation. This simulation used a PC running Microsoft Flight Simulator and was located at a naval base at Corpus Christi, Texas. Raters evaluated two person teams, who were performing a scenario in the flight simulator, on the six team processes. In a multi-trait multi-method analysis, different "traits" (in this case, team processes) are assessed by different "methods" (in this case, raters). If a "trait" (process) can be reliably assessed, correlations between the same "trait" (process) assessed by different "methods" (raters; called mono-trait multi-method correlations) will be higher than correlations between different "traits" (processes) assessed by the same "method" (rater; multi-trait mono-method) or different "traits" (processes) assessed by different "methods" (raters; multi-trait multi-method).

Results showed that ratings of the same process ("trait") by two different raters ("methods") were more highly correlated than ratings of different processes by the same rater or different processes by different raters. Thus, these team processes could be reliably measured. Also, these process ratings were associated with measures of team performance (outcome). However, team process and outcome measures across two different scenarios were not as highly correlated. Thus multiple observations may be necessary to obtain stable judgements of team (process and outcome) performance levels.

10. Caldwell, B.S., & Everhart, N.C. (1998). Information flow and development of coordination in distributed supervisory control teams. International Journal of Human-Computer Interaction, 10(1), 51-70.

Improvements in distributed and/or robotic technology have resulted in team members having to rely on the inputs of other team members who may be geographically separated. For instance, air pilots depend on inputs from air traffic controllers to provide navigational information. Caldwell and Everhart examined the influence of information exchange on a distributed supervisory control task. A distributed supervisory control task typically involves multiple users, who are not co-located, providing inputs via a computer to a central system for the purpose of control and direction. Because of task demands, the input and feedback received by the central system often involves a time lag. This study examined the effects of time delays in communication on team coordination in a distributed supervisory control task.

Fifty-one three-member teams of university students performed the computer game Spectre VR. Spectre VR is a tank simulation game which includes a driver, a long range observer, and an out-the-window observer. The object of the game is to collect as many flags as possible by running over them with the tank. The driver, who cannot see outside of the tank, relies on written inputs from the two observers for direction. The two observers view the outside world differently – one views the short range terrain and the other the long range terrain. In this study, the observers viewed the world as either wire-framed objects or as realistic 3-D filled objects. The out-the-window observer received written hints in his or her display viewer; the long range observer or the driver did not receive any hints. The inputs that the observers provided the driver were either close to real time or time delayed.

Results indicated that performance was best when the views displayed to the observers were wired-framed and there were no hints provided to the out-the-window observer. Caldwell and Everett suggest that in a distributed task, 3-D graphical interfaces place high demands on the system that often leads to time delays on information transmission. These delays negatively affect team coordination. Furthermore, the unequal distribution of hints disrupted the development of a shared mental model. The out-the-window observer either had to communicate fully the information received in the hints to the other team members or had to assume that the information in the hints was already known. This led to either increased workloads or disparate mental models. Caldwell and Everett concluded that for team coordination to be effective, a shared mental model must be developed. Time delays and unequal provision of information hurt the development of a shared mental model and therefore limit team performance.

11. Cannon-Bowers, J. A., Salas, E., Blickensderfer, E., & Bowers, C. A. (1998). The impact of cross-training and workload on team functioning: A replication and extension of initial findings. Human Factors, 40, 92-101.

This study examines the effects of cross-training, or positional clarification, on team performance. Positional clarification is defined as presenting team members with information and hands-on training about other team members' jobs. This study differs from prior studies of cross-training, where participants were only provided with factual information about other team members' jobs. Three-person teams of naval recruits performed a low fidelity naval defense scenario. All participants received individual training on their particular team role or task; one group received training on all three positions. All groups then performed a scenario under high and low workloads. Measures included objective and subjective measures of inter-positional

knowledge (IPK); measures of teamwork (processes such as information volunteered, questions, acknowledgements, etc.); and task outcomes (e.g., number of contacts shot or cleared correctly).

Results validated the cross-training manipulation in that cross-trained teams had more IPK (on both objective and subjective measures) than non cross-trained teams. Cross-training improved team processes in that cross-trained teams volunteered more information than non cross-trained teams. Concerning performance, cross-trained teams accessed information faster and engaged more targets correctly than did non cross-trained teams. Under high workload, cross-training had additional positive effects on both team processes and performance. Specifically, cross-trained teams maintained effective team processes under high workload, while non cross-trained teams did not. Also, cross-trained teams improved outcome performance under high workload, while the performance of the non cross-trained teams remained the same under high and low workload.

12. Cannon-Bowers, J. A., Salas, E., & Converse S. A. (1993). Shared mental models in expert team decision making. In N. J. Castellan, Jr. (Ed.), Current issues in individual and group decision making (pp. 221-246). Hillsdale, NJ: Erlbaum.

This article discusses the role of shared mental models in the performance of tactical decision-making (TDM) tasks. The term TDM refers to a team process that consists of gathering, processing, integrating and communicating information in order to make a task-relevant decision. Teamwork behaviors such as communication, cooperation and compensatory behavior are believed to be related to team effectiveness in a wide variety of team contexts. These behaviors are said to result from the ability of team members to predict the needs and behaviors of others. The authors suggest that the ability to predict the needs of others is based on team members having similar, or shared, mental models. Several forms of mental models exist within a team, including mental models for equipment, task, team interaction and team members' attributes. Mental models which facilitate TDM most likely describe when and how team members must interact with one another in order to accomplish the task. Models of the task which create expectations about how events may unfold and how the team may respond are also important for TDM, as are models which predict specific behaviors and needs of team members.

It is proposed that training can build shared mental models. This training can include direct (didactic) training of mental models of the team or task. Feedback or debriefing at the end of an exercise can also be useful to the extent that it allows members to interpret what was happening at critical times, why other team members behaved as they did, and to what extent expectations (about events or other team members' needs and actions) were correct. Cross-training may help team members understand the roles and functions of other team members. Training team leaders to foster shared mental models may also be useful. One way to accomplish this is to structure the format of pre-task briefings or planning sessions.

Methods to measure mental models are not well developed. One possibility is to assess individual mental models directly and assess the overlap in these models to determine if a shared (team) mental model exists. Perhaps a better method is to assess shared mental models indirectly by assessing the quality and accuracy of team members' expectations for performance. Since

mental models are said to build shared expectations, this is both a good measure and criterion for training of shared mental models.

13. Cannon-Bowers, J. A., Tannenbaum, S. I., Salas, E., & Volpe, C. E. (1995). Defining competencies and establishing team training requirements. In R. A. Guzzo & E. Salas (Eds.), Team effectiveness and decision making in organizations (pp. 333-380). San Francisco: Jossey-Bass.

The authors define four categories of team competencies, using the two dimensions of whether the competency is or is not specific to a particular team, and whether a competency is or is not specific to a particular task. Thus, a competency can be both task and team specific (context driven), only task specific (task contingent), only team specific (team contingent), or neither team nor task specific (transportable). The authors hypothesize that different knowledge, skill and attitude competencies are required for the four categories.

Mental models of both the team and the task figure heavily in the authors' discussions of team and task knowledge competencies. Knowledge competencies consist of declarative, procedural and explanatory knowledge. Declarative knowledge is knowledge of team roles, relationships among roles, and temporal patterns of team performance. Procedural knowledge consists of knowledge about how team members perform their functions, perform together, and how the task is accomplished. Explanatory knowledge includes knowledge about why the team and its members function as they do.

Team skill competencies are defined in terms of teamwork dimensions or processes. Substantial research in this area is reviewed. Team skill competencies or dimensions discussed include adaptability, shared situational awareness, performance monitoring and feedback, leadership/team management, interpersonal relations, coordination, communication, and decision-making.

Team attitude competencies are defined as attitudes toward teamwork, team concept, collective orientation, collective efficacy, cohesion, mutual trust, and shared vision. While attitude toward teamwork refers to a general commitment to collective work, the rest of these attitudes refer to beliefs about the particular team of which one is a member.

The authors then present a table listing the team knowledges, skills, and attitudes required in each of the different types of competencies: context driven, team specific, task specific and transportable. For example, for transportable (task and team generic) competencies, knowledge of teamwork skills, skills in morale building and cooperation, and attitudes about teamwork behaviors are postulated to be needed.

Lastly, the authors suggest that different methods of training are required to match the different types of competencies needed. Methods of training for both task and team competencies include lecture, passive demonstration, role playing, cross-training, task simulation, and guided practice (i.e., behavioral feedback). While these are the methods (how) of training recommended, the content (what) of training depends on the competency to be trained, as described above.

14. Cohen, S.G., & Bailey, D.E. (1997). What makes teams work: Group effectiveness research from the shop floor to the executive suite. Journal of Management, 23(3), 239-290.

The authors of this literature review divide teams into four types: work teams, parallel teams (teams taken out of the existing structure, with only advisory roles; e.g., quality circles), project teams (teams that exist only during the life-span of the project), and management teams. They then considered the impact of seven factors on team effectiveness: task design (e.g., autonomy, interdependence), group composition (e.g., size, diversity), organizational context (e.g., rewards, supervision), environmental factors (e.g., turbulence), internal processes (e.g., communication), external processes (e.g., conflict), and group psychosocial traits (e.g., shared mental models, cohesion).

Team effectiveness was divided into three primary areas: performance outcomes (e.g., quantity and quality), attitudes (e.g., job satisfaction, trust), and behaviors (e.g., absenteeism, turnover). The authors examined the literature on the effects of the seven factors listed above on the effectiveness of the three types of teams. Seven major findings were summarized: (a) The seven factors affect different types of teams differently; (b) Autonomy (self direction) positively affects performance and attitudes of work teams but not parallel teams; (c) Cohesion is positively related to performance for all types of teams; (d) Autonomy is beneficial for work teams, but not project teams; (e) Different raters see different factors related to team effectiveness (e.g., team members see internal processes such as collaboration as related to team effectiveness, while managers see communication with external agents as related to team effectiveness); (f) Diversity of team composition is related to team effectiveness in complex ways (e.g., member diversity was related positively to effectiveness for some types of teams and negatively for others); and (g) Cognitive and affective psychosocial factors have different impacts on team effectiveness (e.g., for several types of teams, task-based or cognitive conflict had positive effects on outcomes, while relationship-based or affective conflict had negative effects). The authors suggest that when attempting to improve team performance, it is necessary to consider the context in which the team operates and the structure of the team. Complex interactions between context and structure effect performance in ways that are not always foreseeable.

15. Cohen, S.G., Ledford, G.E., Jr., & Spreitzer, G.M. (1996). A predictive model of self-managing work team effectiveness. Human Relations, 49(5), 643-676.

The authors examine the relationships between variables theorized to affect work team effectiveness in self-managing work teams. The variables considered included: group task design, encouraging supervisory behavior, group characteristics, and employee involvement. Team performance was operationalized as perceived team performance (by team members and managers), quality of work life (QWL), and absenteeism. To examine the relationship of these variables to team effectiveness, Cohen and her colleagues administered several surveys to employees and managers at a large telephone company. Both self-managing and traditional work teams were represented in their sample.

Path analyses were used to examine the interrelationships among independent and dependent variables separately for self-managing and traditional work teams. Results indicated

that three of the four categories of independent variables showed a relationship with at least one category of dependent variable for both types of work teams. Group task design, group characteristics, and employee involvement were related to measures of team effectiveness (QOL, team performance, and absenteeism) for both self-managing and traditional work teams. Encouraging supervisory leadership was not associated positively with any measure of team effectiveness. As a result of this unexpected finding, the authors suggested that the widely accepted self-leadership theories of the late 1980's should be re-evaluated.

16. Cooke, N.J., Stout, R., Rivera, K., & Salas, E. (1998). Exploring measures of team knowledge. Proceedings of the Human Factors and Ergonomics Society 42nd Annual Meeting: Vol. 1, (pp. 215-219). Santa Monica: HFES.

Team knowledge is considered to be more than the summation of the cognitive abilities of the team members. This paper describes one study in a programmatic effort to develop a measurement of team knowledge that is predictive of team performance and team situation awareness. Twenty-four students, separated into teams of three, were given role specific training in the tactics and use of a Comanche helicopter computer game. Following training, they were given several assessment measures that included game relatedness ratings, a game questionnaire, cue relatedness ratings, an information flow diagram, and a factual test. These assessment measures were then repeated following the completion of the team task.

A Pathfinder network scaling algorithm was used to reduce the data to a network and a graph similarity measure was used to compare the team's network to a logically-derived referent network. Three types of information were interpretable from the networks: knowledge accuracy, inter-positional knowledge, and knowledge similarity. Using the scaling algorithm and the referent network, Cooke et al. were able to determine that overall team knowledge did not significantly increase after completing the mission. In addition, role knowledge (awareness of one's unique assignment on the team), non-role knowledge (awareness of other's roles), and role differentiation (the degree of mastery knowledge of one's role over knowledge of another's role) were assessed. Results weakly indicated that teams gained in non-role knowledge from pre- to post-test. Teams with better non-role knowledge and less role differentiation performed more effectively. Furthermore, mastery of both role and non-role knowledge was indicative of team situation awareness. However, similarity of team knowledge was not related to pre- and post-test performance or situation awareness. The authors suggest that inter-positional knowledge and knowledge accuracy are good metrics of team performance and situation awareness.

17. Cooke, N.J., Stout, R. & Salas, E. (N.D.). Measuring team mental models. Unpublished manuscript. Las Cruces, NM: New Mexico State University.

This paper discusses some of the commonly used techniques for measuring team mental models. Team mental models are defined as the knowledge that allows a team to describe, explain, and make predictions about the surrounding environment. Most often, mental models are assessed with knowledge elicitation techniques such as observations, interviews, process tracing techniques, and various conceptual methods. Process tracing methods, such as "thinking aloud," involve the collection of data concurrently with task performance. Conceptual methods are those that produce graphic or spatial representations of the domain concepts and their

relations. Some of the often used conceptual methods include cluster analysis, multidimensional scaling, and concept mapping. Recently, these modeling techniques have become popular among team researchers.

The selection of a mental model measurement should be guided by the purpose of measurement. These purposes can include knowledge elicitation, hypothesis confirmation, or performance assessment. In order to measure team mental models, knowledge must be elicited at the individual level and aggregated across team members. Commonly, team knowledge is reported in terms of central tendency (i.e., mean, mode, and median) and tends to focus on knowledge similarity and accuracy. Knowledge similarity is reflected in the number, or percent, of responses that are identical for team members. Conceptual methods generally report knowledge similarity in terms of the proportion of shared links in the network or computational model. To measure knowledge accuracy, it is necessary that the correct answers be known. Generally, subject matter experts develop standards to which the team's responses are compared. Knowledge accuracy is usually reported as the average percent of correct answers given by team members. To assess inter-positional knowledge, it is necessary to categorize information by team role. Once information is categorized, it is then possible to assess the extent of knowledge each team member has about his or her role and the roles of other team members. The difference in knowledge of one's own role and the roles of others is called role differentiation. Low role differentiation indicates that team members have a good understanding about the functions of each team member.

18. Dirks, K.T. (1999). The effects of interpersonal trust on work group performance. Journal of Applied Psychology, 84 (3), 445-455.

Although trust is frequently cited as a determinant of group performance, there is little empirical support for the hypothesis. In fact, trust may be a variable moderating the effects of motivation on group performance. For example, within teams that have high trust, motivation may be directed more towards the group's goals than the individual's goals. The author used a group tower building task, with individual and group incentives, to test this hypothesis. Trust was manipulated by informing team members that they could or could not trust their partners to work for the good of the group. Trained observers measured various group processes, such as coordination, helping, effort intensity, and direction of effort. Task motivation was measured by self-report surveys. Performance effectiveness was determined by the number of blocks in the tower and the number of times the tower collapsed across trials. Efficiency was expressed as a ratio of the group's actual performance to the group's expected performance based on individual trials (i.e., group performance as more than, equal to, or less than the sum of individual performance).

Results did not indicate an effect of trust on group processes or performance (effectiveness or efficiency). They did, however, suggest that trust plays the role of a moderating variable on group processes and performance. Groups with high motivation had high coordination (worked well as a group) under high trust, but had low coordination (worked as individuals) under low trust. High motivation had positive effects on efficiency and effectiveness under high trust, but not under low trust. Thus, groups with high trust did not have better processes or performance than groups with low trust, but trust moderated the relationship

between motivation and group processes and performance, such that under high trust, high motivation was associated with better group processes and performance.

19. Duncan, P. C., Rouse, W. B., Johnston, J. H., Cannon-Bowers, J. A., Salas, E., & Burns, J. (1996). Training teams working in complex systems: A mental model-based approach. Human/Technology Interaction in Complex Systems, 8, 173-231.

The authors describe the development of a team mental model training technique. Interviews with instructors and Combat Information Center (CIC) team members had suggested six types of mental models: an equipment model, a task model, a defense system model, a ship model, a team model, and a situation model. Observations of training revealed that the team mental model received the least training. When an analysis of team performance errors was conducted, it became clear that the majority of errors were due to team communications problems. To determine the source of the communication errors, models of expert team communication were developed. Based on these models, a computer-based model called the Team Model Trainer (TMT) was developed. The TMT consists of three parts: training, simulation and feedback. It contains training on all six mental models but most specifically focuses on the team mental model. Training on the team mental model follows the three categories of mental model knowledge: description (what), explanation (how), and prediction (why). Under description, there is training on the various team member roles, the relationships between team members, and the temporal patterns of team performance. Under explanation, training is available on the functioning of team members (how a team member performs his/her job), the co-functioning of team members (how members perform together), and the overall mechanism of team performance (how performance is accomplished). Under prediction, there is training on the requirements fulfilled (why the team member is needed), the objectives supported (why the team is needed), and the behavioral principles applicable to teams.

The authors report on several studies that test the TMT technique. One previous study indicated that teams trained with TMT improved on measures of individual processes. Another study showed that teams trained with TMT improved on measures of team processes. This latter study also showed that volume of team communications decreased from pre- to post-test for TMT trained teams but did not decrease for control teams. Further analysis of the communication patterns showed that the decline in communications for TMT trained teams was due to the decline in number of questions asked by team members. This latter finding suggests that TMT training increased information "push" versus "pull." Lastly, TMT training improved team members' knowledge of team communications (i.e., to whom in the CIC they would provide information and from whom in the CIC they would expect information). These findings suggest that training in mental models, particularly team mental models, can improve team process performance. The authors describe the current TMT as focusing mainly on team communications skills. They state that the TMT could focus just as easily on situation assessment, team coordination, decision making, or team leadership skills.

20. Dwyer, D.J., Oser, R. L., Salas, E., & Fowlkes. J.E. (1999). Performance measurement in distributed environments: Initial results and implications for training. Military Psychology, 11(2), 189-213.

Distributed interactive simulations (DIS) conducted via networked computers are becoming more important in military training. One particular area of challenge is the measurement of team behavior in DIS environments for the purpose of supporting training evaluation, performance diagnosis and feedback. Event Based Training (EBT) is a method that structures training by linking training objectives, exercise design, performance measurement, and feedback. The purpose of exercise events is to create specific opportunities for participants to demonstrate their ability to perform tasks associated with training objectives. Also, the events provide controlled situations in which evaluations can assess performance. This assessment of performance can be used to provide feedback to participants during after-action-reviews (AAR). Events can either be injected into an exercise, embedded (pre-planned) within an exercise, or be expected to occur as a routine course of action. Ideally, multiple events should be specified for each training objective.

The Targeted Acceptable Responses to Generated Events or Tasks (TARGET) method identifies anticipated behaviors for specific events that are linked to training objectives. These behaviors can be used to generate an overall performance score and provide diagnostic feedback. The Teamwork Observation Measure (TOM) is derived from performance measurement research conducted under the Navy's Tactical Decision Making Under Stress (TADMUS), aircrew coordination training, and naval gunfire support training programs. It consists of four teamwork dimensions: Communication, team coordination, situation awareness and team adaptability. Communication consists of factors of correct format, proper terminology, clarity and acknowledgements. Team coordination consists of factors of synchronized actions, timely passing of information, and familiarity with others' jobs. Situation awareness consists of factors of maintaining the big picture, identifying potential problems, remaining aware of resources available and providing information in advance. Team adaptability comprises back-up plans, smooth transitions to back-up, and quick adjustments to situational change. Observers rated performance and provided comments during AARs. The TARGET and TOM were used to assess DIS Close Air Support (CAS) missions in two exercises, consisting of personnel from all four services, and four geographic locations. Each CAS mission was divided into three phases: Planning, Contact Point (CP), and Attack. A distributed AAR was held after each mission. Observer Controllers (OCs) at four sites conducted the TARGET and TOM methods with various soldier groups.

Exercise one: (Only TARGET data for exercise one.) Planning phase: Overall performance improved substantially across all four training days. Patterns for two training objectives (Integration and Interaction) showed decreases from day 1 to day 2 and then an improvement across the remaining days. Intelligence performance rose sharply from day 1 to day 2 and remained high. The CP phase: Overall performance increased dramatically from day 1 to day 2, and then more gradually across the remaining days. Attack phase: Overall performance showed a steady increase across the four training days.

Exercise two: (Minor revisions to TARGET.) Planning phase: Overall TARGET performance improved gradually across the five days. A few problem areas (target selection, establishing airspace coordination area, control of aircraft and synchronization of CAS resources) were revealed. For TOM data, performance also improved across the five exercise days. The CP phase: TARGET performance improved across all five exercise days. For TOM data, a drop in performance on day four for coordination and situational awareness was apparent. Also, TOM data showed considerable room for improvement in all areas; ratings were seldom over the scale midpoint. Attack phase: Performance on both TARGET and TOM showed improvement across all five days. Again, TOM data shows drop in performance on day 4 and, again, considerable room for improvement.

In summary, the techniques, TARGET and TOM, showed generally high overlap. However, there were time periods in which TOM showed decreased teamwork, which was not reflected by performance measures (i.e., TARGET). Presumably, the feedback provided by the two techniques helped increase performance over time. Controlled research is needed to confirm the effectiveness of this methodology.

21. Ehrlich, J. A., Knerr, B. W., Lampton, D. R., & McDonald, D. P. (1997). Team situational awareness training in virtual environments: Potential capabilities and research issues (Technical Report 1069). Alexandria, VA: U. S. Army Research Institute for the Behavioral and Social Sciences.

According to the authors, virtual training environments have the advantage over real-world training centers in that the learning experiences can be rapidly repeated, are less expensive, and present fewer physical risks to the soldier. They therefore present a good opportunity to train certain types of skills, such as the development and maintenance of situation awareness. This report examines the potential of virtual environments for training situation awareness skills to dismounted infantry soldiers. Ehrlich and his colleagues suggest that a situation awareness training program which utilizes virtual reality should satisfy some basic requirements. The training environment should reflect the complexity of the real world. Training should emphasize the need to seek information that conflicts with current situational understanding. Students should be given the opportunity to train in a variety of contexts and have frequent practice opportunities. Furthermore, the students should be cross-trained and taught team skills such as communication and coordination.

Erlich and his colleagues point out problems with some of the extant training simulations, such as low visual resolution, highly artificial self-motion, simplistic behaviors of computer generated forces, and poor gesture recognition systems. They then offer a set of general training strategies for situational awareness training. Training should use clearly defined tasks and standards to maximize the opportunity to measure performance. The use of scenarios and computer generated forces should promote consistency and standardization of training experiences for all dismounted infantry. The training programs should teach the soldier to be adaptive by increasing the task-difficulty as learning occurs. Some key important benefits of virtual training environments are the after-action review and take-home package capabilities. Instructors can take advantages offered in a virtual training environment, including the record and replay features, the automated performance measurements, and the data storage facilities.

Further, the instructors can utilize features such as automated alerts to poor performance and the ability to freeze, restart, reposition and demonstrate performance during after-action reviews. They can also support student learning with features such as automated cueing and coaching, and can take advantage of training management aids such as keeping track of training objectives met.

22. Entin, E. E., & Serfaty, D. (1999). Adaptive team coordination. Human Factors, 41(2), 312-325.

This study examined the effects of a training intervention on team performance under low and high workloads. It was hypothesized that effective teams are better able to perform under stress because they have a more highly developed set of shared mental models than do non-effective teams. Shared mental models, which include an understanding of the situation, the resources, and the other team members' roles and needs, permit implicit coordination to occur during highly stressful periods. This switch from explicit to implicit coordination results in more efficient communication. For instance, team members anticipate information needs and push the information upwards, rather than waiting for requests.

Entin and Serfaty added to their previously developed team adaptation and coordination (TACT) training program the requirement that team leaders issue frequent situation reports. Thus, TACT+ instructed students how to recognize increasing stress/workloads, what adaptive strategies to implement and when they should be implemented. The implementation of frequent situation reports was expected to improve the teams' shared mental model and improve performance. Further, it was expected that teams receiving TACT or TACT+ training would outperform the control group who received a sham training. To test these hypotheses, 59 naval officers and one civilian enrolled in military training programs were assigned to five person teams. Teams initially conducted a pre-training scenario using an anti-air warfare simulation and then received the type of training to which they had been assigned. Following training, they completed a second set of scenarios and then responded to the post-test measurements. Results indicated that the TACT and TACT+ trained teams significantly improved from pre- to post-test and outperformed the control group on low and high workloads. Additionally, teams who had received the TACT/TACT+ training improved in team processes, such as shared mental models and communication. The TACT+ trained teams outperformed the other groups on all measures of performance.

These results suggest that the TACT and TACT+ training programs offer techniques for increasing team performance during periods of high workloads. The training improved both team processes and performance. Training commanders to provide situational updates (TACT+) appeared to provide additional benefits.

23. Entin, E., Serfaty, D., & Deckert, J. C. (1994). Team adaptation and coordination training (Technical Report 648-1). Burlington, MA: Alpha Tech, Inc.

This study reports on efforts to improve the performance of tactical decision making (TDM) teams with the use of team adaptation and coordination training (TACT). It was hypothesized that high performing teams adapt to the situation, whereas low performing teams do not. A salient component of the situation in which most TDM teams work is level of stress,

defined in terms of workload and ambiguity of information. The authors argue that teams need to alter their mutual (team) mental models and concomitant actions according to the level of stress.

Therefore, Entin et al. taught TDM teams to recognize and adapt to signs of stress. Team members were taught to recognize signs of stress in the external environment, individuals, and the team. Then they were taught five adaptive strategies to deal with the stress: preplanning, use of idle periods, use of information versus tasking communications in high stress periods, anticipation of information needs (implicit communication) and redistribution of team workload. The teams were also given assistance in adapting their situational mental model. In one condition, called TACT+, the leader was taught to provide periodic situation updates, giving current priorities and perception of the situation. These updates aid team members in filtering information; i.e., determining which, of the information they are receiving, is currently most important. This training is critical to the work of the team, because determining what information is acquired influences the entire information management process.

The training was successful in improving measures of teamwork, communication, and team performance. Teamwork ratings, by Subject Matter Expert (SMEs) blind to the training conditions, improved significantly from pre to post training for the TACT and TACT+ groups but not for the controls. Concerning communication, anticipation ratio (ratio of information provided to information requests) showed that team members "pushed" more information in the TACT and TACT+ than control conditions. The SME ratings of team performance again showed significant improvement for TACT and TACT+ groups from pre-to-post training but not for controls. In areas of teamwork, communication, and team performance, the TACT+ group was superior to the TACT group, but differences were not statistically significant.

24. Fleishman, E.A., & Zaccaro, S.J. (1997). Toward a taxonomy of team performance functions. In R.W. Sweezey & E. Salas (Eds.), Teams: Their training and performance (pp. 31-56). Norwood, NJ: Ablex.

There is little formal knowledge of the description and analysis of team performance functions. This lack of knowledge inhibits the measurement of team performance and the development of team training. According to the authors, a taxonomic classification of team performance functions, particularly including team coordinated activities, would be useful. This taxonomy should be based on a model of team performance. The authors advance such a model. External conditions imposed on the team (e.g., organizational climate) affect member resources (e.g., member skills, knowledge and abilities), task characteristics and demands, and team characteristics (e.g., group size, cohesion). Task characteristics and demands, in turn, also influence team characteristics. Member' resources, task characteristics and team characteristics affect individual and team performance. From this model, the authors then advance a provisional taxonomy of team performance functions. The team taxonomy includes team orientation functions (acquiring and sharing information), team organizational functions (coordinating activities), team adaptation functions (monitoring and compensatory processes), and motivational functions (defining and enforcing team objectives).

The researchers encountered problems when they attempted an empirical evaluation of this taxonomy. Virtually all of the team functions were related to conveying either information or physical resources. The model was revised to eliminate the adaptation function and divided organizational functions into three separate categories. The new model included orientation functions (planning activities), resource distribution functions (assigning members and resources to particular responsibilities), timing functions (organization of resources to ensure tasks are performed within time requirements), response coordination functions (integration of independent and synchronized member activities), and motivational functions (defined as above). Behaviorally anchored rating scales were then designed and validated using this taxonomy. Results showed moderate inter-rater reliabilities. Another evaluation of the taxonomy suggested that performance monitoring (detection and reporting of task errors) was a separate function. Thus two new categories were added: systems monitoring (actions directed toward detecting errors in the nature and timing of ongoing activities) and procedure maintenance (monitoring behaviors to ensure compliance with performance standards). The final taxonomy, therefore, consisted of orientation functions, resource distribution functions, timing functions, response coordination functions, motivational functions, systems monitoring, and procedure maintenance.

25. Fowlkes, J. E., Lane, N. E., Salas, E., Franz, T., & Oser, R. (1994). Improving the measurement of team performance: The TARGETs methodology. Military Psychology, 6(1) 47-61.

The authors evaluate the effectiveness of the TARGET methodology in measuring team performance. *T*argeted *A*cceptable *R*esponses to *G*enerated *E*vents or *T*asks are behaviors that are identified by the training evaluator, a priori, as being central to effective team behavior. The TARGET method provides the training evaluator with a checklist containing the TARGETs. As the participating teams progress through a training scenario, the evaluator marks off whether the team performed a specified behavior at a given time. Further, the TARGET method is designed to work with existing scenarios such that each scenario elicits TARGET behaviors considered important. This study evaluated the psychometric properties of the TARGET methodology by following helicopter crews through an aircrew coordination training (ACT) effectiveness evaluation. Inter-rater reliability estimates of the TARGET methodology were 97% for determining whether the event or cue signaling a TARGET was present or absent. Given that an event was judged to be present, observers agreed 89% of the time that the teams hit or missed the TARGET. Furthermore, split-half reliability estimates were estimated at .985 (corrected Spearman-Brown). The ability of the participating teams to respond correctly to the TARGETS differed indicating that the TARGET methodology is a sensitive technique for measuring performance.

26. Gigone, D. & Hastie, R. (1997). The impact of information on small group choice. Journal of Personality and Social Psychology, 72(1), 132-140.

This study examined the "common knowledge effect" in small group decision and judgment making. The common knowledge effect is the oft-reported finding that the more group members who knew an item of decision-relevant information before discussion (i.e., shared information), the greater the impact of that information on the group judgment. Forty teams of three undergraduate participants were presented with academic profiles of pairs of students and

asked to choose the student who should obtain the higher course grade. The team members were individually given the information (some of the information was shared by other team members, some was unique to the particular team member) and asked to make their own choice. Further, they were asked to rate the confidence in their choice. After making individual choices, members grouped to make an overall team decision and provide a confidence rating. Results indicated that occasionally the group decision correctly overturned the majority of individual members' opinions. However, the group decision making process apparently relied less on discussing unshared information than would have been required for optimal performance. Choice accuracy by the groups was less than the accuracy arrived at by linear regression models. Moreover, groups tended to access less unshared information when making choices as opposed to when they were making judgments.

27. Goleman, D. (1998, November-December). What makes a leader? Harvard Business Review, 93-102.

According to Goleman, effective leaders are distinguished from ineffective leaders by their level of emotional intelligence. Following an investigation of 188 companies, during which he compared "competency models" and interviewed team leaders, Goleman identified that IQ, emotional intelligence, and cognitive skills are the key ingredients of successful leaders. When the relative importance of these skills was rated, emotional intelligence proved to be twice as important as the others for all levels of leadership. Emotional intelligence is defined as a multi-dimensional construct that consists of five factors: self-awareness, self-regulation, motivation, empathy, and social skill.

Self-awareness means having a deep understanding of one's emotions, strengths, weaknesses, needs and drives. It includes the ability of individuals to recognize their own feelings and how their feelings are influencing their performance, as well as the feelings and performance of those around them. Self-regulation is defined as the ability to control and channel one's emotions in useful ways. Those with good self-regulation tend to create environments of trust and fairness that encourage cohesion and productivity. Further, self-regulation enhances integrity both in oneself and in the company. Motivation includes the drive to achieve beyond personal expectations and the expectations of others. Motivation leads to continually challenging oneself and others to do better and is characterized by optimism and organizational commitment. Empathy means the ability to thoughtfully consider the feelings of others in the process of making decisions. It involves being able to sense and understand multiple viewpoints and has been linked to heightened collaboration among members and increased performance. Social skill, according to Goleman, refers to the ability to move people in an intended direction with friendliness. It also incorporates the ability to build networks of people that may be useful in the present or in the future.

The five components of emotional intelligence are often overlooked by business management when considering applicants for leadership positions. However, as Goleman, indicated, they are potentially more important for the leader to possess than technical skills. He lists characteristics of each of the components that are readily identifiable. Furthermore, emotional intelligence, he says, must be developed and can in fact be trained. An example of a training program is provided.

28. Guastello, S.J. (1998). Origins of coordination and team effectiveness: A perspective from Game theory and Nonlinear Dynamics. Journal of Applied Psychology, 83(3), 423-437.

Coordination is necessary for tasks that are similar or complementary to be performed by two or more people at the same time. In team or small group situations, coordination is considered to be an important and distinct component of performance. Guastello examined the coordination that evolved in 12 teams of four students playing a series of three card games. The teams of participants were designed such that no leader was apparent and talking during the game was prohibited. Absent an identified leader and without verbal communication, it was hypothesized that coordination would evolve implicitly. This type of implicit learning of coordination, Guastello said, is similar to the learning that occurs when drivers learn to coordinate with other drivers at a four-way intersection. Furthermore, it was hypothesized that the teams would coordinate themselves in a self-organizing manner. Models based on game theory and nonlinear dynamics were developed to trace and describe the evolution of coordination over three rounds of game playing.

Results from exponential nonlinear regression analyses suggested that during the first two rounds of the card games, coordination evolved in a chaotic and expanding manner before asymptotically stabilizing. This type of growth was unlike the standard learning curve and was an unexpected result. In the third round, however, where the rules of the game were more difficult, transfer of coordination learning did not occur. Behavior never stabilized and performance never reached high levels. There was clear evidence that team members learned the behavioral rules of the game during the first round and were able to transfer them to the second round but were not able to do so for the third round. Using simulations to project the team's performance into the future, performance in the first two rounds would appear to stabilize relatively quickly. In the third round, however, the performance would eventually decay to the point of extinction (i.e., the team would likely quit or break up). These results are discussed in light of their implications on the evolution of teams. Coordination, which is separate and distinct from cohesion, appears to grow through implicit learning of the behavioral rules that dictate the team's environment and task.

29. Guzzo, R.A., & Dickson, M.W. (1996). Teams in organizations: Recent research on performance and effectiveness. Annual Review of Psychology, 47, 307-338.

Guzzo and Dickson reviewed nearly 120 articles, mainly published since 1990, related to team performance. The focus of this review concerns teams within organizations. They offer the following definition of a work group: "A 'work group' is made up of individuals who see themselves and who are seen by others as a social entity, who are interdependent because of the tasks they perform as members of a group, who are embedded in one or more larger social systems (e.g., community, organization), and who perform tasks that affect others (such as customers or coworkers)" (pp. 308-309). As implied by their definition and by the articles they review, groups (which term they use interchangeably with teams) are dynamic, fluid entities operating within equally fluid, changing organizations. Articles reviewed examine issues relevant to team effectiveness, such as cohesiveness, composition, performance, leadership, motivation, and group goals. Cohesiveness, for example, has been shown to improve

performance under time pressure but is not necessarily advantageous under non-temporally-dependent situations. Team size and heterogeneity of members also shows mixed results depending on the conditions or measures used by the researchers. Leader expectations are effective at improving the aspect of team performance that is related to the leader's expectations, but do not extend to other team behaviors. Research on group goals report similar, task-specific improvements but lack generality.

Specialized team training techniques, such as Crew Resource Management (CRM) and CRM-LOFT (Line-Oriented Flight Training), are reviewed with attention to team processes such as communication and decision making. Despite a paucity of experimentally-controlled studies, the overwhelming majority of CRM observational studies indicate that CRM training does provide limited improvement in crew performance. A second major emphasis of specialized group processes is the involvement of computers and technology. Research with computer-mediated groups in areas such as creativity and communication is discussed. For instance, groups that use electronic group support systems in decision making produce more focused and higher quality decisions than groups that do not use the support systems. Furthermore, various team structures, such as Quality Circles, Task Forces, and Autonomous groups, are presented as having unique aspects that are both beneficial and harmful. Contextual issues, such as the influence of the organization on the team and the influence of the team on the organization, are given considerable attention. The team-organization relationship is perhaps the most complex of the issues addressed by Guzzo and Dickson. The research discussed by the authors suggests that changes at the organizational level influence not only organizational effectiveness but also team performance.

Several open-ended questions are discussed at the end of this article: What is diversity, and how does it affect team performance? Does familiarity help or hurt performance? These and other questions presented by the authors reflect a move towards a systems-approach (i.e., input-throughput-output) to team and group research. Primary concerns for future research, say the authors, are the need to understand the contextual influences on teams, challenges and advantages presented to teams by new technologies, and the development of interventions for improving team performance. Overall, this review article reflects the multi-faceted nature of teams and the lack of clear, unambiguous research results.

30. Hartel, C.E., & Hartel, G.F. (1997). SHAPE-assisted intuitive decision making and problem solving information-processing-based training for conditions of cognitive busyness. Group Dynamics, 1(3), 187-199.

The authors base their team decision making training on a model called autodidactic decision making. Similar to naturalistic decision making, autodidactic decision making refers to the use of one's experience, expertise and acquired schemas in making decisions. The SHAPE acronym stands for *S*crutinize symptoms; *H*ypothesize solutions, *A*nalyze proposed solutions, *P*erform modifications and corrections, and *E*valuate results. In the first step, the decision maker monitors channels of information to detect cues predictive of decision events, assesses information quality and quantity, and detects signals associated with problems by recognizing patterns or indicators of problem onset. In the second step, the decision maker forms a memory association with the situation-appropriate decision. If there is sufficient time, in step three, the

decision maker will analyze the proposed solution. First, domain specific rules of thumb will be applied. Then using mental simulation, the decision maker visualizes the effect of the potential action. In the perform and evaluate steps, the alternative is implemented and evaluated. For evaluation, two simple rules are used, indication and contraindication. For indication, the decision maker determines if the relevant aspects of the problem have been addressed by the solution. For contraindication, the decision maker assesses whether the solution is compatible with all aspects of the problem. If there are undesirable consequences of the solution, these consequences would be treated as reasons for not implementing the solution.

The authors hypothesize that SHAPE training will improve team decision making effectiveness by decreasing the time to find the correct solution and reducing the number of incorrect diagnoses. The training will also reduce stress and improve team functioning. In this study, students participated in a low fidelity simulation as pilot and co-pilot teams. Half of the teams were given training on SHAPE and provided with SHAPE summary cards. All were trained on the simulation and provided information necessary to diagnose an in-flight problem. The task was to fly the helicopter while diagnosing an in-flight mechanical problem, using the information with which they were provided. Those who took longer to solve the problem were exposed to more stressful warning messages. Results showed that nearly all the SHAPE trained crews used the SHAPE methodology to solve the diagnostic problem, while only about a fifth of the untrained crews did so. The SHAPE trained crews solved the problem more quickly, suggested fewer incorrect solutions, and exhibited less stress (as rated by blind observers and themselves). The SHAPE trained crews also performed the flight task better (i.e., deviated from altitude less) than untrained crews. In terms of group functioning, observers rated the SHAPE trained crews higher on anticipating what was to be done without explicit communication, having a better sense of timing, distracting teammates less with incongruent suggestions, and getting confused less often. The authors suggest that SHAPE training improved implicit coordination between team members by creating a common metacognitive decision making strategy. Thus, although SHAPE can be used as an individual training strategy, it is particularly effective for team decision making.

31. Hinsz, V.B. (1995). Mental models of groups as social systems: Considerations of specification and assessment. Small Group Research, 26(2), 200-233.

Hinsz defines a mental model as the representations that individuals hold about their interactions with a social system (i.e., group or team). Mental models include the individual's representation of the attributes, outcomes, and interactions he or she has with a variety of systems. They also include the individual's expectations and beliefs about the system; the individual's mental model influences the interaction he or she has with the system. Mental models are founded on personal perceptions, and are experience-based, dynamic, specific to particular systems, and idiosyncratic across individuals. This article presents several issues concerning group mental models (or socially shared cognitions), including analysis and measurement of the models within the social systems.

Measurement of a mental model includes identification of the potential states of the system, the potential outcomes of the system, and the states of interaction with the system. It also includes understanding how the individual perceives the attributes and interactions of the

system. Hinsz' *Belief Association Matrix* isolates the individual's mental model by determining his or her subjective probability estimates for the specific states and outcomes. According to Hinsz, the resulting matrix specifies the structure of the individual's mental model in terms of the various states that are important. Questions and concerns about the validity and reliability of assessed mental models are discussed. Hinsz concludes by suggesting that awareness of a team's or group's mental model can indicate potential roadblocks for achieving effective performance and, therefore, indicate potential solutions for improving team performance.

32. Hogan, J., Petersons, A.V., Salas, E., & Willis, R.P. (1991). Team performance, training needs and teamwork: Some field observations. (Technical Rep. 91-007). Orlando, FL: Naval Training Systems Center, Human Factors Division.[1]

Hogan et al. identify key components required for training tactical decision making teams based on an analysis of instructor experience. A literature review of team performance is included. Characteristics of a team include (a) having a goal, objective or mission; (b) possessing a formal structure; (c) demonstrating task interdependency; and (d) having specific role assignments. Citing Freeberg and Rock's (1987) meta-analysis, 24 variables are listed which impact team functioning, including the categories of external sources, task characteristics, member resources, and team characteristics. These variables are described as sources of restriction, regulation, reward, operating procedures, and goals for the team. Communication, in which members speak freely, approach decision making rationally, and evaluate and exchange ideas regularly, is considered a key component of effective team performance. Adaptive leadership that is responsive to the characteristics of the task is identified as being important. Twelve measures of team performance, including team cohesion and coordination, are discussed.

Hogan et al. administered questionnaires to 22 instructors at the Guided Missile School in Norfolk, VA, to identify the training needs for a tactical decision making team. The questionnaires probed six areas of performance requirements including leadership, communication, task organization, team decision making, team organization, and information transmission. Results indicated that the most common shortcoming of teams was ineffective communication between team members. Lack of awareness of performance standards, low sense of morale, and lack of task organization was also commonly reported. Inadequate basic skills, such as equipment operation, were also reported as common problems witnessed by training instructors. Overall, instructors report spending more time training individual skills and operating procedures than teamwork techniques. Feedback was restricted mainly to skill-level evaluations, rather than team performance. The instructors report that inter- and intra-team level communication was deficient. Hogan et al. make several suggestions for improving team training.

33. Hollenbeck, J.R., Ilgen, D.R., Sego, D.J., Hedlund, J., Major, D.A., & Phillips, J. (1995). Multilevel theory of team decision making: Decision performance in teams incorporating distributed expertise. Journal of Applied Psychology, 80(2), 292-326.

Using TIDE[2] software, Hollenbeck et al. tested a hypothesis which they had proposed for decision making in teams with distributed expertise. The hypothesis posited that a team decision

[1] This reference is unclassified, but has a limited distribution.

making process must be considered from the team level, the dyadic level, the individual level, and the decision level. At the team level, three core constructs were suggested: *team informity*, *staff validity*, and *hierarchical sensitivity*. Team informity is the degree to which the team is informed of the relevant information associated with the dimensions on which the decisions are based (i.e., situation awareness). Staff validity is the degree to which the team has members whose judgements are predictive of the "true score" of the decision object (i.e.., level of expertise/skill of individual members). Hierarchical sensitivity is the degree to which the team leader effectively weights staff members' judgements in arriving at the team's decision (i.e., assesses the accuracy of each members' input). At the lower levels (i.e., individual level or dyadic level), core constructs are similar to those of the team level, except at smaller doses. Individual validity, for instance, is the predictive validity of an individual team member. In addition to core constructs, there are also non-core constructs which are mediated through the core constructs. Non-core constructs include cue ambiguity, physical proximity of team members, individual's cognitive ability, job knowledge, group stability, cohesion, and role ambiguity. The model suggests that the decisions made by a team leader are influenced by each of the core constructs, which are influenced by the non-core constructs.

According to the authors, a multi-leveled view of team decision making permits an investigator to examine each component separately for strengths and weaknesses. Training can also address each level separately. Hollenbeck et al. tested their multi-level model on teams of four undergraduate students. Participants were asked to make judgements and decisions concerning the identification of aircraft (i.e., speed, direction of heading, threat potential, etc.). The team then produced a decision as to the level of aggressiveness the response should be (*review, monitor, warn, ready, lock-on, or defend*). Team members were trained in different aspects of plane identification (study 1: independent skills; study 2: overlapping skills). Members also varied in level of familiarity with each other and various other non-core constructs. Decisions made by the teams were then evaluated for accuracy. Results indicated that Team informity was of primary importance. If the team was not well assessed of the situation, good decisions could not be made. Good team informity translated into high staff validity (individual members could make good judgements). If the leader of the team was high in hierarchical sensitivity, he could then properly weigh the inputs from the team members and make a good decision. Variables such as familiarity and stability mediated, but did not significantly influence, overall team performance. One surprising finding was that poor stability (members leaving) influenced teams that had members who were previously familiar more so than those with non-familiar members.

34. Hollenbeck, J.R., Ilgen, D.R., Tuttle, D.B., & Sego, D.J. (1995). Team performance on monitoring tasks: An examination of decision errors in contexts requiring sustained attention. Journal of Applied Psychology, 80 (6), 685-696.

Research in vigilance reliably demonstrates a performance decrement that is complete within 35 minutes following the start of the task. Vigilance tasks are prolonged and require detection of a stimulus that is clearly perceptible but not compelling, occurs infrequently and without warning, and is not controlled by the observer. This study expected to replicate the vigilance decrement at the individual level (Hypothesis 1). Also, recent highly salient events that rarely occur can cause post-event errors in the form of "false alarms." This study expected to

find errors on the post-event (Hypothesis 2). Using teams to perform vigilance tasks should reduce errors, as all team members would have to fail to detect the stimulus. That is, if the probability of one person not detecting the event is .50, the probability of three people not detecting the event is .125. However, teams also present problems, such as poor judgement (i.e., ignoring a detection by a member), social distraction, and social loafing. This study predicted the vigilance decrement and post-event (critical trial) errors would occur for teams as well as individuals (Hypothesis 3). The study used an air defense tactical decision making team context (TIDE^2). Each member of the team had information that should be shared to make a decision. The leader, after receiving recommendations from the other three team members, made the final decision. Individual decisions (recommendations) and team decisions were registered on a seven point scale and compared to the "correct" decision. A decision that matched the "correct" decision was termed a "hit." One point off was a "near miss," two points off was a "miss," three points off was an "incident," and four or more off was a "disaster."

Two sets of 18 trials were run, three weeks apart. On the first set, nine presentations of hostile aircraft were followed by presentation of a non-hostile aircraft (critical event) and then another hostile aircraft (post-critical event). For the second set of trials, nine presentations of non-hostile aircraft were followed by presentation of a hostile aircraft followed by a non-hostile aircraft. For both individuals and teams, there were more errors on the critical events and post-critical event than the pre-critical event (i.e., ninth trial). Hostile or non-hostile scenarios had no effect. Thus all three hypotheses were confirmed. Analysis of message traffic showed evidence of social distraction (message content less task oriented as trials went on; more messages after critical event, but discussed failure on critical event, not current aircraft). Also, on post-critical events, leaders relied more on team recommendations than on critical events, therefore showing indecisiveness. Thus, this study shows little advantage for reducing vigilance decrement by making vigilance a team task.

35. Ilgen, D.R. (1999). Teams embedded in organizations. American Psychologist, 54(2), 129-139.

This paper reviews the current state of research on teams embedded in organizations. Ilgen briefly examines findings and trends from the last 30 or so years of team research. In the 80s and early 90s, research tended to focus on psychological processes involved in teamwork, including communication and interpersonal skills. Until recently, however, little attention was given to the organizational context in which teams operated. Team performance (and measures of outcome) was mostly neglected. Recent trends, Ilgen suggests, seem to be moving more towards understanding how teams work within the constraints of an organizational context.

Five critical issues – team performance, team training, levels of analysis, time, and team composition – are described as being the crucial concerns of current team researchers. Concerning performance, Ilgen discusses TEAM, an effort by the Navy to use critical incidents to describe good and poor team behavior. These incidents were then developed into behavior scales. This led to the identification of the teamwork and task work tracks and the development of teamwork dimensions cited elsewhere in this bibliography. Also under performance, Prichard's work on Productivity Measures (PROMES) is discussed. The PROMES is an effort to define and combine objective (outcome) measures of team performance and provide feedback,

goal-setting and rewards relative to those measures. Additionally, more attention is being provided towards developing normative models of teamwork, such as Fleishman's taxonomy of team performance (discussed elsewhere in this bibliography). In relation to training, Ilgen discusses cockpit resource management and teamwork training developed by the Navy. Concerning levels, the idea of teams of (embedded in) teams is discussed. With regard to time, Ilgen discusses how teams develop and change over time. Under team composition, homogeneity and diversity of team membership is discussed. He concludes by describing how research techniques are increasingly using simulations and case studies to understand team research. Additionally, team research is being conducted by more complex research teams, such as the Navy's multi-year project, TADMUS.

36. Johnston, J. H., Smith-Jentsch, K. A., & Cannon-Bowers, J. A. (1997). Performance measurement tools for enhancing team decision making training. In M. T. Brannick, E. Salas, & C. Prince (Eds.), Team performance assessment and measurement: Theory, methods, and applications (pp. 311-330). Mahway, NJ : Erlbaum.

The authors describe a technique, referred to as event based training, developed to improve team effectiveness by providing individuals and teams with feedback on process and outcome performance. In this technique, processes of task work (at the level of the individual) and teamwork (at the level of the team) are defined conceptually. A scenario is designed with cues and events which (should) cause these task work and teamwork processes to be performed. Behavioral indicators of individual and team processes (how the task was performed) and outcome (what was accomplished) are defined. Participants are run through the scenario and process and outcome performance measures are collected by observers. Observers use rating scales designed for the scenario, listing expected individual and team process and outcome behaviors to be elicited by the scenario events. The observers assign individuals and teams ratings on these scales according to process and outcome behaviors observed.

During the debriefing period, observers review definitions and examples of teamwork dimensions. Then the major exercise events and their outcomes are discussed. Third, positive and negative feedback on the teamwork dimensions, in the context of the scenario events, are discussed. Lastly, members agree on areas of strengths and areas for improvement, and set specific goals for the next exercise. Research suggests that this feedback improves team processes over trials.

37. Jones, G.R., & George, J.M. (1998). The experience and evolution of trust: Implications for cooperation and teamwork. Academy of Management Review, 23(3), 531-546.

This article describes the role of trust in teamwork and presents a multi-dimensional, interactive model of trust. Trust, according to Jones and George, is a psychological construct that reflects the interaction of people's values, attitudes, moods and emotions. An individual's value system provides a criterion by which to judge the events and actions of the surrounding world. Attitudes consist of the specific thoughts and beliefs held about other people, groups or organizations and define and structure how interactions will occur with others. Moods are temporary, shifting affective states that are not explicitly linked to specific events, whereas emotions are intense affective states that interrupt cognitive processes and behaviors and are tied

to particular circumstances. Both mood and emotion shape the perceptions of trust and distrust. A person's mood and emotions can influence impressions made during the initial experiences with an individual. A person's mood and emotion can also shape his/her own experience of trust, negatively or positively. Positive moods often lead to more trusting situations. Trust is built partly on expectations held about others. These expectations can be influenced by emotions and moods, particularly because emotions and moods are both specific and general and fluctuate temporally.

Trust evolves through stages. During an initial period of interaction, an individual usually suspends feelings of distrust until evidence is found to support the distrust. Over time, as the individuals or team develops a shared social situation definition, they adjust the level of trust between one another. If progress is made towards the development of a social situation definition, trust becomes conditional. Conditional trust is present when the parties involved are willing to transact with each other, so long as conditions, such as appropriate behavior, are met. Unconditional trust, on the other hand, occurs when trustworthiness is assured and there is a sense of mutual identification. In Jones and George's model, value, attitude, mood, and emotion contribute in important ways to the establishment of the different levels of trust and distrust. Unconditional trust is presented as a facilitator of interpersonal cooperation and teamwork. The authors list and define seven characteristics of unconditional trust that can lead to the development of highly effective and synergistic team relationships. These characteristics include broad role definitions, communal relationships, high confidence in others, help-seeking behaviors, free exchange of knowledge and information, subjugation of personal needs and ego for the common good, and high involvement. Each of these characteristics is described in terms of conditional versus unconditional levels of organizational trust.

38. Kalisetty, S., Kleinman, D. L., Serfaty, D., & Entin, E. E. (1993). Coordination in hierarchical information processing structures (CHIPS). Proceedings of the 1993 JDL Command and Control Research Symposium, Washington, D.C.: Fort McNair.

Many authors in the area of team performance hypothesize that teams are able to achieve better performance by anticipating the information and action needs of other team members. The authors developed an "upward anticipatory ratio." This ratio divides the number of instances that a subordinate supplies information or action by the number of instances that a superior requests information or action. Thus a ratio of greater than one means that subordinates are supplying information or action at a greater rate than it is being requested; or subordinates are anticipating superiors' needs for information or action. A higher ratio indicates that staffs are "pushing" information or actions forward without waiting to be specifically asked, while lower ratios (particularly 1.0 or lower) indicate that superiors must acquire information by "pulling" (requesting) it from the staff. Results from a study described in this paper show a high positive correlation between upward anticipation ratio and team task performance. Higher performing staffs push information more than lower performing staffs. The authors argue that upward anticipation ratio is an indication of better implicit understanding of information requirements and/or a better shared team mental model in higher performing staffs. The significance of this research is that it offers empirical evidence for the value of team members anticipating information or action needs of others.

39. Klein, G.A., Zsambok, C.E., & Thordsen, M.L. (1993). Team decision training: Five myths and a model. Military Review, 53(4), 36-42.

This article presents five common myths and counter-myths concerning team decision making. These include (a) Myth: Exercises alone provide the necessary team training; Fact: Providing practice without feedback accomplishes little; (b) Myth: Course instructors and supervisors already know how to train teams; Fact: Instructors need to be trained specifically in how to teach and observe teams; (c) Myth: The topic of team training is ambiguous because trainers have not figured out what should be trained; Fact: There is a strong shared agreement about what should be trained and several techniques have been developed; (d) Myth: Team decision training is expensive; Fact: Team decision training can be an add-on to existing training with minimal cost; and (e) Myth: Team training programs need to be streamlined into an organization with little interruption or instructor training; Fact: Minimizing instructor training is a mistake. Klein and his colleagues present a developmental model for teamwork (effective team decision making) that includes three components: team identity, team conceptual level, and team self-monitoring. Each of these components has specific behaviors that can be observed and improved. A model of advanced team decision making is presented and discussed. The most important step in team training, Klein suggests, is to teach team members and observers how to observe so that they can provide good feedback to each other.

40. Kleinman, D., & Serfaty, D. (1998). Normative-Descriptive modeling of human teams: A 15-year perspective. Proceedings of the Human Factors and Ergonomics Society 42nd Annual Meeting: Vol. 1, (pp. 206-209). Santa Monica: HFES.

Kleinman and Serfaty discuss the efforts conducted over the last 15 years by APTIMA, Inc., to develop a normative-descriptive (N-D) model of human teams. The push towards N-D modeling has resulted from the realization that prescriptive models, while successful at producing optimal solutions, do not accurately predict human behavior, and descriptive models, while successful at predicting human behavior, do so only when relevant data is available. The development of an N-D model involves producing a normative model of the behavior, generating predictions, running human participants through the model's operationalized task environment, and comparing the participants' results to the model's predictions. When consistent differences or biases result, constraints are added to the model. These constraints can be thought of as reflecting limitations in human information processing.

The APTIMA group has produced several N-D models that address decision making. Recently, the emphasis has focused on team-based decision making in which the teams are distributed and in which there is time pressure and uncertainty. This paper discusses one such model, the COordination and DEcision (CODE) concept. The CODE is based on the notion that team performance depends on coordination, particularly when members are separated by geography, abilities, resources, etc. Shared mental models form the basis for team coordination, situation awareness, and decision making. Findings from the N-D paradigm have suggested that the decision making strategies of teams tend to be myopic, projecting only into the near future. Team members are often "selfish" in their demands for limited resources. They often also overvalue their own information and responsibilities and undervalue those of their teammates.

Other recent findings suggest that successful teams must adapt to the mission environment. This adaptation includes changes in communication processes and structural makeup of the team.

41. Klinger, D., & Thordsen, M. (1998). Team CTA applications and methodologies. Proceedings of the Human Factors and Ergonomics Society 42nd Annual Meeting: Vol. 1, (pp. 206-209). Santa Monica: HFES.

Team Cognitive Task Analysis (CTA) is defined as a method for gathering information about a team's decision making and management strategies. This paper discusses the important role that critical incident interviews play in assessing a team's collective cognitive processes. It is suggested that the use of critical incident interviews allow the evaluators to observe team performances in events that go beyond the normal textbook procedures. Information accessed and utilized during decisions by the team is gathered into decision requirement tables. The tables then are used to help improve the performance of the team in areas such as planning, problem solving, and situation awareness. Each Team CTA is expected to describe five key components of team behavior. These components are concerned with how the team manages information, maintains shared situation awareness, develops shared mental models, develops expertise and implements strategies, and performs meta-cognitively. After describing Team CTA, Klinger and Thordsen review a few research projects where Team CTA was implemented. They conclude by suggesting that Team CTA is a valuable tool that is particularly useful in situations where the team must make decisions and judgments.

42. Kolb, J.A. (1992). Leadership of creative teams. Journal of Creative Behavior, 26(1), 1-9.

Kolb examines the effects of specific leadership behaviors on the performance of research (creative) and non-research teams. Research teams were those which have a "significant research component" whereas non-research teams are those which did not have a research component. Data was collected from 32 teams (16 research, 16 non-research) from various manufacturing, aerospace, and health services organizations. Team members completed the Ohio State University's Leader Description Questionnaire (1962) and the leadership section of LaFasto and Larson's Team Excellence Instrument (1987) and answered two open-ended questions about leadership. Team leaders answered the Team Excellence Instrument and the two open-ended questions. Team effectiveness was determined by asking managers knowledgeable of, but not involved in, the teams' research, to rate each team's current performance and their performance 3-6 months ago.

Results indicate that there was no difference between the leaders' behavior for the research and non-research teams. Several specific leader behaviors, however, were significantly related to the research team performance ratings. Leaders of successful creative teams tended to speak and act as the representative of the group. They maintained cordial relations with, and had influence with, superiors. They kept the group in good standing with higher authority. They exhibited trust by giving the team members important responsibilities. And, they provided team members with the necessary autonomy needed to succeed. None of these behaviors, however, was significantly related to non-research teams. Kolb discusses these results in terms of the

relationship between creativity and workplace environment. Creativity, she suggests, is promoted by the team having operational autonomy and strategic autonomy.

43. Kruger, L.J., Cohen, S., Marca, D., & Matthews, L. (1996). Using the Internet to extend training in team problem solving. Behavior Research Methods, Instruments, & Computers, 28(2), 248-252.

Citing a growing need for innovative training techniques, Kruger et al. present the results from a study designed to evaluate a training program that used face-to-face (FTF) and computer-mediated communication (CMC) instruction. Five participants (two teachers, two principals and a superintendent from the same school system) were involved in a five-month training program that was designed to help them develop team-based solutions to a real-world problem. The training involved two stages. The first stage, FTF instruction, consisted of three days of instruction in using electronic mail (all participants were novice users of electronic mail), team development, and problem solving. Following the FTF instruction, participants were given an email account which was to be used for communicating with other team members and a designated expert. The "linchpin" expert was the only non-team member who communicated directly with the participants about the real-world problem they were solving. Suggestions from other experts were funneled through the linchpin expert to the participants. Participants were allowed to direct e-mail to individual team members, to the group, to the linchpin expert, or to themselves (a strategy known as self-reflection). Following the five-month period, the 134 electronic mail messages that were exchanged were coded in terms of content. Messages were coded as being: observation-based, suggestion, conceptual information, personal information, support, specific feedback, group feedback, or global feedback. In addition, after re-reading the messages they had sent or received, the participants indicated what messages contributed to their expertise in problem solving and then completed Likert-scale questionnaires concerning their perceptions of the importance of CMC and FTF training modalities in their development of expertise.

Results indicated that the majority of the messages were observation-based information and that global feedback occurred least frequently. Only about half of the messages received were rated as being useful in contributing to the participant's expertise development. Of the content-categories, only specific feedback and conceptual information were related to perception of expertise enhancement. Furthermore, participants rated the use of FTF instruction as more useful than CMC instruction. Both were rated as being at least moderately helpful. Kruger et al. concluded that using CMC, such as electronic mail and the Internet, could be useful training techniques. They suggest that information which provides specific feedback and conceptual information is most likely to contribute to the development of expertise.

44. Larson, J.R., Christensen, C., Abbott, A.S., & Franz, T.M. (1996). Diagnosing groups: Charting the flow of information in medical decision-making teams. Journal of Personality and Social Psychology, 71(2), 315-330.

This study examined the use of shared and unshared information during group discussions of a decision problem. Specifically, Larson et al. investigated several hypotheses raised by the Information Sampling Model of Group Discussions. Previous findings had shown

that shared information tends to be discussed more than unshared information and that shared information is discussed earlier in conversation than unshared information. Criticism of earlier research, which involved non-experts making unimportant decisions, suggested that the model lacked generalizability. Larson et al. tested the model by applying it to medical personnel of varying degrees of expertise. Each participant of a three-person group (a resident, an intern, and a student) independently viewed one of three videotapes of a surrogate patient describing pain symptoms. Each videotape contained common and unique information; therefore, there was both shared and unshared information held by the three group members. After a group discussion, the group leader presented the group's diagnosis.

Results indicated that shared information was discussed more than unshared information. Shared information was discussed earlier than unshared information. The probability of shared information being discussed at a given item-serial position declined as the amount of shared items left to be discussed declined. The team leader tended to repeat information raised during discussion more than did the other group members. Contrary to predictions, in post-decision debriefing, team leaders listed more shared information than unshared information relative to other team members. These results are discussed as evidence supporting the Information Sampling Model of Group Discussions and suggest that the model can be generalized to expert decision making teams faced with real world decisions.

45. Leedom, D.K., & Simon, R. (1995). Improving team coordination: A case for behavior-based training. Military Psychology, 7(2), 109-122.

Leedom and Simon examined the effects of standardized behavioral training and battle rostering (fixed crews) on team coordination and performance. Three studies involving UH-60 pilots were conducted. In the first two studies, pilot-pairs (those who came to training previously assigned to each other) participated in a course designed to teach team coordination. Pre- and post training measurements were taken. The Attack Helicopter (AH)-64 grade slip was administered to rate performance levels. Team coordination behaviors were rated by flight instructors according to 13 behavioral scales of the Aircrew Coordination Evaluation. Crew attitudes were assessed with the Army Aviation Crewmember Questionnaire. Results indicated a significant improvement in performance and coordination following the team training. Crew attitudes improved in the first study, but not in the second study. In the third study, pilots who had previously gone through the standardized behavioral training were evaluated with their battle-roster partner in two simulations, and were evaluated with a randomly-assigned partner in another two simulations.

Results showed no significant difference in coordination or performance (except that the battle-roster teams had significantly more kills per attempt than did the mixed crews). Post-experiment interviews showed that the battle-roster teams gave higher intra-team familiarity ratings and performance confidence ratings than did the mixed crews. The authors concluded that the standardized behavioral training of team coordination was more effective at improving team performance than was battle-rostering and that battle-rostering had the effect of producing over-confidence and complacency in the cockpit.

46. Levine, J.M., & Moreland, R.L. (1990). Progress in small group research. Annual Review of Psychology, 41, 585-634.

The authors state that small group research is badly fragmented, due to the failure of researchers working on similar issues to recognize each others' work. The authors delineate small group research into five major categories based on the group's ecology, composition, structure, internal conflicts, and performance. Under ecology, research on physical environment (e.g., crowding, temperature, lighting, territories), social environment (e.g., inter-group relations, shared members, other non-member stakeholders), and temporal environment (e.g., group development, group formation, deadlines) are discussed. Under composition, research on composition as a cause (e.g., group size, demographic characteristics, abilities, opinions, personalities), composition as context (e.g., composition as a moderator variable), and composition as a consequence (e.g., composition as an effect; homogeneity of groups) are discussed. Under structure, research on status systems (e.g., social influence), norms (e.g., allocation norms, decision-making norms, how norms are produced, effects of norms), roles (e.g., leader, newcomer, scapegoat) and cohesion (e.g., measurement, causes, effects) are discussed. Under conflicts, social dilemmas (e.g., collective traps and fences), power, bargaining, coalition formation (e.g., which coalitions will form and how they will divide rewards) and minority-majority influence are discussed. Under performance, leadership (e.g., leader-oriented theories, exchange theories, cognitive theories), productivity (e.g., social loafing, team development, participative goal setting, task design) and decision making (e.g., quality of decision making, groupthink, techniques to improve decision making) are discussed. The authors have two major conclusions: group research is alive and well but living elsewhere (i.e., organizational psychology) and nothing is so good as a practical theory (i.e., a practical or applied approach to groups is good).

47. Mael, F.A., & Alderks, C.E. (1993). Leadership team cohesion and subordinate work unit morale and performance. Military Psychology, 5(3), 141-158.

The authors examine the relationship between leadership team cohesion, soldier attitudes, and platoon performance. The platoon leadership team consists of the squad leader, platoon sergeant and platoon leader. Leadership team Cohesion (LC), as perceived by squad members, was correlated with platoon cohesion, identification with the Army, job involvement, combat training center (CTC) motivation, career intent, and perceived platoon effectiveness. The LC, as perceived by squad leaders, was correlated with all the above except for identification with the Army. The LC, as perceived by platoon sergeants, was correlated with platoon cohesion, identification with the Army and perceived platoon effectiveness. The LC, as perceived by platoon leaders, was correlated with all the latter measures, plus job involvement. Perceptions of LC were correlated among squad members, squad leaders and platoon sergeants. Platoon leader ratings of LC correlated only with that of platoon sergeants. Ratings of actual CTC performance were made by observer controllers (OCs) and all levels of platoon personnel (after the rotation). Squad members' ratings of LC correlated with all ratings of CTC performance (by OCs, squad members, squad leaders, platoon sergeants and platoon leaders). Ratings of LC by other levels within the platoon were not as widely correlated with measures of platoon CTC performance.

The authors draw the conclusion that platoon LC, especially as perceived by squad members, is related to soldier attitudes and platoon performance.

48. Mallubhatla, R., Pattipati, K.R., Kleinman, D.L., & Tang, Z.B. (1991). A model of distributed team information processing under ambiguity. IEEE Transactions on Systems, Man & Cybernetics, 21(4), 713-725.

This study presents experimental results that validate a normative-descriptive model developed to predict distributed information processing in a three-person hierarchical team. Previous findings have indicated discrepancies between normative models and descriptive models of team-based decision making. Normative models, which typically utilize Bayesian techniques for data combination, generally deviate from descriptive models in ways that are predictable. The authors of this study created a model which incorporated into a normative model the human cognitive limitations and biases that generally produce sub-optimal performances. Conservatism and undervaluing of teammates' opinions represented the primary biases that influenced human decision performance.

Six teams of three decision makers (university students) were presented with 60 different detection tasks in four experimental sessions. Two subordinate team members received both unique and universal information pertaining to the threat likelihood of targets. One of the subordinates was considered to be expert at detecting neutrals; the other was considered to be expert at detecting threats. Expertise was manipulated by noise variances designed to provoke judgement errors 10% of the time for experts and 30% of the time for non-experts. Levels of ambiguity were also manipulated: on one level there was no ambiguity about the accuracy of the measurements; on the other, there was 20% ambiguity. The subordinates then communicated electronically their decision and confidence rating about the target threat level to the team leader. The leader, who previously had access only to the universal information, then combined the information from the two subordinates and made a final decision. The leader also estimated his confidence in the decision.

A normative model, using Bayes Likelihood Ratios, was generated and compared with the data obtained from the participants. Mean Square Estimates indicated a less than perfect fit. Constraints were then placed on the model to represent conservatism, recency, and undervaluing of subordinate opinions. The new model, considered to be normative-descriptive, fit the empirical data very closely.

49. Mastaglio, T.W., & Callahan, R. (1995). A large-scale complex virtual environment for team training. Computer Institute of Electrical and Electronics Engineers. Computer Group. Computer Group News), 28(7), 49-56.

Few computer-based simulations currently allow multi-users to interact with each other and the virtual environment. One such simulation, however, is the Close-Combat Tactical Trainer (CCTT) developed jointly by the U.S. Army and Loral. The CCTT is a cutting-edge distributed interactive simulation system which is used to train U.S. Army personnel. Specifically, CCTT consists of a network of computers located in various places around the country and is being used to train ground combat tank and mechanized infantry forces on

simulated equipment using a high-fidelity representation of the actual terrain. When fully completed, the CCTT will permit training on any of three terrain databases, each representing over 15,000 kilometers. Trainees can experience a virtual environment similar to the real world in any of the eight existing simulators: Abrams main battle tank, the Abrams enhanced main battle tank, the Bradley fighting vehicle, a dismounted infantry module, an armored personnel carrier, a fire support vehicle, and a high-mobility, multiple-wheeled vehicle.

This article describes the system and software architecture used to construct the CCTT network and discusses the revolutionary approaches used by engineers and developers during the design and implementation of the CCTT. Three approaches to development are addressed: concurrent engineering, spiral methodology, and usability engineering. The developers of CCTT employed a user-centered design approach which allowed for continuous evolution of the system. The CCTT is described as an exciting new tool that can be used to train soldiers effectively and cost-efficiently.

50. McGrath, J. E. (1997). Small group research, that once and future field: An interpretation of the past with an eye to the future. Group Dynamics, 1(1), 7-27.

McGrath discusses the segregated treatment of small group and team research that has existed in North America over the past 30 years and proposes a new line of research that reflects the beginning of a paradigm shift in team research. Three main trends, which are labeled by the institution with which they are mostly associated, are discussed. The Michigan school of small group research has primarily been concerned with understanding groups as "social systems that functioned as vehicles for influencing members." Major contributions from this school include Festinger's social comparison theory and dissonance theory. The majority of work conducted by researchers associated with the Michigan school has been laboratory-based experiments involving ad-hoc groups working under artificial conditions for short periods of time. The Harvard school of small group research has been concerned with understanding "intact social systems that function as vehicles for patterning human interaction." Major contributions from the Harvard school include Bale's interaction process analysis and Janis' groupthink model. The third group, the Illinois school, viewed groups as "social systems that functioned as vehicles for task performance." Contributions include work on small group decision making, leadership style, and communication patterns. This school was mainly concerned with identifying fundamental group processes that applied across domains and contexts; however, most work was conducted on a small range of groups working under contrived conditions. Interestingly, although the three schools were addressing the topic of small group research, they remained entirely separate from one another. Virtually none of the research produced by these schools has overlapped.

More recent research has been based essentially on three metaphors: groups as information processing systems, groups as conflict-managing systems, and groups as behavior-motivating, -regulating, and -coordinating systems. McGrath suggested that the focus of this research, however, is still limited by the research methods used by the investigators. He proposes that future research should consider teams as complex, adaptive and dynamic systems. Research ought to reflect the fact that teams are embedded in larger organizations, fluctuate over time, and are characterized by higher order interactions of many variables. McGrath briefly

outlines a theory he and his colleagues are currently formalizing that incorporates ideas from general system theory, dynamic systems theory, and the theory of complex systems. New research approaches involving simulations and modeling are proposed to trace the interactions and processes of small groups over time. Considered over time, small groups can be seen to evolve through the stages of formation, operation, and metamorphosis. The model developed by McGrath et al. and outlined in this paper proposes to address the complex, adaptive, and dynamic nature of small groups in exciting and different ways.

51. Minionis, D. P., Zaccaro, S.J., & Perez, R. (1995). Shared mental models, team coordination, and team performance. Paper presented the 10th annual meeting of the Society for Industrial and Organizational Psychology. Orlando FL: SIOP.

This paper examines the influence of team interaction training on team mental models, team coordination, and team performance. Team interaction training, which is premised on the belief that shared mental models are a necessary component of coordination and good team performance, addresses the individual and collective requirements for effective team interaction. These requirements include team members having an awareness of the roles and functions of other team members. This awareness includes understanding the information requirements of each team member and the specific nature of how team members interact with each other. The authors suggest that team interaction training, which is conducted explicitly within a team context, can result in improved performance.

In this study, teams of participants were provided with either high or low amounts of information concerning their teammate's roles, capabilities, and responsibilities. Training was given either to participants individually or as a team, and the enemy faced by the teams in a low-fidelity simulator was either highly or lowly capable. Measures of shared team interaction models, team coordination, team communication, and team performance were collected. To assess the team interaction mental model, each team member was asked to arrange a series of printed index cards to reflect the specific actions a fellow team member would take to complete a certain task. The percentage of time that at least two of the three team members produced the correct card sequence was taken as a measure of the shared team interaction mental model. Team coordination was measured by the average distance between the tanks during the simulation (tanks had to remain close in order to accomplish collective tasks). Team communication was measured by coding team verbal interactions into seven categories (e.g., planning, information exchange, execution). Team performance was measured by a number of objective indicators such as number of enemy destroyed. Performance was divided into overall performance and performance measures requiring team coordination to accomplish, referred to as coordinated performance.

Results indicated that providing team interaction information enhanced the overall team mental model and that teams possessing a team interaction mental model demonstrated better team coordination. Furthermore, the strength of the team interaction mental model was directly related to team performance, particularly in tasks requiring coordination. Teams which received training on the information requirements and roles and responsibilities of teammates demonstrated high levels of team interaction. Contrary to the author's predictions, training was equally effective at the individual and team level and there was no relationship between team

communication and the team interaction mental model. Also, better team interaction mental models were related to coordinated team performance, but not overall team performance. Finally, team interaction mental models did not ameliorate the effects of stress on team performance. The authors conclude that team interaction mental models can be trained and that team interaction mental models affect team coordination and coordinated performance.

52. Mullen, B., & Copper, C. (1994). The relation between group cohesiveness and performance: An integration. Psychological Bulletin, 115(2), 210-227.

Mullen and Copper present the results from a meta-analytic review of the cohesiveness and performance literature. A total of 49 studies, which rendered 66 separate tests of the cohesiveness-performance effect, were included in this study. The results indicated that there does exist a small, but significant, effect of cohesion on performance. This effect tended to be higher in studies that were correlational rather than experimental in nature. That is, studies which attempted to manipulate cohesion did not produce as strong of an effect as did those which used existing cohesion. According to the authors, the use of artificial groups appears to be driving this finding. Pre-existing or real groups that are smaller in size demonstrate a stronger cohesion-performance link than do ad-hoc or large groups. Additionally, the relationship between cohesion and performance is multifaceted, and the component, commitment to the task, more than interpersonal attraction or group pride, appears to contribute most to the link. Lastly, the results from cross-lagged panel correlations suggest that performance more strongly affects cohesion than does cohesion affect performance. The authors, however, caution the interpretation of this final finding. Cohesion and performance are inter-connected and the influence goes in both directions.

53. Orasanu, J., Fischer, U., McDonnell, L.K., Davison, J., Haars, K.E., Villeda, E., & Van Aken, C. (1998). How do flight crews detect and prevent errors? Findings from a flight simulation study. Proceedings of the Human Factors and Ergonomics Society 42nd Annual Meeting: Vol. 1, (pp. 191-195). Santa Monica: HFES.

Orasanu et al. report on a simulator study that examined monitoring and challenging behaviors of team members. In stressful situations, the redundancy resulting from team members monitoring each others' activities serves an important role in performance and error-prevention. This redundancy is useful, however, only when members challenge or question the faulty actions of others. In this study, 20 civilian pilots (10 captains and 10 first officers) were paired with a research confederate during several legs of a simulated flight. The confederate, who alternatively played the role of first officer or captain, was scripted to make errors during the flight. These errors committed by the confederate were considered to have high face threat. Face threat is the degree of challenge to the status or integrity of the person being challenged. During low stress periods, errors were committed in the instructions provided by the air traffic controller. These errors were considered to have low face threat. It was hypothesized that the captains would be more likely than the first officers to comment on the errors, regardless of the face threat. The errors were categorized as high or low risk to the flight crew. It was hypothesized that more high risk errors would be detected and corrected than low risk errors.

The results indicated that the intended manipulations of face threat and risk were correctly interpreted by the participants. Captains detected and commented on slightly more errors than did the first officers. The level of risk made no significant difference in the number of errors detected, and face threat had little influence on the performance of either the captains or the first officers. Despite these findings, Orasanu et al. concluded that captains appeared to be more sensitive to risk and that first officers were more sensitive to face threat. First officers were more hesitant to question the captain's authority than they were to question the authority of the air traffic controller. Monitoring and challenging behaviors in the cockpit are still influenced by social considerations despite the crew resource management training that all participants had previously received.

54. Orasanu, J., & Salas, E. (1993). Team decision making in complex environments. In G.A. Klein, J. Orasanu, R. Calderwood, & C.E. Zsamkok (Eds.), Decision making in action: Models and methods (pp. 327-343). Norwood, NJ: Ablex.

According to the authors of this study, team research involving ad-hoc groups provides little insight into real teams. It has been suggested that the development of a mental model shared by team members is important to performance. In ordinary situations, teams can rely on standard procedures to guide their actions. However, in order to be successful during novel events, teams must develop situation models that include shared understanding of the problem, goals, information cues, strategies and member roles. These shared situation models allow for predicting behavior or needs of other team members and promote more effective communication. For instance, research by the lead author found that aircraft crews which were successful in dealing with simulated emergencies were more explicit in articulating to the crewmembers the problems and plans for coping with the event. Further, it was found that teams tended to use a similar decision making strategy as individuals. Teams considered one option at a time, used their individual and collective experiences to assess and classify the situation, chose the most plausible option, and evaluated its adequacy by mental simulation. The team then either executed the response, modified and re-simulated the response or re-assessed the situation. Therefore, the authors suggest, the principles advocated by the Recognition Primed Decision Making (RPD) model can be applied to teams as well as individuals.

The authors advance two approaches to developing training for effective teams. One is to use emerging theory as a guide and train the skills suggested by the theory. An example of this approach would be to use RPD principles to train teams in situation assessment. Another approach to training is to identify features of successful and less successful teams. Examples of this approach are work by the Navy in training task-work (e.g., situation awareness, mission analysis, decision making) and teamwork (leadership, adaptation, assertiveness, communication). Other examples include studies involving cockpit resource management/aircrew coordination training. According to the authors, the methods of team training and research are expanding beyond the traditional laboratory to include analysis of group behavior in natural settings.

55. Pacanowsky, M. (1995). Team tools for wicked problems. Organizational Dynamics, 23(3), 36-51.

The author differentiates between tame and wicked problems. Tame problems are those with known algorithms for arriving at solutions. These problems can be solved by thinking "inside the box." Although tame problems can be challenging, they are familiar and manageable. Wicked problems, on the other hand, have no known algorithms for solution and must be solved by working "outside the box." They are difficult to define and have an iterative nature, which includes cycling through definition, information gathering, solution, and outcome. Tame problems can be solved by applying a process similar to the Military Decision Making Process (define, generate alternatives, evaluate alternatives on a set of criteria, implement, and seek feedback). To solve wicked problems, however, new team tools or methods are needed. The author discusses five tools: (a) promoting a spirit of inquiry, (b) creating shared displays, (c) managing the "surround" (whole context of learning and knowledge generation and exchange), (d) managing the polarity between teams and individuals', and (e) reflection.

The tool, spirit of inquiry, involves question brainstorming, question division, and thinker-questioner-reflector (TQR). In question brainstorming questions rather than answers to problems are generated. In question division, questions are separated into those pertaining to imagination (what if), fact (what is), and value or need (what should). The TQR involves one team member providing ideas, another member asking questions, and the rest reflecting on the dialogue. The tool, creating a shared display, involves coming up with a common picture of the group discussion. Techniques for creating a shared display include creating domain maps in which causal links are suggested between the problem and its potential solutions. As these answers are organized according to the relationships between them, the domain map becomes a mind map. When these concepts are linked by cause-effect relationships, this becomes a cause map. The tool, managing the surround, involves changing learning from the "person-solo" model to the "person-plus" model. Learning should involve social and extra-cognitive factors (e.g., teams may work better facing each other than sitting in lines). The tool, managing the polarity, involves recognizing that working as individuals and as teams both have advantages (e.g., accountability and synergy, respectively) and disadvantages (e.g., redundant effort and groupthink respectively). Successful problem solving involves cycling back and forth between an individual and team perspective, maximizing the advantages of each approach and minimizing the disadvantages of each approach. Lastly, the tool, reflection, involves both on- and off-line processes. Reflection utilizes both mental simulation and group solution generation, such as developing "icons" for general problems.

56. Proctor, M.D., & Lipinski, M.J. (1999). <u>Measuring the contribution of distributed simulation to unit training</u>. Unpublished Manuscript. University of Central Florida at Orlando.

This paper examines the effectiveness of the Close Combat Tactical Trainer (CCTT) simulation for training team skills in Army units. Because of resource constraints, simulation will become an increasingly important training tool. However, for the training to be effective, good measures must be developed to provide feedback to units. Traditional measures, such as loss exchange ratio (LER), are not particularly good measures of performance. This study used structured scenarios, containing events such as Mission Training Plan (MTP) tasks, to measure task and teamwork performance. Task performance was defined as success or failure on sub-tasks contained in each event. Teamwork was defined as ratings on Navy teamwork dimensions

of information exchange, communication, team initiative and leadership, and supporting behavior. Each of these dimensions have several associated behaviors that are described on the rater worksheet. In this study, company-sized units ran identical pre- and post-Movement to Contact scenarios in CCTT. After action reviews (AARs) followed both missions.

Results showed statistically significant improvement on task and teamwork performance between pre- and post-scenarios. Teamwork performance improved on all four dimensions (information exchange, communication, team initiative and leadership, and supporting behavior) and for 13 of the 15 specific behaviors under the dimensions. The author reviews the results of a limited user's test of CCTT. These results show that although task performance did not improve over CCTT trials, the CCTT-trained group performed significantly better than baseline groups at the National Training Center. The author suggests that if more sensitive task and teamwork measures are used, company teams will show performance improvements over CCTT trials.

57. Rentsch, J.R., Heffner, T.S., & Duffy, L.T. (1994). What you know is what you get from experience: Team experience related to teamwork schemas. Group and Organization Management, 19(4), 450-474.

The authors explore the relationship between generic teamwork experience and mental models of teamwork. Participants, classified as high or low on teamwork experience, sorted 100 teamwork adjectives into self-chosen, self-labeled categories. Similarity ratings were made for each pair-wise grouping of the categories. These ratings were analyzed using multi-dimensional scaling (MDS). Participants also arranged the selected titles on a board to indicate inter-relationships (concept mapping). Participants scoring higher on generic teamwork experience used fewer categories to describe teamwork. Also, blind raters gave higher similarity ratings between the MDS and concept map solutions for those higher in teamwork experience. Thus, those with more teamwork experience had more concise (fewer categories) concepts of teamwork and represented their teamwork knowledge more consistently. The authors suggested that novice team members may benefit from more factual training in teamwork, while more experienced team members would benefit from working in novel team settings.

58. Saavedra, R., Earley, P.C., & Van Dyne, L. (1993). Complex interdependence in task-performing groups. Journal of Applied Psychology, 78(1), 61-72.

Complex interdependence is defined by the authors as the consequences for group processes and performance that arise from the interaction of task interdependence, goals, and performance feedback. Importantly, complex interdependence reflects the consequences of the interactions that are different from the consequences which would be predicted by considering task interdependence, goals, or feedback independently. This study examined the effects of different types of task, goal, and feedback interdependence on group performance. Specifically, four types of task interdependence were considered: pooled interdependence, sequential interdependence, reciprocal interdependence, and team interdependence. Pooled interdependence refers to tasks in which group members all perform the same task with little dependence upon one another. Group performance is the sum of the performances of the individual members. Sequential interdependence refers to tasks in which group members cannot perform their tasks until other group members have completed their tasks (e.g., an assembly

line). Reciprocal interdependence refers to tasks in which one group member's output becomes another member's input and vice versa. In this situation, members generally have specialized roles and work flexibly with each other. Team interdependence refers to tasks in which the group jointly determines how the task should be accomplished and what goals should be sought (e.g., self-managing teams). Two types of goal interdependence were considered: group goals and individual goals. Two types of feedback were considered: group feedback and individual feedback. It was hypothesized that congruency between the type of task, goal and feedback would lead to optimal performance and reduced intra-group conflict.

Participants (118 three person teams of undergraduate students) were asked to make recommendations of raises given to hypothetical employees. A factorial design was implemented: 4 (task interdependence) x 2 (goal interdependence) x 2 (feedback), and teams were randomly assigned to one of the 16 conditions. Performance measures included the quantity and quality of the raise recommendations and self-reported measures of task strategy and conflict. Results generally supported the hypothesis that congruency between the complex interdependent components lead to improved performance and less conflict. For instance, under conditions of pooled task interdependence, performance was optimal when individual goals were set and feedback was provided individually rather than to the group as a whole. Conditions of team interdependence, on the other hand, benefited from setting group goals and providing group feedback. The authors make suggestions about designing tasks that take into consideration complex interdependence.

59. Salas, E., Bowers, C. A., & Cannon-Bowers, J. A. (1995). Military team research: 10 years of progress. Military Psychology, 7(2), 55-75.

The authors review the military team literature of the 1980s with specific attention to theoretical developments in team processes, measurement and training. Advances in theory, such as the Team Evolution and Maturation model, and insights into team processes, such as performance monitoring and backup behavior, are discussed. The notion of implicit coordination, which led to the idea of shared mental models, is heralded as an important contribution. In terms of measurement, standardized scoring criteria such as the critical team behavior form (CTBF) and the aircrew coordination observation and evaluation (ACOE) checklist, began to evolve during the 80s.

The authors then review military team research in the 1990s in terms of the same categories of theoretical developments, processes, measurement, and training. Major advances in theory, such as the Team Effectiveness Model (TEM), are discussed. Research into task characteristics during the 90s emphasized workload, time pressure, and structure. Individual characteristics included individual proficiency. Team characteristics included cohesiveness and inter-positional uncertainty. Various types of mental models, including models of the equipment, team (roles) and task, are mentioned. The major team process researched in this era was communication, but others, such as decision-making, situational awareness, leadership, adaptability, mission analysis and assertiveness were also found to relate to team performance. Measurement during this period included targeted acceptable responses to generated events or tasks (TARGETS). Task analysis of team procedures were used during the development of team

training tasks, and different training techniques, including role playing and simulation, were experimented with.

The authors discuss future research needs in terms of theoretical needs, processes, measurement, and training. In terms of theoretical needs, past research has focused on the behavioral aspects of team performance, while future research needs to focus on cognitive (e.g., shared mental models) and attitudinal aspects of teamwork. Concerning team attitudes, research is needed on the complex relation between team cohesiveness and performance. Also, the nature of competencies required to be an effective team member requires research. Concerning processes, more research into the interactions among input-process-outcome variables is needed. Research on team communication, and effects of automation on teamwork, is also needed. Concerning measurement, measures of cognitive functioning (e.g., mental models) and automated data collection methods are needed. Training research needs include training of distributed teams, use of pre-specified scenarios to trigger practice of targeted behaviors, and use of distributed interactive simulation (DIS) for training. In order to use DIS, training issues such as how to structure distributed scenarios, how to capture performance data, and how to conduct after action reviews must be addressed.

60. Salas, E., Cannon-Bowers, J.A., & Blickensderfer, E.L. (1993). Team performance and training research: Emerging principles. Journal of the Washington Academy of Sciences, 83(2), 81-106.

The authors reviewed the team literature of the 1960s through the 1990s. In the 60s to 70s, the role of interpersonal skills in team performance was first emphasized. This foreshadowed later work on team processes. Then individual skills were studied. However, other researchers noted that individual skills did not account for team performance--there was a process loss. Therefore, the idea of team skills was developed. In the 80s, the concepts of task work and teamwork were developed. Teamwork or team processes were then defined. Research on the evolution of teams over time was performed. In the 90s, many areas of teams were researched. Much research on identifying team skills or processes was performed. Team skills such as adaptation or anticipating other team members' needs caused the concept of shared mental model to be developed. Salas developed a comprehensive input-throughput-output team model, which considered the external environment teams operate in. Measurement issues were also raised. Both team processes and outcomes must be assessed, at the individual and team levels. Team measures must describe, evaluate and diagnose. Rating scales and behavioral event measures were developed. Team training was explored, and role playing and cross training were found useful. The authors propound team performance and the following training principles: Individual proficiency must precede team proficiency; team training must both diagnose and remediate team performance; team training must include lecture, modeling, practice (role playing) and feedback; team training must emphasize interdependence and teamwork skills; team training must allow for systematic (deliberate) practice (repetition).

61. Salas, E., Cannon-Bowers, J.A., & Johnston, J.H. (1997). How can you turn a team of experts into an expert team?: Emerging training strategies. In C.E. Zsambok & G. Klein (Eds.), Naturalistic Decision Making (pp. 359-370). Mahwah, NJ: Earlbaum.

Decision making under stressful situations often leads to costly mishaps and errors. Part of the reason for these mistakes is a breakdown in communication and coordination among team members. The authors of this book chapter examine recent research on the influence of shared mental models on team performance. They suggest that teams with good shared mental models rely less on communication, have better coordination, and are more apt to be anticipatory in their interactions with the team leader. Shared mental models help the team members to have similar expectations and assumptions, which lead to better decision making performance.

Cross-training is discussed as an effective means for teams to develop shared mental models. The Team Model Trainer (TMT) is presented as a training technique which has been empirically shown to improve performance through enhanced communication and coordination processes. Another training approach, called Team Adaptation and Coordination Training (TACT) is presented as a means for increasing the anticipatory behaviors of team members. For instance, communication patterns indicated that TACT-trained members were pushing information to the team leader rather than waiting for the information to be requested by the leader. Both TMT and TACT techniques have been shown to improve team performance under stressful situations. The authors suggest that the Naturalistic Decision Making paradigm is beginning to be implemented into effective training strategies. They conclude the chapter by presenting lessons learned so far and offering guidelines for creating expert teams out of a team of experts.

62. Salas, E., Fowlkes, J.E., Stout, R.J., & Milanovich, D.M. (1999). Does CRM training improve teamwork skills in the cockpit?: Two evaluation studies. Human Factors, 41 (2), 326-343.

This article reports on two studies that utilized the training techniques advocated by the Crew Resource Management model. In the first study, the skills needed for communication, assertiveness, mission analysis, and situational awareness were chosen for training. Training was delivered to a set of crews via lecture, demonstration (videotape), practice (role-playing) and feedback. Assessment consisted of evaluation of training, attitudes toward CRM, knowledge of the principles of teamwork, and use of skills in simulated flight (behavioral changes). The behavioral assessment used Target Acceptable Responses to Generated Events or Tasks (TARGETs). A flight scenario was generated, with events that provided teams the opportunity to exhibit specific, pre-determined behaviors trained in CRM. Subject matter experts, armed with lists of these specific acceptable behaviors, evaluated crew performance to determine whether these behaviors were exhibited or not. The scenario was a low fidelity computer simulation, which consisted of a planning phase, a low workload phase, and a high workload phase. One set of crews took the knowledge test and flight simulation prior to CRM training and another set of crews took the knowledge test and flight simulation after training. Results showed that the crews evaluated training positively. Attitudes toward CRM improved from pre- to post-training. Crews taking the test of knowledge of teamwork principles after CRM training scored better than did crews taking the test before CRM training. Similarly, pilots performing the flight simulation after CRM training "hit" more TARGETs than did pilots performing the flight before CRM training. This was particularly true for the planning and high workload phases of the flight.

In the second study, CRM training was expanded to include communication, decision making, leadership, situation awareness, mission analysis, assertiveness, and adaptability/ flexibility. This CRM training was administered to a group of more experienced aviators. Both pre- and post-data were collected on CRM attitudes and on a flight simulation for both CRM-trained and untrained (control) crews. Training evaluations by the trained crews were positive; however, attitudes toward CRM did not improve for either trained or untrained crews. The trained group scored higher on teamwork knowledge than did the untrained group. Performance improved from pre- to post-assessment only for the trained group, and it was most improved in the planning and high workload phases. This research demonstrates that CRM training can improve teamwork. According to the authors, for team training to be effective, it must be theory based, use a set of competencies specific to the team and task, and use evaluation at multiple levels (e.g., attitudes, knowledge and skills).

63. Salas, E., Prince, C., Baker, D.P., & Shrestha, L. (1995). Situation awareness in team performance: Implications for measurement and training. Human Factors, 37(1), 123-136.

The authors state that situation awareness (SA) is ill-defined. However, there does seem to be some agreement that SA is achieved by perceiving with expectations (i.e., active versus passive perception) based on a pre-existing knowledge base (schemata). The information perceived is integrated using this schemata, which guides comprehension, projection and selection of necessary actions. The SA is continually updated. A review of the relevant literature suggests that team SA involves individual SA and team processes (teamwork). Relevant expectations of team issues or shared mental models are also involved. The authors then discuss measurement and training issues. Concerning measurement, researchers must consider what to measure (individual SA, team processes, and mental models), when to measure (SA is not static) and how to measure (using complex scenarios, with embedded events eliciting key behaviors and processes). Concerning training, researchers must consider what to train (individual processes such as information seeking and processing, plus team processes such as communication), when to train (teams have life cycles) and how to train (practice with feedback, including presentation, demonstration [modeling], and practice of teamwork skills, with feedback). For instance, the authors suggest that cross-training may enhance mental models and situation awareness.

64. Schlechter, T. M., Zaccaro, S. L., & Burke, C. S. (1998). Toward an understanding of the shared mental models associated with proficient team performance. Paper presented at the meeting of the American Psychological Society, Washington, D.C.: APS.

This research examined differences in mental models of experienced and inexperienced platoon-level leaders. Mental models are hypothesized to have three components -- procedural, declarative and conditional knowledge. Procedural knowledge concerns how to do a task or activity. Declarative knowledge concerns why a task or activity should be performed. Conditional knowledge concerns when a task or activity should be performed. Based on a cognitive task analysis of platoon leaders' duties, the authors designed measures for each of the three types of knowledge. Procedural knowledge was measured by mapping items. Participants

were required to complete a procedural map for various platoon-level tasks. The participants were to graphically depict the sequential activities of the platoon for each task. Declarative knowledge was measured by Mission, Enemy, Terrain (own) Troops and Time (METT-T) items. Participants were required to rate the importance each METT-T factor had in a specific tactical situation. Conditional knowledge was measured by battle-action items. Participants were required to rate the importance of 18 platoon tasks in relation to successful completion of different battlefield missions.

The results of the study indicated that experienced platoon-level leaders produced higher quality procedural maps than did the inexperienced platoon-level leaders. Significant differences were also found between experienced and inexperienced platoon-level leaders on ratings of several METT-T elements. Experienced platoon-level leaders' ratings of battle action items were more congruent with SME ratings than were those of inexperienced platoon level leaders. Also, conditional knowledge between experienced and inexperienced participants differed. Significant differences between experienced and inexperienced platoon level leaders were found on 36% of the battle action items. Overall, it would appear that experienced leaders hold mental models which are dissimilar to the mental models held by inexperienced leaders. These differences are seen at the procedural, declarative and conditional knowledge levels.

65. Siebold, G.L. (1999). The evolution of the measurement of cohesion. Military Psychology, 11(1), 5-26.

Cohesion has long been considered a cause of effective unit performance, in terms of a "force multiplier" or mitigating the effects of stress on performance. Seibold reviews several ideas about cohesion that were developed over the past century. Durkheim posited the possibility of inadequate cohesion (individuality), appropriate cohesion, excessive cohesion (too much altruism), or inconsistent bases of cohesion (anomie). Shils and Janowitz defined cohesion in the German Army in terms of degree of stability. The "hard scientists" (Lewin, Moreno and Bales) of the 1940s attempted to measure cohesion using field theory and sociometry. The "small groupers" after World War II (WWII) defined cohesion in terms of attraction to the group, a definition considered ineffective by Siebold. The applied researchers of the 1980s studied real-world groups, with real world outcomes (e.g., productivity), measured cohesion by questionnaires and conceptualized cohesion in terms of group integrity. Sports psychologists of this group highlighted two factors: individual to group cohesion (similar to attraction to the group) and group as a unit cohesion or group integrity. The latter factor was more often associated with team performance. The Walter Reed Army Institute of Research (WRAIR) studied cohesion as part of the new (unit replacement) manning system. They defined cohesion as individual soldiers' perceptions of personal confidence. The Army Research Institute (ARI) took a different tack. They focused on small units (squads and platoons), examined how to train cohesion, used mission performance as a criterion variable and conceptualized cohesion in terms of social control. Cohesion consisted of horizontal (peer), vertical (with leaders) and organizational (identification with the values of the organization) cohesion. Survey measures of cohesion correlated with simulated unit combat performance. The author concludes that cohesion as social control is a useful conceptualization and is both cause and effect of unit performance. Lastly, cohesion must be measured over time as it is not static.

66. Solomon, C.M. (1993). Simulation training builds teams through experience. Personnel Journal, 2(6), 100-108.

Team building through the use of simulation is currently popular in the business world. Solomon, a freelance writer, discusses some of the products being used by companies such as Southwest Airlines, International Business Machine (IBM), and Hostess Frito Lay. The effectiveness of these programs is emphasized through anecdotal evidence suggesting that these simulations enhance team members' self-awareness and self-monitoring. For instance, programs like the Crocodile River training, used by Southwest Airlines, is said to help team members discover their personal role on the team and the roles of their teammates. A member's role on the team is meant to be descriptive rather than qualitative. For example, a member might be seen as an innovator with creative ideas, or as a monitor/evaluator who stands back and watches the process.

Through simulation, according to Solomon, members develop what Jon R. Katzenbach calls team working skills, including basic communication and interpersonal skills. For these team building simulations to be effective, they must be combined with more traditional training methods and the type of training must be appropriate for the team. Furthermore, Solomon says, there are appropriate times for simulation training during the team's life cycle. For instance, the period immediately following a downsizing in which the team loses members is not a good time for simulations. If used appropriately, however, team building simulations can be useful for businesses.

67. Spiker, V.A., Nullmeyer, R.T., Tourville, S.J., & Silverman, D.R. (1998). Combat mission training research at the 58th Special Operations Wing: A summary (AL/HR-TR-1997-0182). Mesa AZ: Air Force Research Laboratory Human Effectiveness Directorate.

This report documents three studies conducted at Kirtland Air Force Base, the first of which is relevant to this annotated bibliography. Spiker, Nullmeyer, and Silverman examined the effects of Crew Resource Management (CRM) training on the mission performance of the air crewmen of Special Operational Forces (SOF) MC-130P Combat Shadow helicopters. The CRM training encompasses crewmember tasks such as team coordination and communication and has recently become a mandatory concern of Air Force instructors. The CRM training includes situation awareness; group dynamics; effective communication; risk management and decision making; workload management; stress awareness and management; mission planning, review and critique strategies; and human performance. Sixty-seven crewmembers were evaluated during the fifth day of their annual refresher training. The simulated training mission included mission preparation, low-level navigation using night vision goggles, an air refueling, an airdrop to a "blind" drop zone, and a covert infiltration/exfiltration. Data was collected using a multi-measure, multi-method mix that included behaviorally anchored rating scales and naturalistic observations.

The study produced several interesting findings. Team coordination was found to be strongly and positively related to mission performance. The quality of pre-mission planning was found to be positively related to ratings of crew coordination. Also, teams who perceived that

they had performed well also perceived that their team had good coordination. Components of the Tactical Team Resource Management (T^2RM) were differentially related to overall performance; the only component that was not related to performance was crew level Command, Control, Communication (C3). Different crew positions were also differentially related to overall team mission performance; four crew positions were strongly correlated with overall T^2RM and two crew positions were weakly related. Furthermore, the importance of crew position to overall T^2RM was mediated by the type of mission the crew was performing. And, crew positions and T^2RM sub-processes interacted with the type of mission. These findings suggest that training objectives should be specific at various levels (including mission, task and platform) and should dictate criteria for individual crewmembers at specific crew positions. The CRM training should be made more explicit during the annual refresher training course. Training feedback should be geared towards CRM performance and organizational effectiveness. Mission planning processes should be given greater emphasis during training and might benefit from advanced planning materials and other training tools.

68. Spiker, V.A., Silverman, D.R., Tourville, S.J., & Nullmeyer, R.T.(1998). <u>Tactical team resource management effects on combat mission training performance</u> (AL/HR-TR-1997-0137). Mesa AZ: Air Force Research Laboratory Human Effectiveness Directorate.

This report documents the efforts by researchers at ANACAPA Sciences, Inc, to identify the components of mission performance. Spiker et al. have proposed a model of mission-relevant behaviors called Combat Mission Training and Tactical Team Resource Management (T^2RM). The T^2RM is loosely based on the commercial airline industry's Crew Resource Management (CRM) model and represents core skills necessary for effective combat mission training. These skills include situation awareness (SA), function allocation (FA), tactics employment (TE), time management (TM), and command, control and communication (C3). Components of the mission include mission preparation (MP), low-level tactical operations (LL), air-refueling (AR), airdrop (AD), and infil/exfil (I/E). The purpose of this study was to replicate and extend previous findings that mission performance was related to team coordination, and to identify key behaviors and characteristics of effective aircrews, while validating a multi-method, multi-measure mix of measurement tools.

Eleven SOF aircrews were followed through an eight month annual review training, during which time they were observed, questioned, surveyed and measured as they performed mission scenarios. Fairly sophisticated and clever measurement techniques were applied. The results and conclusions drawn from the study suggest that crew coordination processes were a significant predictor of mission performance, and that the T^2RM skills (with the exception of C3) were all highly correlated with mission performance. Different aspects of the mission, such as MP and LL, were more highly affected by crew T^2RM, and different sub processes of T^2RM impacted mission performance differentially. For instance, mission preparation was most influenced by situation awareness, whereas low-level operations were most influenced by function allocation. The conclusion is drawn that concrete behaviors of effective team processes can be isolated and subsequently trained.

69. Steckler, N., & Fondas, N. (1995). Building team leader effectiveness: A diagnostic tool. Organizational Dynamics, 23(3), 20-35.

Steckler and Fondas present a technique for identifying the sources of ineffectiveness in leaders of self-managing teams. They propose that workplace difficulties are often inappropriately addressed because the source of the problem has been misidentified. Problems can be brought on by an interaction of the external work environment, internal workings of the team, and the team leader. The "building blocks" of skills used by effective team leaders are organizational, psychological, and behavioral in nature. Organizational building blocks include factors such as incentive systems, role descriptions, and autonomy. Psychological building blocks include emotional stability, willingness to be proactive, and comfort level with peers, subordinates and superiors. Behavioral building blocks include communication skills, the ability to recognize the overlap between personal and organizational goals, and negotiating skills. These building blocks are affected at the level of the leader's relationship with himself/herself, relationship with higher and lower level employees, and relationship with peers (i.e., other team leaders). When team leaders encounter difficulty in their ability to manage effectively, it is important to diagnose which level of interaction is the source of the problem. For instance, organizational characteristics, such as ratings based on team leader comparisons, cause competitiveness amongst peers. As a result, cooperation between teams might be inhibited. The authors present examples of the different types of difficulties encountered by team leaders at two Fortune 500 companies. An example of a problem is given for each level of building block interaction. Techniques for remedying the most common leader problems are suggested. These techniques include developing better communication and organizational skills, and redesigning rating structures such that cooperation between leaders is encouraged.

70. Stewart, G.L., & Manz, C.C. (1995). Leadership for self-managing work teams: A typology and integrative model. Human Relations, 48(7), 747-770.

This paper addresses the role of leaders and leadership styles in self-managed work teams, specifically concerning the question, "How does one lead others who are supposed to lead themselves?" Self-managed teams are defined by Stewart and Manz as work groups that are "formally organized into teams and then, as a whole, given responsibility and authority beyond that traditionally experienced by line workers" (p. 749). Leadership, in the form of guidance and direction, is provided by a formally recognized team leader. A typology is developed which includes four cells of leadership style (Overpowering, Powerless, Power Building, and Empowered) based on two bipolar dimensions: Leader involvement (ranging from active to passive) and leader power orientation (ranging from autocratic to democratic).

Overpowering leadership (autocratic and active) is said to be detrimental to team effectiveness because the team is never given autonomy and has a false sense of empowerment. Powerless Leadership (autocratic and passive) is evidenced in leaders who are silent observers of the team process as long as the team's performance is congruent with the leader's expectations. If the results do not meet the leader's expectations, punishment and sanctions are doled out. This leadership style creates an atmosphere of ambiguity. Power Building (democratic and active) occurs when the leader provides guidance and teaching skills but retains control over team behaviors. Quality of performance is increased, but the team never has the feeling of true

autonomy. Empowered leadership (democratic and passive) is presented as the optimal style. When the team initially forms, the leader plays an active role until self-regulation skills are developed, at which point the leader takes a more passive role. An empowered leader interacts with external groups and helps define the team's position in the grander scheme, thereby reducing ambiguity.

Social Learning Theory (SLT) is presented as the foundation for the typology. Stewart and Manz discuss relevant components of SLT (triadic reciprocality, person and situation characteristics, cognitive mediation, supervisory goals, and team leader behaviors) in a newly fashioned model that is particularly influenced by the cognitive perceptions and goals of the team leader. Ten propositions are made that predict the influences of Stewart and Manz' model of leadership on self-managed teams.

71. Stout, R.J., Cannon-Bowers, J.A., Salas, E., & Milanovich, D.M. (1999). Planning, shared mental models, and coordinated performance: An empirical link is established. Human Factors, 41(1), 61-71.

This research examines the effects of team planning on shared mental models, pro-active providing of information, and performance (errors) in a low fidelity simulation (Gunship). Two person teams playing Gunship were divided into top and bottom thirds on the basis of ratings of planning performance in the pre-mission stage. The teams then completed four mission segments, the first two under low workload and the last two under high workload. Results showed that compared to teams scoring lower in planning, teams scoring highly in planning (a) Had more similar shared mental models (based on pathfinder analysis of paired comparison judgments); (b) "Pushed" more information, under high workload; and (c) Made fewer errors under high workload. Also, teams that pushed more information made fewer errors under high workload. Measures of information push and errors were based on behavioral checklists using pre-determined incidents where information could be pro-actively provided or certain specific errors could be made. Results suggest that better planning resulted in information push, which improved performance and reduced errors.

72. Stout, R.J., Salas, E., & Carson, R. (1994). Individual task proficiency and team process behavior: What's important for team functioning? Military Psychology, 6(3), 177-192.

This study tested the hypothesis that team-work (team process behavior), in addition to individual member skill, determined team effectiveness. Two people were assigned roles of pilot and co-pilot in a low fidelity flight simulation (Gunship). Pilot skill was defined as ability to control the joystick (i.e., keeping targets centered on the screen). Co-pilot skill was defined as ability to control the keyboard (i.e., stabilizing aircraft altitude). A team skill score was defined as the average of these two scores. Team processes were measures of specific behaviors organized under the following dimensions: mission analysis, assertiveness, decision making, adaptability, situational awareness, leadership and communication. Two measures of team effectiveness were used: Mission performance ratings were how well the team maintained altitude, adhered to the route, etc.; number of targets destroyed was also measured. Results showed that team process ratings accounted for unique variance in mission performance, even

when effects of team skill were co-varied out. The authors conclude that in team training, team processes should be trained, in addition to individual skills.

73. Stout, R.J, Salas, E., & Fowlkes, J.E. (1997). Enhancing teamwork in complex environments through team training. Group Dynamics, 1(2), 169-182.

The authors assessed the effectiveness of teamwork training. A two-day training program, based on research in teamwork, was designed to train aviators in team skills of communication, assertiveness and situational awareness. The training program used lecture, demonstration, role-playing and simulator scenarios. Data were collected on reactions to training (survey), teamwork attitudes (survey), knowledge of teamwork skills (multiple choice test) and performance of team competencies or skill dimensions (communication, assertiveness and situational awareness). Performance was measured using the targeted acceptable responses to generated events or tasks (TARGETs) approach. Team competencies or skill dimensions and the generic behaviors related to these dimensions were made task and context specific for the scenario developed to assess these competencies or dimensions. Teams in the experimental condition performed training scenarios in a simulator, after which they were given feedback on their performance of team skills. Then experimental (trained) and control teams were run through a (separate) evaluation scenario. Team performance in this scenario was assessed by raters blind to experimental condition. Trainee ratings of training indicated that the simulator training was helpful. Attitudes toward teamwork increased more from pre- to post-measurement for the experimental group than for the control group. The trained teams had more knowledge of team skills than did the untrained teams. The trained (experimental) teams "hit" more of the TARGETs on team skills than did the untrained (control) teams. Thus the teamwork training improved aviators' team knowledge, skills and attitudes (KSAs). The authors suggest that future research should examine knowledge structures such as mental models.

74. Sundstrom, E., De Meuse, K.P., & Futrell, D. (1990). Work teams: Applications and effectiveness. American Psychologist, 45(2), 120-133.

This review article applies an ecological framework to the understanding of work group and small team performance. Sundstrom et al. develop a model of work teams ("interdependent collections of individuals who share responsibility for specific outcomes") that includes four major linked categories: organizational context, boundaries, team development, and team effectiveness. Organizational context includes both internal and external influences that act upon the group. For instance, work groups often develop mission statements that are unique to the group while maintaining adherence to the organization's overarching objectives. The reward structure in which the group operates also influences the performance of the group as a whole and the performance of the individuals within the group. Boundaries, which can be both physical and psycho-social, are emphasized in this ecological model. Research reviewed by the authors suggests that team members who are located in proximity to one another develop cohesive bonds and are more effective. However, boundaries must be consciously monitored to avoid the group becoming too isolated or not sufficiently differentiated. Team development includes the structural features such as norms and member roles. The dynamic, changing nature of teams is stressed with the emphasis on temporal fluctuations in team processes. Lastly, team effectiveness is treated in terms of performance and viability. Standard quantifiable performance

measures such as quality and quantity of products, are coupled with member satisfaction and other psychological factors.

The underlying theme of this paper is its emphasis on the multifaceted nature of team processes. Sundstrom et al. argue that to understand team performance, one must consider variables such as the organization structure (external factors) and interpersonal relationships (internal factors) that are acting on the team. Sundstrom et al. suggest that team developers and leaders should promote awareness of the unique factors that are influencing a particular team.

75. Teslul, P.E & Mathieu, J.E. (1999). Overcoming roadblocks to effectiveness: Incorporating management of performance barriers into models of work group effectiveness. Journal of Applied Psychology, 84 (2), 200-217.

Most team models are based on an input-process-output paradigm. Input includes individual member characteristics, such as experience, knowledge, skills, and abilities; process includes team interactions; and output includes the tangible or intangible team products. Little attention by researchers is given to the environment in which groups or teams operate. However, environmental factors, such as performance barriers or problems with equipment, materials, resources and work processes, can affect team performance. This study hypothesized that performance barriers have a direct negative influence on team performance (Hypothesis 1) and team viability (satisfaction, cohesion and willingness to stay; Hypothesis 2). However, while teams are influenced by their context (environment, such as performance barriers), teams can also influence their environment. Thus, teams using performance management strategies, such as anticipating problems or taking action to minimize problems, will experience fewer and less severe performance barriers (Hypothesis 3). Also, for teams using performance management strategies, performance barriers will have a less negative effect on performance (Hypothesis 4a) and team viability (Hypothesis 4b). Certain team characteristics influence a team's use of performance management strategies. More performance management strategies will be used by teams with (a) better teamwork processes (coordination, potency/collective self-efficacy, and familiarity with the work environment), (b) self management, (c) internal (first line) leadership that promotes self-management, and (d) external (second line) leadership that promotes self-management (Hypotheses 5 to 8, respectively). Survey data were collected from team members, first-line and second-line supervisors of road crews.

Results of linear regression analyses showed a negative relationship between performance barriers and team performance (Hypothesis 1 supported) but not team viability (Hypothesis 2 not supported). Teams using performance management strategies encountered fewer and less severe performance barriers (Hypothesis 3 supported). However, use of team performance management strategies did not mitigate the negative relationship between performance barriers and team performance (Hypothesis 4a not supported). Conversely, use of performance management strategies did mitigate the relationship between performance barriers and one measure of team viability -- cohesion. When performance barriers are serious, teams using more performance management strategies have higher cohesion than teams using less performance management strategies (Hypothesis 4b partially supported). Teams with more effective teamwork processes (coordination, potency/collective self-efficacy, and familiarity with the work environment), more self management, and more internal and external leadership that is

supportive of self-management, used more performance management strategies (Hypotheses 5 to 8 supported, respectively). Thus, there is correlational evidence that team characteristics (teamwork, self management, leadership) drive use of performance management strategies, which reduces performance barriers, which in turn is associated with team performance. Training of teamwork, self management, leadership and performance management techniques may improve team performance.

76. Urban, J. M., Bowers, C. A., Monday, S. D. & Morgan, B. B. (1995). Workload, team structure, and communication in team performance. Military Psychology, 7(2), 123-139.

This study examines the effects of team structure and workload on communication and performance. Two types of team structure are compared: product organizational structure and non-hierarchical structure. Product organizational structure describes teams in which all members, except the team leader, perform similar tasks, but in different domains or on different products. Non-hierarchical structure describes teams in which team members have similar capabilities and are presented with identical information for performing the task. Two levels of workload (high vs. low) are also compared. Team coordination processes were observed and coded for the purpose of associating certain behaviors with effective teamwork. Twenty-four teams of five undergraduate students were assigned to one of the four conditions (high workload, non-hierarchical structure; low workload, non-hierarchical structure; high workload, product structure; low workload, product structure). Each team performed the resource management (REMAN) task component of the team performance assessment battery. Voice recorded segments were coded and analyzed on eight categories of communication behavior: question, answer, request, response to request, answer forming request, acknowledgment, statement, and other. The REMAN task simulates a radar operator station; participants monitor and attack incoming enemy crafts. Team structure was manipulated by the level of information provided to team members (e.g., non-hierarchical team members each received the same information and firing capabilities.) Workload was manipulated by the amount of resources needed to shoot down an enemy. Under high workload conditions, groups needed to use more resources and coordinate their actions more than did the groups assigned to low workload conditions.

The results indicated no main effect due to workload, but a significant interaction of workload and performance. Under high workload, ineffective teams (as ranked by number of enemy craft shot down) responded more to queries (e.g., answers and answers that formed requests) than effective teams. Product organization structured teams performed worse than non-hierarchical teams under high and low workload conditions. It is suggested that more effective teams required less communication because they were better able to anticipate each other's needs and had better shared mental models. Training suggestions, such as teaching teams to provide needed information before it is requested, are provided. In conclusion, the results of this study suggest that workload, team structure, communication skills, and context all influence team effectiveness.

77. Urban, J.M., Weaver, J.L., Bowers, C.A., & Rhodenizer, L. (1996). Effects of workload and structure on team processes and performance: Implications for complex team decision making. Human Factors, 38(2), 300-310.

This study examines the effects of workload and team structure on team performance. Conditions of the study included three levels of workload (high time-pressure, high resource-demand, and baseline) and two types of team structure (non-hierarchical and hierarchical). Thirty-six teams of five undergraduate students were required to perform both individual and team tasks concurrently. The individual tasks involved monitoring and detecting changes in a stimulus; the team task involved an adaptation of the Distributed Resource Allocation and Management (DREAM) task. In this task, the five team members shared limited resources to destroy targets presented on two separate screens. In the high resource demand condition, more resources were required to destroy a target than in the high time pressure or baseline condition. In the high time pressure conditions, the rate at which targets approached was increased relative to the other two conditions. In the hierarchical team structure, each member was provided with specialized knowledge and limited ability to perform other team roles. In the non-hierarchical structure, all members received the same information and had identical abilities.

Results indicated that the teams performed most poorly under the high time-pressure condition, regardless of team structure. The high resource-demand condition did not reduce performance significantly. Under the high time-pressure condition, but not under the high resource-demand or baseline condition, participants responded more quickly to their individual tasks. As expected, high workload demands reduced communication between team members, especially in the high resource-demand condition. These results are discussed in terms of the effects that different types of workload place on teams and the different communication requirements of hierarchical and non-hierarchical teams.

78. Watson, W., Michaelsen, L.K., & Sharp, W. (1991). Member competence, group interaction, and group decision making: A longitudinal study. Journal of Applied Psychology, 76(6), 803-809.

Most research prior to this article had suggested that group decision making rarely exceeds the performance of the group's best member. In fact, it has been suggested by many that group consensus as a means of decision making is inappropriate. Watson, Michaelsen, and Sharp examine the inconsistency between the findings of prior research and the general trend of businesses moving towards group decision making. To do so, they examined the individual and group decision making performance of participants over a four-month period.

Fifty heterogeneous teams of 5 or 6 graduate students enrolled in a team-based learning course were followed over a semester. At three points in the semester, the students individually completed a multiple choice/true-false exam. Immediately after turning in their exams, the students met with their groups and re-took the exam. Results from the individual and group tests were compared. Consistently, the group score was higher than the highest individual score for nearly all groups. Furthermore, the effectiveness of the group's decision making ability improved over time relative to the individual member's decision making ability. These findings call into question previous research conclusions and suggest that group consensus of established teams is a better form of decision making than relying on the decision making ability of the group's best member.

79. Xiao, Y., Hunter, W.A., Mackenzie, C.F., Jefferies, N.J., Horst, R.L., & the Lotus Group (1996). Task complexity in emergency medical care and its implications for team coordination. Human Factors, 38(4), 636-645.

This study examined the effects of task complexity on team coordination. Xiao et al. observed medical teams perform 48 tracheal intubations in the emergency room over a three-year period. The intubation procedures were classified as being of high or low urgency. A task analysis of the video-recorded procedures indicated that several task characteristics were different between high and low urgency cases. High urgency cases had characteristics different from low urgency cases, such as: the patient was more often unconscious or in shock; less vital information was available; the intubation was more difficult. By comparing high and low urgency task performance, Xiao and colleagues identified four components of task complexity. Teams in the high urgency cases often performed multiple, concurrent tasks rather than performing the tasks sequentially. They were often faced with more uncertainty because of incomplete information. This uncertainty led to discordance in perceived tasks and priorities. They often implemented novel techniques and "changing plans" that could produce conflict in the team members' understanding of the situation. Team members often had to combat compressed work procedures and high workload. These components of task complexity require that emergency medical teams be trained in special skills. Xiao et al. suggested that separate work procedures or protocols should be established for high and low urgency situations. This would allow all team members to know what to expect during high-pressured cases. Also, training should promote the development of communication skills.

80. Zaccaro, S. J., Gualtieri, J., & Minionis, D. (1995). Task cohesion as a facilitator of team decision making under temporal urgency. Military Psychology, 7(2), 77-93.

Zaccaro, Gualtieri, and Minionis examine the influence of task cohesiveness on team performance under temporally urgent conditions. Task-based cohesiveness occurs when team members obtain goal achievement by working together towards goals that would be unattainable by members acting as individuals. One-hundred and thirty-eight participants were randomly assigned to three-member teams. Each team was assigned to one of four levels in a nested design: task cohesion (high versus low) and temporal urgency (high versus low). High task cohesion was produced by instructing members that their task performance was critical to the study, that they should be concerned with overall team performance, and that they would receive extra credit if they outperformed a previous team. Low task cohesion was produced by informing the participants that their performance was not important and that they would not receive any extra credit. The teams completed the Search for Oil task in which each of the three team members made recommendations for drilling sites on a 15x15 square matrix. Recommendations were based on unique information held by each member; successful identification of a good drilling site, however, depended on the integration of information provided by all three members. A four-minute pre-planning period was provided for all teams, and the team interactions during the pre-planning period were recorded and scored by experimenters. During the performance stage, teams assigned to the high temporal urgency condition were allowed 10 minutes, whereas teams in the low temporal urgency condition were allowed 25 minutes. Performance was rated by counting the number of correct recommendations

by: All three members (3-member hits), two members (2-member hits), and only one member (1-member hits).

Results indicated that teams in the high task-cohesion condition outperformed the low task-cohesion teams under high temporal urgency conditions. The high cohesion groups demonstrated better planning prior to performance and therefore were able to act more proficiently during the Search for Oil task. The authors concluded that performance under high time pressure can be improved by stressing the importance of task accomplishment for team members and by encouraging the belief among team members that they can successfully meet most task challenges. Training that stresses goal attainment and motivates teams to be cohesive will improve performance during high time stress periods.

Appendix B

List of Acronyms

AAR	After Action Review
ACOE	Air Crew Observation and Evaluation
ACT	Air Crew Coordination Training
AD	Air Drop
AH	Attack Helicopter
AR	Air Refueling
ARI	U.S. Army Research Institute for the Behavioral and Social Sciences
C3	Command, Control, Communication
CAS	Close Air Support
CCTT	Close Combat Tactical Trainer
CHIPS	Coordination in Hierarchical Information Processing Strategies
CIC	Combat Information Center
CMC	Computer Mediated Communication
CODE	Coordination and Decision
CP	Contact Point
CRM	Crew Resource Management
CTA	Cognitive Task Analysis
CTBF	Critical team behavior form
CTC	Combat Training Center
DIS	Distributed interactive simulation
DREAM	Distributed Resource Allocation and Management
DTIC	Defense Technical Information Center
EBT	Event Based Training
FA	Function Allocation
FASTRAIN	Force XXI Training Methods and Strategies
FEMA	Federal Emergency Management Agency
FTF	Face to Face
I/E	Infiltration/Exfiltration
IBM	International Business Machine
IEEE	Institute of Electrical and Electronics Engineers
IPK	Inter-Positional Knowledge
KSA	Knowledge, skills, and attitudes
LC	Leadership team Cohesion
LER	loss exchange ratios
LL	Low Level

LOFT	Line-Oriented Flight Training
MDS	Multi-Dimensional Scaling
METT-T	Mission, Enemy, Terrain Troops and Time
MP	Mission Preparation
MTP	Mission Training Plan
NATO	North Atlantic Treaty Organization
N-D	Normative descriptive
NGO	non-government organizations
OC	Observer Controller
PROMES	Productivity Measurements
QWL	quality of work life
R&D	Research and Development
REMAN	Resource Management
RPD	Recognition Primed Decision Making
SA	Situation Awareness
SHAPE	*S*crutinize symptoms; *H*ypothesize solutions, *A*nalyze proposed solutions, *P*erform modifications and corrections, *E*valuate results
SLT	Social Learning Theory
SME	Subject Matter Expert
SOF	Special Operational Forces
STO	Science and Technology Objective
T2RM	Tactical Team Resource Management
TACT	Team Adaptation and Coordination Training
TADMUS	Tactical Decision Making Under Stress
TARGETS	Targeted Acceptable Response for Generated Events or Tasks
TDM	Tactical Decision Making
TE	Tactics Employment
TEM	Team Effectiveness Model
TIDE2	Team Interaction Decision Environment/Teams Incorporating Distributed Expertise
TM	Time Management
TMT	Team Model Trainer
TOM	Teamwork Observation Measure
TQR	Thinker Questioner Reflector
VR	Virtual Reality
WRAIR	Walter Reed Army Institute of Research

WWII	World War II